Adrian Park
Raymond Price
Editors

Global Surgery

The Essentials

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Editors
Adrian Park
Department of Surgery
Anne Arundel Health System
Johns Hopkins University School
of Medicine
Annapolis, Maryland
USA

Raymond Price
Department of Surgery
Center for Global Surgery
Department of Family and
Preventative Medicine
Division of Public Health
University of Utah
Salt Lake City, Utah
USA

Department of Surgery
Intermountain Medical Center
Intermountain Healthcare
Salt Lake City, Utah
USA

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To Jennifer, my wife, who, without prior exposure, embraced my early pursuit of surgery in remote corners of the earth and by whose steadfast love and support I am blessed. And to my parents Cedric and Valerie Park who instilled in me at a young age a love for life and integration among disparate cultures around the world.

Adrian Park

To my eternal companion Anne and our wonderful children (Elizabeth, Rachel, Rebekah, Matthew, Michelle, Sarah, Christina, and Stephanie), I express my love and appreciation for their unwavering support and unparalleled example of charity and compassion. And to my parents, Richard and Lynn Price, I am forever indebted for providing a sure foundation through their example of the joy that comes from humble service and their life-long dedication to making the world a better place.

Raymond Price

Preface

When a 4-year-old boy with a strangulated inguinal hernia presents to the attention of a well-trained surgeon who practices in a high-income country (HIC), his condition will be recognized and timely lifesaving surgical care performed. In most of the world, however, such a scenario often plays out to a tragic end.

Anticipating the birth of a child should bring excitement and joy. Where adequate resources and surgical care are available to women whose labor does not progress, a timely C-section can save the baby's life and mitigate life-long disability for the mother. Unfortunately for the majority of laboring mothers in the world, the prospect of childbirth brings dread rather than joy. More than 250,000 women, mostly in low- and middle-income countries (LMICs), still die every year in childbirth, and millions more suffer with vesicovaginal fistulas resulting from prolonged labor.

Over five billion people worldwide lack access to timely, affordable, quality surgical care. Beyond the human tragedy, the economic toll from death and disability resulting from surgically treatable disease is staggering.

For the vast majority of humanity, the prospect for access to surgical care advanced profoundly in 2015 when the World Health Assembly (comprised of 194 nations) unanimously resolved that access to "Emergency and Essential Surgical Care and Anesthesia" is an integral component to universal health coverage. Surely none would argue that all people deserve timely, safe, and effective care for the most common lethal or debilitating surgically correctible conditions.

For the foreseeable future, an immense challenge remains to design and resource systems, as well as train and disseminate skilled surgical caregivers to fulfill this important and ambitious mandate. Inevitably with such challenges come many opportunities. It is encouraging, inspiring even, to see how governmental (LMIC & HIC) and nongovernmental agencies, academic institutions, professional societies, and faith-based and philanthropic efforts are engaging and coming together to seize these opportunities. Many individual surgeons and physicians are intrigued by the concept of global surgery, many of whom are already involved; many more seek to learn how they might serve.

Our intent in creating this book is to tell the story of global surgery, including its brief history and exciting future, and to provide important practical information for those who wish to engage in this most worthy of pursuits. Our hope is that this book will prove to be a trusted and well-thumbed resource for you at whatever stage of your global surgical journey you find yourself.

We wish to thank the contributing authors, some of the most expert yet humble and committed authorities on global surgery, for their practical wisdom, insight, and experience from which you are bound to benefit, when working in differing circumstances around the world. We would also like to thank Stephanie Frost (Springer) who tirelessly provided support and guidance.

Annapolis, MD, USA Adrian Park
Salt Lake City, UT, USA Raymond Price

Contents

Contributors

Emmanuel A. Ameh, MBBS, FWACS Division of Paediatric Surgery, Department of Surgery, National Hospital, Federal Capital Territory, Abuja, Nigeria

Domenech Asbun, MD Department of Surgery, Kern Medical, Bakersfield, CA, USA

Horacio J. Asbun, MD, FACS Department of Surgery, Mayo Clinic Florida, Jacksonville, FL, USA

Yasser Bhatti, DPhil, MSc, Mot, FHEA Division of Surgery & Cancer, Institute of Global Health Innovation, Imperial College London, London, UK

Stephen W. Bickler, MD, DTM&H, FAAP, FACS Division of Pediatric Surgery, Rady Children's Hospital—University of California, San Diego, CA, USA

Brian H. Cameron, MD PGDipMedEd, FRCSC, FACS McMaster Children's Hospital, Hamilton, ON, Canada

Louis L. Carter Jr, MD, FACS Plastic and Orthopaedic (Hand) Surgery, University of Tennessee College of Medicine, Chattanooga Unit, Erlanger Hospital, Chattanooga, TN, USA

Matchecane T. Cossa, MD National Program of Surgery, Ministry of Health of Mozambique, Maputo, Mozambique

Surgery Department – Cardiovascular and Thoracic Service, Maputo Central Hospital, Maputo, cidade, Mozambique

Jonathan L. Dunlap, MD Department of Surgery, Brigham and Women's Hospital, Boston, MA, USA

Department of Surgery, Center for Surgery and Public Health, Brigham and Women's Hospital, Boston, MA, USA

Micaela M. Esquivel, MD Stanford University School of Medicine, Department of General Surgery, Stanford, CA, USA

Michelle Foltz, MD Columbus, MT, USA

Richard A. Gosselin, MD, MPH, MSc, FRCS (C) Department of Orthopedic Surgery, Institute for Global Orthopaedics and Traumatology, University of California at San Francisco, El Granada, CA, USA

Reinou S. Groen, MD MIH, PhD Alaska Native Medical Center, South Central Foundation, Anchorage, AK, USA

Adil H. Haider, MD, MPH Department of Surgery, Brigham and Women's Hospital, Boston, MA, USA

Department of Surgery, Center for Surgery and Public Health, Brigham and Women's Hospital, Boston, MA, USA

Jonathan L. Halbach, DO US Navy Hospital, San Diego, CA, USA

Division of Pediatric Surgery, Rady Children's Hospital—University of California, San Diego, CA, USA

Mark J. Harris, MD, MPH Department of Anesthesiology, Rm 3C444, University of Utah Medical Center, Salt Lake City, UT, USA

Matthew Harris, DPhil, MBBS, MSc FFPH Division of Surgery & Cancer, Institute of Global Health Innovation, Imperial College London, London, UK

Department of Primary Care and Public Health, London, UK

Jaymie A. Henry, MD, MPH Department of Surgery, Charles E. Schmidt College of Medicine, Florida Atlantic University, Boca Raton, FL, USA

R. Gregory Juckett, MD, MPH, FAAFP C TropMed Department of Emergency Medicine/Family Medicine, West Virginia University School of Medicine, Morgantown, WV, USA

Lena Lea Kassab, MD, MBA Department of Family Medicine, Mayo Clinic, Jacksonville, FL, USA

Rosemary Klein SAIL Center (Simulation to Advance Innovation and Learning), Anne Arundel Health System, Annapolis, MD, USA

Wayne Koch, MD, FACS Department of Otolaryngology-Head and Neck Surgery, Johns Hopkins Medical Institutions, Baltimore, MD, USA

Sanjay Krishnaswami, MD, FACS, FAAP Division of Pediatric Surgery, Oregon Health and Science University Hospital, Portland, OR, USA

Janaka A. Lagoo, MD Brigham and Women's Hospital and Harvard, T.H. Chan School of Public Health, Boston, MA, USA

Sandhya A. Lagoo-Deenadayalan, MD, PhD Duke University, Department of Surgery, Durham, NC, USA

Yihan Lin, MD, MPH Program in Global Surgery and Social Change, Department of Global Health and Social Medicine, Harvard Medical School, Boston, MAUSA

Department of Surgery, University of Colorado, Aurora, CO, USA

Morgan Mandigo, MD, MPH Department of Gynecology and Obstetrics, Johns Hopkins Hospital, Baltimore, MD, USA

John G. Meara, MD, DMD, MBA Program in Global Surgery and Social Change, Department of Global Health and Social Medicine, Harvard Medical School, Boston, MA, USA

Department of Plastic and Oral Surgery, Boston Children's Hospital, Boston, MA, USA

Jim Moore, AAS Department of Biomedical Services, AAS Biomedical Technology, AAS Industrial Management, Samaritan's Purse/World Medical Mission, Boone, NC, USA

Swagoto Mukhopadhyay, MD Program in Global Surgery and Social Change, Department of Global Health and Social Medicine, Harvard Medical School, Boston, MA, USA

Department of Surgery, University of Connecticut, West Hartford, CT, USA

Arlene Muzira, MBChB MMed (Surg) Department of Surgery, Mulago Hospital, Kampala, Uganda

Benedict C. Nwomeh, MD, MPH, FACS, FAAP Department of Surgery and Pediatrics, Nationwide Children's Hospital, The Ohio State University, Columbus, OH, USA

Doruk Ozgediz, MD, MSc Department of Surgery, Yale New Haven Hospital, New Haven, CT, USA

Adrian Park, MD, FRCSC, FACS FCS (ECSA) Department of Surgery, Anne Arundel Health System Johns Hopkins University School of Medicine, Annapolis, MD, USA

Robert K. Parker, MD Department of Surgery, Tenwek Hospital, Bomet, Kenya

Warren Alpert School of Medicine at Brown University, Providence, RI, USA

Louis L. Pisters, MD Department of Urology, The University of Texas MD Anderson Cancer Center, Houston, TX, USA

Dan Poenaru, MD, MHPE, PhD Department of Surgery, Montreal Children's Hospital, Montreal, QC, Canada

Raymond Price, MD, FACS Family and Preventive Medicine, Division of Public Health, Intermountain Medical Center, Intermountain Healthcare, University of Utah, Salt Lake City, UT, USA

Matthew Prime, MBBS, BSc, MRCS Division of Surgery & Cancer, Institute of Global Health Innovation, Imperial College London, London, UK

Nakul P. Raykar, MD, MPH Program in Global Surgery and Social Change, Department of Global Health and Social Medicine, Harvard Medical School, Boston, MA, USA

Department of Surgery, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA

Eleni M. Rettig, MD Department of Otolaryngology-Head and Neck Surgery, Johns Hopkins Medical Institutions, Baltimore, MD, USA

Saurabh Saluja, MD, MPP Program in Global Surgery and Social Change, Department of Global Health and Social Medicine, Harvard Medical School, Boston, MA, USA

Department of Surgery, Weill-Cornell Medical Center, New York, NY, USA

Susie Schofield, PGCE, PhD Centre for Medical Education, University of Dundee, Dundee, Tayside, UK

Mark Shrime, MD, MPH, PhD Program in Global Surgery and Social Change, Department of Global Health and Social Medicine, Harvard Medical School, Boston, MA, USA

Office of Global Surgery, Massachusetts Eye & Ear Infirmary, Boston, MA, USA

David A. Spiegel, MD Department of Orthopaedic Surgery, University of Pennsylvania School of Medicine, Philadelphia, PA, USA

Division of Orthopaedic Surgery, Children's Hospital of Philadelphia, Philadelphia, PA, USA

Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA, USA

Orthopaedic Surgery, Hospital and Rehabilitation Centre for Disabled Children, Janagal, Kavre, Nepal

Bruce C. Steffes, MD, FACS, FWACS, FCS(ECSA) Pan-African Academy of Christian Surgeons, c/o Christian Medical and Dental Associations, Bristol, TN, USA

Daniel Q. Sun, MD Department of Otolaryngology-Head and Neck Surgery, Johns Hopkins Medical Institutions, Baltimore, MD, USA

Mamta Swaroop, MD, FACS Department of Surgery – Trauma and Surgical Critical Care, Northwestern University Hospital, Chicago, IL, USA

John L. Tarpley, MD Department of General Surgery, Vanderbilt University School of Medicine, Nashville, TN, USA

Margaret J. Tarpley, MLS Department of Surgery, Vanderbilt Medical Center, Nashville, TN, USA

Russell E. White, MD, MPH, FACS, FCS (ECSA) Department of Surgery, Tenwek Hospital, Bomet, Kenya

Warren Alpert School of Medicine at Brown University, Providence, RI, USA

Richard S. Wood, BA Worldwide Biomedical Charitable Services (WBCS), Lawrenceburg, TN, USA

Sherry M. Wren, MD, FACS, FCS (ECSA) Stanford University School of Medicine, Department of Surgery, Palo Alto, CA, USA

Part I

The 10,000-Foot View: Framing Global Surgery

Global Disparities in Surgical Care

1

Jonathan L. Dunlap and Adil H. Haider

Introduction

Five billion humans worldwide do not have access to safe, timely, and affordable surgical care. Nearly one-third of the global burden of disease can be attributed to conditions treatable by surgery [1]. Not surprisingly, low- and middle-income countries (LMICs) bear the majority of this burden. Less than 6% of surgical operations performed worldwide occur in these countries, and an estimated 143 million additional surgical procedures per year would be necessary to reverse this inequity [2, 3].

Historically, major global public health initiatives have focused on infectious and communicable diseases as the major medical contributors to global morbidity and mortality. HIV/AIDS, tuberculosis, and malaria have stood at the forefront of global attention for decades, and significant progress has been made to eliminate widespread burden secondary to these diseases. But recently, comprehensive surgical care—which includes not only surgery but also obstetric, trauma, and anesthesia care—has surfaced to join communicable diseases for center stage in the global development agenda.

Disease trends in LMICs are changing to match those of high-income countries (HICs). An "epidemiological transition" has accompanied global industrialization, which is contributing to the previously underappreciated global burden of surgical disease [4]. People living in LMICs are now less likely to die from communicable diseases; they are surviving to ages where cardiovascular disease, cancer, and mental health become more prevalent [5]. Furthermore, as technological advancements infiltrate developing LMICs, the number of automotive-, construction-, and trauma-related injuries necessitating surgical care has skyrocketed. We are learning that

J.L. Dunlap, MD (✉) • A.H. Haider, MD, MPH
Department of Surgery, Brigham and Women's Hospital, 75 Francis Street, CA-034, Boston, MA 02115, USA

Department of Surgery, Center for Surgery and Public Health, Brigham and Women's Hospital, One Brigham Circle, 1620 Tremont Street, 4-020, Boston, MA 02120, USA
e-mail: jldunlap@partners.org; ahhaider@partners.org

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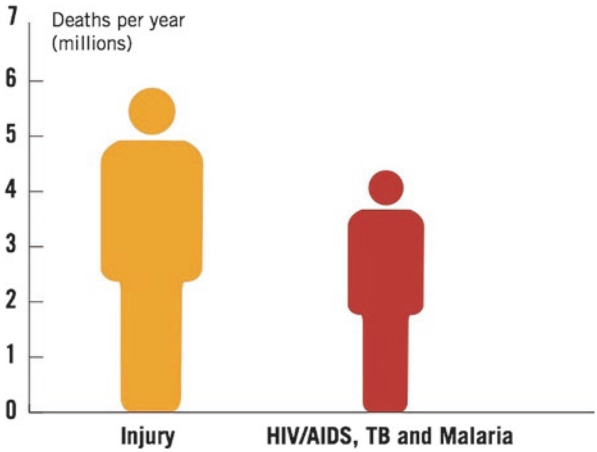

Fig. 1.1 The scale of the problem. About 5.8 million people die each year as a result of injuries, many of which are at least treatable, if not curable, by surgery [8] (Reproduced with permission of the World Health Organization, INJURIES and VIOLENCE and THE FACTS: The scale of the problem. http://www.who.int/violence_injury_prevention/key_facts/VIP_key_facts.pdf)

surgical disease is delicately intertwined with social advancements, economic progress, and increased life expectancy.

Even before this epidemiological transition, surgery was recognized as an "essential," albeit low priority, implementation strategy to reduce the global burden of disease. Surgery was relegated to low priority status due to three key misconceptions: first, surgical disease was thought to comprise a small and thus insignificant percentage of the total global burden of disease; second, surgery was viewed to too expensive to be a cost-effective strategy for large-scale global health initiatives; and third, surgical "missions" were seen as effective crisis interventions, but not as sustainable models for long-term reduction of global burden [6]. We now know these misconceptions could not be further from the truth.

In 2005, the World Health Organization (WHO) launched the Global Initiative for Emergency and Essential Care to promote the importance of surgical care in trauma and emergency situations. For the first time, surgery was included as part of a new comprehensive primary healthcare plan for a major global public health initiative. In 2008, Drs. Farmer and Kim of Partners in Health published a sentinel paper where surgery became popularly known as "the neglected stepchild of global health" [7]. They indicated that surgical diseases accounted for upward of 15% of the total disability-adjusted life years (DALYs) lost worldwide, which is more than HIV/AIDS, TB, and malaria combined (Fig. 1.1 [8]).

Numerous publications ensued, attempting to quantify the true global burden of surgical disease and identify strategies to reduce morbidity and mortality. Surgical and anesthesia care became increasingly recognized as a potentially cost-effective component of primary care initiatives. Surgery even entered the discussion as a possible solution to achieving several Millennium Development Goals (MDGs), specifically those related to reducing child mortality, improving maternal health, and reducing HIV/AIDS transmission [9]. It was becoming clear that surgical disease and access to safe surgical care deserved more medical and political attention. And so the field of global surgery was born to advance the notion that surgical care is a fundamental component of global health [10].

Within the last few years, global surgery has reached new milestones with unprecedented enthusiasm and support. The World Bank Disease Control Priorities 3rd Edition (DCP3) volume on *Essential Surgery* was published, which defined the global burden of surgically treatable disease and described the potentially huge impact that reducing this burden could have. The Lancet Commission on Global Surgery (LCoGS) brought together experts from more than 110 countries to provide an unprecedented evidence-based update on the state of surgery worldwide, an argument for investing in surgical care, and strategies for future delivery. Their work demonstrated the now often quoted and startling statistic that five billion people lack access to surgical care [3, 11]. Finally, the Global Alliance for Surgical, Obstetric, Trauma, and Anesthesia Care—known as the G4 Alliance—has emerged as a global platform to ensure safe surgical care for 80% of the world by 2030 through advocacy, policy implementation, and resource mobilization efforts. It brings together more than 70 international member organizations all advocating for the five billion people worldwide who do not have access to surgical care.

These efforts, in conjunction with the work of countless organizations and initiatives, culminated in the unanimous approval of the World Health Assembly's resolution WHA68.15: "Strengthening emergency and essential surgical care and anesthesia as a component of universal health coverage (UHC)" in May 2015. For the first time, the United Nations detailed its commitment to eliminate the disparities that exists from a lack of safe, universal access to surgical care. The international political agenda finally recognizes that surgery and anesthesia are key components of universal healthcare and health system strengthening [12]. It appears as though the future of global surgery is bright.

Surgical Epidemiology

We now know that two-thirds of the world's population lacks appropriate access to safe, affordable surgical and anesthesia care [3]. We also know that surgical disease does not discriminate based on one's age or the color of their skin. But upwards of 95% of the individuals who suffer and ultimately die from these conditions live in LMICs [11]. In fact, the LCoGS reports that nine out of ten people in LMICs do not have access to basic surgical care when needed. These countries are primarily in South Asia, sub-Saharan Africa, and parts of South America; less than 5% of individuals living in North America, Western Europe, or Australia suffer the same fate (Fig. 1.2).

WHA resolution WHA68.15 recognizes that a wide range of surgical conditions rank among the top 15 causes of worldwide physical disability. These conditions include (in no particular order) obstructed labor, birth defects, cataracts, cancer,

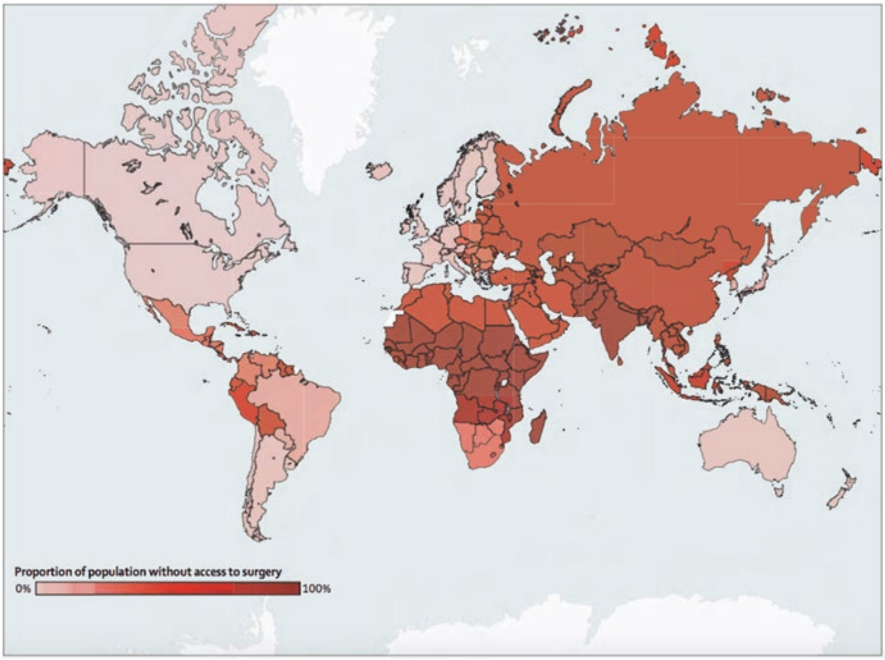

Fig. 1.2 Proportion of population without access to surgery by country (selective tree with baseline assumptions) [11] (Reprinted from Alkire et al. [11], with permission from Elsevier)

diabetes, acute abdominal conditions (hernias, bowel obstruction), and burns and injuries from domestic, industrial, or road accidents [13]. DCP3's *Essential Surgery* identifies a similar group of "essential" surgical conditions that, if basic surgical care were accessible, could prevent 1.5 million deaths per year [14]. They define these conditions as primarily or extensively treated by surgery, having a large health burden, and successfully treated by cost-effective and feasible to promote globally surgical operations.

The conditions fall into three major categories. First are surgical "injuries," which stem from road and construction injuries, falls, drowning, burns, interpersonal violence, and exposure to mechanical forces. Second are "maternal-neonatal" conditions, including maternal hemorrhage, obstructed labor, abortion, and neonatal encephalopathy. Third are "digestive diseases," including appendicitis, gallbladder and bile duct disease, hernia, paralytic ileus, and bowel obstruction. Traumatic injuries account for 76.6% of preventable deaths per year, while maternal-neonatal conditions and digestive diseases account for 14.4% and 9% of preventable deaths per year, respectively.

DPC3's *Essential Surgery* also describes several "selected subspecialty conditions" that, if basic surgical care could be provided, could prevent at least 400,000 deaths and avert 39 million DALYs per year. The conditions responsible for preventable deaths include congenital heart anomalies (66%), neural tube defects (17%), and cleft lip and palate (17%). Cataracts and obstetric fistula account for

11% and 3% of avertable DALYs per year, respectively. A clear role exists for cardiothoracic, neurosurgical, plastic and reconstructive, and urological surgeons in the global surgery conversation.

Burden of Surgical Disease

In 2006, Disease Control Priorities in Developing Countries 2nd ed. (DCP2) published initial estimates, based on expert opinion, which suggested that up to 11% of the global burden of disease measured in disability-adjusted life years (DALYs) could be treated with surgery [15]. This was followed up by Drs. Farmer and Kim's report that surgical conditions accounted for up to 15% of total DALYs lost worldwide. Since then, global surgery researchers have gone to great lengths to better quantify the true burden of surgical disease.

By 2015, newer studies suggested that these early claims were in fact gross underestimates. One study claimed that as much as 33% of the global burden of disease can be attributable to surgical disease [1]. Another study, which assessed the macroeconomic financial burden of surgical disease, projected that surgical diseases will result in annual losses of 1.25% of potential gross domestic product (GDP) or $20.7 trillion (2010 US$, purchasing power parity) by 2030 [16]. Not surprisingly, these financial losses will be unequally distributed across the global population; the same individuals in LMICs who, for financial reasons struggle to access surgical care for their diseases, will face even greater relative costs in the future [16].

In 2010, most leaders in the field agreed that at least two billion people lacked access to basic surgical services based on geographic location or operating room density alone [17, 18]. In 2015, this figure was revised; when new studies included factors such as "timeliness, surgical capacity, safety, and affordability" into their analysis, these data projected the true number to be approximately five billion people [11]. The LCoGS executive report reaffirms this estimate and sheds new light on surgical burden of disease through several other "key messages" [3]. They are worth reproducing here:

- "Five billion people do not have access to safe, affordable surgical and anesthesia care when needed. Access is worst in low-income and lower-middle- income countries, where nine of ten people cannot access basic surgical care.
- One hundred forty three million additional surgical procedures are needed in LMICs each year to save lives and prevent disability. Of the 313 million procedures undertaken worldwide each year, only 6% occur in the poorest countries, where over a third of the world's population lives. Low operative volumes are associated with high case-fatality rates from common, treatable surgical conditions. Unmet need is greatest in eastern, western, and central sub-Saharan Africa, and south Asia.
- Thirty-three million individuals face catastrophic health expenditure due to payment for surgery and anesthesia care each year. An additional 48 million cases of catastrophic expenditure are attributable to the non-medical costs of accessing

surgical care. A quarter of people who have a surgical procedure will incur financial catastrophe as a result of seeking care. The burden of catastrophic expenditure for surgery is highest in low-income and lower-middle-income countries and, within any country, lands most heavily on poor people.

- Without urgent and accelerated investment in surgical scale-up, LMICs will continue to have losses in economic productivity, estimated cumulatively at US $12.3 trillion (2010 US$, purchasing power parity) between 2015 and 2030" [3].

Surgical Healthcare Needs and Delivery

The desire to deliver worldwide, universal surgical care—including trauma, obstetric, and anesthesia care—is an ambitious yet achievable goal. WHA resolution WHA 68.15 has provided a framework for the WHO, member states, and politicians to support greater prioritization of surgical care as part of universal health coverage and national surgical plans (NSPs). The LCoGS and G4 Alliance have proposed several core indicators in an effort to monitor NSPs and track their progress over time. If monitored in a thorough and standardized fashion, these indicators will guide more timely population-level solutions to the unpredictable obstacles that will undoubtedly try to inhibit their success. The LCoGS proposes six core indicators: (1) access to timely essential surgery, (2) specialist surgical workforce density, (3) surgical volume, (4) perioperative mortality, (5) protection against impoverishing expenditure, and (6) protection against catastrophic expenditure [3].

The G4 Alliance agrees with these six indicators as the most important indicators to begin with and recommends that countries should initiate data collection on these immediately. However, for countries that are able to collect further information, it also proposes nine additional indicators—specific to anesthesia, obstetric, and trauma care—with the goal of identifying nuances within individual NSPs. These additional indicators are (1) estimated proportion of seriously injured patients transported by ambulance (trauma), (2) national whole blood donate rate (trauma/obstetrics), (3) cesarean section rate (obstetrics), (4) proportion of operating rooms with pulse oximetry (anesthesia), (5) ratio of anesthesiologists to surgeons (anesthesia), (6) inpatient trauma mortality rate (trauma), (7) maternal mortality ratio (obstetrics), (8) neonatal mortality (obstetrics), and (9) perioperative mortality rate on operative day (anesthesia). Several countries have already begun developing their own NSPs based on these core indicators.

While data collection is fundamental to assessing the future needs and delivery options at the population-based level, individual providers and local initiatives must understand the barriers that currently prevent individuals from accessing surgical care. Alkire et al. established a simple yet realistic "chance tree" including four major obstacles a patient must navigate to access surgical care (Fig. 1.3). The first obstacle is "time." Can a patient physically reach a healthcare facility in a timely manner for both diagnosis and treatment? Time is more frequently typically associated with traumatic or emergency situations like acute appendicitis, obstructed labor, or a motor vehicle trauma. What a patient needs is a healthcare facility within

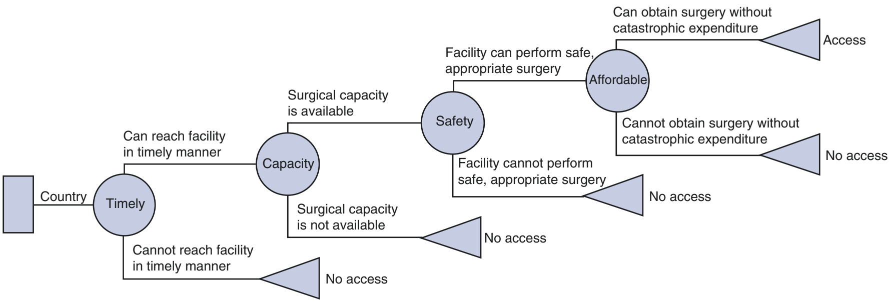

Fig. 1.3 Chance tree to assess global access to surgical care. Each change node represents a dimension of access [11] (Reprinted from Alkire et al. [11], with permission from Elsevier)

a realistic geographic distance that is feasible to get to based on local and affordable modes of transportation.

The second obstacle is "capacity." If the patient can successfully reach the healthcare facility in time, does that facility have the capacity to both diagnose and treat the surgical condition? The facility must have a trained surgical provider and qualified staff (e.g., anesthesia, nurses) who are available to perform the operation. It must also have a sterile operating theater, appropriate pharmaceuticals (pain control, antibiotics), and medical equipment (e.g., X-ray machine, electrocautery, suction) to effectively carry out the operation.

The third obstacle is "safety." Can the surgical team safely perform the operation? The surgeon should have adequate formal training to carry out the desired procedure. He/she must also have the correct instruments, which have been properly sterilized. Similarly, a formally trained anesthesiologist should be present and possess the proper induction medications, airway equipment, and monitoring devices (i.e., pulse oximeter). A designated recovery room with appropriate monitoring and staffing is also important for patient safety.

The final and oftentimes most underappreciated obstacle is "affordability." Can the patient afford the costs of surgical care without incurring catastrophic financial hardship for either themselves or their families? Data from the LCoGS suggests that each year nearly 33 million people worldwide do not pursue surgery for this reason [3]. The morbidity and mortality from surgical disease may actually be preferable to the financial ruin surgical intervention may invoke.

Disparities in Surgical Care

The wealth of new data emerging in the global surgery literature has confirmed what expert opinion has long suspected: clear disparities in surgical care exist between high-income and LMICs. For example, in Sierra Leone, 25% of respondents in a population-level study reported a current need for surgical care [19]. Yet, an overwhelming percentage of them cannot obtain surgery for their diseases. One study group suggests that 30% of the world's population receives almost 74% of the annual major surgical operations; of the 234 million annual major surgical procedures that take worldwide, as little as 3.5% of them occur in LMICs like Sierra Leone [2]. The LCoGS reports that this disparity is closer to 6% of operations being performed in LMICs. Whether the true number is 3 or 6%, it is a disparity that must be eliminated.

In addition to the well-documented intercontinental disparities, new data confirms that alarming disparities also exist within individual countries—both LMICs and HICs. Unequal access to lifesaving surgical care can exist between neighboring communities and even next-door neighbors. One of the first studies to explore these "in-country disparities" on a large scale reviewed a national health survey representing almost 100 million people in Pakistan. They found that wide disparities existed in the utilization of surgical care by population subtypes; urban residents were twice as likely to receive surgery as rural residents, independent of economic status and education level. Urban residence, older age, female gender, and economic status were all independently associated with improved access to surgery [20].

In Haiti, another group examined surgical services provided at nearby rural NGO hospitals. Despite equity strategies geared at assisting the rural poor, the hospitals' efforts may have ultimately widened disparities in surgical care and further disadvantage the rural poor [21]. Urban patients were found to be traveling to and utilizing services at the NGO hospitals instead of seeking care at urban fee-for-service hospitals. This work also emphasized the importance of correctly aligning equity funds when attempting to defray healthcare costs for the poorest people; typically, these costs pertain to transportation, food, and lodging, not necessarily the actual hospital fees. Even in the United States, another study showed that patients in rural communities have higher rates of perforated appendicitis even after adjusting for age, gender, socioeconomic, and insurance status [22]. These three examples of in-country disparities help explain the motivation behind national surgical plans and universal access to surgical care.

Conclusion

These are historic and exciting times in the field of global surgery. We now know that five billion people around the world do not have access to proper surgical care when they need it. We also know that the overwhelming majority of these individuals live in LMICs, but that the vast minority of annual surgical operations take place in those countries. New research has illuminated shocking disparities in surgical care that exist in all levels of society, both in LMICs and HICs.

With this new information comes new hope and new responsibility. Humanitarians and health professionals must work together to effectively reduce and ultimately prevent the global burden secondary to surgical disease. Key policymakers and influential global initiatives are joining forces with dedicated NGOs and local providers with the common goal of providing universal access to surgical care. The evidence is clear and the future is bright; now is the time for surgeons from all specialties to get involved in this movement against global disparities in surgical care.

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The Transforming Power of High-Quality Surgical Care: Surgery's Role in Improving Public Health

2

Jaymie A. Henry and Raymond Price

Introduction

Surgical care, with its ability to save lives, mitigate lifelong disabilities, and improve economic output for individuals, families, and communities, is gaining recognition as a global public health priority and as an essential and transformative part of the health-care delivery system. Less than 50 years ago, the vast majority of surgical procedures in developed countries were performed in hospitals with waiting times for elective operations that spanned weeks and months. With advances in technology, changes in health-care delivery priorities, and growth of the medical workforce, more than 50% of all operations are now performed either as an outpatient procedure or in ambulatory surgical centers (ASC). In high-income countries, surgery is safer, more accessible, and less expensive than at any other time in history. These changes, alongside recent policy shifts, have the potential to make the transformative power of this level of high-quality surgical care a global experience: one available for people living in low- and middle-income countries (LMICs).

2015 was a watershed year for advocates of increased access to high-quality surgery in low-income settings. Several landmark events occurred, representing the collective efforts of individual, community, academic, and political will for global surgical care. These included the publication of the World Bank Disease Control Priorities 3rd Volume on Essential Surgery (DCP3) [1]; the convening of the Lancet

J.A. Henry, MD, MPH (✉)
Department of Surgery, Charles E. Schmidt College of Medicine, Florida Atlantic University, 777 Glades Road, Boca Raton, FL 33431, USA
e-mail: jaymiehenry@health.fau.edu

R. Price, MD, FACS
Family and Preventive Medicine, Division of Public Health, Intermountain Medical Center, Intermountain Healthcare, University of Utah, Salt Lake City, UT 84113, USA
e-mail: Raymond.Price@imail.org

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Commission of Global Surgery [2]; the launch of the Global Alliance for Surgical, Obstetric, Trauma, and Anesthesia Care (G4 Alliance) [3]; and the passage of a World Health Assembly (WHA) resolution [4] on surgical care and anesthesia as a component of universal health coverage. Advocacy efforts that have contributed to increased political will for global surgical care have also included nongovernmental organizations, grassroots efforts, surgical societies, and the contributions of tens of thousands of hours donated by individual surgeons and health-care professionals. These events occurred at an opportune period in history, as the United Nations recently recognized the importance of achieving universal health coverage as a Sustainable Development Goal [5].

Access to surgical care in developing countries has been long neglected and poorly understood in the global public health framework. Recent estimates have shown that there are as many as five billion people with little access to essential surgical care [6]. As a result, minor injuries become life-threatening, common birth defects become lifelong disabilities, and easily treatable conditions cause death [7]. The neglected surgery patient is one who suffers from the lifelong consequences of inadequate treatment and management of common conditions such as obstructed labor, cataracts, hernias, cancers, injuries, and untreated congenital and infectious diseases.

Surgery as a Public Health Catalyst

Untreated surgical diseases are among the top 15 causes of physical disability worldwide. More than 11% of the world's burden of disease stems from conditions that can be treated successfully with surgery [8]. There is no dispute that surgery can and does save lives regardless of the setting in which it is performed. Surgery also transforms lives and communities by offering affordable and direct solutions for mitigating and preventing lifelong disabilities. In the case of disability, surgery is not merely curative but also prevents the social and economic disparities that accompany untreated disabilities. Like other public health solutions, surgery improves the economic output and viability linked to improved population health.

The depth of inequity and the disparities in surgical access both within and between nations are difficult to fathom. In Burundi, there are 19 surgeons, 17 centered in the capital city, serving a nation of almost 11 million people. In Rwanda, there is one surgeon for every 200,000 people [9]; in Tanzania, there is 1 surgeon for every 300,000 people; this is compared to 18 surgeons for every 100,000 people in Australia and 30 surgeons for every 100,000 people in the UK. Even within the USA, "trauma deserts" are found in certain areas of Chicago where outcomes from trauma such as gunshot wounds occurring more than 5 miles from a trauma center were associated with an increased risk of death [10]. From LMICs to high poverty regions in the USA, the lack of ready access to emergency and essential surgical care presents an often deadly and costly public health hazard.

The outbreak of the Ebola virus became a crisis of epic and historic proportions because of weak and nascent public health infrastructures impacting national security and regional economies in the worst affected countries such as Guinea, Liberia, and Sierra Leone [11]. The lack of access to surgical care holds the potential for similar, but less publicized catastrophes as demonstrated in the thousands of lives lost due to inadequate access to emergency care following the devastating 2015 earthquake and its aftershocks in Nepal [12]. The same was true following the devastating 2013 Typhoon Haiyan in the Philippines. Without adequate infrastructure or without facilities outfitted and staffed to offer the most basic surgical responses to trauma, lives are lost and lifelong disabilities are incurred.

In the case of Typhoon Haiyan, just over 27,000 people were reported injured and more than 6,000 died [13] with little way of determining how many initially survived the storm with significant injuries only to succumb a few a days later due to lack of adequate medical care [14]. Medical missions and first-response surgical teams reported treating soft tissue injuries, fractures, burns, and performing amputations [15, 16]. In Nepal, following the two 2015 earthquakes, more than 8,000 died and over 14,000 people were injured. As with the situation following Typhoon Haiyan, surgical teams in Nepal reported that a lack of equipment, implants, and skilled manpower to perform challenging procedures, such as internal fixation of fractures, factored into an increased and potentially preventable morbidity rate [12]. In both cases, communities were devastated by a lack of access to surgical care within the first 24 h following each disaster.

Need for a Shared Understanding Based on Evidence

Until recently, there was little shared understanding, framework, or consensus around a roadmap for increasing global surgical access. Access to surgical care in developing nations was perceived by many as simply impossible due to the cost of surgical interventions and the magnitude of the need. To the contrary, evidence shows that surgery as a part of the public health safety net can and does transform communities. The effects of surgery on communities improve the capabilities and support for general medical care, establish lines of trust and communication within the community, pave the way for the integration of other health-care interventions, increase the number of people returning to functional capacity, sustain robust workforces, and promote local microenterprise development [17].

The availability of certain index "essential operations" such as Cesarean sections, trauma care, or emergency laparotomy strengthens the overall health-care system capabilities, which in turn expands possibilities for additional surgical and medical care. Once the infrastructure for surgery is established, the same infrastructure can be used to support many different applications. For instance, as emergency procedures are performed by well-trained practitioners with adequate infrastructure development and support located within the community, more people will be returned to functional capacity resulting in decreased mortality and long-term disability. Surgery can even open doors to improved primary care by establishing lines of trust and communication in the community [17].

Essential surgical principles can augment other primary care capabilities like neonatal resuscitation and airway management that can be lifesaving. As surgical capacity increases, it is supported by improved infrastructure development such as pathology, blood banking, laboratory, and x-ray capabilities with improved diagnostic and treatment modalities that then support improved general medical care [17]. Providing surgical care, especially in rural areas, has also been shown to favorably impact improving other public health needs such as child malnutrition and pre- and postnatal care for pregnant women [18]. Surgeons in resource-poor regions have access to a phenomenal amount of information. Through the Internet, LMICs (such as Ethiopia, Mongolia, and Ecuador) as well as high-income countries (such as Europe or the USA) easily access international standards and guidelines applicable for quality surgical care worldwide. Expanding and developing surgical care instills hope in the surgical care providers and the community.

Essential Factors in Improving Public Health with Surgery

Transforming Power

The Essentials

- *High-quality surgical care's role in improving public health offers a much-needed framework and a tool for building consensus around the following:*
- *Low-cost, high-impact surgeries addressing trauma, maternal health, acute emergency, and other essential surgical conditions can and do transform community wellness.*
- *With current technologies and innovations, surgical care is affordable and can be made available regardless of patient income.*
- *Technology and innovation can make surgery accessible where resources are scarce outside of the urban centers.*

The cost-effectiveness of surgical care in developing countries is being established (Table 2.1). It is imperative that the impact of low-cost, high-output surgical fields such as trauma, maternal health emergencies, acute emergencies, and other essential non-acute surgical conditions are fully understood. Moreover, it is time to dispel the myth that surgical care is too expensive, a luxury only for those who can afford it, and only available in urban centers where resources are

Table 2.1 Cost-effectiveness of surgical interventions in low- and middle-income countries (LMICs) [19]

Procedure	Cost/DALY averted range
Basic surgical services	US$ 0.93
Cataract surgery	US$ 5.06–$106.00
Circumcision	US$ 7.38–$319.29
Elective inguinal hernia repair	US$ 12.88–$78.18)
Cleft lip and palate repair	US$ 15.44– $96.04
Emergency cesarean section	US$ 18–$3,462.00
Emergency and trauma surgery	US$ 32.78–$223.00
Vitamin A supplementation	US$ 6.00–$12.00
Highly active antiretroviral therapy for HIV	US$ 922.00
Breastfeeding promotion	US$ 930.00
Oral rehydration therapy	US$ 1,062.00

concentrated. This myth has been challenged by several studies demonstrating the cost-effectiveness of certain high impact surgical interventions [19, 20]. These surgical cost-effectiveness studies need to be included in discussions that aim to inform policymakers on the appropriate allocation of resources for health systems strengthening.

Establishing Priorities

Prioritizing surgical interventions offers promise in informing public health efforts and ensuring that primary care initiatives use evidence in making difficult decisions for the allocation of limited resources. The term "noncommunicable diseases (NCDs)" has come to mean the four major NCDs (cardiovascular disease, diabetes, respiratory diseases, and cancer). These four diseases were agreed on by consensus among the major stakeholders in NCDs. The measures used to select these four major NCDs included disease burden, cost, impact, and availability of known interventions. In the realm of surgical care, the World Bank recommendations for prioritization of surgical conditions include 44 surgical conditions (DCP3) [1] that correspond to 15 categories supported by more than 50 leading global surgical organizations [21] (Table 2.2).

Prioritization of surgery in global health efforts must also address and respond to the information provided by essential and preventive surgeries. From the WHO Essential Trauma Care Project [22] to the Safe Surgery Project, [23] these are notable successes in prioritizing and increasing the safety of and access to essential and emergency surgeries in high-, middle-, and low-income nations.

Table 2.2 Comparison of essential surgical procedures [1, 2, 7], *denotes the Bellwether procedures

Major global health category	15 essential surgical conditions	Essential surgical procedures		
		The World Bank Disease Control Priorities (DCP3) [1]	The Lancet Commission on Global Surgery bellwether*/WHO SAT [2]	The International Collaboration for Essential Surgery (ICES) [7]
Maternal health	Obstructed labor	Normal delivery	Cesarean section*	Cesarean section
		Cesarean birth		
		Vacuum extraction/forceps delivery	Dilation and curettage	Symphysiotomy
		Manual vacuum aspiration and dilation curettage	Obstetric fistula	Assisted or manipulative delivery
		Repair obstetric fistula		
	Severe uterine bleeding	Hysterectomy for uterine rupture or intractable postpartum hemorrhage	Tubal ligation/vasectomy	Evacuation of retained products of conception
		Ectopic pregnancy		B-lynch suture
		Tubal ligation/vasectomy		Repair of uterine perforation
		Visual inspection with acetic acid and cryotherapy for precancerous cervical lesions		
Infectious diseases (requiring surgical management)	Surgical infections	Drainage of superficial abscess	Incision and drainage of abscess	Incision and drainage of abscess
		Male circumcision	Male circumcision	Bone drilling
		Drainage of septic arthritis	Drainage of osteomyelitis/septic	Arthrotomy
		Debridement of osteomyelitis		Dental extraction
		Dental extraction		Tympanotomy
		Drainage of dental abscess		
		Treatment of caries		

Acute care surgery/injury	Airway obstruction	Resuscitation with basic life support measures	Resuscitation	Management of compromised airway
		Resuscitation with advanced life support measures, including surgical airway	Cricothyroidotomy/tracheostomy	Cricothyroidotomy/tracheotomy
			Removal of foreign body	Removal of foreign body
	Severe head injury	Burr hole		Cranial burr holes, management of head injury, elevation of depressed skull fracture
	Chest injury and infections	Tube thoracostomy drain	Chest tube insertion	Intercostal drainage, thoracostomy
	Severe wounds/ burns	Suturing laceration	Suturing for wounds	Suturing, hemostasis, debridement
		Escharotomy/fasciotomy	Acute burn management	Fasciotomy, escharotomy
		Skin grafting	Skin grafting and contracture release	Skin grafting
	Fractures and dislocations	Management of non-displaced fractures	Joint dislocation treatment	Reduction of fractures and dislocations
		Fracture reduction	Open fracture treatment*	Casting and splinting
		Irrigation and debridement of open fractures		External fixation
		Placement of external fixator, use of traction		
	Severe limb ischemia, sepsis, and injury	Trauma-related amputations	Amputation	Amputations
	Acute abdomen	Trauma laparotomy	Laparotomy*	Emergency laparotomy including appendectomy
		Appendectomy	Appendectomy	
		Bowel obstruction		
		Colostomy		
		Repair of perforations (e.g., peptic ulcer disease)		
		Gallbladder disease, including emergency surgery		
	Urinary outflow obstruction	Relief of urinary obstruction, catheterization, or suprapubic cystostomy	Cystostomy	Suprapubic catheterization
			Urethral stricture dilatation	

(continued)

Table 2.2 (continued)

Major global health category	15 essential surgical conditions	Essential surgical procedures		
		The World Bank Disease Control Priorities (DCP3) [1]	The Lancet Commission on Global Surgery bellwether*/WHO SAT [2]	The International Collaboration for Essential Surgery (ICES) [7]
Child and neonatal health	Hernia	Hernia, including incarceration	Hernia	Hernia repair
		Hydrocelectomy	Hydrocele	
	Clubfoot	Repair of clubfoot	Club foot repair	Casting and splinting, tenotomy
	Simple cleft lip	Repair of cleft lip and palate	Cleft lip	Cleft lip repair
		Shunt for hydrocephalus	Neonatal surgery	
		Repair of anorectal malformations and Hirschsprung's disease		
Blindness	Cataract	Cataract extraction and insertion of intraocular lens	Cataract surgery	Cataract extraction and intraocular lens insertion
		Eyelid surgery for trachoma		

An Era of Change

In 2015, a landmark resolution on surgical care and anesthesia was passed at the World Health Assembly (WHA) through the unanimous support of 194 member states, ending decades of neglect [24]. WHA resolution A68_R15, "Strengthening emergency and essential surgical care and anesthesia as a component of universal health coverage," urges countries to improve provision of emergency and essential surgical care and anesthesia at the primary health care and first referral hospital level [4].

The Essentials

- *This resolution (A68_R15) introduces a potentially transformative opportunity to increase the attention and resources directed toward surgical and anesthetic care, including:*
- *Appropriate analysis of surgical, obstetric, trauma, and anesthetic services at the country level currently being provided by governments and partners*
- *Identification of critical gaps in the provision of surgical, obstetric, trauma, and anesthetic services*
- *Development of national surgical plans and integration into current health plans*

Specifically, the resolution acknowledges and recognizes surgical care and anesthesia services worldwide "as important public health investments that have so far been left out of discussions on health systems strengthening, universal health coverage (UHC), and emergency and humanitarian response preparedness." The resolution also "stimulates improvement in the provision of surgical and anesthesia services as close to the people as possible." The resolution specifically requests member states to (1) identify and prioritize a core set of emergency and essential surgery and anesthesia (EESA) services at the primary health care and first referral hospital level and (2) to develop sustainable financing systems for provision of care.

The resolution recognized that "emergency and essential surgical care and anesthesia are neglected but efficacious and cost-effective additions to the basic package of health services and that strengthening emergency and essential surgical capacity together with anesthesia, particularly at the first-level and referral hospitals, is a highly cost-efficient solution to the global burden of disease." [4] These efforts build critical consensus and understanding about the true costs of care and the necessity of prioritizing surgical procedures and frameworks for essential and preventative surgical interventions.

An Affordable and Essential Solution

Systematic reviews of published data on the cost-effectiveness of surgical interventions indicate that strategically selected surgeries have equal to or greater cost-effectiveness as standard public health interventions (Table 2.1). While disability-adjusted life years (DALYs) and DALYs-averted offer an important cost benefit for surgery as a public health intervention, it is critical to examine the other costs incurred from a lack of surgical access. These include:

- A lack of educational and work opportunities for children born with debilitating congenital deformities that results in lost income. In the Philippines, 83% of orofacial cleft patients are unrepaired, incurring an estimated USD 73–88 million in lost revenue. The cost of development of a national surgical infrastructure to address cleft patients was estimated to adequately offset tax revenues regained [25].
- Inability to work due to debilitating neglected surgical conditions such as cataracts, fractures, hernias, and advanced tumors. In Pakistan, the prevalence of blindness was more than three times higher among the poor compared with affluent clusters in the same geographic region [26]. Cataracts are a condition for which cost-effective surgical treatment exists. Governments can incorporate national cataract surgical care programs as a means of poverty alleviation. Cost-benefit analyses that include an assessment of lost wages, caregiver costs, and other expenses associated with blindness can inform projects on the returns on investments (ROIs) on inexpensive cataract procedures. Demographic and epidemiological data can further inform total costs saved by making a single procedure accessible as part of universal health coverage.
- Loss of trained clinicians to other countries or the "brain drain" in which medical personnel seek employment in regions or nations with surgical infrastructures. Localizing surgical operations and the microenterprise opportunities that can accompany those endeavors can contribute to local economic development.

The Cost and Benefit of Surgical Care in the Developing World: Case Studies

When presenting surgery as an essential and necessary part of the primary healthcare infrastructure in LMICs, the issues of economy, quality, and supply chain are often raised. There is a misperception that high-quality essential and emergency surgical services are not "affordable" or somehow prohibitively expensive in developing parts of the world or that the scale of change needed is impossible to achieve.

The Essentials

- *Low-cost and high-yield solutions exist that address the delivery of surgical interventions for conditions that impose a high mortality and public health burden in society* (i.e., *trauma, maternal health emergencies, acute emergencies, and certain non-acute surgical conditions*).
- *Innovations in surgical service delivery in India, Pakistan, Mozambique, and Somaliland demonstrate that it is possible and economical to expand the reach of high-quality surgical services from beyond the operating rooms of centralized hospitals into the local systems of care in LMICs* (Boxes 2.1–2.3).

Case studies such as those found in successes of Narayana Hrudayalaya Heart Hospital in India [27] (Box 2.1), the Edna Adan Maternity Hospital in Somaliland [28], Indus Hospital (Box 2.2) [29], and Aravind Eye Hospital in India [30] (Box 2.3), illustrate that not only is it possible to provide high-quality essential and preventive surgeries, it is also possible to provide high-quality and affordable specialty surgical care as well.

Case Studies

The following case studies demonstrate tangible solutions for cost-effective surgical care in developing nations. These case studies have been selected because of the range of surgical care provided; from cardiac to cataract, these examples share high-quality, replicable, and scalable approaches. Each of the programs examined in the case studies is premised on the dual values of exemplary quality and affordable surgical care. The programs also embrace innovation in technology, staffing, and human resource development. Similarly, each program has overcome the barriers represented by the cost of providing care and workforce shortages through high volume operations.

Box 2.1 Narayana Hrudayalaya Heart Hospital (NH)

NH is an essential case study that demonstrates that high-quality, cost-effective surgery can be provided in low-income settings that have workforce shortages. Through the use of innovation in patient care, organizational structure, staffing, and delivery systems that maximize efficiencies in every area of operations, NH is realizing its vision to provide cost-effective and high-quality cardiac surgical care even in areas of India without established cardiac surgical programs. Today, only 8% of the world's population can afford heart operations. With current levels of surgical staffing, India is estimated to have the capacity to perform 80,000–90,000 heart surgeries annually. This compares with the large unmet need for heart surgery globally with approximately 2.5 million people, many from very low-income countries, annually. Without treatment, these cardiac conditions become disabilities resulting in loss of income and, oftentimes, death.

The operational strategy at NH follows the dual principle of highest quality at the lowest cost. There were no compromises made in the quality of the hospital's facilities, equipment, or support services. The hospital uses novel technologies and innovations to reduce costs of diagnostic procedures and to monitor supply chain on a granular level, and from 2001 to 2011, the hospital has completed over 11,228 open-heart surgeries (OHS), half of which were pediatric. In 2004 alone, it performed 4,276 surgeries, of which 1,467 were on children. The lower cost has not come at the expense of quality. NH's mortality rate (1.27%) and infection rate (1%) for a coronary artery bypass graft procedure is as good as that of US hospitals' (mortality rate; 1% for low risk, 2–5% all patients) [31] and better than Brazil's mortality rate (6%) [32]. Incidence of bedsores after cardiac surgery is anywhere between 8% and 40% globally. At NH, it has been almost zero in the last 4 years [33]. To complement the surgeries, NH also performed 5,430 catheterization procedures in 2004. Calling his strategy "the Wal-Martization of health care," founder Dr. Shetty and his team leveraged their strong reputation in cardiac care to perform a high number of procedures while maintaining high quality. NH performed approximately 19 OHS and 25 catheterization procedures a day, almost eight times the average of other Indian hospitals. The potential of NH to offer a distinct model to take cardiac care to the masses is clear.

To provide affordable cardiac care to the masses, NH followed a hybrid strategy of attracting paying patients by virtue of its reputation for high-quality care combined with a relentless focus on lowering its costs of operation wherever possible so that a larger number of people could afford to seek treatment. The surplus gained from paying patients was used to subsidize procedures performed at, or below, cost for patients who could not afford the full fee. In 2004, the proportion of patients who paid NH's full price to those who could not afford to pay was about 60:40. The break-even price for a typical OHS at NH was approximately 90,000 rupees (Rs.) (US$2,000) for adults and Rs. 130,000 (US$2,900) for children. This compared with over US$324,000 for OHS performed in the USA.

A major component of Dr. Shetty's ambition was to provide cardiac care to the rural poor through the use of telemedicine that builds the capacity of general practitioners (GPs). In order to provide immediate treatment and care in rural areas, Dr. Shetty set up nine coronary care units (CCUs) across India, linked to NH or Rabindranath Tagore Institute (RTI) of Cardiac Sciences, a 150-bed heart hospital with 3 operating theaters and a 22-bed intensive care unit using modern training and technology. GPs at the CCUs assess, monitor, and administer treatment to patients with consultation from specialists in NH. This extends even to remote areas with a network of around 100 family physicians that allows patients early access to cardiac care through local clinics that capture diagnostic information that is shared electronically with NH. Patients in remote areas are triaged, stabilized, and then referred and transported to appropriate treatment. NH is just one example of how high-quality surgical care can be scaled and provided in a cost-effective manner in a profoundly under-resourced and underserved area. As founder Dr. Shetty says, "The wealth of a nation has little to do with the quality of health care its citizens *can* enjoy."

Box 2.2 Indus Hospital

Indus Hospital in Pakistan is a nonprofit, private charity hospital that opened in July 2007 to serve a catchment area of about 2.5 million people. The founders of Indus Hospital believe that all patients have a right to the latest technology in medicine and high-quality care, regardless of ability to pay. Indus provides high-quality surgical services and impacts health in a resource-constrained setting. They use a unique financing structure to offer free care, which is in high demand given Pakistan's health-care system and its political, socioeconomic, and epidemiological context. Seven years since its founding, Indus has provided 43,209 inpatient services, 1,782,222 outpatient services, and 108,045 surgeries worth USD 36,855,937.

Typically, charity hospitals provide curative services or focus on a surgical specialty area. However, early on, Indus Hospital researchers conducted studies that mapped health resources and showed linkages between improved surgical outcomes and access to primary care delivery systems. This created awareness among surgeons and co-founder Dr. Zaidi "that one hospital could make a difference not just for individual patients, but could potentially impact the health of an entire community." This case illustrates the importance of integrating surgical care into the larger health system while planning expansion of service delivery to include primary and preventive care. In fiscal year 2010–2011, the hospital had an average daily census of 96 patients and admitted 11,500 patients. The 113 general ward beds were full 90% of the time. The intensive care and cardiac care units (each with six beds) were almost always full. The hospital was unprepared for the exponential growth in emergency department patients, which increased from 1,500 patients in fiscal year 2007–2008 to nearly 100,000 patients in fiscal year 2010–2011. Doctors in the 24-hour, 10-bed emergency department saw more than 400 patients per day.

Operating theaters are utilized 24 hours a day with elective surgeries being performed at night; Indus recognized value in high volume. To meet the demand for services, the hospital developed staff training programs based on internally created standard operating procedures. To ensure reliability and appropriateness of care delivered, the hospital was working toward developing ways to assess the quality of care and to hold clinicians accountable. One of the biggest challenges for the leadership of Indus Hospital is the exponential demand for increasing services. No one is turned away for lack of ability to pay. Creative approaches to pay are employed, such as booking elective surgeries for paying patients at night to offset the cost of no or low fee surgeries performed during the day. There is a recognized need to enhance the link between inpatient and outpatient care in order to prevent unnecessary hospitalizations and ensure that patients stayed healthy after being discharged. The tertiary facility has to be part of a care network that is adapted to the local needs.

Box 2.3 The Aravind Eye System

Aravind Eye System, founded in 1976 in India, by Dr. Venkataswamy (Dr. V), is a hybrid business encompassing several eye hospitals in India, educational and training programs, and a research foundation. As with the other projects that increase access to surgery, this one also takes an innovative approach to service delivery and provides a high volume of surgeries.

Project Impact, an established Aurolab in India, is a major and critical operating partner of Aravind Eye Care System in its role of reducing supply chain costs. Aurolab manufactures intraocular lenses at about $4 each in India, compared to $100 in the USA. As a nonprofit charitable trust, Aurolab provides affordable intraocular lenses, suture, pharmaceuticals, and eyeglasses that facilitate over 300,000 eye surgeries performed annually at Aravind. This has led to the standardization and engineering of cataract surgery for high volume production. Incorporating training of staff is key to the success of the program. Roughly 900 ophthalmic assistants are trained every year to assist specialist doctors in providing efficient eye care. A recent Aravind Eye Hospital research study quantified the economic and social impact on postsurgery Indian cataract patients. The study indicated that 85% of men and 58% of women regained the jobs they lost due to cataracts [34]. This allowed family caregivers to go back to work as well. The study concluded an increase in household income in the first year after surgery of patients that was equivalent to 15 times the cost of cataract surgery. Today, the Aravind Health Care System includes five Aravind Eye Hospitals and two Aravind Managed Eye Hospitals. Aravind also reaches out to the public by promoting sponsors in local communities to create eye camps for rural patients who cannot access the eye care facilities in major cities and hubs – making Aravind Eye Care System the largest eye care program in the world.

Prioritization of Surgical Conditions

Surgery is a treatment modality that spans the entire range of human disease. The scope of surgical care further complicates measurement of the prevalence and effect of surgical conditions on the population. One of the challenges surrounding the surgical debate is that health conditions cannot be neatly split between conditions that require surgery and those that do not. The dialogue is further complicated by the perception that low-cost means low-quality surgery; these misperceptions are addressed through the examination of case studies presented (Box 2.1–2.3). Other factors necessitate the employment of essential surgery frameworks in setting policy and resource priorities. The term "Essential Surgery" was developed to create a basis for prioritizing surgical conditions and drew inspiration from the concept of 'Essential Medicines,' a well-established concept in global health. "Essential Medicines" are "those drugs that satisfy the health care needs of the majority of the population; they should therefore be available at all times in adequate amounts and in appropriate dosage forms, at a price the community can afford" [35]. This standard was used to shape the debate and consideration of both essential surgical procedures and the conditions to be treated.

Although 'surgical conditions' were previously defined as "any condition that requires suture, incision, excision, manipulation, or other invasive procedure that usually, but not always, requires local, regional, or general anesthesia, [36]" this definition precludes surgical conditions for which non-operative intervention is indicated (i.e., non-operative management of small bowel obstruction (SBO), uncomplicated diverticulitis) and involves dedicated surgical training to master its management. Thus, an expanded definition is warranted that encompasses the nature of surgical disease which a fully trained surgeon addresses on a daily basis.

Initial policy efforts have focused on high-impact, low-cost surgical interventions including: cataract surgery, hernia repair, cleft lip and palate repair, trachoma surgery, hydrocephalus repair, and cesarean section, all of which were determined to be very cost-effective. More recently, an expert panel comprising five of the world's most distinguished economists noted a compelling need to strengthen surgical capacity in the developing world, where low-cost investments could be highly effective. Moreover, given a budget of USD 75 billion to solve the world's biggest global health challenges, the panel suggests an investment of USD 3 billion per year toward strengthening surgical care, one of the highest ranked suggested investments among the listed priorities [37].

The Essentials

Essential surgery has been differentiated to mean basic surgical procedures, which save lives and prevent permanent disability or life-threatening complications and treat essential surgical conditions, medical needs that meet the following criteria [7]:

- *Are interventions that primarily or extensively treat basic and common surgical conditions*
- *Address conditions with a large health burden*
- *Address conditions that can be successfully treated by a known surgical procedure and other surgical care that is effective, cost-effective, and feasible to promote globally*

Essential surgeries and the conditions they treat should also be "appropriate, high quality, safe, accessible at all times, and affordable to the community." Low-cost and readily accessible should not be equated with lower or substandard quality of care.

Various groups have proposed different methods for identifying the conditions and procedures for an essential surgical agenda:

1. The World Bank Disease Control Priorities (DP3): "Essential Surgery Package" (44 surgical conditions)
2. The Lancet Commission: "Bellwether Procedures" (three bellwether procedures)
3. The International Collaboration for Essential Surgery (ICES) supported by the Amsterdam Declaration on Essential Surgery (15 surgical conditions)

The Disease Control Priorities 3 (DCP3)

The Disease Control Priorities 3 by the World Bank (DCP3) has a dedicated volume on surgery that proposes 44 surgical procedures (Table 2.2). The procedures detailed in column three treat conditions that account for 4.7 million deaths (nearly 10 % of all deaths) in LMICs. This figure likely underestimates the disease burden from surgical diseases as the burden of several common surgical conditions (e.g., bowel obstruction or gallbladder disease) are not included as distinct entities in the WHO Global Health Estimates. The list of procedures also takes into account the cost-effectiveness of surgical platforms and facility types. Basic essential procedures are likely to be cost-effective when delivered at any level of the health-care system. However, the first-level hospital has been found to be especially cost-effective as a surgical delivery platform, with costs of US$10–US$220 per DALY averted for all surgical care delivered, across a wide range of LMICs [38–40].

DCP3 recognizes the potential for essential surgery to cost-effectively address a large burden of disease and offers viable short- and long-term options for improving access to quality surgical care. Using a rubric that assesses quality, number of procedures, and access to care, the DCP3 posits a formula that predicts best investment choices to impact improvements in access, quality, or increased surgical services. This rubric includes identified platforms of essential surgical procedures that are suggested to be made available at the community facility and primary health centers, first-level hospitals, and referral and specialized hospitals (tertiary centers) [1].

The Lancet Commission on Global Surgery "Bellwether Procedures"

The Lancet Commission on Global Surgery is an effort to summarize current knowledge in the field of global surgery as well as to identify recommendations for strengthening surgical services both nationally and internationally through additional research. It is unequivocal in its position that surgery is an "indivisible, indispensable part of health care" and in its assertion that surgical and anesthesia care should be an integral component of a national health system in countries at all levels of development [2]. In conjunction with the WHO Information Management Working Group, the Lancet Commission identified the capacity and preconditions necessary to perform three procedures that could serve as "bellwethers" for the readiness of health-care delivery systems to provide up to 24 essential surgical procedures (Table 2.2). As with the other assessment methodologies, metrics including population size, access to surgery, workforce capacity, and unmet need were factored into determining "bellwether procedures." These procedures can guide policymakers in assessing mature and established surgical systems' capacity to provide surgical care and identify gaps for improvement.

Data from 1,009 facilities obtained via convenience sample of self and researcher-reported facility surveys from 52 countries were used to ultimately interrogate the hypothesized three "bellwether procedures"; emergency cesarean delivery, laparotomy, and treatment of open fracture. These three procedures provide metrics to predict the capacity for management of other WHO primary care package procedures (Table 2.2).

Using a "three-delay" framework adapted from maternal health, [41, 42] (Fig. 2.1), the Lancet Commission made recommendations for leveraging existing health resources to create new efficiencies in health-care delivery and management. This framework identifies the interdependency of existing health-care delivery sites and makes recommendations to discuss surgical and anesthesia care delivery at the first-level hospital.

Using this framework and the "bellwether" procedures, the commission laid out an ambitious recommendation to track six indicators that can monitor progress toward achievement of universal access to safe, affordable, surgical, and anesthesia care when needed [2] (Table 2.3).

International Collaboration for Essential Surgery (ICES) 15 Surgical Conditions

The International Collaboration for Essential Surgery (ICES) convened as a group of practicing surgeons, educators, academics, and policymakers to promote the effective use of 15 categories of low-cost surgical interventions that save lives and prevent disability around the world. Through a process that included reviewing original data obtained from surgical registries of surgical

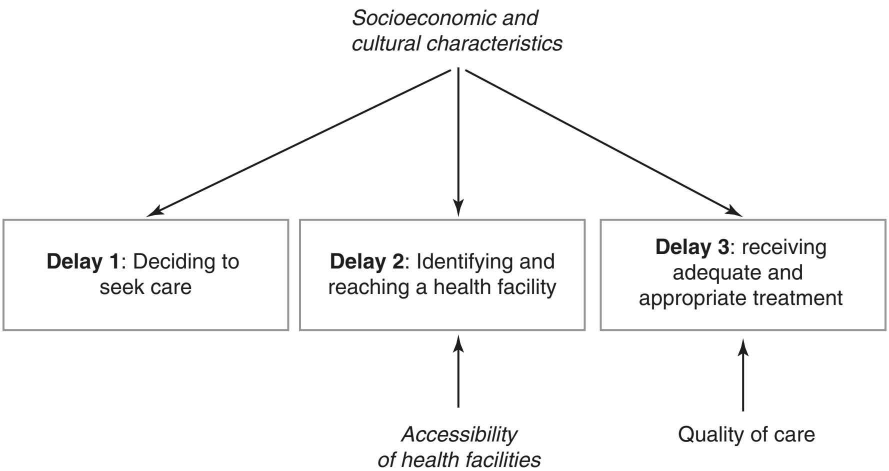

Fig. 2.1 The three-delay model in emergency care [41]

Table 2.3 Proposed six indicators of the Lancet Commission on Global Surgery [2]

Indicator	Definition
Group 1: preparedness for surgical and anesthesia care	
Access to timely essential surgery	Proportion of the population that can access, within 2 h, a facility that can do cesarean delivery, laparotomy, and treatment of open fracture (the bellwether procedures)
Specialist surgical workforce density	Number of specialist surgical, anesthetic, and obstetric physicians who are working per 100,000 population
Group 2: delivery of surgical and anesthesia care	
Surgical volume	Procedures done in an operating theater, per 100,000 population per year
Perioperative mortality	All-cause death rate before discharge in patients who have had a procedure in an operating theater, divided by the total number of procedures, presented as a percentage
Group 3: effect of surgical and anesthesia care	
Protection against impoverishing expenditure	Proportion of households protected against impoverishment from direct out-of-pocket payments for surgical and anesthesia care
Protection against catastrophic expenditure	Fraction of households protected against catastrophic expenditure from direct out-of-pocket payments for surgical and anesthesia care

trainees from LMICs, and conducting literature searches to identify relevant articles that documented surgical registries in developing countries, an analysis was done to identify the type and frequency of surgical procedures performed. Experts in the field were consulted with the above findings to compile a list of 15 categories of essential surgical procedures that are posited to address almost 80% of the burden of surgical disease in a community [7] (Table 2.2). The effort inspired the creation of "The Amsterdam Declaration," [21] a statement from 51 major global surgical organizations urging all nations of the world to support the World Health Assembly resolution on strengthening emergency and essential surgical care and anesthesia as a component of universal health coverage through the provision of 15 essential surgical interventions [21].

Like the other frameworks detailed above, ICES also supports prioritizing and focusing on essential surgical procedures and conditions. Nonphysician providers and medical officers who receive specific and narrow training in targeted surgical procedures can often provide these interventions.

The Essentials

Based on these actions, ICES recommends a seven-point strategy for ensuring that surgery transforms public health [43]:

1. *Incorporate essential surgical care as part of national health services within universal health coverage (UHC).*
2. *Realign and increase the allocation of resources to improve essential surgical care delivery.*
3. *Make training accessible to health workers providing essential surgical care.*
4. *Ensure the provision of supplies, equipment, and infrastructure for safe, essential surgical care.*
5. *Develop protocols for ethical surgical practice, assessment, audit, and follow-up.*
6. *Optimize collaboration among all stakeholders such as professional organizations, institutions, charities, and funding agencies to avoid duplication and maximize efforts to promote essential surgical care.*
7. *Support the proposed World Health Assembly resolution "Strengthening emergency and essential surgical care and anesthesia as a component of universal health coverage" in May 2015.*

Summary

It is clear that regardless of the specific framework employed there is an increasing consensus on the importance of prioritizing essential and emergency surgery as a foundational and transformative part of universal health coverage and primary care service delivery. "Surgery is an indivisible, indispensable part of health care [6]." Surgical and anesthesia care should be a robust component of national health systems in countries at all levels of development and can and will change the landscape of health care while supporting economic, workforce, and community development.

Surgical services are a prerequisite for the full attainment of local and global health goals in areas as diverse as cancer, injury, cardiovascular disease, infection, reproductive, maternal, neonatal, and child health and to ensuring readiness for addressing disasters. Universal health coverage and the health aspirations set out in the sustainable development goals (SDGs) are possible by ensuring that surgical and anesthesia care is available, accessible, safe, timely, and affordable.

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The Economic Case for Surgical Care in Low-Resource Settings

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Nakul P. Raykar, Swagoto Mukhopadhyay, Jonathan L. Halbach, Matchecane T. Cossa, Saurabh Saluja, Yihan Lin, Mark Shrime, John G. Meara, and Stephen W. Bickler

"Instead of development assistance for health, funding surgery is health assistance for development."
Ramiro Guerrero

N.P. Raykar, MD, MPH
Program in Global Surgery and Social Change, Department of Global Health and Social Medicine, Harvard Medical School, 641 Huntington Avenue, #411, Boston, MA 02115, USA
Department of Surgery, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA 02115, USA
e-mail: nraykar@bidmc.harvard.edu

S. Mukhopadhyay, MD
Program in Global Surgery and Social Change, Department of Global Health and Social Medicine, Harvard Medical School, 641 Huntington Avenue, #411, Boston, MA 02115, USA
Department of Surgery, University of Connecticut, 55 Northbrook Drive, West Hartford, CT 06117, USA
e-mail: swagotom@gmail.com

J.L. Halbach, DO
US Navy Hospital, 34800 Bob Wilson Drive, San Diego, CA 92134, USA
Division of Pediatric Surgery, Rady Children's Hospital—University of California, 3030 Children's Way, Suite 107, San Diego, CA 92123, USA
e-mail: jonathan.halbach@gmail.com

M.T. Cossa, MD
National Program of Surgery, Ministry of Health of Mozambique, Maputo, Mozambique
Surgery Department – Cardiovascular and Thoracic Service, Maputo Central Hospital, Avenida Agostinho Neto 1164, Maputo cidade, Mozambique, 258
e-mail: matchecane@gmail.com

S. Saluja, MD, MPP
Program in Global Surgery and Social Change, Department of Global Health and Social Medicine, Harvard Medical School, 641 Huntington Avenue, #411, Boston, MA 02115, USA
Department of Surgery, Weill-Cornell Medical Center, 525 E 68th Street, New York, NY 10065, USA
e-mail: sausaluja@gmail.com

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Y. Lin, MD, MPH
Program in Global Surgery and Social Change, Department of Global Health and Social Medicine, Harvard Medical School, 641 Huntington Avenue, #411, Boston, MA 02115, USA
Department of Surgery, University of Colorado, 12631 E 17th Avenue, Aurora, CO 80045, USA
e-mail: yihan.lin@mail.harvard.edu

M. Shrime, MD, MPH, PhD
Program in Global Surgery and Social Change, Department of Global Health and Social Medicine, Harvard Medical School, 641 Huntington Avenue, #411, Boston, MA 02115, USA
Office of Global Surgery, Massachusetts Eye & Ear Infirmary, Boston, MA, USA
e-mail: shrime@mail.harvard.edu

J.G. Meara, MD, DMD, MBA
Program in Global Surgery and Social Change, Department of Global Health and Social Medicine, Harvard Medical School, 641 Huntington Avenue, #411, Boston, MA 02115, USA
Department of Plastic and Oral Surgery, Boston Children's Hospital, 300 Longwood Avenue Enders 114, Boston, MA 02115, USA
e-mail: john.meara@childrens.harvard.edu

S.W. Bickler, MD, DTM&H, FAAP, FACS (✉)
Division of Pediatric Surgery, Rady Children's Hospital—University of California, 3030 Children's Way, Suite 107, San Diego, CA 92123, USA
e-mail: sbickler@ucsd.edu

Introduction

Surgical care in LMICs, a therapeutic necessity for the treatment of almost a third of the burden of human diseases, has long been hindered by the misconception that it is too expensive for settings of limited resources, or that it has limited public health value [1]. The consequences of this neglect have made a bad situation worse. Currently, almost 70% of the world's population lacks access to safe, affordable, and timely surgical and anesthesia care, including over 90% of those living in the world's poorest regions [2]. Fortunately, research over the past 15 years is changing how surgical care is viewed within global health. A more contemporary view of emergency and essential surgical care is that it is a cross-cutting intervention with a role in a wide spectrum of clinical problems; capable of addressing a large burden of disease while strengthening health systems, and cost-effective as many other widely accepted public health interventions.

In this chapter, we trace the remarkable transition in thinking that has occurred around the economics of surgical care in LMICs. First, we provide a brief overview of global economic development and its relationship to health. We then review research demonstrating the economic importance of surgical care. The chapter concludes with a section on the financing of surgical care in the era of the new Sustainable Development Goals (SDGs).

Brief Overview of Global Economic Development and Its Relationship to Health

The Essentials

- *A new focus on global economic development originated post-World War II*
- *Global economic growth has been substantial but uneven*
- *A healthy population is critical for economic growth, and* vice versa
- *The World Bank and other institutions view improved health as a vehicle for growth*

The concept that global economic development is important originated in the reconstruction period following World War II [3]. The rationale for this new found enthusiasm for global economic development is perhaps best illustrated by some of the comments made by President Harry Truman in his 1949 inaugural speech [4]:

> More than half the people of the world are living in conditions approaching misery. Their food is inadequate; they are victims of disease. Their economic life is primitive and stagnant. Their poverty is a handicap and a threat both to them and to more prosperous areas. For the first time in history humanity possesses the knowledge and the skill to relieve the suffering of these people … I believe that we should make available to peace-loving peoples the benefits of our store of technical knowledge in order to help them realize their aspirations for a better life… Greater production is the key to prosperity and peace. And the key to greater production is a wider and more vigorous application of modem scientific and technical knowledge.

By the time Harry Truman was elected president, international efforts were already underway to improve social and economic development in some of the least developed areas of the world. The World Bank was created in 1944 with the stated goal of eradicating global poverty, attempting to do this by providing loans to developing countries for capital programs [5]. In 1948, the World Health Organization (WHO) was organized with the mandate to attain the highest possible level of health for all people through coordination of international public health efforts [6].

Since then, the world has made significant gains in reducing the number of those most impoverished. According to the World Bank's most recent estimates, the percent of the world's population living at or below \$1.90 per day has declined from 44% in 1981 to 12.7% in 2012 [7]. These numbers translate into almost a billion people living at or below the \$1.90 per day in 2012. If the slightly higher income cutoff of \$3.10 per day is used, this exceeds two billion people. Moreover, reductions in poverty have not been uniform across the world. As an example, more than two-fifths of individuals in Sub-Saharan Africa still live in poverty.

It has long been recognized that economic development and health are inextricably linked [8]. In general, economic growth results in higher private incomes that allow for greater investments in social services such as healthcare, safe drinking water, and public education. The converse is also true: healthier populations achieve greater economic growth. The reason for the latter is that improved health and adequate nutrition lead to increased productivity; decreased disability and illness reduce production losses by creating a more robust labor pool; and healthy children are better prepared for learning, education, and economic advancement [9]. In fact, an increase in life expectancy of a population from 50 to 70 years is estimated to raise the rate of GDP growth by 1.4% per year, while undernutrition is known to reduce global economic output anywhere from 0.23% to 4.7% [10, 11]. Improvements in social services (such as access to healthcare) also address income inequality, as the impact of social services is usually distributed evenly across the community, benefiting everyone.

In the late 1980s, the World Bank began to focus more closely on health care in LMICs. As part of this effort, they reviewed their disease control priorities and began using cost-effective analysis to inform decision making on how to distribute the limited resources available for health care in LMICs. This process resulted in the 1993 publication of the first edition of *Disease Control Priorities in Developing Countries* (*DCP1*) [12]. In the same year, the World Bank examined the case for investing in health in their 16th Annual World Development Report (WDR) [13]. WDRs are the World Bank's chief mechanism for evaluating the evidence on a specific topic and for developing and sharing its policy messages with countries, development agencies, and the academic community; and are one of the world's most widely distributed economic publications. The *WDR 1993: Investing in Health* [13] showed finance ministers that well-chosen health expenditures were not an economic drain but an investment in economic prosperity and individual wellbeing. It argued that allocation of resources toward cost-effective interventions for high-burden diseases offered a rapid and inexpensive pathway to improvements. The *WDR 1993* used the findings of *DCP1* and was based on the first global and regional estimates of numbers of deaths by age, sex, and cause and of the burden (including the disability burden) from more than 100 specific diseases and conditions.

On the 20th anniversary of the *WDR1993*, a *Lancet* Commission revisited the case for investment in health and proposed a new investment strategy to achieve dramatic health gains by 2035 [14]. The key findings of the Commission report, as stated in executive summary, are shown in Panel 3.1.

Panel 3.1 The Key Findings of the Lancet Commission on Investing in Health [14]

- There is an enormous payoff from investing in health. The returns on investing in health are impressive. Reductions in mortality account for about 11% of recent economic growth in low- and middle-income countries (LMICs), as measured in their national income accounts. However, although these accounts capture the benefits that result from improved economic productivity, they fail to capture the value of better health in and of itself. Between 2000 and 2011, about 24% of the growth in full income in LMICs resulted from the value of additional life-years (VLYs) gained. This more comprehensive understanding of the economic value of health improvements provides a strong rationale for improved resource allocation across sectors.

- *A "grand convergence" in health is achievable within our lifetimes.* A unique characteristic of our generation is that collectively we have the financial and the ever-improving technical capacity to reduce infectious, child, and maternal mortality rates to low levels universally by 2035, to achieve a "grand convergence" in health. With enhanced investments to scale up health technologies and systems, these rates in most LMICs would fall to those presently seen in the best-performing middle-income countries. Achievement of convergence would prevent about ten million deaths in 2035 across LMICs relative to a scenario of stagnant investments and no improvements in technology. With use of VLYs to estimate the economic benefits, over the period 2015–2035 these benefits would exceed costs by a factor of about 9–20, making the investment highly attractive.
- *Fiscal policies are a powerful and underused lever for curbing of noncommunicable diseases and injuries.* The burden of deaths from noncommunicable diseases (NCDs) and injuries in low- and middle-income countries can be reduced by 2035 through inexpensive population-based and clinical interventions. Fiscal policies are an especially promising lever for reducing this burden (see last section of the chapter for further details).
- *Progressive universalism, a pathway to universal health coverage (UHC), is an efficient way to achieve health and financial protection.* The Commission endorsed two pro-poor pathways to achieving UHC within a generation. In the first, publicly financed insurance would cover essential health-care interventions to achieve convergence and tackle noncommunicable diseases and injuries. This pathway would directly benefit the poor because they are disproportionately affected by these problems. The second pathway provides a larger benefits package, funded through a range of financing mechanisms, with poor people exempted from payments.

The significance of the Lancet Commission on Investing in Health is that it represents a culmination of economic thinking on global health development over the past 30 years. Moreover, it delineates a pathway through which dramatic health gains can be achieved by 2035.

The Economic Case for Surgical Care in LMICs

The Essentials

- *Surgical conditions comprise a large proportion of the global burden of disease*
- *The Disease Control Priorities (DCP)-2 and DCP-3 unequivocally demonstrate the cost-effectiveness of surgical care at the first-level hospital*
- *The Lancet Commission on Global Surgery showed significant economic losses due to the burden of surgical conditions*

Although surgery is only briefly mentioned in *DCP1* and *WDR 1993*, both are incredibly important from a surgical perspective, as nearly every important economic theme in global surgery (e.g., cost-effective analysis) evolved from these works. Why surgical care was not better represented in this initial work is an important question, but probably best explained by the minimal data demonstrating surgical conditions as an important public health problem at the time. Further, it was not until almost a decade later that the comparative cost-effective analysis methods were applied to surgical care. In a seminal study from Bangladesh in 2003, McCord and Chowdhury reported that the cost of emergency obstetric care at a rural hospital in Bangladesh was US $11 per disability adjusted life-year (DALY) averted [15]. This finding surprised many in the public health field at the time, as these costs compared favorably with many other primary health care interventions, such as vitamin A distribution (US $9 per DALY averted), acute lower respiratory infection detection and home treatment (US $20 per DALY averted), or measles immunization (US $30 per DALY averted) [16, 17]. The concept of the DALY is shown in Fig. 3.1, with important economic principles in global surgery described in Panel 3.2. The cost of selected surgical interventions and how they compare to other global health preventions and treatment are shown in Fig. 3.2.

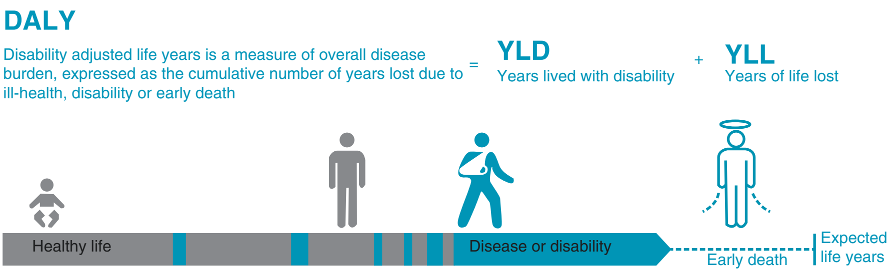

Fig. 3.1 The disability-adjusted life year (DALY). The DALY is the cumulative number of years lost due to ill-health, disability, or early death, and has become the cornerstone of cost-effectiveness analysis [32] (Reprinted from Disability-adjusted life year [32])

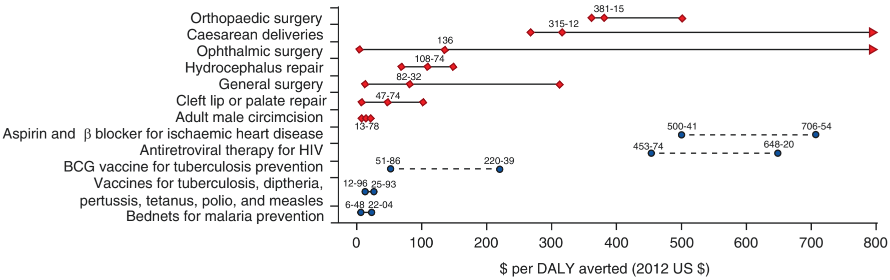

Fig. 3.2 Cost-effectiveness of surgical interventions. The cost effectiveness of surgical interventions is similar to some of the most widely used global health prevention and treatment [33] (Reprinted from Chao et al. [33], © 2014, with permission from Elsevier)

Panel 3.2 Important Concepts in the Economics of Surgical Care in LMICs [29–31]

How Is Cost-Effectiveness Calculated?

Several metrics can be used to measure cost-effectiveness of surgical interventions. Three of the most popular are:

- Cost per DALY averted (DALY = YLL + YLD)
- Cost per life year saved (LYS)
- Cost per quality associated life year (QALY)* gained

*The QALY is a measure of the quality and quantity of a life lived. In some ways, it is simply the inverse measure of the DALY, but there are many important nuances [29].

What Is Considered "Cost-Effective"?

It depends on the country from whose perspective cost-effectiveness is calculated. According to the World Health Organization's Commission on Macroeconomics and Health [9], an intervention that costs less than triple a country's per capita GDP, it is considered "cost effective," whereas if it costs less than the country's per capita GDP, it is considered "very cost effective." Unfortunately, cost effectiveness data is still scarce in most of the low-resource world.

What Is Benefit Cost Analysis (BCA)?

BCA attempts to estimate the net economic benefit of an intervention in monetary terms. It thereby allows researchers to investigate the potential economic return on an investment. It allows governments to compare investments in health as opposed to other sectors (transportation, education, etc.).

How Does BCA's Estimate of Economic Benefit Extend Beyond GDP and DALYs?

The BCA approach assumes that GDP per capita does not fully capture a country's economic welfare, and hence develops a methodology to value additional life years in economic terms [30]. It employs the value of statistical life (VSL) concept (e.g. if an individual would be willing to pay US$7 to decrease the risk of mortality by one in one million, then this individual's VSL would be US$7,000,000) [31]. The economic benefit, then, is calculated as the DALYs averted * value of statistical life-year (VSLY).

Fortunately, the lack of attention to surgical conditions in *DCP1* would begin to be remedied in the *Disease Control Priorities, Second edition (DCP2)* with a chapter focusing on surgical care [18]. The *DCP2* chapter, perhaps best known for its estimate that 11% of the global burden of disease was treatable by surgical care, demonstrated that surgical treatment provided in low-tech community hospitals is cost-effective. *DCP2* was also a step forward in several other respects. While *DCP1* focused on clusters of the diseases, *DCP2* drew together implementation responses to groups of conditions—for example, schools, health systems, and integrated management of childhood diseases. *DCP2* also included discussions on research priorities and product development opportunities.

The marked success of the surgical chapter in *DCP2* led to an entire volume being devoted to surgical care in the third edition of the Disease Control Priorities (*DCP3)*. The DCP3 project, which is ongoing, involves the World Bank, the World Health Organization (WHO), the Gates Foundation, and several other notable groups. Released in February 2015, the Essential Surgical volume of *DCP3* is the most comprehensive effort to date to evaluate the cost-effectiveness and population-wide effect of surgical care [19]. The important findings of the Essential Surgical volume of *DCP3* are shown in Panel 3.3.

Panel 3.3 Important Findings of the Essential Surgical Volume of *DCP3* [19]

- Provision of essential surgical procedures would avert about 1.5 million deaths a year, or 6–7% of all avertable deaths in low-income and middle-income countries.
- The avertable burden from scaling up basic surgical care at first-level hospitals and advanced care in specialized clinics in LMICs (116.1 million DALYs per year) exceeds the unaddressed global burdens of HIV/AIDS (81.6 million DALYs), tuberculosis (49.4 million DALYs), or malaria (82.7 million DALYs).
- Essential surgical procedures rank among the most cost-effective of all health interventions. These procedures are all very cost-effective, with most costing \$10–\$100 per disability-adjusted life year (DALY) averted. This puts cost-effectiveness of surgical care in the same range as accepted and extremely cost-effective public-health interventions such as immunizations and bed nets for prevention of malaria.
- Measures to expand access to surgery, such as task sharing, have been shown to be safe and effective while countries make long-term investments in building surgical and anesthesia workforces.
- Substantial disparities remain in the safety of surgical care, driven by high perioperative mortality rates including anesthesia-related deaths in LMICs.
- The large burden of surgical disorders, cost-effectiveness of essential surgery, and strong public demand for surgical services suggest that universal coverage of essential surgery should be financed early on the path to universal health coverage.

Several months after the release of the Essential Surgical Volume of *DCP3* the *Lancet* Commission on Global Surgery published their findings [20]. Close collaboration between the two groups ensured that research efforts would not be duplicated. The *Lancet* Commission on Global Surgery brought together an international, multidisciplinary team of 25 commissioners, supported by more than 500 advisors, collaborators, and contributors from 110 countries and 6 continents. The Commission focused on solutions within domains of health-care delivery and management; workforce, training, and education; economics and finance; and information management. The Commission had five key messages, a set of indicators and recommendations to improve access to safe, affordable surgical and anesthesia care in LMICs, and a template for a national surgical plan. The key messages from the Commission report are shown in Panel 3.4. Considered together, the Essential Surgery volume of *DCP3* and Lancet Commission on Global Surgery provide a strong economic argument for including emergency and essential surgical care as part of health care systems in LMICs.

Panel 3.4 Key Messages from *The Lancet* Commission on Global Surgery [20]

- *Five billion people do not have access to safe, affordable surgical, and anesthesia care when needed*. Access is worst in low-income and lower-middle income countries, where nine of ten people cannot access basic surgical care.
- *One-hundred forty-three million additional surgical procedures are needed in LMICs each year to save lives and prevent disability*. Of the 313 million procedures undertaken worldwide each year, only 6% occur in the poorest countries, where over a third of the world's population lives. Low operative volumes are associated with high case-fatality rates from common, treatable surgical conditions. Unmet need is greatest in eastern, western, and central sub-Saharan Africa, and South Asia.
- *Thirty-three million individuals have catastrophic health expenditure due to payment for surgery and anesthesia care each year*. An additional 48 million cases of catastrophic expenditure are attributable to the nonmedical costs of accessing surgical care. A quarter of people who have a surgical procedure will have financial catastrophe as a result of seeking care. The burden of catastrophic expenditure for surgery is highest in low-income and lower-middle-income countries and, within any country, lands most heavily on poor people.
- *Investing in surgical services in LMICs is affordable, saves lives, and promotes economic growth*. To meet present and projected population demands, urgent investment in human and physical resources for surgical and anesthesia care is needed. If LMICs were to scale-up surgical services at rates achieved by the present best-performing LMICs, two-thirds of countries would be able to reach a minimum operative volume of 5,000 surgical procedures per 100,000 population by 2030. Without

urgent and accelerated investment in surgical scale-up, LMICs will continue to have losses in economic productivity, estimated cumulatively at US $12.3 trillion (2010 US$, purchasing power parity) between 2015 and 2030. Globally, this will amount to $21 trillion in losses of economic productivity, and up to 2% of GDP in some of the world's poorest economies (Fig. 3.3).

- *Surgery is an "indivisible, indispensable part of health care"*. Surgical and anesthesia care should be an integral component of a national health system in countries at all levels of development. Surgical services are a prerequisite for the full attainment of local and global health goals in areas as diverse as cancer, injury, cardiovascular disease, infection, and reproductive, maternal, neonatal, and child health. Universal health coverage and the health aspirations set out in the post-2015 Sustainable Development Goals will be impossible to achieve without ensuring that surgical and anesthesia care is available, accessible, safe, timely, and affordable.

Financing Surgical Care in the Era of the Sustainable Development Goals (SDG)

The Essentials

- *Achieving the SDGs will require universal access to surgical and anesthesia care*
- *Economic losses in LMICs from burden of surgical conditions will amount to $12.3 trillion through 2030*
- *The estimated cost of scaling up surgical care in LMICs is between $300 and 500 billion*
- *A combination of international and national-level funding sources will be required to finance the surgical scale-up*

The SDGs, which have an end target date of 2030, have the potential to further catalyze the progress that has been made in global health. In contrast to the Millennium Development Goals (MDGs) which had eight specific targets to address extreme poverty—with several relating directly to health, the new agenda has one overarching health goal—SDG3 ensure healthy lives and promote wellbeing for all at all ages. As noted by Abdullah and Henry [21], surgery best fits under target 3.8: achieve universal health coverage, including financial risk protection, access to quality essential health care services and access to safe, effective, quality, and affordable essential medicines and vaccines for all. Surgical care also has a role in ending poverty (SDG 1) and achieving gender equality through access to essential

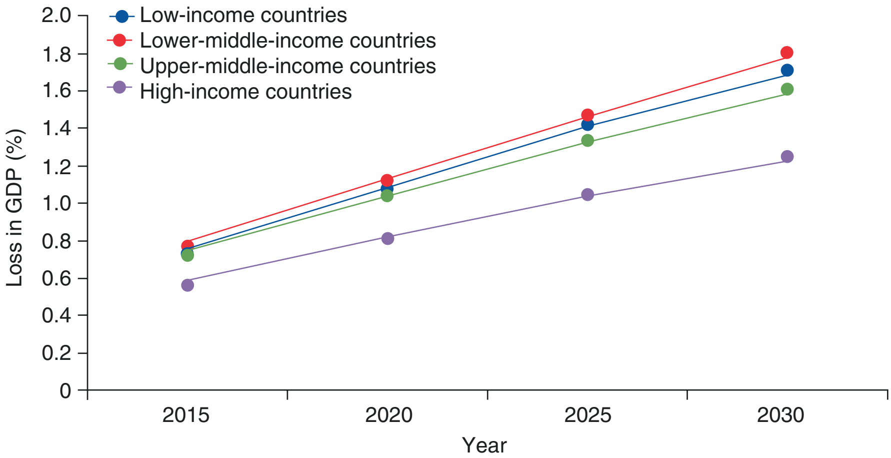

Fig. 3.3 Projected annual economic losses due to surgical conditions, as a percentage of GDP, forecasted to 2030 by income category. The world's poorest economies may lose almost 2% of GDP by 2030 [20] (Reprinted from Meara et al. [20], © 2015, with permission from Elsevier)

reproductive health services (SDG 5). The consideration here is that surgical care, especially its role in strengthening health systems aligns well with the SDGs. Further, synergism exists between the SDGs and World Health Assembly Amendment 68.15 "Strengthening emergency and essential surgical care and anesthesia as a component of Universal Health Coverage" [22].

The most important question facing global surgery is how to finance the surgical scale in LMICs that is so badly needed. Keeping in mind that little effort has been made to develop surgical care in LMICs, and this neglect has resulted in massive deficits in workforce and infrastructure, the amount of money to bring surgical care up to even minimal levels will be massive. One of the many important contributions of The Lancet Commission on Global Surgery was their estimate on the projected cost to reach minimal surgical standards by 2030. These estimate range from $300 to $550 billion through 2030 or $16 to $31 billion annually [23]. A middle-of-the-road approach, using rates of scale-up seen during Mongolia's recent health system expansion (increase in surgical volume by 8.9% per year), would cost $420 billion through 2030, or $23 billion per year. The variability in the estimates comes from different choices for the unit cost of surgical procedures, infrastructure construction costs, and the proposed rate of scale-up of surgical services. An important caveat to the Lancet Commission estimate is that it does not include training costs for the global surgical workforce.

In addition to scale-up costs, affordability of surgical care must be considered as a part of its financing. The reason for this is that scaling up of surgical access without concurrent increases in financial risk protection could cause inadvertent harm. Currently, out-of-pocket user-fees constitute the bulk of financing mechanism for surgical care in much of the low-resource world. Again, of the relative few who are able to access surgery, over 81 million people experience financial catastrophe after payment for surgical care [24]. If the world had complete access to surgical care, an estimated 3.9 billion—over half of the global population—would be at risk for catastrophic expenditure. Financing of surgical care must be done in concurrence with global goals toward universal health coverage. As noted earlier in the chapter, while the cost of scaling up surgical care at first glance may seem prohibitive, the cost of inaction is even higher—an estimated $21 trillion in losses of economic productivity by 2030, representing 2% of GCP in some of world's poorest economies (Fig. 3.3).

Short of developing a global surgery fund to address the cost of the surgical scale-up—which seems unlikely given the current global economy—the Lancet Commission on Investing in Health, the Lancet Commission on Global Surgery, and the Disease Control Priorities outline several options:

- *Obtain funding through existing development assistance for health (DAH) programs.* DAH has been defined as "financial and in-kind contributions made by channels of development assistance—that is, by institutions whose primary purpose is providing development assistance to improve health in developing countries" [25]. In 2013, donors disbursed a total of $31.3 billion to improve health in LMICs, more than five times the amount that was disbursed in 1990 [26]. Much of this was distributed amongst select, specific health goals—with the majority going to infectious diseases and the remainder to maternal and child health. To our knowledge, DAH has thus far not been applied directly to surgery. Regardless, given that the cost of surgical scale-up alone would be $23 billion/year and that total DAH funding currently totals $31.3 billion for all health causes combined, it would be insufficient for long-term scale-up of surgical care.
- *Increase governmental spending on surgical care.* Typically, governments spend 20 times more of their own resources on health than they receive in assistance. This is extremely important as the distribution of the majority of health-care dollars within a country is set by local priorities. In many ways, this is good news, as economies across the world are growing and such growth translates into a potential for greater tax-revenue and increased availability of resources for government spending on health. Projecting mid-range economic growth of about 4% per year, LIC economies will approach $1 trillion and lower middle income economies will approach $8.7 trillion by 2035 [26]. As such, annual costs of scale-up would represent less than 10% of *new economic growth* amongst the world's low- and lower-middle-income economies in 2035. Nevertheless, many of the poorest countries simply do not have enough resources for meaningful investment in surgical care.
- *Develop new revenue streams for funding surgical care.* One of the key reasons the MDGs were so successful was that it created new financing mechanisms such as the Global Fund to Fight AIDS, Tuberculosis and Malaria and Gavi, the Vaccine Alliance, allowing remarkable progress on critical health challenges [8]. Similarly, new financing strategies will be necessary for surgery. One such strategy is to broaden the tax base with health-promoting taxation, such as a tax on tobacco and alcohol consumption [14, 27]. In addition to compelling evidence that taxes on these industries can change usage behavior and shift the burden of noncommunicable diseases over the coming decades, taxation of these industries

could be a significant source of revenue. A tobacco tax in India alone could generate as much as $2 billion annually [28]. Improved intersector allocation of domestic resources can be another source of funds for scale-up of health systems. Global energy subsidies, for example, amount to over $2 trillion annually on a post-tax basis. In sub-Saharan Africa, energy subsidies amount to over 3.5% of GDP—well exceeding the proportion allocated to entire health budget in many countries in Africa and beyond [14].

Aligning surgical care with the larger global health agenda, especially as it relates to health system strengthening, will be an important strategy for the scale up of surgical care in LMICs. Given the amount of resources required, and the economic state of some of the poorest countries, a broad-based approach combining domestic government financing with external DAH support will be necessary, at least in the early stages.

Finally, a great deal of effort has been directed toward making a moral case for improving surgical care in LMICs. This argument, based on health equity and social justice principles, is straightforward, obvious, and compelling. For those still unconvinced, there is now strong economic argument for improving surgical care in settings of limited resources. Emergency and essential surgical is highly cost-effective and can yield a high return on investment. Perhaps, most important is that inadequate surgical care can exact a devastating toll on economic growth of LMICs. Policymakers worldwide should take notice.

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Part II

The 1,000-Foot View: Sustainable Surgical Training

Surgical Training in Low-Resource Settings

4

Rosemary Klein and Adrian Park

Introduction

Consensus has developed around the reality that surgical care could ameliorate a significant burden of disease in low- and middle-income countries (LMICs). There is agreement also that this need remains largely unmet. As provision of surgical services in the developing world has attracted global priority, training LMIC surgeons and surgical staff has gained traction in importance and immediacy.

The clarion call on this issue was sounded over three decades ago. In 1983 Dr. Alfred Yankauer, who had been an advisor with the Pan American Health Organization (PAHO) during the early 1960s, regretted that "Surgery is rarely mentioned in pronouncements about what should be done to meet the health needs of developing countries" [1]. Concerns raised at that early stage continue, having been addressed but not resolved. Then as now local surgeons were few in number and rarely committed to rural, remote assignments. As well there was an expectation of the professional calling for surgeons in developed countries to work, even if for the short term, in the developing world.

In light of the above and inspired by historical contemporary mandates, this chapter offers perspective on delivery, in its many varieties, of surgical education within LMICs. Surgical care in the majority world is currently met by those who come to it in diverse roles, the training for no one of these groups decided or standardized.

R. Klein
SAIL Center (Simulation to Advance Innovation and Learning), Anne Arundel Health System, 2001 Medical Parkway, Annapolis, MD 21401, USA
e-mail: rklein1@aahs.org

A. Park, MD, FRCSC, FACS, FCS (ECSA) (✉)
Department of Surgery, Anne Arundel Health System, Johns Hopkins University School of Medicine, 2001 Medical Parkway, Annapolis, MD, 21401 USA
e-mail: apark@aahs.org

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This chapter will primarily reference LMIC postgraduates, high-income countries (HIC) residents seeking exposure to global surgery, and nonphysician clinicians (NPCs) engaged in the provision of surgical services. This chapter also offers general concepts and specific elements that may prove instrumental in the continuing establishment and eventual sustainability of essential surgical training.

Historical Mandates

Achieving competencies through training and deliberate practice in the face of constrained resources and funding presents challenges. Increasingly, there is resolve—bolstered by the World Health Organization (WHO) and the World Health Assembly (WHA)—to see that meaningful, useful education is in place, allowing LMIC practitioners to acquire and maintain skills to perform much needed surgeries.

WHO established its educational approach Global Initiative for Emergency and Essential Surgical Care (GIEESC) in 2005 [2]. A decade later the WHA, the policy- and decision-making body of WHO, formally expressed in resolution A68.15 its commitment to strengthening surgical care and anesthesia, both emergency and essential, as principal to universal health coverage [3].

Both the WHO's initiative and the WHA's resolution espoused surgical training. One objective of the bidirectional GIEESC was aimed at quality of care and the other at safety. To achieve these dual intentions, GIEESC pledged to improve delivery of health services—including surgery—in resource-challenged countries. The intent being that emergency and essential surgical procedures could be relevantly adapted, safely undertaken, and would contribute to quality of care. GIEESC sought to build this capacity through fortifying existing teaching and education programs.

The WHA's 68.15 resolution noted that surgical training is often inadequate in LMICs and that numerous countries lacked the ability to reach "the threshold of 2.28 skilled health professionals per 1000 population" [3]. The resolution challenges member states to develop a sufficiently "integrated surgical care network." The foundation for resolution 68.15 is clearly laid 4 years earlier in the WHA's 2011 resolution 64.6, which concentrated on the healthcare workforce, urging that attention be directed toward training, motivating, scaling up, managing, and retaining [4].

The resolutions and programs put forth by the WHO and the WHA mandate the achievement of varieties and levels of training within LMICs. Surgical skills, competence, and knowledge, the desired output of any surgical training effort, may be acquired through harnessing technology in the adoption of established LMIC and HIC training modalities and efforts. Standardized training will be increasingly developed and assessed and will provide critical certification pathways. Standardizing education will ensure a future where a skilled and educated LMIC surgical workforce will be capable of consistently providing needed surgical care.

Workforce Constraints

The Essentials

- *More extensive, extended training is needed for nonphysician clinicians.*
- *Basic surgical care needs in the developing world may be met in part by nonphysician clinicians.*
- *Such fundamental surgical care can be safe.*
- *Standardization of terminology referring to nonphysician clinicians would encourage data collection that could shed light on scope of duties as well as provision of surgical care and outcomes.*

Indispensable surgery assets such as surgical supplies and diagnostic equipment, fuel, oxygen, electricity, water, blood, and beds are often in short supply in LMICs. Descriptions are also plentiful of equipment that has been left with those who are unclear about how to operate it or that has surrendered to malfunction among those unable to provide remedy.

The most critical resource lacking in the developing world, however, is a healthcare workforce sufficient to provide necessary surgical services that ensure peoples' right to essential surgery as an element of basic healthcare. As one physician lamented "The absence of surgeons from rural areas takes a ghastly toll [5]." Just as the reality exists that essential surgery must be achieved for those in the majority world, it is a reality that in that world surgeons are in very short supply. A study of eight district hospitals in Uganda, Mozambique, and Tanzania, for instance, reported that among them all, there were no specialist surgeons or anesthetists [6]. Nurses represented the largest group of healthcare workers (77.5%), followed by mid-level providers (MLPs), most of whom were not surgically trained (7.8%). Physicians and surgeons performed the bulk of surgeries (54.6%); MLPs performed 35.9%.

WHO has proposed more extensive training and use of NCPs in provision of emergency, surgical, and anesthesia procedures, particularly at the district level, to meet basic surgical needs in the developing world [7].

The designating terminology for those delivering this crucial component of surgical care differs by country and organization. Terms including mid-level healthcare practitioners or mid-level providers (MLPs), assistant medical officers (AMOs), generalist physicians, NPCs, surgical technicians, and clinical officers (COs) are used equally and interchangeably, provoking confusion over roles and responsibilities [6–9]. The terminology confusion is additionally compounded by the prevalence of studies that refer to surgeries performed by NPCs as major or minor but in no way specifically designate the procedures or interventions included within those broad terms [8–10]. The responsibilities of NPCs remain largely defined by individual hospitals or centers rather than being standardized nationally or even regionally. Among other challenges, these types of terminology and definition issues hamper collection of relevant workforce data. In one fairly exhaustive account covering 25 LMICs [8], clinical officers could practice minor surgery, left undefined, in three countries, while in three other countries, they were also allowed to perform caesarean sections or administer anesthesia. Seven countries did not permit clinical officers to practice minor surgery, although one allowed them to administer anesthesia. In Ethiopia health officers were permitted to practice minor surgery and perform caesarean sections, whereas in Cape Verde and Zimbabwe, they could do neither. Chu et al. [11] have advocated also for community health workers (CHWs) to take on an expanded role. They reason that CHWs have been capably trained to identify diseases necessitating surgical intervention, and given training and supervision could provide wound management, basic life support and trauma care, and, possibly, identification of and referral for acute surgical needs.

The training of NPCs remains variously and insufficiently described. Mozambique training extends for 3 years and culminates in a degree, after which a 2-year supervised internship begins [12]. Lassi et al. [13] report that with some variance, 3–4 years of postsecondary education, including clinical medicine and surgery, is typical. Data and publications from Clinical Officer Surgical Training (COST)-Africa, a surgical training program initiated in Malawi and Zambia, could add to knowledge of standardized training. Among other successes, COST-Africa advocated for the Bachelor of Science (Bsc) in General Surgery for Clinical Officers, accredited by the University of Malawi [14].

Retention of NPCs is good, especially in rural areas, where patients and hospitals alike benefit from their knowledge of area language and customs [9, 15]. The retention rate is likely shaped by the fact that surgical privileging for an NPC tends to be country and even hospital specific. On balance, consensus is that nonsurgeons can safely handle the most common general surgical procedures [16, 17].

Postgraduate Surgical Training

The Essentials

- *There are a variety of country- or region-specific programs through which physicians can qualify to become specialists.*
- *Surgical trainings, including subspecialty offerings, are increasing.*
- *Consideration should be given to developing an ongoing accounting of postgraduate surgical training within LMICs.*

As provision of surgical services in the developing world has attracted global priority, training LMIC surgeons and surgical staff has gained traction in importance and immediacy. Comprehensive accounts of the specifics of postgraduate education in LMIC regions or countries, however, are lacking. The numbers of LMIC surgeons overall do not meet the need for patient care, institutional and program research and administration, or student training and supervision. This is evidenced particularly in Sub-Saharan Africa (SSA) and South and Southeastern Asia. Select examples from these three regions highlight existing, suggested, and evolving models of surgical training.

Sub-Saharan African physicians qualify to become specialists through programs within their country, through regional bodies exemplified by the West African College of Surgeons (WACS) and the College of Surgeons of East Central and Southern Africa (COSECSA), through organizations such as Pan-African Academy of Christian Surgeons (PAACS), and through programs abroad. Despite the majority of SSA countries having opened at least one medical school some four decades ago, it has only been within the past 10–15 years that medical students within much of SSA could avail themselves, in their own or neighboring countries, of comprehensive quality surgical training opportunities [18].

A recent summation of surgical need and training addressed ten LMICs as one unit (the Great Lakes region of Burundi, Democratic Republic of Congo, Ethiopia, Kenya, Malawi, Mozambique, Rwanda, Tanzania, Uganda, Zambia) [19]. Few of the 52 medical schools in the region were reported to offer specialty surgical training. Those who do pursue and graduate from specialist surgery training offered in the region are likely awarded either the university and college medical schools' Masters of Medicine (MMED) degree or a Fellowship of the College of Surgeons (FCS) from COSECSA. An FCS acquired in general surgery, orthopedics, urology, pediatric surgery, otorhinolaryngology (ENT), or plastic surgery requires 5 years training, six in neurosurgery, and the successful completion of "high-stakes" exams.

An additional survey of these countries revealed that, in general, each country maintained three government-funded, university-offered MMED surgical programs, usually of 4-year duration, that most trainees were salaried and receiving benefits, that some placed government or public services requirements on their incoming or outgoing students, and that the countries as a whole were increasing both their surgical training and subspecialty offerings [20]. Variety and duration of surgical programs were supplied for each country. Mozambique's cardiothoracic surgery, neurosurgery, pediatric surgery, and plastic surgery programs were termed "hybrid" in that the initial 2 years of fundamental training took place in the country and the remainder of training was done abroad, usually in Brazil or Spain, while general surgery, ENT, maxillofacial surgery, urology, ophthalmology, and orthopedics programs taking 3 years were offered complete in the country. Upon concluding training students receive a specialist certificate from Mozambique's Medical Council. Uganda is described as having ten medical schools, four of which offer surgery and anesthesia postgraduate training that includes a dissertation presenting original research [21].

Another review approached the issue from a slightly different perspective [22]. Commonly, postgraduate LMIC surgical education did not have a universal set of standards, a characteristic said to resemble the diversity among HIC surgical training program parameters.

Pakistan, the sixth most populated country worldwide [23], is described as home to over 90 medical colleges and 129 training institutes. In the latter, over 10,000 accredited training seats exist for postgraduate residents [24]. There are two postgraduate training programs: Fellow of College of Physicians and Surgeons (FCPS) and Master of Surgery (MS)/Doctor of Medicine (MD). Early specialty training is being tried. The number of women in surgical residency programs has substantially increased since 2000 [25].

A survey of Pakistani medicine and surgery residents at two tertiary teaching hospitals/centers reported that just 64.6% of the surgery residents indicated job satisfaction [26]. Additionally, 59% indicated being stressed, attributed to lengthy residency hours. A number of surgery residents were reported to be working more than the 80-h limit set by each hospital.

The supervised apprenticeship model is commonly used but not without challenge. Its formality, reflective of cultural and social norms, subordinates trainees and discourages fundamental communication or any questioning of authority around scholarly or clinical issues. Discouraging fundamental communication is so pervasive that comparison has been made to the substantial number of accidents experienced by aircraft pilots in similar communication-restricted cultures [27]. One antidote to these aviation accidents proved to be a literal switch to use of a new language (in this case English rather than Korean), which did not "mirror [the] hierarchical society and culture" and, thus, encouraged an easier flow of communication [28]. An answer that might better resolve a too rigidly hierarchical supervisor and apprentice relationship is Crew Resource Management (CRM), a training method first used in 1979 to resolve the three types of failure—communication, leadership, and decision-making—that had been implicated in aviation accidents caused by human error [29]. CRM is specifically suggested as well for training of surgeons and may be particularly suited to addressing the structured hierarchical approach common to medical training settings [30]. Time and workload for mentors are impacted by the shortages of both faculty and surgeons. Knowledge taught is often narrowed to the patients at hand. Tutelage in research and dissertation methods and methodologies is limited [31].

An assessment of Pakistan's postgraduate training performed for the Higher Education Commission suggested that selection processes and final assessments would benefit from national standards [31]. Trainees contributed considerably to the care of patients, yet some received stipends for their work and some did not. Career paths were not apparent. One corrective proposal suggested that those completing fellowship be required to gain an additional one to two years' experience at a District Headquarters Hospital (DHQ), followed by a position at a teaching hospital if performance was good. The merit here is considerable when one considers the magnitude of faculty shortage. Rawalpindi DHQ, for example, a typical Pakistani teaching hospital, has for years been working with 450 beds on a budget intended for almost a hundred beds less and has only three professors for its 2,500 patients per day [32].

The Cambodian system governing surgical care availability is decentralized, administered by district hospitals and local government [33]. In 2014 surgery training in Cambodia was characterized as sparse with Khmer-Soviet Friendship Hospital, governed by the Ministry of Health (MoH), offering plastic, thoracic, and maxillofacial surgery training, Battambang Provincial Referral Hospital providing ENT and plastic training, Siem Reap Provincial Hospital offering general surgery training, and Angkor Hospital for Children (AHC), a nonprofit teaching hospital concentrating on pediatric procedures [34]. AHC in conjunction with the MoH works to provide every Cambodian child quality healthcare access. Residents may undertake surgical training at the University of Health Sciences. The Sihanouk Hospital Center of HOPE, a privately financed NGO, offers an internal medicine and a surgical training program, less recently for 35 Cambodian postgraduates [35].

Proper compensation must be secured for specialists in Cambodia if they are to be retained. Ensuring sustainable, appropriate salaries demands that system requirements be relaxed to allow specialists sufficient time to work in private clinics as well as state hospitals. Such accommodation can be difficult, but—as one MoH official noted—system requirements followed rigidly "without tolerance and flexibility" would drive away surgeons and specialists, decimating a workforce already in short supply [36].

Collaborative Infrastructure

The Essentials

- *Collaborative infrastructure is integral to developing the surgical workforce.*
- *Collaborative infrastructure plays a part in sustaining the surgical workforce.*

A notable response to the determination to develop and sustain a surgical workforce within LMICs may be seen in the Pan-African Academy of Christian Surgeons (PAACS). The organization has dedicated itself to building maintainable, rigorous residency programs for African medical school graduates.

In 2011 PAACS reported that it had established six such programs, had 19 surgeons who had completed training, had 35 residents in four countries in the midst of their education, and had seen that gifted graduates had opportunities to be mentored at teaching hospitals with the potential to themselves become PAACS faculty [37]. The organization now reports 12 programs in ten countries including Cameroon, Egypt, Ethiopia (2), Gabon, Kenya (2), Malawi, Niger, and Tanzania and plans to train 90 surgeons yearly. Additionally, it records that 45 of its graduate general surgeons and six of its graduate pediatric surgeons remain in practice or fellowship throughout Africa [38].

Collaborative infrastructure has, of course, been central to the successes of PAACS. The WACS, COSECSA, and Loma Linda University, CA, USA, offer hospital and program accreditation to PAACS training sites. COSECSA and WACS extend training and professionalism beyond residency, offering accredited fellowships. The operating budget comes from private donors.

Two notable successes linked to PAACS graduates are that they, by and large, have not only remained in the country (serving countries such as Angola, Cameroon, Ethiopia, Ghana, Guinea-Conakry, Kenya, Madagascar, Republic of Congo) but have often chosen to work in underserviced and rural areas [39]. These graduates universally share a strong desire to provide surgical care where the need is greatest. There is also an expectation of the organization and its leadership, who fully support the residents' training and stipends through philanthropic donations, that they serve for a period of a few years following graduation at such a mutually agreed upon medical center.

Collaboration is increasingly offered to American and Canadian surgical trainees within LMICs through surgical residency rotations (which satisfy requirements in 35 US programs) [40]. Such short-term collaboration is not meant to substitute, however, for local surgical training programs of sustained capacity and duration. Encouragement must be offered to HIC surgical programs that are invested in supplying resident trainees as trainers in the LMIC environment to come together in collaborative agency. While HIC residents embark upon their LMIC rotations with a well-intended enthusiasm to teach and enhance the surgical care at their destination hospitals, their reported experiences are often very revealing. Anecdotal testimonies abound from humbled HIC residents, who felt they had learned more than they taught and benefited personally and professionally far beyond what they may have contributed through their LMIC clinical and social experiences.

HIC programs should look to (1) create uniform standards for trainees prior to these rotations, (2) determine what data will be collected and how responsibility for its analysis and dissemination will be established, and (3) determine what responsibilities other than clinical training have been required of the trainees so as to better contribute to both short-term and sustainable solutions.

Data Collection

The Essentials
- *Need to significantly expand quantitative and qualitative data collection.*
- *Adoption of standard indicators should be considered integral to data collection.*
- *Need for focus on and standardization of data characterizing postgraduate training.*

Data collection has been unattended to for so long that large-scale efforts are looked to in the LMICs for addressing the information gaps. The LMIC surgical workforce has never been adequately described. A decade ago WHO estimated that 57 countries had critical healthcare workforce shortfalls [41]. Urban areas significantly had larger healthcare workforces than rural areas in most countries. The effects of the urban/rural disparity on regions—most pronounced in SSA but obvious in Southeast Asia as well—gave additional concern. The Global Health Workforce Alliance (The Alliance) was created in 2006 with a 10-year mandate regarding Human Resources for Health (HRH) in the LMICs. The Alliance held a global forum at the halfway point of its mandate, during which country-specific data was determined to be insufficiently identified and collected, marked by unreliability, and only sporadically revised [42].

Using the WHO standard of fewer than 228 physicians, nurses, or midwives per population of 100,000, Hoyler et al. [43] conducted a literature review to determine numbers of surgeons, OB-GYNs, or anesthesiologists within LMICs. A time frame during which the articles were retrieved was not provided; in all 593 potential articles were identified. Of these, only 38 detailed nation- or region-specific numbers of surgeons, OB-GYNs, or anesthesiologists within 42 LMICs. For 23 of the 57 countries WHO had identified as being in crisis, no publications offering the requisite workforce numbers were located. The review underscored the reality that institutions rarely collect the suitably wide-ranging data that are necessary to establish national or regional quantification of surgeons. This considerable lack was taken to imply that data characterizing the surgical workforce are not regarded as "essential indicators of healthcare quality." This failing, the authors proposed, could be addressed by establishing national surgical provider density as a metric.

Another review emphasized the "critical need for systematically collected, national-level data regarding surgery providers in LMICs to guide improvements in surgery access and care" [44]. Both reviews cited the data being housed in the WHO Emergency and Essential Surgical Care (EESC) Global Database. Its current website posts that the WHO Tool for Situational Analysis to Assess EESC has been completed by over 1,300 medical facilities in 54 countries [45]. They also referenced The Harvard Global Surgery Initiative data-collecting efforts [46].

Hoyler et al. [43] recommended additionally collecting data on "non-physician providers with surgical skills." The classification "non-physician providers with surgical responsibilities" as noted previously could perhaps provide even more wide-ranging and realistic estimates of the surgical workforce.

Technology

The Essentials

- *Communication and information technologies contribute to educational delivery.*
- *Mobile phones, in particular, advantage connectivity.*
- *Data regarding innovative uses of new technology in surgical service and training are important to acceptance and use.*

Communication and information technologies contribute to educational delivery in both developing and developed countries and provide collaborative connectivity between them. Connectivity is an enabling component, allowing, for instance, global or smaller consortia to address training in developing countries. A consortium established between Memorial Sloan Kettering Cancer Center in the United States and three prominent Nigerian teaching hospitals researched the differing patterns of colorectal cancer in patients from both countries [47]. Phone and conference calls are credited with allowing smooth communication. Cell phones enabled the research by permitting follow-up to be conducted with patients and their families.

Fig. 4.1 Mongolian Ger at Black Water Lake, Western Mongolia, with solar panel and satellite dish (Permission Raymond R. Price)

Cell phones and satellite dishes connected onto solar panels have brought surgeons throughout rural Mongolia together, providing those in all quarters remarkable access to information that heightened their comprehension and facilitated their involvement in broadening surgical care quality in unprecedented ways [48] (Fig. 4.1).

Connectivity advantages will accrue with the ever more common use of mobile phones. All manner of referral systems among hospitals, clinicians, and other healthcare staff will finally be established, providing solutions to common dilemmas such as face LMIC patients who must locate urban hospitals when rural hospitals are unable to provide treatment or staffs without specialists who may now gain access through teleconsultation.

Apps are being designed to provide interactive clinical training and serve as educational references and resources. This type of training tool requires users to have tablets or mobile phones with Internet service. The Pew Research Center recently reported that about 17% of the SSA adult LMIC population do not have a cell phone, though more than 50% of those do have occasional access to one [49]. The survey's percentages affirmed the remarkable surge in cell phones owned by adults in Ghana (83%), Kenya (82%), Nigeria (89%), Senegal (83%), Tanzania (73%), and Uganda (65%). In all six countries, women were less likely to own cell phones than men. Health eVillages is one of a growing number of nonprofit organizations that bridge the technology gap by supplying LMIC healthcare professionals with tablets loaded with customized apps [50]. Cost-effective training is viewed as a positive, empowering result of such technology. However necessary and likely such adoption of technology becomes, it must be kept in mind that for some in these resource-poor countries just charging the phone could be an expense that would cut a month's income by 20% [51].

Adequate network infrastructure powered by dependably consistent and low-priced energy will have to be secured for technology to begin to exact changes in the delivery of surgical training in the majority world. Apps will only succeed at providing viable interactive practice if the visual, text, and spoken content they deliver have been overseen through development and assessed for accuracy by the appropriate surgical and medical organizations or professionals. The potential for apps in this context is seemingly limitless. Already, WhatsApp is enabling South African pediatric surgeons from the coast and rural regions to connect professionally as well as with parents of their patients [50]. The cross-platform WhatsApp is favored for allowing text and multimedia messages to be sent and received for free and without ads. The Touch Surgery app delivers modules, each of which focuses on the signs, symptoms, indicators, reasons for, and surgical risks associated with surgeries. Initially offering eight common procedures (including appendectomy and cholecystectomy), the app is now described as offering more than 40 [52, 53]. Each surgery is presented as an interactive simulation using a virtual patient and allowing preoperative planning, step-by-step practice, and training that can be tested. Animation is realistic and graphics are accurately detailed and compelling. Surgeons from institutions including Stanford University, Imperial College of London, and Johns Hopkins University develop each module [52–54].

Once classified as a conceptually new technology, laparoscopic surgery must be a vital component of surgical training in LMICs. Its classification—as it is transferred as "an established technology" from HICs to "a new environment" the LMICs—becomes what Mytton et al. term contextually new technology [55]. They define it as the inception of an established technology within a setting where it is untested. They remind that laparoscopy presents "a radically different way of operating" when measured against open surgery.

Studying the adoption of laparoscopy in Africa, Choy et al. [56] found that, in the hierarchical surgical culture, laparoscopic techniques were first taught to senior surgeons, who proved disinterested in using the new method and disinclined to teach it to residents and junior surgeons, who had to pursue learning it on their own. Additionally, the senior surgeons were disinclined to take on the setup, upkeep, or sterilization associated with laparoscopic surgery, responsibilities the shorthanded nursing staffs were untrained in. Laparoscopy has been successfully introduced in Mongolia [48], and data regarding the attitudes of both surgeons and the local populations toward that adoption are anticipated [57].

Curriculum

The Essentials

- *Standardized curricula per specialty should be developed.*
- *An examination series should be created to accompany the curricula.*
- *Partnership strengthens the development and assessment of curricula and examinations developed in LMICS.*

There is a pressing need to develop standard curricula per specialty. This necessity has been asserted in combination with an appeal for guidelines and evaluations accompanied by consistent, high-stakes, multi-staged examinations of knowledge and competency for both general and subspecialty surgeons [22, 58].

Concern is understandably focused on who determines content and competencies. Data indicates that a general surgery training program that is wide-ranging in breadth is more suited to the actual operations performed in LMIC clinical settings than one that is specialized. This important training principle was illustrated in a study that surveyed 19 Pakistani district hospitals and found that under half of patients had had operations that are part of common conventional general surgery training in HICs [59, 60]. The data, considered to mirror conditions in other developing countries, underlies the argument that a training program or curriculum's tasks or procedures be the hosts' determination [60]. Realistic determinations of patient needs should shape the surgical curriculum of any country or region. In the development of the Surgical Council on Resident Education (SCORE) curriculum undertaken by a consortium led by the American Board of Surgery (ABS), both essential and complex operations were used to determine patient care competencies [61].

Realizing the provision of emergency and essential surgical care as a principle of universal health coverage as mandated by WHA A68.15, NPCs in large numbers will need to be trained to help improve access to quality surgical care in LMICs. Surgeon leaders and educators will do well to work closely with national governments to ensure appropriate curricular development and oversight for NPCs who will provide many EESC services. It would be ideal for these curricula and the more comprehensive surgical residency training programs of the majority world to evolve in an integrated manner, one benefit being that graduating surgeons could learn how to supervise and mentor the NPCs with whom they are likely to be working.

Basing LMIC surgery curricula on local needs blended with those established internationally has long been thought to be a model prototype. An important light has been shone on this concept in research done by Goldstein et al. [62]. The study innovatively focused on conclusions drawn from the responses of surgeons and surgery trainees hailing from 12 LMICs to two established online curricula: SCORE and School for Surgeons. SCORE in addition to patient care skills is based on other competencies set forth by the American Council for Graduate Medical Education (ACGME), including medical knowledge, technical skills, communication, and professionalism. The School for Surgeons curriculum using often African-based case studies as well as online tutors resulted from joint Royal College of Surgeons in Ireland (RCSI) and COSECSA efforts.

Study participants were urged to investigate the resources within both online programs and to consider the uses of each within their particular clinical environment. All completed a similar specified module in each curriculum. Participants found the subject matter of both courses of study to be largely relevant to their needs and indicated that they would very much use either curriculum on a routine basis. They also indicated that the systems were effectively organized and easy to work with and that they would recommend both to coworkers and associates.

That all students found both curricula relevant proved a prescient response to the actionable concept in WHA's 68.15 resolution that "appropriate core competencies" be introduced to students in any relative fields of health knowledge through "relevant health curricula, training, and education" [63]. Validated core surgical curricula are transferable between very different environments [62]. Curriculum should be subjected to students' critique evaluating whether the learning is appropriate, relative, relevant, and useful.

A noteworthy model for curriculum and examinations done in partnership is that of the University of Guyana and the Canadian Association of General Surgeons (CAGS) [64, 65]. Begun at the request of Guyanese surgical leadership seeking to stem the country's brain drain and more adequately attend to rural areas, the Guyana-based postgraduate training culminated after 2.5 years in a postgraduate diploma in surgery. It was based on local resources and needs, was taught by local and CAGS faculty, and incorporated faculty and resident exchange between the two countries. Outcomes of this partnership, which graduated 14 students since its 2006 inception, included the arranging of instructional content into a standard curriculum, the establishment of evaluation processes (including program and faculty evaluation), and exacting examinations. Where there had been no structured local postgraduate training, a surgical career was now possible for program graduates who had been instructed in the use of available resources for management of surgical conditions common to the area. Local faculty are now totally in charge, a foundational element of the program that bodes well for its sustainability.

Conclusion

Surgical training and delivery systems of low-resource countries are too often inadequately conceived and implemented for as well as coordinated with the people they serve, thus limiting the likelihood of the establishment of reliability and sustainability. Surgical care delivery can be sustained only if surgeon, healthcare practitioner and staff training is developed at all levels, including system, institution, and individual.

The shortage of LMIC surgeons as well as NPCs affects all aspects of patient care: quality, services, infrastructure capacity, and, certainly, education and professionalism. The skills of training and the competencies of professionalism are served (but not supplemented) by technologies and innovations, but they are best delivered, we are reminded time and again, by humans. Nothing surpasses the time-proven wisdom surfaced in the conclusion of an LMIC review of training and learning tools: "The role of medical teacher is not only to impart communication of knowledge but also for holistic care in capacity building to improve the health care scenario in any country…In the last place it is the man behind the machine that imparts communication in [the] health care scenario [66]."

Standardized curricula and consequential, validated examinations must be part of training. To accomplish this, it will be critical to identify who will make determinations regarding what data will be routinely collected, how doing that will be accomplished, who or what will have responsibility for its analysis, and how its dissemination will be achieved.

The WHO initiative and the WHA resolution placed emergency and essential surgical training at the center of a framework that emphasizes integrated management of care as well as an integrated surgical care network. The integrations WHO and the WHA seek are imperative, urgent, and achievable.

Moving forward, we would do well to regard and honor the thought expressed by a Malawian surgical resident, who noted:

In Africa, being a doctor is not enough.
To make a difference, a doctor must become a surgeon [67].

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Delivery of Subspecialty Surgical Care in Low-Resource Settings

5

Russell E. White and Robert K. Parker

Introduction and Overview

The Essentials

- *Subspecialty care should be readily accessible, safe, financially feasible, and allow exchange of ideas for continued quality improvement.*
- *Expanding upon essential surgery, subspecialty surgery consists of the provision of care by trained subspecialists and typically requires advanced technology, materials, and infrastructure related to the services provided.*
- *The history of how subspecialty surgery has developed in resource-limited settings can contribute to an understanding of how to advance its provision.*

Globally, subspecialty surgical care should be readily accessible, safe, financially feasible, and allow exchange of ideas for continued quality improvement. This ideal is not the current situation for millions of people worldwide. In low-resource settings, availability of care is sporadic, outcomes are often subpar, costs are prohibitive, and the skilled personnel and appropriate infrastructure to accomplish this task are lacking. In this chapter, we will discuss the history of subspecialty surgical care, the current models used to deliver it, and how the individual provider may fit into this continuum with the hope of advancing access and improving quality of subspecialty care to low-resource communities.

R.E. White, MD, MPH, FACS, FCS (ECSA) (✉) • R.K. Parker, MD
Department of Surgery, Tenwek Hospital, PO Box 39, Bomet 20400, Kenya

Warren Alpert School of Medicine at Brown University, Providence, RI, USA
e-mail: russ.white@wgm.org; robert.k.parker@gmail.com

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Definitions

The Lancet Commission on Global Surgery recently detailed the appalling lack of surgical care for billions of people [1]. The report focused mainly on the lack of essential surgical care, defined as "any and all procedures, contextually and culturally dependent, that are deemed by that region, society, or culture to promote individual and public health, wellbeing, and economic prosperity." In some settings, this essential surgery is performed by those with medical degrees and further training. In other locations, it is performed by those with apprenticeships and procedural training only. Within low- and middle-income countries (LMIC) that have accredited specialists in surgery, these specialists may provide both essential surgical care and subspecialty surgical care. These divisions of labor will be further explored in the different models available for subspecialty surgery.

In most resource-limited settings, subspecialty surgical care is rarely or sporadically available. Expanding upon essential surgery, subspecialty surgical care consists of the provision of care by trained specialists and includes various subspecialty disciplines such as ophthalmology, ENT, plastic and reconstructive surgery, pediatric surgery, urology, neurosurgery, advanced laparoscopy, and cardiothoracic surgery. Typically, subspecialty care requires advanced technology, materials, and infrastructure related to the services provided. Although some straightforward subspecialty care could be provided at the district hospital level, advanced care is generally suited for a referral center serving a larger population [2, 3].

History of Subspecialty Care in Developing Countries

To better understand the way forward for global subspecialty surgery, it is imperative to understand past successes, failures, and the many factors historically that have contributed to a shortage of healthcare workers, a myriad of health disparities, and a lack of subspecialist surgical care [4]. Global surgery was perhaps founded decades ago during an era defined by highly dedicated expatriates. Funding was often supplied through the generosity of nongovernmental organizations, such as churches and charities. In these early years, expatriates dedicated their careers and lives to the cause of bringing surgical care to people without such access. For example, Peter Parker, who introduced anesthesia to China, was among the first missionary surgeons [5]. Lucille Teasdale practiced surgery in Uganda for years until finally contracting and dying from HIV/AIDS. With a higher purpose of caring for individuals and communities, missionary surgeons invested not only their careers but their lives to the cause. As mission hospitals expanded, general and subspecialty surgical care for community-identified problems also grew. Throughout this era, the surrounding communities of these hospitals were significantly impacted and enjoyed the benefits of considerable investment in infrastructure, workforce development, and provision of healthcare. But hospitals were dependent upon the missionary to stay and invest his or her life into the cause. Furthermore, the effect was localized, and national healthcare systems were rarely influenced [6].

The Alma Ata Declaration, in 1978, signaled a change in the delivery of healthcare worldwide [7]. In an inadequately supported attempt to achieve "healthcare for all," funding was directed toward community health initiatives such as breastfeeding, oral rehydration, and immunization, while structural adjustment programs limited investment in medical personnel and infrastructure [8–10]. Although worthy goals, this resulted in disturbingly preferential investments at the great expense of surgical capacity [11]. Consequently, scores of capable, educated physicians and nurses left home for brighter futures elsewhere [12]. Some workers moved to private, urban hospitals within their own countries. Tragically, many were actively recruited by resource-rich nations to fill an increasing need for healthcare workers in those countries [13, 14], depriving LMICs of healthcare workforces and potential leaders [15–17]. In this way, the Alma Ata agreement contributed to the current health disparities, where worldwide, over five billion people lack access to surgical care which the workforce is not yet capable of delivering [1, 18].

The current era is one of increased focus on global provision of surgical care but with an unfortunate lack of focus, organization, and accountability. Globalization has increased awareness of the problem and made travel easier and more affordable. A relatively recent understanding of global surgery as a population-based, cost-effective avenue to restoring health and improving infrastructure has enabled a newfound interest in its promotion. As a result, healthcare providers from resource-rich nations have flocked to resource-poor areas, mostly with good intent, but regrettably too often with mixed results. Hundreds of short-term surgical camps have materialized [19]. In 2004, the American College of Surgeons created a database of volunteer opportunities and facilitated short-term involvement calling the campaign, "Operation Giving Back" [20]. Short-term surgical trips (STSTs) have been a significant yet unquantified source of subspecialist surgical care in resource-constrained settings. Given the abundance of STSTs and the inconsistency in accountability, it is impossible to accurately detail the impact of STSTs on subspecialty surgical care. Both global organizations and academia are beginning to understand the necessity of promoting surgical access in order to further the health and success of communities and have attempted to correct the incongruity of STSTs by establishing partnerships, cultivating educational efforts, and aspiring to longitudinal collaboration [21, 22]. National governments and Ministries of Health have occasionally recognized subspecialty care, although budgets are often constrained by other priorities. And finally, local institutions, including mission hospitals, have tried to adapt subspecialty surgical care appropriate to their settings, but this access is only sporadically available.

Current Overview of Subspecialty Surgical Care in Low-Resource Settings

The Essentials

- *Although data is sparse, evidence suggests there is a large burden of disease globally that could be correctable by subspecialty surgery.*
- *Sufficient personnel for subspecialty surgical care is lacking in low-resource settings.*
- *Access to subspecialty care is challenging and often limited to urban areas.*

The availability of subspecialty surgical care is varied throughout the world, but in LMICs access is especially limited. Few studies exist regarding subspecialty surgical care in LMICs, and extensive data is not yet available to draw conclusions. Current qualitative research shows that there exists great potential for improvement. Outcome reports for various models and experiences are sparse (Table 5.1). The data currently available to draw conclusions may not accurately reflect the ongoing efforts of those working within low-resource settings because many hospitals and surgeons have provided subspecialty care but have never published their experiences. There are many reasons that specialist availability in LMICs is limited including the lack of infrastructure, resources, and trained personnel. Subspecialty care, where available, is often focused on a specific condition and provided by a fragmented group of outside specialists, urban academic institutions, nongovernmental organizations, faith-based hospitals, and various combinations thereof.

Need for Subspecialty Surgical Care

Attempts at quantification of the burden of surgical disease as well as its contribution to disability and premature death of a population have been of recent interest. There is a particular interest in essential and emergency surgery given its role in immediate reversal of health disparities. However, little data exist about the burden of subspecialty surgical disease. Specific surgical conditions, those which typically require subspecialty training, have been addressed in various reports of their cost-effectiveness, availability of services, occurrence of disease, and the related disability and mortality caused by the condition. For example, congenital conditions are a leading cause of pediatric mortality and morbidity. An estimated 93 million children and 7% of all births are impacted with some form of moderate or severe deformity [46, 47] which would benefit from surgical intervention. Surgically correctable conditions may significantly negatively impact quality of life. Reports exist on the burden of cataracts [48], otitis media [49], osteomyelitis [50, 51], hypospadias [52], urological conditions [53, 54], and congenital conditions such as cleft lip or palate and clubfoot [55, 56]. As a whole, subspecialty surgical care has not been as

Table 5.1 Reported outcomes of various models [23–45]

Author	Organization	Location	Operation/condition	Outcome
Short-term surgical trips				
Endocrine/ENT				
Rumstadt 2008 [23]	Department of Surgery, Diakonie Hospital Mannheim, Germany, and Hopital de Leo, Burkina Faso	Burkina Faso	Endemic goiter; 253 patients	Recurrent nerve injury 0.8%; exploration for bleeding 1.2%
Cheng 2012 [24]	Mercy Ships	West Africa	Thyroid multinodular goiter; 48 patients	Serohematoma 6%; 2% vocal cord palsy; comparable to results in UK cohort
ENT				
Sykes 2012 [25]	Obras Socíales del Hermano Pedro, Catholic Mission Hospital	Guatemala	Tonsillectomy; 204 patients	197 with follow-up; 1.5% complications
Snidvongs 2010 [26]	Sakaeo Hospital	Thailand	Otologic surgery; 35 patients; 32 with otorrhea; 31 with tympanic membrane perforation	74% with hearing improvement by average 22.9 dB
Horlbeck 2009 [27]	Otologic surgical team from Wilford Hall Medical Center, San Antonio, Texas	Paraguay and Honduras	Chronic ear disease; 117 patients, 77 with follow-up; 20 with dry perforations; 30 chronic drainage; 25 cholesteatomas	Surgical success reported on those with follow-up as 60% dry perforation, 74% chronic drainage, 92% cholesteatomas
Barrs 2000 [28]	"Oye, Amigos!"	Mexico	Otologic surgery; 85 tympanoplasty patients	Follow-up 83.5%; success rate of 41% for first 2 years and 74% for the following 3 years
Plastic and reconstructive surgery				
Huijing 2011 [29]	Facing Africa and Project Harar	Ethiopia	Facial reconstruction; 35 patients	Objectives met in 14/17 patients with simple operations and 5/18 with complex operations; 26 complications – 2 life threatening, 24 with problems in wound healing

(continued)

Table 5.1 (continued)

Author	Organization	Location	Operation/condition	Outcome
Maine 2012 [30]	Rostros Felices and Resurge International	Ecuador	Cleft palate repair (North American surgeons 46 patients, Ecuadorian surgeons 82 patients)	Oronasal fistula rate 57% for Ecuadorian surgeons and 54% for North American surgeons 20-fold higher than high-income countries
Orthopedic surgery				
Cousins 2012 [31]	Kenya Orthopedic Project (KOP)	Kenya	Orthopedic operations; 187 patients	"Doing well"/of those with follow-up; 10/14 hip; 41/58 lower; 18/25 upper; 2/7 osteomyelitis
Cardiac surgery				
Adams 2012 [32]	CardioSalud	Peru	Cardiac surgery; 15 patients	1 mortality, 2 with bleeding requiring takeback
Falese 2013 [33]	Lagos State University Teaching Hospital	Nigeria	Cardiac surgery; 51 patients (42 cases with visiting teams, 9 cases with local team)	Mortality 18% (14% visiting teams, 33% local team)
Swain 2014 [34]	Rwanda Ministry of Health, Rwanda Heart Foundation, Brigham, and Women's Hospital	Rwanda	Cardiac surgery; 86 patients	30-day mortality 5%; cerebrovascular accident = 1, hemorrhage with reoperation = 2
Tefuarani 2007 [35]	Operation Open Heart	Papua New Guinea	Cardiac surgery; 337 patients	1.9% short-term mortality; complications "unremarkable"
NGOs				
Young 2013 [36]	SIGN Fracture Care International	Multiple LMICs	Intramedullary nail; 46,113 operations	Follow-up in 23%. Infection rates among patients with follow-up: 2.9% humerus, 3.2% femur, and 6.9% tibia
Jenkins 2014 [37]	International Quality Improvement Collaborative for Congenital Heart Surgery in Developing World Countries	28 sites in 17 LMICs	Congenital heart disease; 15,049 operations	Mortality 6.3%; major infection 7%

Novick 2005 [38]	International Children's Heart Foundation	83 trips in 14 LMICs over 10 years	Pediatric cardiovascular services; 1,580 operations	Mortality 15.4% first 5 years of experience, 6.7% during second 5 years
Specialty and referral hospitals				
Gathura 2012 [39]	BethanyKids at Kijabe Hospital	Kenya	Ventriculoperitoneal shunt; 574 patients	Shunt function at 2 years 65%; complication rate 20–11% shunt malfunction, infection 9.1%; mortality 7.1%
Kulkrani 2010 [40]	CURE Children's Hospital	Uganda	Endoscopic third ventriculostomy (ETV) for pediatric hydrocephalus; 979 patients	No difference in ETV survival when risk-adjusted outcomes compared to 12 resource-rich centers
Meier 1995 [41]	Baptist Medical Centre	Nigeria	Suprapubic prostatectomy; 240 patients	Complication rate 20%; transfusion 5%, clot retention 7%; 3% return to operating room
Stephens 2015 [42]	SIGN – 3 referral trauma centers	Kenya, Ethiopia, Pakistan	Distal tibial metaphyseal fractures; 160 patients	Fracture union 97%; acceptable alignment (<5° deformity) 83%; infection 9%; revision surgery 6%
Leon-Wyss 2009 [43]	Unidad de Cirugia Cardiovascular de Guatemala	Guatemala	Pediatric cardiac surgery; 2,630 procedures	Complication rate 20%; late mortality 2.7%
Gnanappa 2011 [44]	Madras Medical Mission	India	Adult congenital heart surgery; 153 patients (102 "simple", 51 "complex")	Major complications: 8% "simple," 29% "complex." Mortality: 0 "simple," 4% "complex."
Schonmeyr 2015 [45]	Guwahati Comprehensive Cleft Center	India	Cleft lip repairs; 3,108 patients	2062 follow-ups. 4.4% complications; dehiscence 3.2%, infection 1.1%

emphasized as emergency and essential care, which in of itself has not been as emphasized as many other public health priorities.

Number of Subspecialist Surgeons

Quantifying the number of surgeons serving a population is a difficult task [57]. Variations of definitions between those who perform operations, general surgeons, surgeon specialist, and surgical subspecialist prevent a complete understanding of the number. Furthermore, surveys of Ministries of Health may not capture the substantial contributions of NGOs and faith-based hospitals. As an example, in southwestern Uganda, a survey of hospitals revealed 43 consultant specialist surgeons (0.7 accredited surgeons per 100,000 population) including all of the specialties of general surgery, obstetrics, orthopedic surgery, ophthalmology, dental surgery, neurosurgery, ENT, and urology. The survey, which reviewed mandatory logbooks maintained at each of the 27 hospitals, observed that 55% of procedures were performed in mission/NGO hospitals, 45% in government hospitals, and <1% in a private hospital. Cleft lip and palate repair was predominately undertaken by plastic surgery teams, with external funding, who performed 80% of 140 operations [58]. Notably the number of operations performed in southwestern Uganda was higher than previous estimates [59]. Walker et al. postulate that the inclusion of NGO and mission hospitals which performed the majority of the procedures accounted for this finding and estimates do not reflect current services available.

As examples of subspecialty surgery, there are only six plastic and reconstructive surgeons in Ghana for a population of 22 million and three in Uganda with a population of 28 million, and in Zambia with a population of 10 million, there is only one [60]. Similarly, there are only six neurosurgeons in Uganda [61]. For urology, Zambia has one trained urologist per 2.3 million people, and most conditions are managed by either general surgeons or nonphysician providers [53]. Though accurate and complete measurements are not yet available, it remains apparent that sufficient personnel for subspecialty surgical care is sorely lacking [62].

Access to Subspecialty Care

Access to subspecialty surgical care is limited in low-resource settings. At least 4.8 billion people do not have access to surgery, including greater than 95% of the population of South Asia and central, eastern, and western sub-Saharan Africa. This compares to the less than 5% of high-income North America, Western Europe, and Australia who lack access to surgery, highlighting the inequitable distribution of healthcare [63].

In most low-income countries, specialty-trained surgeons and anesthesiologists, if available, work exclusively in referral hospitals [64–66]. As a result, district hospitals are staffed by general practitioners and nurses [67]. Even when hospitals are able to provide emergency and essential surgery, their capacity to deliver subspecialty surgical care is often hindered [66, 68]. In a review of hospitals within Haiti, 93% claimed the ability to perform hernia repairs, while more specialized care was limited: operative repair of fractures (51%), clubfoot (42%), cleft repairs (31%), and cataract surgery (27%) [69].

As anyone who has practiced in a LMIC has experienced, patients travel long distances [70–72], often delay seeking treatment [73, 74], and consequently, present with advanced disease. This becomes particularly true with subspecialty surgical care and is true for the authors' experience with esophageal cancer in western Kenya [75, 76]. A review of the burden of waiting by Poenaru et al. demonstrated significant delays in surgical care and resultant increased burden of disease. They demonstrated prolonged average wait times for pediatric orchidopexy (72 months) and anorectoplasty (74 months) [77] and compared these to much lower wait times in resource-rich Canada.

Millions of people worldwide face catastrophic expenditures from the costs of surgical care and conditions requiring surgery. These prohibitive costs fall mostly upon LMICs and on poor patients within any country [78].

Finances of Subspecialty Surgery

The days of thinking subspecialty surgery is too expensive or a bad investment in low-resource settings are over. Available data and experience point toward massive benefits of life-changing care for individual patients and the resultant improved capacity and infrastructure for communities [21, 79]. Multiple reports suggest the cost-effectiveness of subspecialty surgery: pediatric inguinal hernia repair [80], pediatric neurosurgery [81], orthopedics [82, 83], ophthalmology (cataract [84–88] glaucoma [89] and trachoma [90, 91]), cleft repair [92–95], hand surgery [96], and cardiothoracic surgery [97]. When comparing subspecialty surgery to other public health interventions, the cost-effectiveness profiles are competitive: cleft repair ($47.74 per disability-adjusted life year (DALY), hydrocephalus ($108.74 per DALY), ophthalmic surgery ($136 per DALY), orthopedic surgery ($381.15 per DALY) as compared to BCG vaccine ($51.86–$220.39), and antiretroviral therapy ($453.74–$648.20 per DALY) [98]. High complexity care can reduce costly disabilities while maintaining a cost-effective profile. Pediatric neurosurgery for infant hydrocephalus has been demonstrated to be cost-effective at the permanent referral center of CURE Children's Hospital of Uganda [99]. Provision of care by local surgeons could be most cost-effective; however, in an era where services are not available, even short-term trips, such as a pediatric neurosurgical brigade to Guatemala, are still more cost-effective than no care at all [81]. These reports are encouraging as they reflect the experience of first-line providers who understand the important role that subspecialty surgical care plays in improving public health.

Various Models for the Provision of Subspecialty Care

The Essentials

- *Numerous models, platforms, or methods of delivery for subspecialty surgical care exists.*
- *These models include short-term surgical trips, university and academic partnerships, telemedicine, task shifting/sharing, government initiatives, private health facilities, nongovernmental organizations, and faith-based mission hospitals.*
- *Each of these models has various advantages and disadvantages.*
- *Delivery of subspecialty care could best be viewed as a continuum with various combinations of these models.*

Categorizing each effort into a specific defined platform presents a problem in understanding complex methods of delivery. Although such classification into platforms can greatly inform our understanding of advantages and disadvantages [100], delivery of subspecialty care could perhaps more easily be viewed as a continuum. Often, providers utilize a number of delivery methods to achieve their desired goal. As an example, subspecialists may briefly visit a permanent NGO clinic that partners with faith-based organizations and the local government to address either a specific condition or subspecialty need. Over time, by building on the foundation of short-term service trips, important development can occur, progressing even to a community-owned hospital capable of subspecialty surgery. Trying to describe each method of delivery independently may not be possible, but recognizing the assorted nuances of each variable may facilitate the understanding of the best methods and models available for the needs of a specific community. These findings can then be scaled to the national and global levels. Understanding this continuum of care provision, as seen by first-line providers of subspecialty care, enables appropriate implementation.

There are a number of models for provision of subspecialty surgical care, each with its own advantages and disadvantages (Table 5.2). The range includes short-term surgical trips, academic partnerships, government initiatives, nongovernmental organizations, faith-based mission hospitals, and various combinations of these models. We can crudely break these down and describe approaches. The acknowledgment of the methods, personnel, location, and investment of time of each model may delineate how to best provide subspecialty care to a community.

Short-Term Surgical Trips

Historically, the traditional STST is an outsider approach where a group of skilled individuals bring resources, both human and material, to provide medical services. In scientific literature, there are myriad reports of "mission" or "service" trips,

Table 5.2 Various models of healthcare delivery with benefits and challenges

Model	Characteristics	Benefits	Challenges
Short-term surgical trips	A group of skilled individuals bring resources, both human and material, to provide medical services	Large volume of patients cared for by well-trained subspecialist surgeons	Relatively worse outcomes and little continuity of care
		Potential to advance to long-term partnerships and collaboration	Potential to overwhelm the community and/or infrastructure in place
		Beneficial to and easy for the participating healthcare provider	Often not conducive to health system strengthening
University and academic partnerships	Universities and academic organizations develop partnerships to improve educational efforts and quality of care	An acknowledgement of common interests and a collaboration toward furthering service, education, and research	Potential for unequal partnerships; the resource-rich university can take the credit for the partnership, while the institution in the resource-poor setting accepts the funding without being invited to the table to make decisions
		Can encourage training and provide accreditation	Disconnected from first-line providers
Telemedicine	The use of electronic information and telecommunications technology to enable clinical healthcare and education over long distances	Transfer of knowledge and expertise without the costs of travel	Significant technology costs and the infrastructure to put telemedicine into practice
			Difficulty in maintaining technology
Task shifting	The delivery of surgical care by nonphysician providers	Provision of healthcare to communities that would otherwise have no reliable access to care	Lack of adequate supervision and quality control
		Reduced cost and time of training physician providers	Care may be compromised in situations where further training and expertise is necessary
Government health facilities	The public sector, funded by the government, rarely offers consistent subspecialty surgical care	May eventually be the path to universal healthcare coverage	Perceived to lack the hospitality and timeliness of the private sector
			Subspecialty surgical care and training is a low funding priority

(continued)

Table 5.2 (continued)

Model	Characteristics	Benefits	Challenges
Private, for-profit, hospitals	For-profit private hospitals are typically located in urban settings and care only for patients who can pay for services	Allows physicians to have a "dual practice" which may limit brain drain	In "dual practice," private patients receive preferential treatment over poorer patients at public hospitals
		Patients often prefer the private sector due to better accommodations and worker-patient relationships	Care is not available to those who cannot pay the often exploitative prices
Nongovernmental organizations (NGOs)	NGOs can be involved in a range of projects, from community-based programs to global efforts based on a surgically correctable condition, and vary widely in their methods of delivery	Bring vast resources to care for patients regardless of profit	Often work beside the government hospitals with little attention to building public infrastructure
		Provide a results-oriented passion for certain disease process or healthcare priority	The project stops once the initiative is completed, interest is lost, or funding runs out
Faith-based mission hospitals	Faith-based organizations account for a significant percentage of global healthcare, invest in their surrounding communities, and place a priority on serving poor and marginalized people	Within their communities, they are typically among the best choices for care, with high patient satisfaction rates, and in some areas are the only choice that exists	Financial constraints due to dependence on external funding sources
		Tend to adapt to the desired needs of the community, and subspecialist care is provided for the given need	Lack of collaboration with government institutions could reduce the achievement of universal health access as mission hospitals are often not accounted for in the implementation of health planning and policy

which often focus on the volume of patients served. The concept of providing care to a high volume of patients over a brief period of time has been described in numerous terms: surgery camps, brigades, safaris, blitzes, and teams. Since the nineteenth century, faith-based groups have organized, partaken, and advocated for short-term mission trips [19], and surgical groups are among the most represented participants in short-term service [101]. Despite the fact that these groups often share a common goal of encouraging development of the local community, reports and studies are almost uniformly from the perspective of the outsider providers of care and training rather than the receivers [24, 25, 27, 31, 38, 102–105]. This has led to questions about the relevance of such groups from the view of the local community [106].

Advantages of this model include a large volume of patients cared for by an ideally well-trained and capable subspecialist surgeon. The patients with problems that no one has been able to care for in years may have their lives drastically changed. Perhaps, the most dramatic STSTs include quick solutions such as ophthalmology care where sight is immediately restored. These STSTs are attractive to volunteers and are typically reported as positive experiences for the healthcare provider [107]. On the positive side, a short-term trip may be the experience necessary to pique the awareness of an individual so that he or she invests long term in a community [108, 109]. Yet, the long-term impact on patients and communities is rarely reported or understood. Many camps have been successful in developing longstanding commitments to providing care where care would otherwise be unavailable. An example in the ENT subspecialty is the work of BRINOS, Britain Nepal Otology Service, with years of experience sending Nepalese and British ENT surgeons into remote areas lacking ear care [110]. Organizations, such as Resurge International, that have involved plastic and reconstructive surgeons in short-term service trips have also grown to understand the need for long-term partnerships. The group of subspecialist surgeons reported their needs for cooperation with local physicians, predictable presence, emphasis on teaching, and links with structured organizations [111].

STSTs have their drawbacks as well, especially if conducted poorly. While beneficial for the healthcare provider, this model may have the potential to do the most damage to a community. If not done correctly, an STST may amount to "voluntourism" – a perverted form of altruism where providers enjoy the benefits of travel, overstep their qualifications, limit opportunities for local physicians to flourish, are not conducive to health system strengthening, and damage relationships between local healthcare providers and communities in need [112, 113]. During subspecialty camps, a decreased number of elective operations outside the subspecialty offerings are able to be completed at the hospital. Thus, at these times, there are surgeons who could be offering their services, but are unable to do so because of the lack of operating space, an extremely valuable commodity in a resource-constrained hospital [106, 114]. When a large number of visitors descend upon the hospital community, it can be a stressful time with misunderstandings of the local culture. Although these misunderstandings can be partially alleviated by partnerships of the visiting team with local personnel, this must be considered in planning each STST. Typically, there is a considerable amount of logistical work that is required for visitors, which has the potential to overwhelm local staffing. When specialists are already present and actively caring for patients, these brief surgical camps can create more of a burden on the existing infrastructure than necessary [30, 106]. There are examples of relatively poor outcomes during STSTs that could urge caution in their application to deliver surgical care or at least warrant further exploration in causality [29]. It should be recognized that reports of good outcomes or those equivalent to high-resource settings may be the result of poor follow-up and thus a lack of awareness of complications [115]. Although STSTs may eventually advance to longer partnerships and collaboration among organizations, it remains unknown how many of these efforts fall apart as personnel change or lose enthusiasm.

In response to these questions, the academic surgical community and others have responded to STSTs with ample guidelines, warnings, and lessons [116–121] (Table 5.3). With these suggestions, there is now a trend toward discouragement of these STSTs unless there exists no other possible surgical care alternatives [106, 122, 123]. These attitudes of "first do no harm" must not regress into "first do nothing" [124]. Successful surgical camps are particularly relevant for the provision of specialized surgery in low-resource settings where services are otherwise not available. Short-term teams may be necessary to fill these gaps, provide the necessary resources, and build the capacity and infrastructure necessary to advance the project along the continuum of the delivery of subspecialty care.

University and Academic Partnerships

Numerous, important publications describe how universities and resource-rich organizations have developed partnerships, improved educational efforts, and aspired to longitudinal collaboration [21, 22, 125–128]; yet, there is a paucity of descriptions of the organizational efforts from institutions within resource-limited settings. It is important to note that universities, academic institutions, and professional societies in LMICs have been training and supporting surgeons for years before such partnerships. The College of Surgeons of East, Central, and Southern Africa (COSECSA) is an independent, academic organization that encourages postgraduate training in surgery and accredits surgeons [129]. Some university partnerships are based upon short-term care delivery [130], while others focus on developing long-term partnerships, research, and education [131–134]. Advantages of the university partnership are the acknowledgement of common interests and a collaboration toward furthering service, education, and research. A disadvantage is that the resource-rich university often takes the credit for the partnership, while the institution in the resource-poor setting accepts the funding without being invited to the table to make decisions [135]. Hospitals and universities in low-resource settings may take whatever help might be offered, in the hope of acquiring needed resources, from numerous partnerships that may lack the depth or desire to invest in a community. These high-resource partners may benefit from a distinguished, yet shallow, partnership through publications, increased interest among applicants to their program, and recognition. It is still early to discern if recent partnerships between surgical departments will persist despite changing personnel.

Table 5.3 Guidelines, warnings, and lessons for short-term service trips [106, 116, 117, 119, 121, 122]

Grimes et al. 2013 [116]	Ensure that all projects are appropriate with locally identified need
	Have an emphasis on training local healthcare providers
	Monitor outcomes
	Work alongside local and regional training programs
Welling et al. 2010 [117]	Avoid all of the following "sins":
	Leaving a mess
	Not matching technology to local needs and abilities
	Failing to cooperate with other NGOs
	Not having a follow-up plan
	Allowing other factors to be more important than "service"
	Being poor guests or coming when not welcomed
	Having disingenuous motivations
Meier 2010 [119]	Helpful do's and don'ts:
	Do remember you are a guest and respect the culture
	Don't try to make sweeping reforms
	Don't blame your hosts for perceived inadequacies
	Do treat your hosts as colleagues
	Do plan follow-up trips to the same locale
	Do relax, be flexible, provide quality care, and train local personnel
Wright et al. 2007 [121]	Assess the needs of the community
	Involve the local team at every opportunity
	Have team members who are experts
	Conduct research which contributes to the sustainability of the project
Nthumba 2010 [106]	Involve the local community with a goal to train and retain surgeons
	Work with local training institutions
	Partner directly with smaller, rural training institutions to overcome bureaucratic hurdles
Dupuis 2004 [122]	One should never perform an operation abroad that one would not perform at home
	Residents should not be unsupervised
	Avoid trying to maximize the number of patients treated

Telemedicine

Telehealth is the use of electronic information and telecommunications technology to enable clinical healthcare, education, and administration over long distances [136]. As the availability of technology advances and feasibility improves [137], telemedicine may help with more thorough preoperative workup and evaluation for STSTs [138, 139], remote screening [140], and postoperative follow-up [141]. Telemedicine may also improve educational collaboration and be relevant to continued training, mentoring, and skills development [142–144]. Telesimulation, linking trainees and instructors in simulation through the Internet, has been shown to be promising, teaching laparoscopic skills to surgeons in Botswana and Colombia [145, 146]. As surgeons practicing in a low-resource environment with limited subspecialists available, the authors can personally attest to the importance of discussing complex cases via phone, email, or video conferencing with colleagues trained in subspecialty disciplines.

Task Shifting Versus Task Sharing

Many LMICs and organizations have attempted to overcome surgical disparities by training nonphysicians to perform procedures [147]. Task shifting, the delivery of surgical care by nonphysician providers, has been shown to be a viable solution in some low-resource settings with limited workforces [148]. Nonphysician providers have been advocated in essential surgery [149, 150], obstetrical care [151–153], and even subspecialty surgical care: orthopedics [154], pediatric surgery [155], and select urological and neurosurgical procedures [156]. The advantages of task shifting include the provision of healthcare to communities that would otherwise have no reliable access to care and the reduced cost and time of training physician providers. Disadvantages include the lack of adequate supervision and quality control and the concern that care may be compromised in a low percentage of situations where further training and expertise are necessary. Most advocates for task shifting acknowledge these limitations and recommend a restricted number of procedures be carried out by such providers. Certain subspecialty procedures, such as cataracts, could be adopted by nonphysician providers if appropriate oversight is in place [157]. To help address the lack of access, some subspecialty care such as basic and emergency neurosurgery in Tanzania has been taught by neurosurgeons to nonphysician clinicians. In that model, the trained healthcare workers then taught other healthcare workers to perform basic and emergency neurosurgery independently [158]. Clear definitions of the scope of practice, high standards for accreditation, and shared responsibility and oversight with specialist providers are necessary to ensure safe and quality care by the nonphysician provider [159, 160].

While task-shifting seems like a necessary stop-gap measure in the current era of significant disease burden, we advocate for a task-sharing approach with adequate training of physicians to oversee nonphysician providers [161]. This training model requires the long-term presence of highly trained personnel which results in a remarkable investment of human potential [162]. There are many challenges in training subspecialty surgeons in low-resource settings including a lack of standardization [163–165]. The authors do not advocate for sending personnel to high-resource institutions for further subspecialty training due to their propensity to stay and work in these high-resource settings. Training models appropriate to the resource-level and context should be developed and maintained to provide adequately trained personnel [166].

Government Health Facilities

Within LMICs, government hospitals, or the public sector, provide a variable amount of subspecialty care, and district or county hospitals do not typically offer subspecialty surgery [3, 66, 68, 150, 167, 168]. A review of district government hospitals in Mozambique, Tanzania, and Uganda demonstrated that no general surgeons were present. With essential surgery lacking priority in administration of these hospitals, subspecialty surgical care is not possible [67].

Generalized comparisons of public vs. "private" (including for-profit, nonprofit, faith-based) sectors show that the public sector is perceived to lack the hospitality and timeliness of the private sector [169]. Arguments exist that the public sector may offer expanded coverage to poor patients and is the path toward universal coverage. However, there is no data to guide the debate in subspecialty surgery. Governments often lack commitment to funding subspecialty care and training [170] and sometimes send patients abroad for subspecialty care [33, 171]. Yet, there are encouraging examples of how governments have partnered with institutions to expand and strengthen their specialist workforce [133, 172].

The facilitation of cataract surgery in India during the 1990s is one example of a government-identified need in which subspecialist surgical care was subsidized, expanded, and improved. Each district was allowed to finance providers to accomplish the goal of reducing blindness. Government mobile camps, state medical hospitals, and nongovernmental hospitals had an average cost for each individual patient of $97, $176, and $54, respectively, and resulted in patient satisfaction at 51%, 82%, and 85%, respectively [88].

Where specialists are not locally available within the public sector, there is certainly a role for short-term surgical camps. Though when specialists are already present and actively caring for patients, these brief surgical camps may create more of a burden on the existing infrastructure than necessary [30, 113].

Private, For-Profit Hospitals

Due to perceived problems in the public sector, private for-profit clinics and hospitals are quickly increasing their market share in LMICs, particularly in urban centers [173, 174]. Physicians often have a "dual practice" in a public hospital, such as a university, with a private clinic to supplement income [175]. Fifty-five percent of physicians working in three capital cities in Africa subscribed to this dual practice [176]. Private health facilities have often been small operations, owned by individual practitioners, which then grow over time into larger hospitals [177]. If dual-practice providers have patients in both private and public institutions, the private patients may receive preferential treatment at the expense of patients in public hospitals.

The Muhimbili Orthopedic Institute in Tanzania attempted to overcome the perception that specialty care could only be done at private or NGO facilities. They reported on their acceptance of and recruitment of private patients to maintain a private/public mix. During a 5-year period, private patients accounted for only 30% of outpatient visits and 5% of inpatients, yet generated 77% of the hospital's income from patient fees and 35% of all hospital income including government subsidies. With their experience, they found that patients prefer the private sector due to poor accommodations and the perceived poor worker-patient relationships in the public sector [178].

Nongovernmental Organizations

Numerous nongovernmental organizations (NGOs) or charitable organizations provide surgical care in low-resource settings. It is difficult to quantify the number of NGOs involved in care and equally impossible to estimate their impact. NGOs can be involved in a range of projects, from community-based programs to global efforts based on a surgically correctable condition, and vary widely in their models for delivery [179]. In a review by Ng-Kamstra et al., 313 NGOs were identified delivering surgical care in all 139 LMICs. Subspecialty surgery is performed and supported by numerous NGOs. Of all the NGOs surveyed, a number contributed to some form of subspecialty services including 22% of NGOs which perform cleft repair and 28% of NGOs which provide ophthalmology care [180].

Some NGOs are devoted to a specific condition, while others focus on a specific subspecialty. Smile Train is the largest charity group aimed at the subspecialty surgery of cleft repair. As a condition recognized to cause significant morbidity without operative repair, Smile Train has funded thousands of operations through local institutions and trained scores of local providers [181]. Throughout the last 20 years, a nonprofit organization, IVUMed, has supported educational programs for urology through numerous partnerships. In over 30 countries, IVUMed has worked in conjunction with a network of providers, institutions, societies, and industry to create collaboration built on training the subspecialty surgical discipline of urology [182]. Each NGO has a role in reducing the surgical burden of disease within its own area of strength.

NGOs are often involved in multiple delivery models even within their own organizations; 66% utilize STSTs and 68% claim to have long-term partnerships [180]. This allows us to draw comparisons between models within an NGO. One interesting example comparing the STST to a permanent center was done by Nagengast et al. in India [183]. They reviewed the costs associated with providing cleft repair during surgical missions, or short-term trips, to a center developed and staffed in an area found to have a high burden of disease from clefts. They found a 40% decrease in cost per surgery for the center as compared to the mission and a different distribution of expenses. Within the STST, air travel (52%) and hotel expenses (22%) were the largest expenses. In contrast, the center's budget expenses were attributed to salaries (46%) and infrastructure costs (20%). This finding reflects a goal of rewarding institutions that shift aid dollars toward the local economy and should encourage the movement of partnerships along the continuum of care delivery.

Faith-Based Mission Hospitals

The aforementioned era of physicians and surgeons motivated by faith, who first recognized the importance of providing surgical care to a low-resource community, consequently helped to build mission hospitals, and devoted lifetimes to service, did not disappear entirely. They, along with their local counterparts, have continued to invest in their surrounding communities with access to hard-to-reach populations and a priority on serving poor and marginalized people [184]. Faith-based organizations still account for a significant percentage of global healthcare provision, estimated at 20–70% of the health infrastructure in Africa [185–188]. However, these estimates are markedly different for individual countries and communities and cannot be generalized to all low-resource settings [189, 190]. Currently, there are numerous faith-based hospitals operating in resource-limited areas throughout the world, and there is a growing awareness that faith-based organizations play an important role in the delivery of global healthcare [191]. These mission hospitals and the surgeons that help staff them have long been and continue to be an incredible asset to the communities in which they serve [192, 193]. Within their communities, they are typically among the best choices for care, with high patient satisfaction rates [194], and in some areas the only choice that exists. Mission hospitals tend to adapt to the desired needs of the community, and subspecialist care is provided for the given need [39, 42, 75]. There is great potential for academic surgery to partner with faith-based organizations that offer cross-cultural experience and context-appropriate surgical knowledge, which is essential for a successful training model [161, 191]. Nevertheless, disadvantages of this model have been noted. There can be the perception of weak governance at the administrative level [195], but when compared to teaching and district hospitals, a mission hospital had the highest management ratings [196]. Any management issues are contrasted by a motivated staff providing service exceeding expectation [197, 198]. A possible lack of collaboration with government institutions could reduce the achievement of universal health access as mission hospitals are often not accounted for within the organization and implementation of health planning and policy [190].

The Continuum of Delivery of Subspecialty Surgery

While in some situations, the delivery of healthcare is achieved through a pure form of one of the above models, the most successful and “sustainable” programs usually employ some combination. By recognizing that the delivery of healthcare to low-resource settings is a continuum, it enables stakeholders to realize that no model, in of itself, is wrong; rather, all are working toward the same goal: universal, affordable access to subspecialty surgical care.

Within this continuum, partnerships are instrumental to success [199]. Collaboration and networking have a role among surgical subspecialists who have similar interests in reducing health disparities. A unique collaborative effort among subspecialists exists within the pediatric surgery community, with surgeons delivering care through multiple platforms and models. With an emphasis on networking, educational efforts, research, and advocacy, this global network of surgeons helps to encourage and advance the cause of pediatric surgical care in low-resource settings [200]. Learning from others' experiences in the provision of care within similar resource-limited settings can help to overcome challenges and provide encouragement.

Until access to subspecialty surgical care is universally available, there will be a need for outside personnel and resources. The key to providing the best possible care is to balance each of the advantages and disadvantages of different models to create the ideal template for the individual region, nation, and community.

Classification of Models

The Essentials

- *Models can be understood through time, personnel, and location.*
- *Long-term investment in a community is a goal. Where this is not possible, shorter duration of care, but only if conducted effectively, is better than no care at all.*
- *There is a balance of personnel providing subspecialty care where "outsiders" offer expertise while "insiders" offer effective provision of care that is culturally relevant.*
- *The benefits from the referral of subspecialty care must be balanced with appropriate access to care.*

These various models can be understood through different means. The investment of time, the location, and the personnel delivering care help to inform the advantages and disadvantages of each model. With this understanding, one can draw conclusions for the appropriateness of the model to a community.

Classification by Time Investment

Perhaps the most notable distinction in the various care delivery models is the amount of time the individual or team providing subspecialty surgery invests in a particular community. The time invested can vary from a few days of an STST to decades of development by a community-owned hospital offering specialty services (Table 5.4). Although difficult to generalize, it can still be informative to evaluate the type of delivery platform and the time desired to attain the goals of providing subspecialty surgical care to a community. The duration of partnership between hospitals and Smile Train, a large international NGO, showed improvement in surgical care, patient follow-up, increased number of trainees, and additional ancillary services [201]. As STSTs develop over time, outcomes improve [28, 202].

It is our view that long-term investment in a community is a goal during the provision of subspecialty surgical care. Where this is not possible, shorter duration of care, but only if conducted effectively, is better than no care at all.

Table 5.4 Investment of time in surgical subspecialty care

Models of delivery	Investment of time
Short-term surgical trip	Days
University partnerships	
NGO partnerships	
Private, for-profit, hospitals	
Nongovernmental organization hospitals	
Government hospitals	
Faith-based hospitals	Decades

Table 5.5 Personnel involvement in surgical subspecialty care

Models of delivery	Personnel
Short-term surgical trip	"Outside" specialists
University/NGO partnerships	
Nongovernmental organization hospitals	
Faith-based hospitals	
Private, for-profit, hospitals	
Government hospitals	
Task-shifting	"Local" providers

Classification by Personnel

Some models rely on the presence of "outsider" personnel with the necessary skills to provide specialist care. Others focus on local or "insider" providers trained to do specific operations. Most care providers acknowledge some balance in this spectrum in order to deliver optimal care to a population (Table 5.5).

A sometimes contentious issue of who should be providing subspecialty care allows us to classify these models of delivery by the personnel's understanding of the local culture and community. This understanding is a key to success in the delivery of quality care and is closely tied to the time invested by an outsider subspecialist. Time learning language, culture, and investing in relationships [203] may result in an "outsider" having a more complete understanding of a local community than a national government. The transfer of skills through training can also accomplish this aim. We should be clear that the reciprocal benefits of cross-cultural collaboration exceed the pure transfer of skills and resources [108]. So, the goal is not for complete transition from the cultural outsider to the insider, but for long-term exchange of ideas, skills, and ingenuity. Rewarding cross-cultural experiences can be fulfilling to both partners as demonstrated by collaborative neurosurgical training in Ethiopia [204]. There is too much to gain from both sides working alongside one another to unbalance the scale toward one side or another.

Table 5.6 Location of surgical subspecialty care

Models of delivery	Location
Task-shifting	Rural, community-based
Short-term surgical trip	
Faith-based hospitals	
Government hospitals	
University partnerships	
Private, for-profit, hospitals	Urban, referral

Classification by Location

Similar to resource-rich countries, outcomes for subspecialist care are better at referral centers with high volumes of specific conditions [205, 206] and when performed by experienced subspecialty surgeons [207–209]. This acceptable referral benefit must be balanced with appropriate access, especially due to the burden of travel expenses on poor patients [70] (Table 5.6).

Comparisons of models for subspecialty surgery are limited. But a study from Peru examined surgical outcomes after cleft lip and palate repair. When comparing location of operation, whether a mission model or a private referral center, and while controlling for surgeon and technique, the authors found that the mission model showed an increased complication rate [210]. An Ecuadorian study found similar results with the complication of palatal fistula ten times more likely in the mission model than the private center [30]. Moving along the continuum from surgical camp to referral center seems to also have cost-savings implications as well. Hackenberg et al. compares 17 STSTs and a comprehensive care center for cleft lip and palate surgery in Guwahati, India. The researchers found that the cost/disability-adjusted life year ranged from $247/DALY through medical missions to $190/DALY at the center [95].

The Tenwek Hospital Experience

The Essentials

- *Tenwek Hospital, a faith-based mission hospital, utilizes a number of models to provide subspecialty surgical care.*
- *To meet a significant need, a successful cardiac surgery program has developed through the investment of time, training of personnel, and improvements in infrastructure.*
- *The Tenwek Hospital experience demonstrates that the progression from temporary, short-term teams to self-sustaining independent care is truly a continuum.*

The particular experience of Tenwek Hospital is an example in several areas of moving along this continuum from very short-term isolated advancement to sustainable programs providing capacity building and training of local healthcare providers in an independent setting. Tenwek Hospital is a 300-bed mission hospital in southwestern Kenya. It began as a small clinic in the late 1930s staffed by American missionary nurses. A full-time American missionary doctor joined the staff in 1959, and the hospital began to grow rapidly throughout the 1960s and 1970s. In the 1980s, a nurse training school was begun with a goal of providing higher-level training for local nurses, and providing a reliable source of nurses for the hospital, thus making it less reliant on outside resources. In the late 1990s, the hospital began cooperating with the national Ministry of Health in providing internship training for new graduates of Kenyan medical schools. In the early 2000s, a program of residency training was established in family medicine, followed by a general surgical residency in 2008 and an orthopedic surgery residency in 2014. Currently, there are more than 35 African doctors training at Tenwek Hospital in postgraduate medical programs. In addition to this, Tenwek serves as a clinical rotation site for many Kenyan medical students from a variety of medical schools around the country. Graduates from these programs are taking up posts around the country, and throughout other African countries, providing reliable, cost-effective healthcare to large areas of the region.

Development of subspecialty care was also occurring during these years at Tenwek Hospital. With the arrival of a full-time American thoracic surgeon in 1997 (R. White), Tenwek began to be able to offer more advanced pulmonary and esophageal surgery. Given the very high incidence of esophageal cancer in the region [76, 211], Tenwek soon became the regional referral center for thoracic surgery. When the general surgical residency became fully functional, residents were exposed to thoracic surgical training in a more extensive way than in most general surgical residency programs. By the completion of 5 years of general surgical training, graduates of the Tenwek General Surgical Residency Program usually feel quite comfortable with esophagectomy and basic pulmonary resection techniques.

Different types of subspecialty surgery require different investments of time and infrastructure. Some areas of subspecialty surgery require relatively short, prescribed times of training and limited changes in infrastructure and equipment. Examples of this include cleft lip repair and pedicled soft tissue transfers in the area of plastic surgery. Other areas, such as advanced laparoscopy [212, 213], require more careful planning and outlay of capital investment and infrastructure. Then there are other areas, such as cardiac surgery, which have extensive requirements for training, infrastructure, and physical facilities [33, 44, 214–216]. In these areas, it often requires a "quantum leap" to move into them, rather than a gradual introduction of new procedures and techniques.

Rheumatic heart disease is endemic in the area around Tenwek Hospital. Most patients present with advanced valvular disease at a stage when valve replacement is the only reasonable option. In fact, many present when myocardial function has suffered so severely that any surgical intervention is extremely dangerous. Although the need was clear, it initially seemed that the training, technology, and infrastructure requirements were so monumental that it would not be wise to embark upon a program of cardiac surgery at Tenwek Hospital. Cardiac surgery made its first appearance at Tenwek Hospital in 2007 through an unusual circumstance. A personal friend of one of the authors (R. White) is an American cardiac surgeon who visited Kenya that year with a view toward starting a cardiac program at one of the government facilities in the country. After visiting several facilities, he became convinced that those particular institutions lacked the necessary infrastructure to begin such a program. With several days of extra time remaining in his planned trip, he visited Tenwek Hospital. Seeing the burden of disease and the existing infrastructure, he challenged us at Tenwek to consider beginning a cardiac program. This began with several cases of mitral commissurotomies for severe mitral stenosis performed with no cardiopulmonary bypass. Success in these cases encouraged us to plan for acquisition of all the necessary equipment to prepare for open heart cases requiring cardiopulmonary bypass. The open heart program began very clearly with short-term surgical trips, with teams coming regularly from Brown University, Vanderbilt University, Maine Medical Center, and the Ocala Heart Institute. These teams would consist of surgeons, perfusionists, cardiologists, anesthesiologists, and critical care physicians and nurses. During the first few STSTs, the visiting team members carried out virtually all of the direct patient care. However, within a short time, a very purposeful transference of knowledge and skills began to occur. Through specific times of didactic and hands-on-learning, the Tenwek staff began to take over areas of critical care medicine and nursing, cardiac anesthesia, and perfusion, while the author (R. White) resurrected cardiac skills not practiced for many years. It was very gratifying for the STSTs to find themselves less required for direct care and spending more and more time perfecting the skills in the Tenwek staff. Likewise, the local staff found that their ability to care for other critical, noncardiac patients improved considerably during this time. After 4 years of visiting teams, it seemed an appropriate time for the Tenwek team to begin open heart cases in the absence of visiting teams. To date, we have completed nearly 300 open heart cases at Tenwek Hospital, with about 2/3 of these performed with visiting teams present and 1/3 done solo. This has been achieved with a perioperative mortality rate of less than 1%. Currently, straightforward cases are handled by the Tenwek staff, while riskier cases and small pediatric cases are saved for the STSTs.

From this example, it is clear that this progression from temporary, short-term teams to self-sustaining independent care is truly a continuum. Tenwek Hospital has made significant progress along this continuum; yet, there remains much to accomplish. Tenwek continues to depend on outside help for some areas of equipment procurement and in management of complex cases. However, it seems inevitable that this progress will continue.

Role of Subspecialty Care in Reducing Disparities in Global Surgery

The Essentials

- *Subspecialty surgical care provides benefits not only to the individual patient but also to the community at large.*
- *Since subspecialty care requires certain infrastructure and training, other healthcare priorities can benefit from its implementation.*
- *Enhanced ability to care for patients improves acceptance of primary care.*

Over time, the care of the individual benefits the community at large by improving its access to healthcare, infrastructure, skilled personnel, and microeconomics [217]. Through the examples of Tenwek Hospital and others, the associated improvements surrounding the implementation of subspecialty surgical care become apparent.

Building Infrastructure and Capacity

Considerable infrastructure is often required for subspecialist surgery. With this infrastructure, other departments reap the benefits as well [218–220]. Improvements in anesthesia care benefit all surgical patients. The laboratory and blood banking capabilities [221] are able to withstand the shock of the subspecialty care and are thus better prepared for both challenges and routine care. The screening program has both stemmed from and advanced the community health and primary care programs at Tenwek Hospital [222]. Radiology [223] benefits from enhancements in echocardiography and ultrasound. Donated equipment is provided, but biomedical engineers work together with the hospital maintenance department to ensure equipment does not fall into disrepair and abandonment [224, 225]. The potential for curative intervention improves outpatient relationships. The hospital administration [196, 226] fosters the growth and development of a program to help build a major referral center [227].

Improving Personnel Skills and Retention

As departments improve, it is only through the personnel that guide them. At Tenwek, the nursing staff and operating room technicians have been involved in the cardiac camps, and the eagerness to strive for excellent cardiac care helps in the care of all patients. Personnel have readily participated in improvement of critical care [228]. And, there is a greater willingness and ability to take care of patients who are critically ill.

Improving Community Access and Care

In communities with a distrust of modern medicine, the successful treatment of an individual should not be disparaged as a lack of investment into community. Inspirational stories of recovery and treatment can encourage a community to seek care at that hospital and surrounding healthcare facilities. It is difficult to quantify the impact on a community from the care of an individual. Anecdotal experience from Tenwek Hospital demonstrates increased participation in screening programs and public health ventures among communities with direct knowledge of previous patients' treatments and recovery. The Tenwek cardiac program has improved the lives of a number of individuals. Yet, it has also improved the care that the hospital provides to the community. The excellent care of an individual patient is evidence that inspires that patient's community.

As the cardiac program has progressed, numerous referrals for cardiac care from outside institutions have occurred, and reciprocal referrals from Tenwek to outside institutions for other specialty services have improved. This advantage has improved not only the perception of the local community but awareness in the national healthcare system. Additionally, these referrals improve communication and connect providers, all trying to deliver optimal healthcare to a large population in need.

Role of the Individual Subspecialty Surgical Provider

The Essentials

- *The key question is not related to where along this continuum the individual provider finds himself or herself, but rather that he or she is moving in the right direction.*
- *It is helpful to consider strategic questions prior to becoming involved in subspecialty surgical care.*
- *Involvement in subspecialty surgical care and its advancement within low-resource settings can be extremely rewarding for all involved.*

Understanding the Model of Care and Making Progress on the Continuum

The role of the individual provider in delivering subspecialty surgical care in low-resource settings is often described as a dichotomous choice between two extremes that is phrased something like this: "is the goal of the surgeon to directly care for a handful of individual patients, and in so doing provide himself/herself with the self-satisfaction of having reached out to those of a lower socioeconomic status, or is it to selflessly empower local caregivers to develop independence and skill in caring for complex cases and situations to the extent that eventually the external provider's presence will no longer be required?" Common to many situations in life in which a multileveled process is reduced to a dichotomous decision, the appropriate answer to the question as phrased here is probably simply "Yes." Of course the individual provider will hopefully be changing the lives of a small group of actual patients during his or her time in a given situation. And of course, this should reasonably bring satisfaction to the provider who is reaching out to a group of people who may not enjoy all the privileges that the individual provider has available. But this does not need to be exclusive of the goals of developing sustainable programs which empower local caregivers to provide this care in the future as well. As has been described in this chapter, providing subspecialty care in low-resource communities represents a continuum of development. The key question is not related to where along this continuum one finds himself or herself, but rather that he/she is moving in the right direction.

In this same train of thought, subspecialty surgical programs are in a unique position to contribute to the research literature in their endeavors within LMICs. However, this also needs to be done with the same thoughtful consideration of developing local capacity and infrastructure. Academic affiliations with STSTs and

Table 5.7 Questions for an individual provider to consider prior to engaging in subspecialty surgery in a low-resource setting

Physical infrastructure
1. Does the facility have adequate supplies for the intended care?
2. Does the facility have adequate sterilization facilities?
3. Does the facility have adequate oxygen and suction?
4. Does the facility have reliable electrical supply?
5. Should the provider consider taking along self-contained head lamps or necessary equipment?
6. Does the facility have adequate intraoperative and postoperative monitoring capabilities (oxygen saturation, ECG, pressure monitoring, etc.)?
Staffing infrastructure
1. Does the facility have adequate staffing to accommodate the intended care?
2. Should the STST consider bringing along staff to make up for gaps in local staff?
3. Is there adequate staffing for safe, effective postoperative care?
4. What is the plan to ensure that all patients are cared for completely through recovery to the time of discharge (potentially after the team leaves)?
Financial infrastructure
1. What is the plan to cover patient costs?
2. Is this plan eventually a sustainable plan?
3. Is there a plan for costs of equipment maintenance?

longer-term teams can be very effective in fostering an environment of inquiry and research [229–231]. Both institutional and individual partnerships can be sought to benefit both the visiting teams and the local providers, in addition to the population being served. Once again, this is often not a simple dichotomous question of "either/or," but rather "both/and," as long as care is taken in planning to truly achieve a "both/and" result.

There are also a variety of very practical issues which should be considered by any individual subspecialty provider engaged in this type of work. Particularly in the area of STSTs, these relevant questions (by no means an exhaustive list!) should be considered (Table 5.7).

Words of Caution

Programs offering subspecialty surgical care often fail to achieve long-term stability and independence for a variety of reasons. Frequently, the driving force behind the initiation of the program is the interest of the individual or group dedicated to that specialty, rather than a real need within the community. In some cases, communities will accept outside input in areas with minimal need, with the hope that the providers will eventually bring something of more benefit to the community. This can lead to disappointment in the minds of the providers and a feeling of being "used" for ulterior motives. When subspecialty surgical care requires significant physical materials (as in the case of cardiac surgery), there is often little thought about the long-term

Table 5.8 Questions for consideration before initiation of a subspecialty surgical program

1. Is there a genuine perceived need within the community?
2. Is there ownership/buy-in from the appropriate administrative body?
3. Is there a plan in place for eventual local procurement of needed supplies?
4. Is there a tangible element of teaching and capacity building within the program from the outset?
5. What will be the effect of the program on the existing infrastructure?

supply of these materials. When local staff are given inappropriate or incomplete training, there can easily develop a feeling among the staff that they have been "used and abused." Finally, introduction of subspecialty care will necessarily have some effect on the provision of other care within the institution (either in a positive or negative fashion). It is therefore wise to consider the ramifications for the existing infrastructure. With these thoughts in mind, it is helpful to consider the questions in Table 5.8 when considering involvement in a program of subspecialty surgical care.

Words of Encouragement

Despite such warnings, involvement in subspecialty surgical care and its advancement within low-resource settings can be extremely rewarding. Regardless of the model, participation in delivering surgical care to people in need can be immensely satisfying to all involved. The cross-cultural experience and collaboration to solve difficult problems are fulfilling. Providers, including the most specialized surgeon, should be quick to learn from their colleagues. Practicing in resource-limited settings can foster innovation [232–239] and benefit not only the recipients of care but the providers.

Conclusion

Surgery has only recently been considered a global health priority, and subspecialty surgery remains an even newer area of consideration. Yet, more and more data are emerging that support the cost-effectiveness, practicality, and numerous benefits of prioritizing the provision of many subspecialty surgical services to communities in need. Models for delivering subspecialty care are numerous, and the most efficacious method of delivery is variable region to region and country to country, likely requiring a combination of multiple models. As the proponents of global surgical care, and specifically subspecialty surgery, continue to work toward a goal of quality surgical care for all, it must be with an awareness of past mistakes and shortcomings. We must also recognize the successes of particular organizations and programs as examples and standards of how such care can be offered capably, responsibly, and successfully, even in the most resource-constrained setting. We believe excellent, compassionate care of patients through subspecialty surgery can not only significantly impact the lives of the individual patients but will also improve the care of the community and as such should be a global health priority.

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Sanjay Krishnaswami, Mamta Swaroop, and Benedict C. Nwomeh

Introduction

Globally, rising economies are leading to an epidemiologic transition wherein injury, cancer, and congenital malformations are becoming much more prominent public health threats in low- and middle-income countries (LMIC) [1]. The Lancet Commission on Global Surgery, the Disease Control Priorities-3 project, and the World Health Assembly 2015 resolution on Emergency and Essential Surgical Care and Anesthesia all underscored the role of surgery as an essential component of the comprehensive global public health agenda [2, 3]. With the need to improve the very infrastructure of surgical-care systems to achieve this, there has been a paradigm shift from traditional reliance on intermittent short-term volunteerism toward a strengthening of the education and research pillars for surgical healthcare in developing regions, a role ideally suited for academic surgery (Fig. 6.1) [4, 5]. Academic Global Surgery (AGS) leverages the scientific approach, educational focus, and outcome examination that characterize academic medicine and applies them toward the strengthening of surgical care in under-resourced regions, international or domestic [6].

S. Krishnaswami, MD, FACS, FAAP (✉)
Division of Pediatric Surgery, Oregon Health and Science University Hospital, 3181 SW Sam Jackson Drive, Mail Code CDW7, Portland, OR 97239, USA
e-mail: krishnas@ohsu.edu

M. Swaroop, MD, FACS
Department of Surgery – Trauma and Surgical Critical Care, Northwestern University Hospital, 676 North St. Clair Street- Suite 650, Chicago, IL 60611, USA
e-mail: mswaroop@nothwestern.edu

B.C. Nwomeh, MD, MPH, FACS, FAAP
Department of Surgery and Pediatrics, Nationwide Children's Hospital, The Ohio State University, 700 Children's Drive Columbus, Columbus, OH 43205, USA
e-mail: benedict.nwomeh@nationwidechildrens.org

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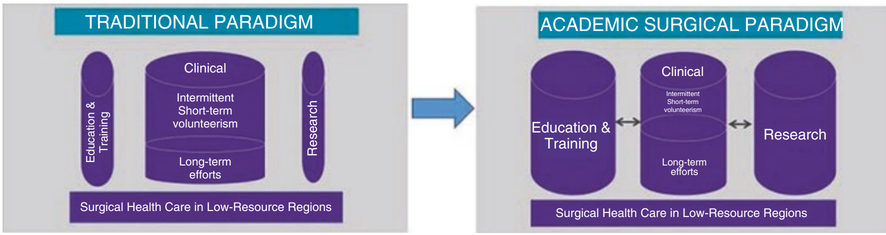

Fig. 6.1 Pillars of surgical care in low-resource regions: traditional vs. academic surgical paradigm

The preponderance of interested trainees and the increasing number of faculty are fueling the emergence of AGS within our profession. This has led to wide-ranging effects including international rotation guidelines being established by the Accreditation Council for Graduate Medical Education and the American Board of Surgery, residencies offering formal global surgery tracks, and a sharp increase in research output in the subject. In addition, numerous academic surgical societies such as the Association for Academic Surgery, the Society of University Surgeons, and others now actively assist development of their members in this burgeoning field [7].

In this chapter, we outline the role of academia in global surgery; career considerations for the academic global surgeon; concepts underpinning successful clinical, research, and educational collaborations; and funding for AGS projects and touch on ethical considerations inherent to global surgery research initiatives.

The Role of Academia

Academic surgery is primarily concerned with scientific advances that improve the surgical health and the quality of lives of patients, through education, development, research, and advocacy. Therefore, the role of academic *global* surgery is to extend this mission to support the provision of high-quality surgical care in resource-poor regions across the globe.

AGS is an emerging field, and one that is distinct from traditional surgical volunteerism. For decades, surgeons from western countries have joined other physicians, nurses, and health workers on humanitarian mission trips to LMIC providing needed care and saving countless lives. Until surgical capacity can be fully developed in LMIC, volunteer missions will continue to have an important place in global surgery. Even then, surgical volunteers will always be needed in situations where conflicts, natural disasters, and other emergent conditions overwhelm existing surgical capacity [8]. The critical role of clinical volunteerism has been highlighted by the heroic efforts of surgeons in providing care to victims of the Haiti earthquake and recent conflicts in Iraq, Afghanistan, and Syria.

Yet, the major pitfall of most volunteer surgical missions is that by their short-term nature, it is extremely difficult to produce a sustainable improvement in

Fig. 6.2 The four cardinal areas for academic global surgery

surgical capacity at the recipient sites. Traditionally, little effort was made toward training of local providers and even less attention to research. In contrast, the ultimate goal of academic global surgery is to create a sustainable increase in capacity such that citizens of LMIC will no longer depend on volunteer surgical missions for routine surgical care. An important aspect of sustainability is the development of homegrown teaching and research facilities that will train future surgical workforce and conduct research needed to improve health systems. Academic global surgery can also help to provide direction and guidance on the appropriate role of volunteer missions, advocacy for resources, and leadership essential to building surgical capacity in LMIC [4, 9].

The four cardinal areas for Academic Global Surgery (Fig. 6.2) are the same as for all other academic surgical fields and include [10, 11]:

1. Education (guiding trainees, surgeons, and multidisciplinary providers, whether domestically or abroad)
2. Research (furthering clinical, education, or basic science)
3. Advocacy (supporting international surgical care through policy change, promoting activities of global surgeons within academia, or other methods)
4. Development (creating clinical programs, surgical systems, or career pathways in the field)

The Academic Global Surgeon

An academic global surgeon is connected to universities and/or associations, which can function as the platform to help transform the surgical needs of resource-poor regions into measurable improvements in care. The actual time spent as an AGS may vary from full- to part-time and can occur whether in the collaborating country or at home. Given that global surgery is emerging as a new field, the academic surgeon has the opportunity to shape this field by contributing in a multitude of ways [12]. Aside from the customary role in research (basic science, clinical, or health services), or education, many nontraditional avenues for academic involvement exist.

A number of surgeons associated with relief organizations and humanitarian groups have engaged in scholarly activity through the planning, implementation, or evaluation branches of these organizations. Other AGS providers work through societies to build platforms for global surgical research to be highlighted, disseminated, and funded, allowing AGS to further establish its legitimacy as an academic pursuit. Still others are involved in advocacy at the level of major international organizations such as the International Red Cross, the United Nations, and the World Health Organization [13]. This effort is often accomplished through contributing to official documents, policies, and guidelines that may guide health planning in LMIC and help set the agenda for philanthropy [14].

The Role of Academic Surgical Departments and Societies

As an emerging field, one of the urgent goals for academic global surgery is to become integrated fully into the realm of academic surgery. It is imperative that interested medical students, residents, and young faculty can see a clear path to establishing their career and becoming successful as global surgeons [15]. Surgical departments and societies have a pivotal role in helping to define and support the academic mission of global surgery.

An increasing number of departments are developing global surgery programs in response to a sharp interest among faculty and trainees and as part of an overall institutional strategic focus. These programs are critical to developing the next generation of surgical leaders capable of addressing and identifying solutions to the challenges of surgical care worldwide, particularly in LMIC. In creating such programs, Price and colleagues have outlined a few areas that must be addressed [16].

Developing Multidisciplinary and Interprofessional Alliances

- Within every institution, there are faculty members in different departments, including allied health professions and disciplines outside of healthcare such as engineering, law, business, anthropology, etc., which have common interests in improving global health. Creating alliances among these important stakeholders is helpful in developing an institutional value proposition. Such collaborations could lead to new discoveries, external funding opportunities, and development of patents and entrepreneurial initiatives that could have important economic benefit for the institution.

Aligning the Global Surgery Program with the Institutional Mission

- An understanding of the new paradigm of AGS as described earlier should help refute lingering misperceptions that all global surgery is volunteerism. Once the mission of AGS is properly defined, particularly the focus on the scientific endeavor to study surgical care and systems of care in the context of global health, it becomes easier to align it with institutional missions that typically include innovation, discovery, and education.

Promoting the Program Proposal to Key Administrative Leaders

- Several methods can be used to promote the academic aspects of global surgery that could generate broad support within the academic and local community and draw the attention of key administrators within the institution. Opportunities abound to give grand round lectures, resident seminars, and lectures in medical student, graduate, and undergraduate classes. Departmental and section meetings are also avenues to provide updates on specific global surgery successes and discussing ideas for potential expansion of activities. Many of the successful academic surgical programs have also utilized social media, particularly Facebook and Twitter, to showcase their efforts and create new partnerships. The national and international recognition that often follows also helps to strengthen the institutional value proposition.

Demonstrating the Academic Capacity of Global Surgery Activities

- The realm of academics revolves around teaching, research, and discovery, and the accepted currency for academic relevance includes research activities, grant funding, patents, and dissemination through peer-reviewed publications and presentations to local, national, and international audiences. Contribution to science can be measured in several other ways such as service to specialty societies, editorial boards, and review panels. These requirements should be no different for faculty engaged in global surgery. Many surgical departments have introduced international resident rotations and fellowships, created opportunities for advanced degrees in global health, and helped to cultivate the interest and foster mentorship among medical students, residents, and young faculty in academic global surgery. Exposure to global surgery can help trainees achieve progress in all professional competency domains. Also, by expanding the academic spectrum available in the department, these programs enhance the opportunity to recruit medical students, residents, and faculty to the institution.

Preparing and Sustaining a Career in Academic Global Surgery

In the not too distant past, the concept of an academic career in global surgery was met with a large measure of doubt. However, the increasing trainee and faculty involvement and the expanding body of scholarly work in the field suggests that AGS is not a passing fad, but rather a growing field of academic pursuit. There are, of course, unique challenges to formation of a career in this emerging field. Acknowledging these while properly preparing oneself for success will allow obstacles to be viewed as opportunities.

Potential Obstacles to a Career in Global Surgery

AGS is perhaps the latest among the recent new fields to join the ranks of academic surgery, including clinical outcomes research, surgical education, surgical ethics, and surgical innovation/technology among others. As these fields have emerged, they have shared certain common challenges. In addition, there are some obstacles that are unique to AGS. Among these are the following as modified from that stated by Ozgediz and Ameh [11]:

- Continued misperception within the public health community that surgery is not essential to population-level healthcare
- Persistent view within the academic surgical community that global surgery is just volunteerism
- Uncertainty around the impact of scholarly work within global surgery and the presence of a defined pathway for academic advancement in the field
- Absence from home institution and local teaching/clinical duties causing potential frustration among colleagues
- Logistics in sustaining collaborations across geographic boundaries
- Ability to obtain grant-based funding

Despite increased general awareness of the role of surgery within public health, many surgical departments still lack the collaborations with their local school of public health that are essential to establishing a successful AGS program [17]. Additionally, many individual academic surgeons with career interest in AGS do not have local mentors, lack the support of their chairs, or have no defined career path within their institution [18].

Furthermore, any misconception about the scope and academic potential for global surgery within the surgery department will need to be addressed by the aspiring global surgeon. Unlike the basic scientist or clinical researcher, the "laboratory" of the academic global surgeon is typically not a concrete space within the university, but instead is often dispersed in field locations around the world. This can make the concept of global surgery a little harder to mentally grasp as an academic pursuit. However, at its core, AGS remains focused on the quality clinical care, education, research, and advocacy that marks all scholarly pursuits within medicine.

While there will always remain inherent difficulties in building partnerships with distant institutions, information technology is helping to bridge these gaps. In turn, this can allow academic global surgeons to successfully contribute and maintain involvement even without being in the collaborating region all the time. Lastly, with the rising profile of surgery in public health, funding avenues are beginning to open up to allow the development of a sustainable career in this field.

Preparation: Things to Consider When Starting Out

The Essentials

- *Identify what questions/problems are the most intellectually and emotionally stimulating.*
- *Study the relevant literature. Know the results of the Lancet Commission on Global Surgery, the Disease Control Priorities 3rd edition, Volume 1, and relevant articles in surgical and public health journals.*
- *Consider obtaining advanced degrees (M.P.H/M.Ed.,* etc.*) and improving your contextual language skills.*
- *Find advisors early on in your quest – start by identifying those who do what you want to do.*
- *Work on a plan to communicate your interests.*
  - *Write a vision statement/career plan.*
  - *Develop a 5-min elevator speech based upon above.*
- *Cultivate long-term relationships with just one or two institutions in your region of interest. Begin with bilateral observational visits, then need assessments, then project planning, and then execution.*
- *Always consider opportunities to relay your experiences and experimental ideas, results, and impact by documenting these in the literature in partnership with local collaborators.*

Although not mutually exclusive, the initial setup for a career in academic global surgery may differ significantly from the preparation for a purely clinical volunteerism pathway in the field. The key to viewing the challenges to a career in AGS discussed above as opportunities begins with proper preparation [11]. While preparation for a career in AGS should not supplant effort spent gaining the requisite clinical knowledge and skills to make a competent surgeon, significant time will be needed early on to successfully prepare for this career. This is no different than dedicating one's early career to launching a basic science lab and should be viewed as integral to developing a career in AGS.

Academic Promotion as a Global Surgeon

The options to pursue a career in AGS may often be restricted by the ability to gain acceptance and support for this pursuit. A critical aspect of this is the process of obtaining promotion within the university. There are traditionally three criteria that are considered when evaluating a faculty member for academic promotion – patient care, research, and education. While promotion criteria have traditionally bent toward numbers of publications and grants, increased attention has been given recently to service and teaching activities within many universities in North America. Fortunately, AGS provides ample opportunity to

Table 6.1 Basis for academic promotion

Service
Deep involvement in patient care
Clinical productivity
Development of innovative care options
Reputation as expert
Clinical trials
Research
Creation of new knowledge
Ongoing contribution to literature
External funding
Education
Teaching and scholarly activities
Acknowledgement of teaching excellence
Development of coursework to increase expertise
Educational publications

earn academic credit in several of these domains and therefore a path to promotion in many institutions [11] (Table 6.1).

Although the mainstays of promotion detailed above do not need significant modifications for AGS, their interpretation may need to be expanded upon and the significance of AGS activities clarified to those outside the field [15, 16]. As an example, time spent building alliances with Health Ministries and program development in emerging regions is crucial to creation and maintenance of AGS endeavors, but will warrant description to others in the context of promotion. Similarly, although the funding currently available to faculty in AGS is limited, project funding for trainees interested in the field is much more obtainable. Of course students and residents could not qualify for such funding without faculty, who should be credited for their close mentorship and study development when seeking promotion.

Practicalities of Employment

Unless the academic global surgeon plans their activities solely during personal time or relocates permanently abroad, it is critical to convey a plan early and often to employers and practice partners to assure its success. A contractual agreement should stipulate whether time away will be compensated and at what rate. Negotiating a favorable agreement will require effective communication of the significance of global health work to the institutional mission and demonstration of the deliverables that will be produced [11].

It is often helpful to demonstrate the local relevance of the international work. As employers, both the hospital and academic department typically want to know how the activities will improve their reputation and working processes, for example, by reflecting trust to the community. Will the work directly or indirectly benefit patients in their region? Can the work influence models of care in the home institution? Every healthcare organization wants to demonstrate how they take care of the needy, wherever they are. In promoting the activities of a global surgeon who also works hard for the local community and underserved, it can demonstrate the institution's commitment to accessible, cost-effective, culturally sensitive, high-quality services that are balanced with available resources. From the standpoint of the academic department, it may be helpful to modify one's scholarly activities to fit within its current model. Will the AGS activities advance the education of the department's trainees? Are there parallel research projects that could be undertaken within similar populations at home? The answers to these and similar questions can help demonstrate the true breadth and value of AGS to those unfamiliar with the field.

Sustaining Success

Achieving professional legitimacy is key to sustaining success. Funding is central to achieving this goal. Fortunately, the rising profile of noncommunicable disease in public health is beginning to open up new funding avenues for clinical care and research in global surgery. Institutional, regional, governmental (such as the NIH and NCI), and even nongovernmental donors such as the Gates foundation are all showing new interest in surgical work. Besides competing for funding, a few other strategies to accomplish and sustain legitimacy include [19]:

- Differentiate AGS work from that of an NGO (demonstrate the academic components of the work).
- Set up a new paradigm for care or for thinking about a disease or intervention.
- Establish global surgery interest groups.
- Develop an ACGME-approved international rotation for trainees.
- Engage residents in opportunities to publish and present at meetings.
- Develop coursework or textbooks in the field.
- Pose questions and always leave a paper trail – figure out ways to study the problems, investigate it, report on it, and write about it.

With proper preparation and patient self-application, a rewarding career in AGS is possible. Understanding the criteria for academic promotion and the view of potential employers is key to success. However, academic advancement as a global surgeon should always be kept in perspective and is not the end itself. Ultimately, a successful career in AGS should always be motivated by the desire to improve surgical care across economic and geographic boundaries through bilaterally beneficial clinical, educational, and research opportunities.

Academic Collaborations

Long-term collaborations are the cornerstone of academic global surgery. Such partnerships not only center around clinical interactions but also research and educational initiatives as well.

Clinical Collaborations

In establishing clinical collaborations, the academic surgeon goes beyond volunteerism and seeks to foster partnerships that support education, training, research, and scholarship. Interactions that occur inconsistently or on a short-term basis are not ideal platforms for academic collaborations. Clearly, sustainable long-term collaborations are preferable, but a well-planned short-term trip may also serve a useful academic purpose. For example, short-term trips may provide an opportunity for elective clinical experience and/or research projects leading to broader understanding of local issues [20].

Meaningful academic collaboration with colleagues in LMIC often begins with a well-executed clinical mission. Although needs assessment will likely reveal the desire for assistance in developing clinical care and capacity, it is often that immediate need to improve surgical care in their communities that will bring LMIC colleagues to consider academic collaborations. To start, clinical projects can create opportunities for academic engagement that can add value to the project [21]. Take the example of a disaster relief mission that is seemingly far removed from academia: an academic input into planning could incorporate aspects of disease surveillance, outcome measurement, and quality improvement. Even the introduction of periodic case review conference to discuss difficult cases or complications can be an important academic contribution to improving outcomes. It is important to note, in many cases, such reflection may not be a part of the local practice and cultural sensitivity will be required in conducting case reviews. To increase acceptance and encourage participation, it is imperative to adopt a “no-fault” approach to discussing poor outcomes and ensure focus on quality improvement.

Research Collaborations

Research, being central to the mission of the academic global surgeon, will entail on-site projects that cannot be accomplished without serious engagement with local partners. Some basic research projects can be embedded in short-term clinical projects. However, more detailed projects, which can attract significant funding and produce high-quality scholarship, will require detailed planning and attention to developing bilateral or multilateral collaborations. These partnerships are not always only north-south but also include possible combinations of north-north and south-south arrangements. The following are some of the important considerations in establishing north-south research collaborations [21, 22].

Identification and Training of Local Research Partners

One of the most significant barriers to be encountered in planning global surgery research is to identify individuals at the local site with the interest and skills to participate in the project. Initial contacts could be made during preceding clinical or exploratory visits. Potential collaborators may be identified through their research publications or presentations at scientific meetings. In some cases, it could be much easier to identify peer collaborators because they are more readily visible through the avenues mentioned above. However, mid-level research staff – research assistants, coordinators, etc. – may be more difficult to find; such individuals with training in research methodology are not always readily available. Therefore, in planning a large research project, allowance should be made for training of local staff. Academic surgeons in high-income countries may be in a position to support their LMIC collaborators to attend research training courses or short-term visits in their own institutions. Some research grant mechanisms include opportunities for helping build such research infrastructure at LMIC sites.

Identification of Stakeholders and Logistics

Understanding the local context and identification of important stakeholders is vital. Preliminary engagement or a formal needs assessment can help to ascertain the relevant parties and issues to be considered for successful execution of the project. What approvals are required from local institutions or governments? Is there a local research ethics committee with jurisdiction over the research site? What logistical considerations are needed for fieldwork? What arrangements are needed for transportation, housing, utilities, personnel safety, handling of specimens, and data?

Grant Applications with North-South Collaborations

Research grant applications that leverage significant local participation are likely to be rightfully favored over those in which all the investigators are from high-income countries. However, the LMIC individuals to be listed as principal investigators or co-investigators in such grant applications will be subjected to the usual level of scrutiny as others. The typical criteria – demonstration of expertise, research experience, scholarship, and track record of working with research team members – will apply to all investigators. Usually, years of sustained interaction through clinical engagement, exchange visits, pilot projects, and joint publications will be needed to establish a credible partnership [21, 23].

Educational Collaborations

True educational opportunities in global surgery must address learning objectives for participants from both HIC and LMIC. The traditional volunteer medical mission has often included training opportunities and experience for undergraduate and postgraduate trainees from HICs, but rarely their counterparts at the LMIC site. A more inclusive and ethical view of academic global surgery demands reciprocal concern for the training needs of the host countries [24].In any case, designing educational experience for trainees from either or both sides provides an opportunity for various forms of educational research [25].

Educational Opportunities for Trainees from High-Income Countries

International rotations have become increasingly popular among medical students and residents from the USA [26]. Such an elective rotation offers an opportunity to appreciate the value of surgery as a public health tool. These trainees gain an understanding of the cultural, social, and economic determinants of surgical diseases, which could inform their diagnostic and therapeutic decision-making, hopefully leading to a more judicious utilization of resources. For many of these trainees, the international rotation could be their first exposure to the daily struggles of people in LMIC with poor infrastructure, limited supplies, and inefficient allocation of resources. Also, these trainees from HICs will appreciate the huge disparities in the working conditions of their peers in the host countries. For example, having become accustomed to limited work hour rules, they will appreciate that their peers in the host countries still work much longer hours for significantly less stipends. They will also experience a different level of attention and approach to ethical and medicolegal issues [21].

Both the American Board of Surgery (ABS) and the Surgery Residency Review Committee (RRC) of the Accreditation Council for Graduate Medical Education (ACGME) have approved a mechanism for overseas rotation to count toward the requirements of general surgery residency training in the USA. However, currently only a select number of residency programs have obtained the approval for their international rotations. Such is the presumed value of the international experience that many residents from programs that have not obtained formal approval still engage during their vacation time and often at personal expense.

A likely benefit for the academic global surgery field is that these experiences may serve as a springboard that will propel medical students and surgical residents to consider a career in global surgery. Exposure to unusual diseases, conditions, patterns of care, or other local practices may inspire future research ideas. Also, the relationships and network established during the visit could be the basis for future research collaboration, perhaps as an academic global surgery faculty [27].

Educational Opportunities for Trainees from Low- and Middle-Income Countries

While trainees from HIC seem to have unfettered access to patients while on rotations overseas, their counterparts from LMIC often face a highly regulated set of conditions when visiting HIC. The regulatory obstacles are often justified on the need for patient safety and liability protection for the HIC host institution. Consequently, most LMIC visiting trainees are relegated to an observation status, with few opportunities for practical experience, thus severely degrading the training value of the visit.

Despite these limitations, attention to certain detail when preparing for visits by LMIC participants could help to optimize their experience. Careful planning of the observational experience, such as attendance at ward rounds, operating room sessions, clinical and research conferences, and journal club, may make the visit worthwhile [21].

Increasingly, the focus of the academic global surgeon seeking to improve training in LMIC is training that can be provided on-site in the LMIC. The visiting surgeon could help to design experiences that complement existing training efforts in the LMIC or may undertake the task of creating new programs. Designing the curriculum for LMIC settings requires thoughtful collaboration with local stakeholders, needs assessment, and contextual relevance [25, 28]. Most commonly, such curricula emphasize medical knowledge and technical skills training. Yet, it is equally important to include the nontechnical aspects of training such as professionalism, safe surgery, and ethics. Whatever its focus, the program should have clear, achievable goals and timelines. Benchmarks to measure quality of the training may include number of cases performed, examination pass rates, and trainee and faculty research or academic output [28].

A successful surgical training program in a LMIC must include a path to local certification and credentialing. In most cases, this is through national or regional professional training and regulatory bodies (e.g., the West African College of Surgeons (WACS) or the College of Surgeons of East, Central, and Southern Africa (COSECSA) for sub-Saharan Africa). Every effort must be made to align any collaboratively designed curriculum to the requirements of these entities. Some governments and training bodies in LMIC require a mandatory period of training, usually with some subsidized funding. Such programs provide yet another opportunity for academic global surgeons from HIC to create regular trainee exchange visits that could provide the continuity of an international collaborative program.

Global Surgery Collaboration: A Contemporary Example

The Alliance for Global Clinical Training is a consortium of US surgical departments (University of California San Francisco, University of California Davis, and Oregon Health & Science University) that provides continuous educational support in Dar es Salaam, Tanzania, at the Muhimbili University of Health and Allied Sciences. This alliance is a new endeavor focused on the development of a mutually beneficial partnership to enhance the training of surgical residents from both Dar es Salaam and from the USA. The current effort is concentrated on providing more teaching coverage, equitable distribution of educational support among the trainees, and the development a formal surgical curriculum **[28]**.

Funding Research in Global Surgery

Securing funding for global surgery projects is a challenge and can be frustrating as more surgery faculty attempt to build academic careers in the area. Many faculty rely on the more available funding for their medical students and residents to facilitate project initiation. Unfortunately, this can be sparse as well. However, the combined efforts of the *Lancet Commission on Global Surgery*, the *Disease Control Priorities 3rd edition (DCP3)*, and the effect of the May 2015 World Health Assembly resolution 68.15, “Strengthening Emergency and Essential Surgical Care and Anaesthesia as a Component of Universal Health Coverage,” should lead to an increase in focus and funding from the government and NGO donors for surgical work and research [29, 30].

Despite the paucity of funding for global surgery research and program development, it is still possible to obtain funding provided that projects are designed well, have goals that align closely with donor's priorities, and if one is persistent! Frost et al. suggested the following steps to improve one's chances of receiving funding in the *current* environment [31]:

- Make sure the aims of your project fit with prioritized global health problems. You are more likely to get funded if the project fits into a "hot" theme. As an example, the WHO has stated that prevention and treatment of injury should be added to the global health agenda. Additionally, the Fogarty International Center and many NGO foundations have recently increased their funding for noncommunicable disease research and training. A surgical project relating to some aspect of trauma would therefore fit into the noncommunicable diseases and injury topic and may be more likely to get funded in the current environment [13].
- Align your project to fit the scope of the funding agency. All granting agencies have strict rules about what they can and cannot fund. It is, therefore, essential to investigate the type of projects that have been funded. Contact the project officer and review the mission statements and rules for grant seekers. All of this information can be found on the donor's website. BE FLEXIBLE! It is essential to create multiple variations of a single project to fulfill the objectives of several different potential funders.
- Have a sustainability plan built into the application. Funding agencies want to know the long-term effects of the grants they finance, and all projects are reviewed for sustainability. Short-term "mission trips" are a traditional approach in global surgery, but unless there is a design for training or a concomitant collaboration around research or long-term clinical care, they may have little enduring impact. Proposals should always include distinct outcome measures and demonstrate how the project and its gains will be durable after completion.
- Build a reputation for global surgery research or program development. Donors are more likely to fund projects if the principle investigator has been successful in the past. Evidence of such a record includes the principal investigator's (PI's) own prior funding, residents, or medical students that have been funded, as well as presentations, abstracts, and published manuscripts on the topic. As importantly, publications are key to overall academic success and demonstrate to your department that global surgery is a serious academic endeavor.
- Submit well-written proposals with clear goals and measurable results. Writing a QUALITY project proposal takes time and effort. No one rises to low expectations. Set high expectations for yourself and do your own final edits. Don't rely on others to do this for you. One of the best ways to learn how to write a great proposal is to obtain previously successful applications.
- Never, ever quit! You have to submit an application to secure a grant. Yet, more often than not, there will be several failed attempts before breaking through.

Even the best ideas are not always funded, and a reasonable success rate for global surgery grants currently is around 10%. If you are turned down, always seek feedback and consider discussing the rejected application with the program officer. Critiques of your proposal can be difficult to read, but they provide insight on how to improve for the future.

Ethics and AGS

A consideration of ethics is imperative. While the goal of academic global surgery is to deliver positive change for underserved populations, it carries the risk of causing unintended harm. Ethics is commonly understood as defining good (appropriate) from bad (inappropriate) conduct, but what constitutes ethical conduct can vary according to cultural norms and local practices. Thus, during global health encounters, it is not unusual to find visitors with notions of ethics that differ from their hosts [24].

When such conflicting view arises, deference to local concerns is generally expected. Our brief discussion of some ethical aspects of academic global surgery will center on research and will be anchored on the principles of beneficence, nonmaleficence, autonomy, and justice.

Beneficence and Non-maleficence It seems obvious that global health practitioners would act in the best interests of the communities they have chosen to serve and will cause no harm. However, concerns have been raised in the past about some research studies conducted in poor countries that appear to have their rich sponsors as the primary beneficiaries. Global surgery researchers must ensure the local significance of their work.

Autonomy This principle respects the right of competent persons to give informed consent for medical treatment and participation as research subjects and to have control over their bodies. This right extends not only to decisions being made at an individual level but also community-level decisions that affect the individual. Informed consent practices during global surgery encounters must go beyond the legalese and ensure that patients/subjects are able to make an independent risk-benefit assessment. This will require utilization of culturally appropriate informed consent tools with appropriate interpretive services. Another important expression of autonomy concerns the participation of local partners in the research enterprise. If the local partners are engaged and feel ownership of the project that is relevant to them, then a true collaborative relationship has been created. The autonomy of the local partners in this research arrangement is expressed by assigning them appropriate equity and credit in research presentations and publications [32].

Justice This principle requires that the benefits and risks of medical care (and research) be distributed fairly and equitably to all persons. An example in global surgery research might be how their projects influence the implementation of clinical care guidelines or health policies and the responsibility to ensure that the greater burden is not placed on the most disadvantaged segments of the communities.

Conclusion

The ultimate success of recent efforts toward increasing capacity, access, and funding for surgery across the globe will likely hinge upon the complete integration of research, education, and advocacy initiatives into existing models of clinical care. The involvement of universities, surgical departments, and professional societies will be critical to global surgery going forward. Through both supporting the careers of the many interested trainees and faculty in AGS and by facilitating ethical, mutually beneficial collaborations, academia can serve as the vehicle that launches surgical care into a new era of worldwide equity.

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E-Learning in Global Surgery

7

Brian H. Cameron and Susie Schofield

Introduction: Why Should Global Surgeons Be Interested in E-Learning?

The Essentials

- *The Internet has transformed medical education globally.*
- *Global surgery initiatives often have a strong educational component.*
- *Online learning can complement but not replace effective face-to-face instruction.*

Within a generation, medical educators have adopted increasingly complex classroom teaching tools, moving from chalkboards to slides, and overhead projectors to smartboards. With the arrival of the World Wide Web in 1991, increasing computer power, decreasing costs, and the increasing penetration of Wi-Fi, there has been an exponential growth in use of educational technology via the Internet. Over the last decade, this has completely transformed medical education and the learning environment of the twenty-first century [1]. E-learning in medical education is "The use of the Internet and multimedia technology to deliver instruction and facilitate learning" [2, 3]. The technologies and terminology are changing quickly – key terms and definitions are summarized in Table 7.1 [4].

B.H. Cameron, MD, PGDipMedEd, FRCSC, FACS (✉)
McMaster Children's Hospital,
1200 Main Street West, Room 4E7, Hamilton, ON L8N 3Z5, Canada
e-mail: cameronb@mcmaster.ca

S. Schofield, PGCE, PhD
Centre for Medical Education, University of Dundee,
Mackenzie Building, Kirsty Semple Way, Dundee, Tayside DD2 1NU, UK
e-mail: s.j.schofield@dundee.ac.uk

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Table 7.1 E-learning terminology and definitions [4]

Term	Definition
E-learning	Teaching and learning that is facilitated via information and communications technology, both inside and outside the classroom
Blended learning	A mixing of different learning environments and approaches that often includes both face-to-face classroom methods and computer mediated activities in and/or outside the classroom
Distance learning	Teaching methods and technology for learners who are not physically present in a traditional classroom. Pure e-learning and blended learning are examples
Video teleconferencing	A way to engage people at different locations in synchronous interaction; includes video and audio feeds streaming in real time
Computer-assisted instruction (CAI)	The use of instructional material presented by means of a computer or computer system to enhance instruction and facilitate interactive learning
Web-based learning (WBL)	An educational approach that involves the use of the Internet for delivering learning materials and supports teaching and learning using various online resources
Course management system (also known as a virtual learning environment, VLE)	A web-based application for the administration, documentation, tracking, and reporting of educational programs
Asynchronous discussion board	E-learning strategy to expand the reach of a faculty, whereby comments on lectures, seminars, grand rounds, and journal clubs are shared asynchronously with individuals who are unable to join a discussion session
Wiki, blog, webinar, podcast, social media, polling	Examples of Internet-based e-learning tools

Computer-assisted instruction (CAI) with interactive tutorial modules have been around for several decades, but web-based learning (WBL) using the Internet has been a more recent revolution. However, information technology is a tool rather than a teaching method, and leading medical e-learning advocates Cook and Triola [1] recognize that "effective education requires good teachers and lots of hard work." Surgery – which requires the development of critical thinking and appraisal skills in addition to technical skills – cannot be learned independently online. Global surgeons are as much learner-educators as service providers, and almost all global surgical projects will have – or should have – an educational component. E-learning tools have unique advantages in distance learning, such as allowing learners to be engaged synchronously with an online lecture, or review and respond through an asynchronous discussion board. Surgeons collaborating in global surgery partnerships may want to access existing online learning resources or develop their own. Early global surgical e-learning initiatives focused on making static educational resources such as journal articles available online to surgeons in low- and middle-income countries (LMICs) [5]. Internet listserv groups accessed intermittently and asynchronously have evolved into synchronous chatrooms and live webinars, with surgical educators taking advantage of each new e-learning technology [6].

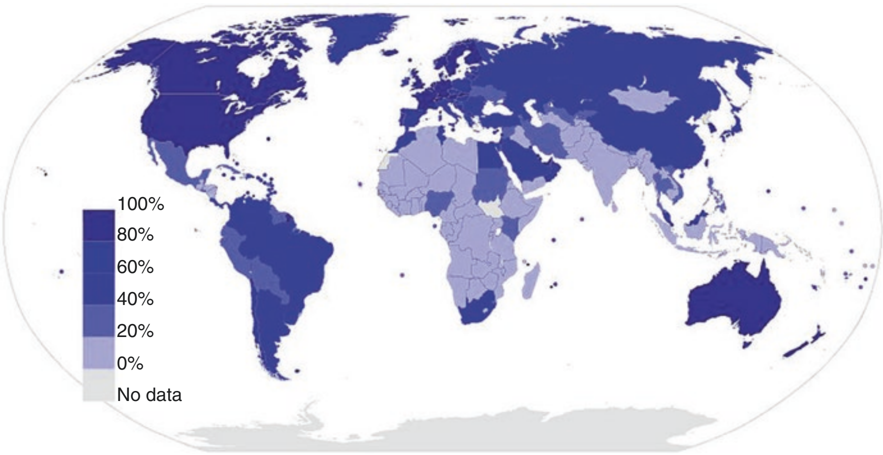

Fig. 7.1 Internet users in 2012 as a percentage of a country's population [7]

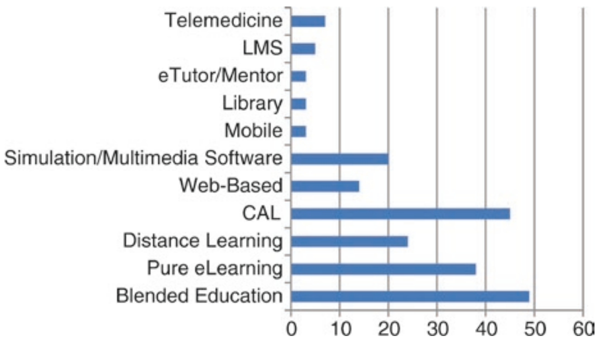

Fig. 7.2 E-learning modalities used in medical education in resource-constrained countries [4]

The global penetration of computers and smart phones and access to the Internet continues, reaching even the remotest parts of the least developed countries. The number of active mobile subscriptions now exceeds the world population, and the digital divide in Internet access in the developing world is decreasing [7, 8] (Fig. 7.1).

Access to the Internet in Africa is now growing at an even faster rate than mobile telephone ownership, and e-learning in Africa is expanding rapidly [8, 9]. Increasingly reliable broadband and wireless communication has expanded access to surgical education resources for postgraduate trainees and continuing professional development (CPD) in the global south [10, 11]. Frehywot et al. [4] reviewed the literature on the use of e-learning in medical education in LMICs and found a broad range of e-learning modalities being used in resource-constrained settings (Fig. 7.2) [4]. The majority of publications reviewed came from Brazil, India, Egypt, and South Africa, and most included partnerships with universities in high-income countries. E-learning was found to be beneficial in supporting faculty shortage, supplementing formal teaching, and expanding resources for distance medical education.

The focus of this chapter will be on instructional design and course configuration, examples of successful implementations, evaluation approaches, and future directions for e-learning in global surgery. The chosen examples are postgraduate or CPD surgical initiatives, many from Africa, where many north-south partnerships are making an impact in surgical education.

Course Configurations: Computer-Based Curricula vs. Face-to-Face Learning

The Essentials

- *The "flipped classroom" model expects learners to review e-learning resources on their own, using classroom face-to-face time to discuss examples and problems.*
- *Challenges of e-learning in the global south can be addressed by making e-resources simple enough to be downloaded and accessed with slow internet speeds.*

As with any teaching and learning method, e-learning programs have advantages and disadvantages over face-to-face instruction. According to Jayakumar et al. [5], potential advantages of e-learning include:

- Ease of access
- Flexibility of learning
- Easily updatable
- Presented with multimedia
- Economies of scale
- Personalized learning

Potential disadvantages include:

- Dependent on Internet speed
- Impersonal learning
- High initial cost
- Programming expertise required

Bediang et al. [12] surveyed health sciences students, residents, and faculty in Cameroon regarding their attitudes and experience of e-learning. Overall there was great enthusiasm for computer-based learning, but minimal experience. Eighty-one percent of residents had their own laptop computers, but only 61 % had Internet access at home, whereas the rest used a cyber café. Most residents searched for health literature using Google, and only 16 % knew about MeSH headings. The most common added values that residents perceived from e-learning were improved access to educational resources, improved method of personal working, and development of autonomy in learning.

Course configurations may include self-directed tutorial modules, discussion groups, or interactive patients [1]. Virtual learning platforms (such as Blackboard™

and Moodle™) provide an interface between the teacher, the learner, and the learning resources. Active learning is supported by technology by using web 2.0 features, e.g., online discussion boards and blogs. There is increased interest in the "flipped classroom" model where course content is provided, with or without online discussion, for participants to engage with before a face-to-face session. This session can be used to work through problems and answer questions [13]. Multimedia, online text chat, and polling (e.g., PollEv.com) are some of the other increasingly sophisticated interactive online presentation tools to enhance the learning experience.

Disadvantages of e-learning in developing countries include the challenge of engaging learners, the cost of developing relevant content, and the limitations of unreliable Internet service. In the global north, millennial learners are more familiar with "learning by doing," are experienced multitaskers, and have zero tolerance for delays. Distance learning is student-centered and self-directed, which may be challenging for students used to more specific direction. Some studies suggest that students don't always like pure e-learning courses and some have worse outcomes than traditional classroom learning, an opinion also shared by some funders [14].

The challenges for learners in the global south may be different. Students in developing countries may have to deal with unfriendly user interfaces, lack of digital literacy, and unreliable and costly Internet access [15]. Learning styles in many developing countries are based on a traditional hierarchy of teacher over learner and respect for authority. Safie et al. [10] describe e-learning strategies at the United Nations University International Institute for Global Health in Malaysia. Their students are used to teacher-centered didactic learning and need to become more self-directed learners to gain the most from e-learning. Non-motivated learners tend to drop out of online courses. Surgical trainees in developing countries may struggle with balancing service time with their education, financial difficulties, lack of academic confidence, obstacles due to age or gender, and lack of a supportive study environment. Overcoming the challenge of becoming self-directed learners can be addressed by providing opportunities for collaborative learning, peer-mentoring, and life-long learning as part of a community of practice [12, 16, 17].

Explicit information (factual knowledge) adapts most easily to e-learning programs, whereas the experiential knowledge required for surgical practice (e.g., communication skills, professionalism) is harder to teach and learn online. Although technology generally becomes less expensive over time, online courses with engaging presentation features such as multimedia can become increasingly complex and costly to produce, requiring a large amount of instructor preparation time [1]. It is possible to develop E-learning resources using low-cost or free software and simple production methods easily learned by the teacher/producer [18]. Developers of global surgery online resources must also consider keeping presentations simple enough to be easily accessible with minimal bandwidth and potentially downloadable since trainees may be accessing Internet from public sites such as Internet cafes or from their mobile device if not too expensive.

Instructional Design: How Should E-Learning Resources Be Designed?

The Essentials

- *Adult learners respond to active engagement, relevant content, and immediate feedback.*
- *E-learning resources should be simple, readable, and focused.*
- *An online e-learning Community of Inquiry has a clearly defined curriculum, develops social connections, and develops critical thinking through reflection and discussion.*

Computer-based curricula are only as effective as their instructional design. Merrill indicates that adult learners are engaged by real-world problems, by connecting to previous knowledge, by demonstration and application of new knowledge, and by opportunities to integrate new knowledge through reflection and discussion [19]. Harden [20] summarized four strategies required for effective learning as the FAIR principles: Feedback to the student, Active engagement of the learner, Individualized instruction recognizing different learning needs and styles, and Relevance of content to allow application of theory to practice. These fundamental principles for adult learning should be applied to the development of e-learning resources.

Instructional methods that improve e-learning outcomes enhance cognitive engagement, give feedback from self-assessment questions, and provide repetitive content [21]. Principles of e-learning instructional design can also be summarized as five Is:

1. Individual student directed.
2. Integrate content into experience.
3. Interactivity with technology, peers, and teacher.
4. Immediate feedback.
5. Iterative concepts to reinforce learning.

Curricular content should be simple, focused, positive, readable, and avoid jargon. E-learning courses need to consider readability, especially when English is a second language, for surgical residents in developing countries. The Gunning fog index is a measure of text readability based on the importance of using short words and short sentences [22]. Koski and Mann [23] identify the ABCs to check when developing effective e-learning resources. These ABCs are:

(A) Accuracy of spelling and grammar
Appropriateness to audience
Arguments: will key points influence the reader?
(B) Brevity
Balance of description, opinion, guidance, and information
Background: does the content add something new?
(C) Comprehensive: does it cover the objectives?

Clarity of layout and readability
Coordination: does the content hold together visually and conceptually?

Ruggeri [15] has summarized a number of institutional, instructor, and learner characteristics that are critical factors for successful e-learning programs. Both instructors and learners must have positive attitudes toward e-learning, digital literacy skills, and the motivation to develop and use e-resources. E-learning programs that incorporate blended programs, synchronous, asynchronous, colocated, and remote learning, are most likely to balance the benefits of face-to-face learning with e-learning's flexibility and user-centered learning.

Online discussion forums provide an opportunity for learners to engage, share their challenges, and work together. Salmon [24] describes a five-stage model, where learning is scaffolded, with a gradual move from moderator-directed instruction and technical support to a constructivist approach, encouraging higher participation rates and increased student satisfaction. Establishing an online social presence with the course participants is important to creation of a safe and effective learning environment. Garrison [25] has developed a widely recognized framework that is applicable to understanding what makes an online distance-learning course effective and is particularly applicable to global surgery education. Within this framework, the online course promotes learning by developing a Community of Inquiry with three online dimensions: social presence connecting learners, cognitive presence developed by assignments that demand critical thinking, and instructor presence providing a clear outline of objectives and assessment criteria. This framework of instructor, social, and cognitive dimensions to online learning is useful in designing and evaluating e-learning initiatives.

Examples of E-Learning Initiatives in Global Surgery

The Essentials

- *High-quality surgical videos can be produced inexpensively, but require attention to detail and must respect patient confidentiality.*
- *Online surgical courses and qualifications designed specifically for global surgery are increasingly interactive and sophisticated.*
- *Live and recorded webinars as well as online telementoring are effective ways to bring global surgeons together.*

CAI (Computer-Assisted Instruction): Making Static Learning Resources Better

Multimedia computer technology can make standard lectures or PowerPoint slide presentations more engaging and polished. Articulate ™ (https://www.articulate.com/) is an add-on software program for PowerPoint ™ that can add audio, video, and interactive quizzes and images to make a standard lecture into a self-directed module. Podcasts and YouTube videos can also be easily created with standard computer software [26]. All of these surgical teaching resources can be archived and made available at any time on the web [27]. Surgical education videos are now easily accessible to the majority of the world via YouTube. The biggest challenge for learners is to select instruction that is accurate and high quality, since these videos are generally not peer-reviewed.

Rehim et al. [28] outlined some of the practicalities of producing effective surgical education videos including equipment, software, editing, and archiving logistics. Their excellent article provides guidance on inexpensive production of high-quality surgical videos. Tip includes using an inexpensive handheld HD camcorder with a large depth of field and using optical zoom and macro mode to maintain image resolution and focus. Slight underexposure without bright overhead lights is preferred. Video editing can be done with minimal experience using basic Apple™ (iMovie) or Windows™ (Sony™ Vegas Studio) software, and the total length of a surgical video should be no longer than 3–5 min. Voiceovers should be recorded without background noise and added after the final edit. The most widely used video compression formats are MPEG and Quicktime™. Informed patient consent for any photography is critical in today's world. Images should only show patient faces or identifiable characteristics when absolutely necessary and specific consent is obtained.

Structured Online Postgraduate Surgical Courses with Tutor-Student Online Interaction

The Branch for International Surgery at the University of British Columbia now delivers a fully online four-course Graduate Certificate in Global Surgical Care. Courses include an overview of global surgery, surgical disability, disaster response, and program planning and evaluation. Twenty-three percent of the course graduates are from outside Canada, including from India and Pakistan [29].

Some online surgical curricula developed for residency training in the global north are being made accessible to surgical trainees in the developing world. The American Surgical Council on Resident Education curriculum (SCORE) was piloted with African surgical trainees who rated it favorably, but the article notes that SCORE was designed specifically for American surgical trainees [30]. Although there is a lot of common ground for a global surgery curriculum, the differing prevalence of surgical disease and lack of many sophisticated diagnostic and therapeutic tools mean that imported surgical curricula may not be locally relevant.

Online surgical courses, such as the Master of Surgical Sciences course run by the University of Edinburgh in the UK, have demonstrated a positive correlation with performance in the MRCS exams [31]. This course includes case discussions with tutor feedback, MCQs, and essay assignments. The pass rate is over 80 %, and only 11 % of the initial cohort withdrew from the course. Of particular interest is the course's success in recruiting trainees from 40 countries, many in the developing world. Course leaders stated that "the majority of students (81 %) considered that the (course) would improve their chances of gaining a surgical training post" [31]. This raises the question of whether the course will enhance surgical training in the developing world or will contribute to the brain drain of surgeons to the developed world. Although this and similar courses provide

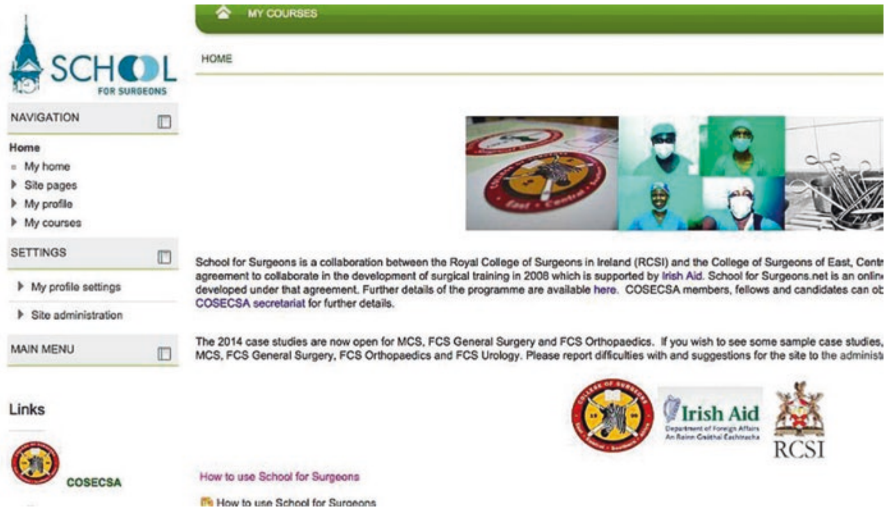

Fig. 7.3 Screenshot from School for Surgeons, an online surgical curriculum for African surgical residents hosted by the Royal College of Surgeons in Ireland, in collaboration with the University of Toronto and McMaster University [32]. Used with permission from School for Surgeons

internationally recognized qualifications, surgical program directors in low-resource settings will need to consider the competing priorities of providing access for their trainees to high-quality e-learning resources that may not align with their local needs.

Other online curricula are specifically being developed collaboratively for surgical trainees in LMICs. Moodle ™, an open-source content management system, is used as the platform for the School for Surgeons online curriculum for surgical residents training through the College of Surgeons of East, Central and South Africa (COSECSA) [32]. The site includes case-based discussions, evidence-based reviews, and self-directed modules (Fig. 7.3) [32]. The Royal College of Surgeons of Ireland manages the site, and surgical trainees are required to complete a fixed number of modules. Course coordinators have learned that submission of assignments is a better participation measure than time spent online, page views, or downloads [33].

Jotwani et al. [34] reported their experience from the All India Institute of Medical Science with an open-access online Moodle™-based Neurosurgery Education and Training School (NETS) that provides access to educational resources that include 344 downloadable presentations and 135 videos (operative, animated, and recorded lectures). The site also incorporates a Q&A discussion forum, Facebook discussion group, and live broadcasts. The authors reported over 5,000 visitors annually (57 % repeat visitors) including many non-neurosurgeons. One hundred ninety subscribers accessed the surgical videos, 3-D animation, and graphics-based training modules, accounting for 64,380 views. The site includes an ongoing discussion forum with, at time of publication, 968 members from 45 nations, the majority from developing nations of Asia and Africa. Another collaborative online course for Ghanaian neurosurgery residents found that participation improved with introduction of assignments and an active online discussion forum contributed to student satisfaction [35].

Fig. 7.4 Guyanese surgical residents participate in a Skype conference with Canadian faculty [37]

Videoconferencing: Virtual Symposiums/Webinars – Live and Recorded

Raigani [36] provides an excellent overview of the uses of videoconferencing in global surgical education. Teleconferences have been used for decades, but the Internet and desktop computing have made webinars available inexpensively to virtually anyone, anywhere in the world. Conferencing softwares such as Adobe Connect, GoToMeeting, and Skype are just a few of the free or low-cost platforms being used by surgeons [37] (Fig. 7.4).

One of the more successful regular weekly online surgical seminars is broadcast from a South African pediatric surgical unit to regional satellite hospitals and an increasingly worldwide audience [36]. PowerPoint talks are prepared by trainees and presented to their peers and faculty, and Q&A through the Chat Board. Recorded conferences are downloaded 300 times a month, and DVD recordings are distributed to other African countries where bandwidth is too poor to participate in the live broadcasts [38]. Globalcast MD has taken the virtual surgical symposium a step further, with professional production, expert panelists, and high quality multimedia presentations [36]. Discussion and audience participation are encouraged similar to a conference panel, an engaging format for continuing professional development. Participants can see presentations, engage by video with faculty in numerous locations, and participate in online polls (Fig. 7.5) [36].

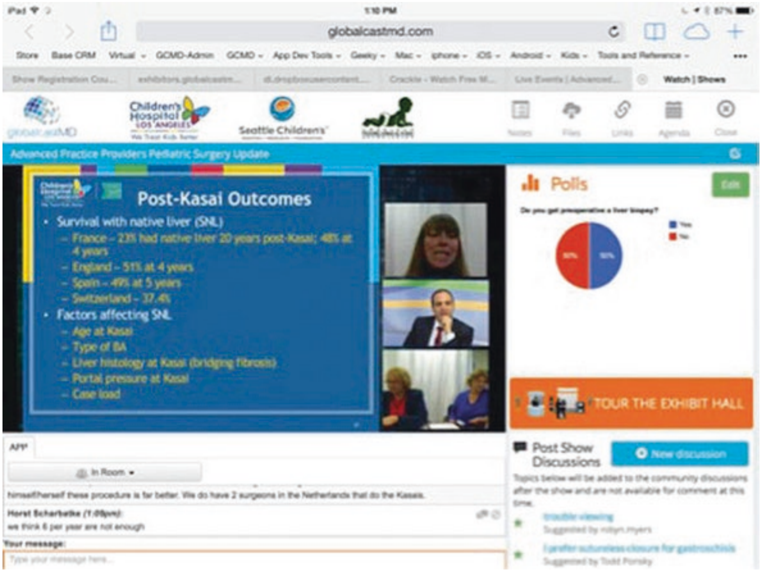

Fig. 7.5 Screenshot from a GlobalCastMD online webinar [36] (Reprinted with permission from Raigani et al. [36] , with permission, © Georg Thieme Verlag KG)

Telementoring is another application of videoconferencing that has particular applicability to surgical training. Okrainec et al. [39] have used Skype from Canada to demonstrate and mentor surgeons in Botswana in simulated laparoscopic skills training. Surgeons are also being telementored in the operating room by experienced surgeons as they work through their learning curve for new minimally invasive surgical procedures, an exciting development that also brings new ethical and medicolegal considerations. Websites of some surgical e-learning resources are listed in Table 7.2.

How Can E-Learning Initiatives Be Developed Within a Surgical Department?

The Essentials

- *Academic surgical departments can develop e-learning policies and resource needs.*
- *In producing surgical education materials for today's digital world, patient confidentiality and intellectual copyright issues should always be considered.*

How often have we been frustrated by watching someone try to get their laptop connected to the projection system, or by having to update software before we can access an online module, or by having to reset our forgotten password to the online

Table 7.2 Specific global surgical e-learning initiatives

Website	Host country	Description and surgical discipline
surgicalskills.co.za/web-meetings	South Africa	Weekly pediatric surgery webinar
globalcastmd.com	United States	ENT, general, thoracic, pediatric surgery
aiimsnets.org	India	All-India institute neurosurgery
schoolforsurgeons.net	Ireland	COSECSA general, orthopedic, urology
websurg.com/cme	France	Websurg laparoscopic technique videos
internationalsurgery.med.ubc.ca	Canada	Graduate Certificate in Global Surgical Care
facs.org/education/resources/elearning	United States	American college of surgeons e-learning

course? These difficulties of access are compounded in the global south when basic Internet access can be unreliable, too costly to use, and/or have inadequate bandwidth. However, surgeons are very creative and often develop work-around solutions such as downloading readings at the local Internet café or using the broadband Internet in the administrative office to access webinars. Technical challenges such as firewalls, computer viruses, theft of devices, and lack of reliable Internet providers will require expert IT assistance.

As more e-learning materials are developed and shared, surgeons working in academic institutions need to be aware and part of the development of policies for their use. A surgical departmental e-learning policy document should address issues such as:

1. *Purpose* of E-learning. How does the use of e-learning align with the vision and direction for the institution? Leadership commitment will be necessary for success.
2. *Participants*. Who are the learners and what are the learning objectives? Is the goal to deliver blended content to existing local learners, to focus on distance learners, or to make content openly available?
3. *Resources*. What teachers, resources, and systems are needed to support these objectives? Does our department need a full-time IT person to ensure our needs are met, or will we be dependent on a centralized computer services unit? What training is necessary for those developing and using the e-learning platform?
4. *Collaborators*. Who will we work with outside the university to develop an evidence-based, reliable, and appropriate approach to e-learning? Do we need to hire an experienced consultant to help us implement our plan, or is it better to depend on in-house expertise?
5. *Logistics*. What considerations are needed to ensure ease and reliability of access to the IT, cost-recovery, security, and copyright? How can a new strategy be communicated and implemented in the least disruptive way?
6. *Outcome Measures*. How will the success of new e-learning initiatives be measured? Online metrics allow collection of data regarding recruitment, retention,

and completion rates of learners. Research and iterative quality improvement needs to be incorporated into the strategy from the beginning. What external accreditation standards need to be met?

Confidentiality and copyright are two ethical issues that deserve specific mention in implementing e-learning in global surgical education. The basic principles of respecting patient privacy and confidentiality also apply to online educational materials. With wider use of cellphones and social media, educational platforms may be used to share specific information about interesting cases. For example, surgeons often use clinical case photographs or videos in their teaching materials. Surgeons involved in global surgery educational initiatives should be aware and model the same appropriate behaviors toward protecting patient information that they would in their home country. Many professional medical organizations have developed ethical guidelines for social media use [40].

The easy posting and sharing of copyrighted materials such as journal articles also raise ethical issues. Strictly speaking, most journals will allow online sharing of articles by copyright holders to their enrolled learners (generally behind a password protected website). Copyright is being infringed if such materials are being shared openly and freely online or through a commercial site. Educators have developed a number of Creative Commons websites to share copyrighted learning materials with other educators. Generally materials are provided for free as long as they are credited to the original authors and the user registers on the website. Examples are the AFMC Canadian Healthcare Education Commons, the AAMC, and the Association for Surgical Education [41–43].

Evaluation and Accreditation of E-Learning Initiatives

The Essentials

- *There is little evidence that new learning technologies lead to improved learning outcomes, but they do expand the number of potential faculty and learning resources for global surgeons.*
- *Evaluation of e-learning should include measures of participant participation, satisfaction and learning outcomes, and ideally even changes in behavior and patient outcomes.*

Two meta-analyses of e-learning led Cook et al. [44, 45] to conclude that e-learning is generally as effective, but no better than traditional teaching methods. Cook and Triola [1], both experts and enthusiasts for e-learning, recorded an interesting discussion about the hype and hope of new e-learning technologies. Newer information technologies make e-learning easier, faster, more open-access, and even less expensive; however, there is little evidence of new technology leading to improved learning outcomes, and there is a danger that the financial cost and instructor time necessary to produce sophisticated e-modules may discourage their use. With the large amount of faculty time and costs of new IT, it is important that new e-learning initiatives be evaluated both for outcomes and for cost-effectiveness. Outcome measures should include more than just student satisfaction. Belfield [46] identified five increasingly valid measurement levels to evaluate a medical education intervention: participation, learner satisfaction, changes in knowledge/skills/attitudes (learning), changes in behavior, and changes in patient outcomes (impact).

1. Participation. E-learning makes participation metrics easier to audit. Page views, downloads, time online, and course completion rates can be easily monitored but may not reflect true learning or learner engagement. Increasingly, technology can aid in analyzing learner usage and adapt curricula to individual needs.
2. Learner satisfaction. Were the e-learning resources accessible? Easy to use? Engaging? The Community of Inquiry survey tool developed by Arbaugh et al. [47] for online distance learners surveys the perceptions of the instructor's role, the social presence, and the cognitive requirements of an online graduate course. Can we identify student factors leading to success vs. dropout?
3. Learning. These are the traditional measures of changes in knowledge, skills, or attitudes as a result of the intervention, which are most often measured as pre- to post-course comparisons. Formative structured feedback during the course can be incorporated into instructional design. Summative assessments should be valid and reliable if used for high-stakes certification.
4. Behavior. As competency-based surgical training becomes the norm, more valid direct observation assessment tools are being developed for trainees (e.g., OSATS). However, it is hard to ascribe a change in behavior to an e-learning intervention when there are often other inputs and variables.
5. Impact. Changes in patient outcome are the gold standard measure for an educational intervention, but are rarely measured. Incorporating measures of changes in behavior and patient outcomes into an e-learning program is difficult and perhaps only possible by self-reporting, but blended surgical curricula could require such assessments.

Ruggeri [15] proposed a comprehensive model for evaluating e-learning programs in health that can be applied to surgical education. The model includes course outcomes as well as obstacles and benefits. Ruggeri also argues that organizations supporting e-learning in health should develop guidelines for accreditation. However, Walsh [48] opines that formal accreditation fits poorly with e-learning and may lead to unintended consequences such as discouragement of innovation, unnecessary bureaucracy, and expense.

The World Federation of Medical Education (WFME) has developed Global Standards for Quality Improvement in Postgraduate Medical Education, which should be considered when developing north-south collaborations in formal surgical training programs [49]. The document recommends that training programs have a policy to address effective use of ICT and that trainer and trainees should be competent to use ICT for self-learning. More rigorous methods of evaluating e-learning are being developed and are necessary to guide the best use of scarce educational resources especially in developing countries.

The Future of E-Learning in Global Surgery

The Essentials

- *E-learning initiatives can be a key part of global surgery partnerships.*
- *Surgeons in many LMICs are taking the lead in developing relevant e-resources that global surgeons can participate in and learn from.*
- *Medical education is forecast to increasingly use social media, simulation, and game-based learning, providing surgeons an opportunity for educational innovations with truly global dimensions.*

The average number of faculty in African medical schools is only 10 % that of American medical schools. E-learning has the potential to expand the capacity and number of available faculty by involving surgeons from the global north as remote faculty to medical schools in LMICs. In 2010, a new US-funded Medical Education Partnership Initiative allocated $130 million dollars over 5 years to 13 African medical schools for capacity building, retention, and regionally relevant research [50]. Support for e-learning initiatives was included in all project proposals, as was support for medical education research. The introduction of new e-learning modalities and projects by global surgeons provides numerous research opportunities. The European Commission has funded an initiative in Egypt, Ghana, Cameroon, and Mali to further research and south-south networking in e-learning and collaborative development of informatics tools [51].

Walsh [52] forecasts that e-learning in healthcare professional education will continue to evolve to be more mobile and include more simulation, game-based learning, and adaptability to individual learning needs. The costs of e-learning are projected to decrease, and it will increasingly be used as part of blended medical educational curricula. Social media such as Facebook and Instagram can be used as ways to connect learners and teachers (remembering that their content is open to the public). Twitter is quickly developing as an effective medium for continuing professional education. Choo et al. [53] identified some of the advantages of Twitter in supporting a medical community of practice and barriers including information overload and lack of fact-checking.

E-learning applications in global surgery have moved from an era of few content creators and limited Internet access to an era of partnerships, interactivity, and innovative content. As surgical faculty, residents, and practitioners in LMICs increasingly utilize information technologies, it will be important to consider the need to make content relevant and engaging for learners. Evaluation of surgical e-learning partnership initiatives will provide opportunities for bilateral mutual learning and "reverse innovation" [54]. Globally minded surgeons will continue to be on the cutting edge using innovation and new technology to teach their craft.

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Part III

The “100-Foot” Perspective: Preparing for International Involvement

The Importance of Contextual Relevance and Cultural Appropriateness in Global Surgery

8

Janaka A. Lagoo and Sandhya A. Lagoo-Deenadayalan

Introduction

Academic programs in the USA have taken a strong interest in global health [1], making it a fast-growing discipline. Medical disciplines have hitherto focused on the doctor–patient dyad, but in global health, the core skills for practitioners are based on understanding that the health of a single patient is enmeshed in a complex system of individual behaviors, family and community relationships, environmental surroundings, and economic limitations [2].

This chapter deals with the importance of contextual relevance and cultural appropriateness in global surgery and addresses the key features of education that can contribute to these domains. Contextual relevance for healthcare workers requires an understanding of the healthcare system in the context of a community's social and political history. In brief, this can be further broken down into knowledge of the community's educational systems, current workforce, national health policies, economic strengths and weaknesses, and medicolegal systems. Cultural appropriateness is more complicated, because in addition to understanding what is unique in the lifestyle and behaviors of diverse communities, culturally appropriate practices are respectful of differences and emphasize the need to find common ground in order to achieve common aims: to deliver good, efficient, and value-added care.

J.A. Lagoo, MD (✉)
Brigham and Women's Hospital and Harvard, T.H. Chan School of Public Health, Ariadne Labs, 401 Park Drive, Boston, MA 02215, USA
e-mail: janaka.lagoo@gmail.com

S.A. Lagoo-Deenadayalan, MD, PhD (✉)
Duke University, Department of Surgery, Erwin Road, Durham, NC 27710, USA
e-mail: lagoo002@mc.duke.edu

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In order to better align the state of surgical education with the complex challenges of global surgery, the chapter has the following goals:

1. To explore traditional forms of cultural education and see how they need to be adapted to ones that better incorporate the multifaceted realities of present-day globalization
2. To discuss the need for continuous change in the way in which a surgeon educates himself and his team, so as to be always relevant in constantly changing times

It is becoming clearer that contextual relevance and cultural awareness are needed not only for healthcare delivery abroad but also domestically as immigrant populations continue to grow in the USA. Additionally, given the layered and dynamic nature of this training, it would be ideal that such educational initiatives be offered to all surgeons in training, not to only those interested in global surgery, and should start at the beginning of training and continue throughout their careers. Mid-career surgeons will also benefit from training platforms that can facilitate participation in global surgery initiatives.

The Need for Contextual Relevance

Contextual relevance in global surgery encompasses three important tenets mentioned below:

- An understanding of the country or region where future work is planned
- Access to information regarding local laws, customs, and regulations
- Identification of a need with a potentially workable solution

Why do we need contextual relevance in surgical education? Although it seems that this should be a foregone conclusion, there is still ambivalence about who should lead the initiatives to educate surgeons and surgical trainees and who should be responsible for implementation and continued monitoring of adherence to guidelines involving this competency. Briscoe et al. argue that the ultimate responsibility to learn and practice cultural sensitivity lies with the individual. Leaders and institutions need to establish educational modules that can facilitate and foster this learning and provide support when individuals seek help during difficult or adverse events [3].

Understanding the Host Country

The first tenet includes an understanding of the existing healthcare system, the current workforce, the strengths, and both immediate and long-term needs. It is important to have an accurate account of the medical schools, schools of public health, physicians, and specialty organizations in the area [4] and also the operative capacities of district hospitals [5]. Identification of partners on the ground and having a good grasp over their standing within the different organizations is critical.

Access to Information Regarding Local Laws, Customs, and Regulations

Information about local laws is available through the host institution, international offices, and embassies. Most of this material can be accessed online and helps to inform surgeons about the need to obtain temporary medical licenses to practice. It is also necessary to inform their own institution about their plans, so that they can obtain malpractice insurance. Surgeons should verify that all members of the team, including nurses, pay heed to these matters. Familiarizing oneself to local customs and regulations can be done by discussions with team members who have previously visited the host institution or partners in the host country. Team members can also be requested to keep a log of their activities, with an attention to details that may help future visiting faculty.

Identification of a Need with a Potentially Workable Solution

Efforts at the front end help pave the way for choosing a rational intervention that has a reasonable likelihood of success. True success is appreciated by both the entity delivering the healthcare and the recipient. When there is a true need that is addressed, the recipient and the family see the value of the intervention and are more likely to support similar further interventions (Box 8.1).

Box 8.1. Identifying the Problem That Needs a Solution

Drs. Abhay and Rani Bang are physicians and public health advocates who founded and run the Society for Education, Action, and Research in Community Health (SEARCH) in Gadchiroli, India. Their primary focus is to enlist the help and expertise of the community to identify crucial needs for health intervention. Their efforts have led to major improvements in the neonatal mortality, maternal mortality and morbidity, and awareness of sickle cell disease. The lack of access to essential surgical practices was identified as a major community health need, with community members citing chronic pain and lost work as key issues when dealing with such surgical issues as hernias and/or urological problems. Thus, the SEARCH team decided to initiate the development of "operative camps." They recruited top surgeons from throughout India who were willing to commit to routinely attend operative camps at SEARCH on an at least an annual basis and bring additional nursing personnel. In addition to recruitment of excellent surgical talent, they concurrently focused on building health capacity to ensure that there was thorough preoperative evaluation of all patients (utilizing the fully equipped laboratory at SEARCH), up-to-date operative equipment and resources, and a strong inpatient hospital system for highly responsive and effective postoperative care.

The evaluation of these operative camps is currently underway, but preliminary results point to significant sustainability (given the longevity and growth of the camps over the past decade). Additionally, the camps appear to be addressing previously unmet surgical needs for numerous rural patients, while also serving as a driving factor in ongoing health capacity building. Ultimately, the project very much highlights one of the key tenets of Bang's work: "Ask the people and they will lead you."

In Mongolia, the initial plan by Price and colleagues was to teach trauma. However, their involvement with the local health systems and their attention to the needs expressed by their hosts resulted in amazing improvements in the infrastructure of the hospital: improved electrical resources, improved sterilization procedures, and the establishment of recovery rooms to monitor patients after surgery. They were able to advance the cause of laparoscopic surgery and help establish a collaborative effort to improve surgical care, offering through educational modules a platform for local surgeons, nurses, and administrators to continue their efforts [6], reinforcing the importance of attending to cultural context. In Uganda, a neurosurgery program highlighted the importance of health capacity building. Specifically they focused on improved training and education to perform more complex cases [7]. There are innumerable such accomplishments that have shown that thorough knowledge of context is relevant and can maximize chances of success.

The Importance of Cultural Awareness and Diversity

Cultural awareness and diversity are words that are frequently used, and it is occasionally difficult to understand how they translate into medical care and global surgery. That is not surprising, given they are complex ideas and require considerable maturity for implementation. It begs an individual to be:

- Willing to allow for personal change and growth
- Aware of similarities between different cultures
- Able to have empathy for human rights and justice

Willingness to Allow for Personal Change or Growth

Cultural competency is needed both within the USA and abroad. Within the USA, this is needed based on the increasing cultural diversity that is encountered in our patient population [8]. In 2001, Mary Duffey [9] presented the theory that cultural education, based on traditional anthropology, was no longer sufficient to address the growing globalization in healthcare. She suggested that newer transformative ways of education were needed. The tenets of this transformative form of education required a willingness to be open to personal change and growth and to accept that cultural education was not meant to be a tool to use to make one's own culture of healthcare delivery that of the culture of the recipient.

Awareness of Similarities Between Different Cultures

The goal of adding cultural diversity training to a curriculum should not be to emphasize how different another culture is. Rather it should be to develop an understanding of another culture in a way that makes one aware of how many similarities exist. Such an understanding is more likely to overcome obstacles and to resort to open and continuous dialogue. One of the most important aspects of human nature that crosses all borders and cultures is the capacity for human resourcefulness in face of paucity of services or limited finances. The culture of "finding a way to make it happen" is as deserving of respect in countries with limited resources as it is in the developed world.

Empathy for Human Rights and Justice

Another important aspect of global surgery work is to understand that cultural awareness is not limited to understanding the history of the people alone. In today's global environment, it is important to understand the current dynamic events that shape peoples' lives and impact their future [9].

There are some very significant barriers to achieving true cultural competency. First, there is always the tendency to stereotype other cultures versus actually building a true understanding of the culture's customs and norms. Secondly, and on a greater scale, there is also the misunderstanding that it is only "knowledge of another culture" that is required. Neither of these contentions is correct. The hope is that knowledge of another culture can serve as a starting point to further understand the complexities of that culture and will lead to the delivery of more informed and empathetic care [10].

Curriculum Design Around Contextual Relevance and Cultural Awareness

Designing educational platforms for surgeons interested in pursuing careers in global surgery can be challenging. It is important to appreciate that these are adult learners and the emphasis should be more on facilitation and conflict resolution. Case studies and small group discussions should address the following:

- Culturally and linguistically appropriate services in health and healthcare
- Capacity for reflection and self-education
- Ability to tolerate ambiguity, complexity, and change

Culturally and Linguistically Appropriate Services in Health and Healthcare

It is useful to plan ahead of time for help with translation when providing services in host countries. Inadequate translation capabilities can be a health hazard for the population one wishes to help. Patient- and family-centered care should be the goal at all times, and discussions regarding patient consent are not possible unless lines of communication are clear and transparent. If consents have to be signed, it is important to have these translated from English into the language of the host country and then translated back to English to check for accuracy. This is required when getting IRB approval both at home and abroad. Fortunately, the US Department of Health and Human Services has set up National Standards for culturally and linguistically appropriate services in health and healthcare that can be accessed at their site, www.thinkculturalhealth.hhs.gov/content/clas.asp#clas_standards [11].

Capacity for Reflection and Self-Education

Freire's critical pedagogy emphasizes student reflection before beginning an academic or field experience in an effort to unmask and critique the assumptions, privilege, and power dynamics that enable student participation in such an experience [12]. On the other hand, transformative education [13] begins with an initial student experience and then moves to reflection, discovery, analysis, generalization, and future action based on the previous experience. A comprehensive style has been adopted more recently in teaching global health ethics for graduate students. It focuses instead on metacognition and fostering student ability to confront moral ambiguity in the context of ethical decision-making [14].

Online resources for cultural competence training and interprofessional education can be used to facilitate care both at home and abroad. By expanding a physician's knowledge of the patients they are serving and the unique ways in which their patient's culture can shape their understanding of health and interaction with the healthcare system, these online resources can lead to greater patient-centered care. Specifically, there will be more emphasis on the following: patients' goals of care, their expectations from interventions, and their assessment of change in quality of life. Such training has been shown to enhance education in each of the American College of Graduate Medical Education (ACGME) core competencies, with valuable training in cultural competence. Residents participating in plastic surgery training programs have been able to appreciate the global burden of disease, an appreciation of global health issues and increased cultural sensitivity. Cultural sensitivity is particularly relevant because these residents are eager to apply what they have learned when they return home and take care of patients who are recent immigrants and hail from underserved populations [15]. Plastic surgery residents interested in humanitarian mission work were appreciative of a properly structured and proctored program that prepared them for global work with Operation Smile. Preparation included a preparatory meeting that replicated the typical Operation Smile workflow, and the mission was conducted under mentorship of attending surgeons. This prepared the residents for participation in all aspects of care, including screening, decision-making for appropriateness for surgery, scheduling, operating, and providing postoperative care, all within the norms of the host institution. For young surgeons venturing abroad, a preparatory meeting of the type mentioned above will be valuable. Although they may not need mentorship or proctorship, it is always beneficial for the first trip or mission abroad to be in partnership with a senior colleague. Such a person can share experiences and insights into the capacity in the host institution and make introductions that further the cause of current and future missions, resulting in long-term collaborations and partnership (Table 8.1).

Several institutions have integrated global health into surgery residency [16]. Charles and colleagues [17] have identified key factors that must be addressed before starting such a venture. They include home institution mission, resident expectations, and host institution qualifications. Others have identified several concepts that can help surgeons pursuing a master's in public health learn cultural awareness [18]. They include, but are not limited to, a willingness to identify oneself as a cultural being; to identify multiple dimensions across which similarities and differences occur within groups; to be willing to tolerate ambiguity, complexity, and change; and to understand critical consciousness and social action. Additionally, global health ethics focuses on establishing competencies for overseas short-term training [19].

Table 8.1 Online resources for cultural competence training and interprofessional education [11]

Think Cultural Health US Department of Health and Human Services and Office of Minority Health Flagship Initiative	www.thinkculturalhealth.org
Think Cultural Health: Cultural Competency Program for Oral Health Professionals	https://oralhealth.thinkculturalhealth.hhs.gov/
National Center for Cultural Competence	nccc.georgetown.edu
National Interprofessional Initiative on Oral Health	www.niioh.org
Smiles for Life: A National Oral Health Curriculum	www.smilesforlife.org
Interprofessional Education Collaborative	https://ipecollaborative.org/

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Ability to Tolerate Ambiguity, Complexity, and Change

Even with a well-defined idea of what cultural awareness or cultural competency is, Kumagai et al. [20] point out very convincingly that these qualities are not enough. Having the knowledge, the skills, and the attitudes that one develops after training toward cultural awareness is only a means toward the goal. That knowledge of cultural awareness needs to be fortified with a critical consciousness of oneself, others, and the world and with commitment to addressing issues of social justice and relevance in healthcare. Discussions in several small groups and dialogues regarding topics addressing human and societal needs, medical ethics, and the physician–patient relationship are encouraged. These small groups are maintained over long-term periods to offer comfort and familiarity. Faculty members are expected to be facilitators, encouraging the use of stories to present questions that stimulate discussion and to keep discussions as current and relevant as possible. In such endeavors, there is no need to attempt to make a trainee adept at work within a particular host country or cultural environment; rather, it is important to prepare them to adapt their self-education to whatever needs may arise either at home or in a host institution. In the USA, it is customary to discuss disease processes with adult patient and to get them to sign their own consent for procedures. In many parts of the world, it is not unusual that women look to their husbands to help them make their decisions. It is important to encourage women to participate fully in their own medical affairs, and yet, this message can be conveyed gently, without hurting the sensibilities of those involved. The willingness to be able to change one's own approach without compromising on one's philosophy is critical in matters of foreign affairs, and the medical field is no exception. Persistence and diligence usually result in change and progress; we have to remember that it also takes time.

Preparing for Cross-Cultural Living and Working

When preparing to travel abroad, it is beneficial to familiarize oneself with various factors in the host country such as:
- Respect for social norms and religious beliefs
- Communication with stakeholders and local leadership
- Advantages of providing continuity of involvement

Respect for Social Norms and Religious Beliefs

Awareness of social norms is critical no matter where one travels. Within countries, these norms may differ in urban and rural areas and also among different socioeconomic groups. So, what are some practical ways that one can both become accustomed to such norms but then also act in such a way that these social and religious norms are supported while also providing quality surgical care?

Nothing brings as much a happiness in any community as the birth of a child. Whether it is a natural delivery or a birth by C-section, people's lives change forever. It is also a time where traditional norms are given great importance and should be treated with respect. In addition to the celebrations and festivities that surround a child's birth, it also is a time of reflection and an opportunity for cross generational discussion about health – the child's, the mother's, and the family as a whole. An understanding of regional customs helps establish trust and a willingness to accept advice that could improve maternal and child health. Why do surgeons need to be aware of these issues – because C-sections are one of the common procedures performed worldwide. More importantly, any surgeon who wishes to practice in resource poor settings needs to be adept at this procedure – there is no saying when one may be the only physician available to be called upon to perform a Cesarean section (Box 8.2).

Box 8.2. Establishing Trust by Understanding Regional Customs

An obstetrical anesthesiologist with significant global health experience shared the following experience: During a C-section, after the birth of the baby, she usually makes small talk with the parents and always asks what they are planning to name the baby. On her first trip to Ghana, she did just that and got a very strange look from the mother; in Ghana babies are not given a name until 2 weeks after birth once it seems clear that they will live; at this point the mother has a big celebration; they dress themselves in white and parade around town with the baby to announce that they have arrived and all are alive and well! This is not an unusual custom in parts of the world with high neonatal mortality rates – and has been honored in order to alleviate to some extent the emotional devastation that follows the loss of a child.

Let us consider examples of certain cultural norms and how they have intersected with healthcare delivery. Following the devastating Indian earthquake, for example, there was a global outpouring of support in the way of donations. Beyond monetary donations, many clinics were inundated with donations of clothes. However, it quickly became apparent that these clothes did not meet the local norms for dress (whether in regard to cultural appropriateness or ease of use given the weather, daily work requirements, etc.). Therefore, donated clothing was often used as fuel for fires instead of garments for wear. Though the intent was a good one, this example provides a key lesson on how important it is to fully assess a community's needs prior to sending and/or bringing supplies. Often monetary donations when sent through the proper channels and when accountability and transparency are prioritized can give local health agencies the autonomy to truly meet community health needs in the most appropriate manner.

Additionally, cultural practices can directly affect the way that local communities respond to the delivery of healthcare. For example, in Mongolia, there is a prevailing cultural belief that Tuesdays are associated with bad luck. Therefore, people might be less likely to want to schedule clinic appointments or operations on this day, and it is an important consideration for visiting healthcare providers to recognize. These examples highlight the importance of cultural (social and religious) sensitivity when providing healthcare globally. However, there is no perfect road map for gleaning this understanding. In addition to using published literature, talking to past volunteers and engaging with the local hospital or facility you will be working in prior to your travels is ideal. In addition to knowledge generation, having an attitude of openness and acceptance of the important role of cultural understanding is paramount.

Establishing Robust Communication

Preparing to live and work abroad is filled with exciting challenges and opportunities. Specifically, in this era of enhanced communication technologies, it is critical to use these technologies to our advantage while trying to establish cultural competency. There is a lot to be learned from readings of the country's social and political history. However, in today's constantly changing world, one cannot discount the advantages of real-time information. Innovative ways have included cross-cultural online education that used written and task-oriented discussions on key topics such as professionalism, community health, and leadership [21]. Faculty at the Foundation for Advancement of International Medical Education and Research (FAIMER), an international fellowship program for mid-career interdisciplinary health faculty, found that participation in such educational initiatives was more likely to result in establishing a network to support one another in achieving similar common goals.

Social awareness can be enhanced by encouraging community participation in all endeavors. Feedback is important, and every effort should be made to elicit it from members of the host institution by direct communication, paper or electronic surveys, and telephone contact. This makes it possible to compare activities and interventions, with intentions identified at the start of a program, and to ascertain that such interventions address a community's need [22]. Successful management of an acute problem results in sustainability for the program due to community and occasionally government support. Additionally it allows the providers to delve into the etiology of various disease processes, thereby making it possible to entertain ideas that could help with prevention and timely intervention. This awareness then should be put into action, even if it means that implementation pathways need to be modified. An example of this is the way in which modification of a best practice pathway was adapted in response to participant feedback. Participants included the care providers and community members [23]. In essence, the ultimate goal of global surgery is to ensure worldwide access to safe surgical care while simultaneously supporting systems that lead to the long-term sustainability of this care.

Continuity of Involvement in Host Countries

International surgical missions have been incorporated into surgical residency training in several institutions. In addition to enriching the surgical education, these also provide opportunities to enhance cultural awareness and establish academic partnerships [24] over long periods of time. A survey of residents who participated in such programs was conducted. It showed that residents valued the opportunities when such initiatives were supervised and well planned and addressed their social and medical needs, security, and well-being [25]. This can be assured when the residents are given adequate information about the host country prior to participating, with details regarding the medical needs, socioeconomic structure, and barriers to specialty care. This also allows a platform for surgeons to stay involved in global partnerships long after they have completed formal residency training.

Contextual Relevance and Lessons to Bring Back Home

Considerable thought has been put into how to improve the access and quality of essential surgical services to resource-constrained communities. Resource-rich communities have the opportunity to bring manpower, skill, and technology to underserved areas, but in order to build long-term sustainability, health capacity building must occur at the community level. The lessons learned from resource-constrained communities must be transported back to ensure the most effective use of resources.

The relevance of what one has to offer is important in global surgery. In 2001, Blanchard et al. [26] discussed the fact that C-sections, appendectomy, and prostate surgery were three named procedures, access to which differed markedly in different parts of the world. Today, one still hears reports that C-section rates need to be at least 19 % to be able to provide this surgery for women in need and to be able to reduce maternal and fetal mortality [27]. Creating an infrastructure in countries in need, where such care can be offered is an example of how the context can determine future measures. Such infrastructure includes a stable supply of electricity, communication, access to basic laboratory needs and medicines, and plans for sustainability.

Surgical care in the USA has now been burdened by the need to reduce costs and to make this care accessible to populations that do not have access to surgical care due to economic constraints. Several countries that have faced this problem have become resourceful by developing solutions that make such care possible. Learning from such institutions can help identify solutions that may be relevant in the HIC setting (refer to Frugal Innovation chapter Reverse Innovation section). Examples include training of surgical technicians who can provide care under supervision and offer a workforce that can be deployed to underserved areas [26]. The Aravind Eye Care system is an amazing success story that used sustainable service delivery models to address community needs. Innovative private-sector solutions offer efficient care to impoverished populations. Studying such an organization can educate us on how to overcome barriers to delivering care in low-resource settings in several countries and across other surgical disciplines [28].

Case Study: Safety in Surgery and Application of Contextual Understanding in Diverse Operating Rooms

Safety is an important issue in surgery, and it is necessary to understand the culture of safety in the country and institution of interest. The WHO Patient Safety Research Training and Education Expert Working Group of WHO Patient Safety designed a framework of competencies for patient safety [29] that included competency in patient safety, research methods, and knowledge translation. The host institution's position on these issues is critical, so that one can plan to work within the existing framework and plan to collaborate with the host institution for implementation of additional initiatives. Hull et al. [30] have presented a detailed account of a training program in 2011 in Bogota, Columbia, for clinical and non-clinical researchers to conduct patient safety research. Issues addressed were operating room teamwork, the operating room environment, and the culture of safety. Discussions about the value of these training programs and inclusion of local surgeons as instructors or mediators in the program may help improve participation.

Ibrahim and colleagues detailed a very elegant framework to achieve these training programs, stressing that such initiatives should occur longitudinally over a span of several years, should encompass cultural and institutional factors, and should try to evaluate the impact at a community and national level [31] (Box 8.3).

Box 8.3. Need for Workforce Training in Host Countries Prior to Surgical Missions

A plastic surgeon with extensive global health experience was made acutely aware of the need for such a strong medical and surgical workforce following his experience in Nigeria. He now believes that complex, staged plastic surgery procedures in developing countries should be considered with caution. So-called "prefabrication" or "pre-lamination" of flaps may be indicated; however, this may be difficult to accomplish due to the time constraints during a plastic surgery service trip. He participated in two missions in Nigeria, specifically managing facial defects caused by Noma infection. His team planned and executed several flap prefabrication procedures at the beginning of the mission. Unfortunately the hospital staff went on strike during the second week of their endeavor, and they were unable to complete the actual reconstructions. Having consistent discussions with the healthcare workforce that you will be working with during a surgical service trip and ensuring that there is shared understanding regarding expectations, resources, roles and responsibilities, and management of emergency situations would at least partly ameliorate this problem.

The pattern of implementation of safety checklists to decrease morbidity and mortality differ in various countries. This can be affected by the attitudes toward public acceptance of errors and the consequences of such transparency. Both need to be taken into account when attempting to standardize the use of checklists. The success of checklist implementation has been maximized when communication, training of frontline personnel, and creation of a culture of change are in effect [32, 33].

In the global health setting, the notion of leapfrog technologies or innovations is often heralded. For example, while many rural parts of low-income countries lacked landlines for phone communication, the introduction of cell phones was a game changer that suddenly resulted in vastly improved connectivity [34]. Cell phones opened the door for a huge array of mobile health applications and can be readily integrated into global surgery endeavors with examples ranging from sending surgical appointment reminders to providing home-based instructions on postoperative wound care. There are numerous lessons to be learned from practicing surgery in underserved communities, and there is also a great potential to think about innovative ways to disrupt old systems and establish novel solutions.

Conclusions

Global surgery continues to evolve. More and more medical students, residents, and staff (both in academic and community settings) are being drawn to serve in underserved populations both domestically and abroad. This movement is driven by numerous motivations: growing awareness regarding the gaps in access to quality surgical care, the quest to contribute to improving health inequities, and the desire to learn and expand one's own scope of practice and skill set. In light of the diverse set of backgrounds and motivations represented by those who work in global surgery or aspire to, it is crucial that students and physicians alike are prepared for the unique challenges they may face, and the focus is on truly optimizing their experience and impact.

In this chapter, we sought to expound upon the importance of contextual relevance and cultural appropriateness in global surgery and address the vital educational factors that can enrich these domains.

As global health issues become more diverse and complex, the borders between countries become more porous, the need for access to safe surgical care grows, and the importance of contextual relevance and cultural awareness becomes more acute. Understanding these concepts will help in the development of truly innovative, sustainable, and effective ways to improve the quality and access to excellent surgical care across the globe.

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Practical Checklists

9

John L. Tarpley and Margaret J. Tarpley

Introduction

Short-term surgical volunteer trips require careful planning for experiences that prove of most benefit to the host institutions as well as for personal fulfillment of the surgeon participants [1]. Scheduling a mutually convenient visit with the host institution opens the process. Initial communications should include inquiries concerning:

- Most likely work opportunities (e.g., operations, clinic, and classroom) while keeping in mind that these could change before arrival or during visit
- The level of safe anesthesia and airway management capability [1]
- Accommodation arrangements including availability of prepared food or necessity of self-catering
- Climate and weather for guides to clothing and gear, including culturally acceptable items

Next comes investigation of requirements for visas, medical licensure, malpractice insurance, and recommended vaccinations. Travel arrangements involve air tickets, visa procurement (if needed), travel clinic visit, and emergency evacuation insurance. Equally vital is identifying the appropriate contact person from the host institution with whom one communicates the travel itinerary and verifies arrangements for airport pickup, ground transportation, and accommodation. Keeping host contact phone numbers and addresses with travel documents facilitates communication in the event of delays or other issues.

J.L. Tarpley, MD (✉)
Department of General Surgery, Vanderbilt University School of Medicine,
Surgery Education Office, D-4314 Medical Center North, Nashville, TN 37232, USA
e-mail: john.tarpley@vanderbilt.edu

M.J. Tarpley, MLS
Department of Surgery, Vanderbilt Medical Center,
1161 21st Avenue South, Nashville, TN 37232, USA
e-mail: margaret.tarpley@vanderbilt.edu

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Daily recording the cases performed, patients seen in clinic, lectures given, photos taken, and other activities, in a diary or log book is highly recommended. This journal can be a paper notebook, laptop, tablet, or smart phone. Increasingly, short-term physicians are requested (even required) to provide metrics to their institutions and sponsoring bodies to validate the experience. Consider adding comments about experiences, sights, interactions, even smells, that is, nonclinical sensations, observations, and events. What meals did you enjoy or not; were there interactions with your hosts outside the hospital, etc.? The cross-cultural experiences are often more valuable than the medical ones; journaling enables you to put down reflections acutely and helps jog your memory later on.

Required Documents Checklist

Whether or not a visa is needed, many countries and custom officials require that a passport be good for more than 6 months after the planned exit from the country and the passport must contain several blank *passport* pages (not the blank end sheet) available for stamps or visa certificates. American citizens anticipating travel outside the USA can start investigating visa requirements on the government website "U.S. Passports & International Travel" (Table 9.1). Visas almost always have a fee and can be obtained directly from an embassy or consulate in person, by mail, sometimes online, or with the aid of a visa service. Even if someone has visited a country in the past without obtaining a visa, that country's policy should still be researched as visa rules can literally change overnight. Some countries permit visas to be purchased in the airport on arrival, but many visas must be obtained before travel.

As soon as the destination is known, one must check with local hosts about medical licensure requirements if operations and medical practice are planned because—if

Table 9.1 Useful websites

American College of Surgeon's Operation Giving Back	Resource to find volunteer opportunities best suited to different expertise, interests, and level of experience	http://www.operationgivingback.facs.org/
CDC Travelers' Health Information	Information on country-specific health issues including required vaccinations	http://wwwnc.cdc.gov/travel/destinations/list
Global Health	Free educational resources	http://global-help.org/
Global Paediatric Surgery Network (GPSN)	Volunteer opportunities for pediatric surgery	http://globalpaediatricsurgery.org/
Global Partners in Anesthesia and Surgery (GPAS)	Projects, partnerships, and resources	http://www.globalsurgery.org/
Health Volunteers Overseas (HVO)	Volunteer opportunities	https://hvousa.org/
International Red Cross	Free educational resources	www.ifrc.org

Table 9.1 (continued)

Médecins Sans Frontières (MSF)—Doctors without Borders	Volunteer opportunities—minimum 6 weeks for surgeons	http://www.msf.org/
Pan-African Academy of Christian Surgeons (PAACS)	Volunteer opportunities with surgery training programs	http://www.paacs.net/
Pulse oximeters	Pocket-size portable models $20–$40	Available online from a variety of sellers
Pulse oximeters: Lifebox Foundation	$250/ unit, including worldwide delivery	http://www.lifebox.org/safe-surgery
TALC	Teaching Aids at Low Cost	http://www.talcuk.org/
U.S. Passports & International Travel	Passport and visa requirements	http://travel.state.gov/content/travel/en.html
Vanderbilt Travel Clinic	Information about immunizations and health travel kits	http://www.vanderbilthealth.com/travelclinic/
World Health Organization (WHO)	Information on health issues across the globe; produces the *International Certificate of Vaccination or Prophylaxis*	http://www.who.int/en/

needed—the application process may be time-consuming. Purely educational efforts such as teaching, providing CME, or skills sessions would likely be exempt. Whether or not medical malpractice insurance is required or recommended can be ascertained from the host or from legal advisors in the traveler's home institution.

Copies of the passport pages and visa carried separately from the originals (including secure digital cloud-based copies as well as paper) are useful in the event documents are lost or stolen and must be replaced at an embassy or consulate. Consider a body pouch or other secure holder for passport and cash. Immigration officials have authority to inspect a traveler's health card, known officially as the *International Certificate of Vaccination or Prophylaxis*, for required immunizations. See Checklist 9.1.

Checklist 9.1 Required Document's Checklist

- Passport with multiple empty pages and valid beyond 6 months after return.
- Travel itinerary—Even with electronic ticketing, a copy of the electronic ticket is mandatory for each traveler in case computer systems fail or if travel interruptions occur
- Evacuation insurance
- Visa—if required
- International Certificate of Vaccination or Prophylaxis
- Medical license, local—if required
- Malpractice insurance—if required or recommended

Health and Safety Checklist

Many institutions house a travelers' clinic providing advice and services concerning recommended health measures, preventive and prophylactic. The CDC Travelers' Health Information site offers facts and advice on country-specific health issues including vaccinations required for entry into each country (Table 9.1). Vaccinations and other preventative measures should be documented by the provider in the *International Certificate of Vaccination or Prophylaxis* issued by the World Health Organization (WHO) that may be obtained from the travelers' clinic or other health-care providers. If malaria is endemic, prophylaxis—if recommended—should be adhered to. Also one should limit skin exposure, especially outside nocturnally, with long pants, socks, etc., and use mosquito netting at night, if available. Sunscreen and hats reduce exposure to potentially harmful sunlight, especially if using doxycycline for malaria prophylaxis. Health measures should begin well ahead of the travel date because some treatments such as rabies vaccinations are done in series and yellow fever vaccine often requires advance scheduling due to short shelf life of the open multidose vial. The Vanderbilt Travel Clinic site warns "Immunizations require at least 14 days before travel to be effective." This site also includes suggested items for a health travel kit [2]. Travelers should check with their own medical insurance company to learn about any coverage for health issues that occur outside the USA. Persons who think they might need medication for gastrointestinal problems, sleeping difficulties, or other issues should seek advice from their personal physicians.

Emergency evacuation coverage is imperative. Even relatively routine issues such as appendicitis or a fracture could become life-threatening in remote or poorly equipped situations. In most low- and middle-income countries (LMIC), the greatest danger to health is road travel, especially at night due to poor road conditions and lack of lighting, which means that objects in or near the road are invisible until struck. One should limit travel at night by vehicles and avoid riding on or operating a motorcycle any time. When in remote areas where evacuation could be slow and difficult, avoid excessive physical exertion or extreme sports which could lead to injury or illness.

Ask if water is safe for consumption. Water can be purified several ways: by boiling, by special filtering systems, or with chemicals. Fresh fruits and vegetables can be made safe to eat by soaking them in water to which a small amount of household bleach has been added (about a capful of bleach per quart of water). See Checklist 9.2.

Checklist 9.2 Health and Safety Checklist

- Vaccinations required/recommended
- Medical insurance coverage
- Emergency evacuation insurance
- Protection for sun exposure
- Road safety strategies
- Water and food
- Contact information—Phone numbers for hosts, transportation, and accommodations

Budget Checklist

Air tickets can be purchased through a travel agency or online from airlines or discount sites, and all these options should be investigated to ascertain the optimal price and schedule. Prices change constantly; therefore, when searching for bargains, it pays to access the various companies a number of times to get a feel for cost and availability. When traveling to places in the world with few flights each week or remote, less visited areas, dealing with a travel agency might be wise as the traveler then has a contact person if any plans go awry. Travel agencies may also offer visa information although visa services can be found online. Economy air ticket price estimates in 2016 range from $1,000 to $2,500 round-trip for many international destinations, but ticket prices fluctuate widely depending on country or city of departure as well as destination. Most volunteers pay most or all of their travel expenses. For long-haul flights, paying the surcharge for an economy seat with added leg room may be cost-effective. If a host institution is subsidizing expenses, the surgeon should be mindful of financial challenges faced by the host and consider choosing the most economical travel arrangements rather than business class. Arrange for sufficient layover time if plane changes are needed and be aware of time zone differences when in airports in order to reach the departure gates in time to board.

Visas, if required, average $50 and $100 and the visa service can add another $100 more or less. Travel clinic visits and recommended vaccinations and other preventive measures can run as much as $200–500 or more. Medical licensure costs vary but could be several hundred dollars. Emergency evacuation insurance is absolutely essential, and basic coverage runs about $5–10/day or more depending on company and benefits. Coverage can be purchased for individual trips, and there are also policies that may cover multiple trips over a specified period of time. Some institutions offer emergency evacuation coverage to employees on business and may require the employee to register the trip before embarking. Malpractice rates should be researched.

On-ground expenses include airport pickups, transportation, accommodation, and food. Estimating costs across the globe is purely speculation, but using a US price for a service would offer a reasonable guess. If possible, make arrangements through the hosts or the hotel to be met at the airport and inquire about costs. This provides peace of mind as well as added safety. Some institutions offer housing for a low rate, while other situations require using hotels and guest houses priced as much as $100/day or more.

Food options, prices, and availability vary widely throughout the world, and the visitor should inquire about the alternatives when planning the trip. Estimating costs across the globe is difficult, but food prices in many places would be similar to American prices with locally produced and fresh items often less expensive. Sometimes visitors live in guest houses that offer reasonably priced meals. If accommodations include access to an equipped kitchen, preparing simple meals can reduce expenses and even save time over restaurant visits. In addition to groceries, supermarkets in larger communities frequently offer ready-to-eat items more cheaply and quicker than restaurant dining. Transporting granola bars, peanut butter, snacks, canned products such as tuna, or other nonperishables provides backup food in the event the location has limited grocery options, work schedules do not allow for meals, or the traveler prefers familiar items. Visitors are encouraged to sample local dishes for a more complete cultural experience as well as reducing outlay. Supermarkets may also offer household goods, small electronics, and other useful items.

While many US phones have global capabilities, global roaming plans can be much more expensive than service through a local company. The following example reflects costs in Kenya: an unlocked US phone (one allowing use of local SIM card) or locally available phone (basic model \$20–30) and a locally available computer modem or hot spot with SIM card (\$20–40) with local phone services for international calls and data plans costing about \$10–30/week depending on usage. To conserve data fees, all unnecessary apps should be disabled.

Most major credit cards have global coverage, but travelers are advised to check if their card is accepted in the country of destination. Travelers also need to notify their company when cards are to be used outside the US, both for coverage information and to forestall denials. Contact information to report lost or stolen credit cards should be in an accessible paper or digital location. Some cash in the form of new (dated less than 10 years old) US 100 dollar bills is highly recommended for those occasions when credit cards or traveler's checks are not accepted as well as for emergencies. Vital documents and cash can be carried in body pouches for added safety.

In resource-challenged environments, supplies and equipment may require supplementation if the visiting surgeon's time and expertise are maximized. Seeking donated materials reduces costs, but items essential to a specialty should be included in the estimated budget so that the surgeon can function optimally under the circumstances (see Medical Supplies and Equipment Checklist). The patient population frequently includes persons with very limited abilities to pay for surgical care. The short-term surgeon may be faced with the question concerning whether or not to subsidize costs for patients who will otherwise be unable to undergo a procedure. The visitor is advised to discuss this question with the host surgeons and decide whether or not to include this possible expense in the trip budget. Any direct requests from patients or families to pay for procedures or other expenses involved in surgical care should be referred to the host.

Recreational excursions as well as souvenirs can add substantially to trip costs. Global surgical trips provide opportunities to visit exciting and exotic environments, but tourism should neither interfere with the primary purpose of the surgical experience nor become a burden added to the duties of the host physicians. See Checklist 9.3. Plan any stopovers on the return leg of your trip to avoid added baggage fees due to weight allowance variability as well as added risk of customs queries about medical supplies and equipment.

Checklist 9.3 Budget Checklist

- Air ticket
- Visa
- Vaccinations and prophylaxis
- Emergency evacuation insurance
- Medical licensure
- Malpractice coverage
- On-ground transportation
- Accommodation/hotel
- Food
- Communication (phone and data usage)
- Supplies and equipment, if needed
- Surgical procedures subsidy
- Recreation/souvenirs

Personal Gear and Carry-On Checklist

Essential personal medications must be transported in your carry-on luggage (never in checked bags which can be delayed or even lost) with a sufficient supply for your entire stay if at all possible. Never assume your medication or other personal needs can be obtained abroad—you can ask your hosts about availability but "no condition is permanent."

Every professional owns a phone and computer or tablet, which, fortunately for the international traveler, are compatible with electrical systems across the globe, needing only a plug adapter that can be found online, in stores catering to travelers, or even purchased after arrival. A locally compatible multi-outlet power stick is highly recommended in case accommodations have too few outlets for charging all electronics simultaneously. A computer modem or hot spot as well as a phone that can use local SIM cards are both recommended for the frequent traveler and can be obtained locally as noted above.

Investigate the climate—some areas in Africa, South America, Asia, and Europe are very cool, even cold, especially at night; lightweight long underwear might be appropriate as well as jackets, hats, and even gloves. For example, most of South Africa is not tropical. If you cross the equator, seasons reverse. A lightweight waterproof jacket and folding umbrella are advised if rains are expected. Carry-on luggage should include 2–3 days of basic clothing in case bags get delayed or lost.

Sensible, sturdy footwear is a must, especially when in rural or remote areas without sidewalks or smooth roads and paths. Along with scrubs, closed OR shoes such as clogs are recommended. A flashlight or even a headlight is needed for walking at night or when electricity goes out.

Many places have cultural norms that dictate proper attire for each gender—ask your host about appropriate clothing choices. A separate chapter deals with cultural issues. See Checklist 9.4.

Checklist 9.4 Personal Gear Checklist

Medications and other personal necessities

- Electronics
- Clothing
- Flashlight
- Personal carry-on checklist
  - Travel itinerary (paper copy of ticket) with phone numbers and addresses of contacts in host country
  - Passport
  - Visa
  - *International Certificate of Vaccination or Prophylaxis*
  - Letter concerning donated medical supplies
  - Medications
  - Personal essentials (may differ by gender)
  - Computer, phone, camera
  - 2–3 days of basic clothing
  - US dollars in cash for emergencies

Medical Supplies and Equipment Checklists

Check to see if there is an organization in your town that collects supplies and equipment for humanitarian purposes that might donate items for your use on the trip. Ask your hospital OR staff to save sutures, gloves, etc., [3] that would otherwise be headed to the landfill when hospital policies deem them unusable. The website of the American College of Surgeon's Operation Giving Back lists organizations that donate medical materials [4] as well as links to the WHO guidelines on donated materials [5]. Volunteers should avoid transporting expired drugs or medical supplies [6] for a number of reasons including safety (some expired drugs degrade into unsafe or toxic products and sutures can degrade as well). Carry a letter on letterhead from someone in authority at the home institution or humanitarian organization stating that the medical supplies and equipment in accompanying baggage are donations and not for resale; produce the letter only if customs officials question the luggage contents. Once working in the institution, appreciate what is there and avoid criticism when certain items are not available. See Checklist 9.5.

Checklist 9.5 Medical Supplies, Equipment, and Educational Resources

- Personal Use
  - Loupes
  - Portable headlight
  - Portable pulse oximeter for personal use (inexpensive models available online)
  - Caps
  - Masks
  - Gloves
  - Scrubs
- Procedures
  - Specific instruments required for your specialty procedures
  - Scissors
  - Pickups
  - Special suture
  - Pulse oximeter for OR/wards (see Table 9.2)

Table 9.2 Suggested free and/or inexpensive educational resources

Ameh EA, Bickler SW, Lakhoo K, Nwomeh BC, Poenaru D. *Paediatric Surgery: A Comprehensive Text for Africa*. Vol. 1 Seattle: Global HELP Organization; 2010. http://www.global-help.org/publications/books/help_pedsurgeryafricavolume01.pdf (Free download)
Cotton M, et al., editors. *Primary Surgery Volume One: Non-Trauma* (Second Edition). Seattle: Global Help, 2016. http://global-help.org/products/primary-surgery/#download (Free download)
Gionnou M, Baldan M. *War Surgery: Working with Limited Resources in Armed Conflict and Other Simulations of Violence, Volume 1*. Geneva: International Committee Red Cross, 2010 https://www.icrc.org/eng/assets/files/other/icrc_002_0973.pdf (Free download)
Gionnou M, Baldan M, Molde A. *War Surgery: Working with Limited Resources in Armed Conflict and Other Simulations of Violence, Volume 2*. Geneva: International Committee Red Cross, 2013 https://www.icrc.org/eng/assets/files/publications/icrc-002-4105.pdf (Free download)
King M, et al., *Primary Anesthesia*. Oxford: Oxford University Press. 1986
King M, Bewes P, Cairns J, Thornton J, et al. *Primary Surgery Volume One: Non-Trauma.* Oxford: Oxford University Press, 1990 (See above Cotton, 2nd edition as free download)
King M, Bewes P, et al. *Primary Surgery Volume Two: Trauma.* Oxford: Oxford University Press; 1987
Meara J, McClain CD, Rogers SO, Mooney DP, editors. *Global Surgery and Anesthesia Handbook: Providing Care in Resource-Limited Settings.* (See especially Chap. 4 "Preparing for a trip: OR management" and Appendix "Safety, security, and survival considerations for health care providers in remote, hostile, and disaster areas"). Boca Raton: CRC Press; 2014. Available as a single volume paperback or an e-edition
Principles of Reconstructive Surgery in Africa. Carter, Jr. LL, Editor. Bristol, TN: Pan-African Academy of Christian Surgeons; 2013 http://paacs.net/wp-content/uploads/2012/09/PAACS-Principles-of-Reconstructive-Surgery-in-Africa-v.2-072413.pdf: *Principles of Reconstructive Surgery in Africa*. Carter, Jr. LL, Nthumba, P., Editors; 2016 Revised Edition http://www.paacs.net/wp-content/uploads/2012/09/PAACS-Reconstructive-Surgery-Text-v.-2-072516.pdf (Free download)

Self-Protection

1. Adopt "standard infection control practices," the update to "universal precautions" which evolved in the 1980s [7]:
   - Hand hygiene**:** the single most important aspect of standard precautions. Where water is scarce, consider using disposable plastic "bread" or freezer bags on your hands to remove dressings, examine wounds, etc. to provide a barrier from possible contamination.
   - Personal protective equipment (PPE): gloves, gowns, mask/eye protection—seek to always double glove for operative procedures—consider it an "equity investment." Gloves can be washed, assessed for leaks, be re-sterilized, and then reused, especially for the inner pair. Eye protection with face shields or goggles is mandatory to thwart splashes even if there is high temperature and humidity with consequent fogging.
   - Soiled patient-care equipment: gowns in many LMIC countries are permeable by fluids. Though hot, consider wearing a rubber or impenetrable apron under your scrub gown as a barrier, especially for trauma cases, C-sections, and any case with a projected significant blood loss.
   – Environmental control such as bleach cleansing of surfaces
   – Careful handling of soiled/contaminated linens and instruments for protection of all workers and OR personnel
   - Needles and other sharps: use a "safe home base" island such as a kidney basin for scalpel and needle transfers, thus avoiding "blind" handoffs to and from surgeon and scrub assistant. Insist on use of containers for sharps.
   - Prevent direct contact with mouth and oral secretions during patient resuscitation.
   - When possible isolate patients who might infect others or who are immunocompromised.
   - Respiratory concerns—e.g., when tuberculosis is a concern, utilize a N-95 type respirator mask, tightly fitted, to avoid inhalation of mycobacteria whether in the exam room or in the theater for bronchoscopy, decortication, or other thoracotomy [7].
2. The overall HIV prevalence rate for sub-Saharan Africa is 4.5% but with by-country variations from 2% to 25% compared to 0.5% for the Americas and a 0.8% prevalence worldwide [8]. Consider taking along tenofovir disoproxil/emtricitabine (trade name Truvada) for postexposure prophylaxis (PEP) should a concerning exposure occur with the potential for HIV transmission by a cut, bone fragment injury, needle stick, eye splash, or other mechanism. Truvada should be started within 2 h of exposure. Know where in-country HIV testing can be performed promptly and accurately, for example, a PEPFAR program clinic or other center. Preexposure prophylaxis (PrEP) for surgeons/OB-GYN physicians practicing in areas of high HIV prevalence and limited protective gear might even be considered for those tasked with frequent, routine high-risk trauma (war zones, vehicular trauma) or emergency obstetrical procedures.
3. Hepatitis: see Checklist 9.2. Follow the advice from your Traveler's Clinic and/or the CDC website on international travel. *UpToDate* has a good section on

travel medicine as well. Hepatitis B immunization has been available since 1982 and is 95% effective in preventing infection, chronic disease, and liver cancer due to hepatitis B [9]. There is no vaccine yet for hepatitis C, but there are now very effective agents for cure. If an exposure occurred, then consider screening for hepatitis C periodically on return; if conversion occurs, commence therapy with one of the new drugs, e.g., ledipasvir/sofosbuvir (trade name Harvoni).

Educational Resources

Educational resources are highly recommended whether or not the primary purpose of the trip is training and teaching. Plan to take an atlas and a surgical text (print copy, e-text, or both), and, if a print copy, consider leaving it behind with your hosts. These resources will help you “refresh” on procedures you feel competent for but do not perform as frequently now as in earlier practice or residency. Do not feel obligated to attempt procedures you feel uncomfortable performing or for which the postoperative care and rescue interventions for any complications are not locally available. As Art Brooks of Vanderbilt noted: “There is no condition that can’t be made worse with an operation.”

- Take along any prepared talks just in case an opportunity to share arises. Internet connection challenges and intermittent power supply make online resource availability unpredictable. Groups such as the International Red Cross and Teaching Aids at Low Cost (TALC) provide free and/or inexpensive surgical education materials.

Summary

A successful short-term experience involves:

- Displaying a flexible and accepting attitude toward the surgical environment
- Developing warm, collegial relationships with the host physicians and the hospital teams
- Employing health and safety strategies that begin with adhering to travel clinic recommendations
- Being prudent about physical activities that have a potential for injury and avoiding road travel after dark as well as operating vehicles, especially motorcycles
- Being aware that the benefit to the participant may equal or exceed the benefit to the host institution

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Basic Bioengineering: Essential Equipment Use and Troubleshooting

10

Jim Moore and Richard S. Wood

Introduction

Assuring the availability of safe and functioning medical equipment in the developing world is challenging. Given the limited resources, repairing defective medical equipment on the field is an even greater challenge. This chapter discusses the various causes of equipment failure, how to correct those failures, and how to prevent future equipment failures. Learning how to quickly and properly troubleshoot a problem or failure will not only improve patient safety but will reduce equipment downtime and save valuable resources. Regardless of your technical abilities, this chapter will assist you in solving a variety of medical equipment problems.

J. Moore, AAS
Department of Biomedical Services, AAS Biomedical Technology,
AAS Industrial Management, Samaritan's Purse/World Medical Mission,
801 Bamboo Road, Boone, NC 28645, USA
e-mail: jmoore@samaritan.org

R.S. Wood, BA (✉)
Worldwide Biomedical Charitable Services (WBCS),
606 Third Street, Lawrenceburg, TN 38464, USA
e-mail: rick@techmd.org

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Causes of Failure

The Essentials

- *A large variety of available devices result in operating and service difficulties.*
- *Inappropriate donations result in poor quality and nonfunctioning devices.*
- *A shortage of biomed techs or service staff results in nonfunctioning devices.*
- *Inadequate equipment usage training for clinical staff results in failures.*

Equipment problems and failures occur at a much higher rate in the LMIC (lower- and middle-income countries) than in US health systems. There are many factors contributing to this unfortunate situation, and they include the wide variety of available equipment, the source and condition of this equipment, and the shortage of biomedical technicians or qualified maintenance personnel to maintain it.

A surgeon in the USA will typically be exposed to a limited variety of equipment because the equipment is usually selected based upon the desires of the surgeon and medical facility where they practice. Unfortunately, when traveling globally, surgeons will be exposed to a significantly larger variety of medical devices. According to the World Health Organization (WHO), ". . . there are more than 10,000 types of medical devices available. The selection of appropriate medical equipment always depends on local, regional or national requirements; factors to consider include the type of health facility where the devices are to be used, the health work force available and the burden of disease experienced in the specific catchment area. It is therefore impossible to make a list of core medical equipment which would be exhaustive and/or universally applicable" [1]. This exposure to such a vast number of devices results in a challenge not only with servicing and maintenance but also with proper operation of the equipment.

Although many hospitals, clinics, and surgical teams try to stretch their budgets by relying on donated equipment, the need or desire to depend upon "free" or donated equipment can often have tragic consequences. Many users are more concerned with what they can get for the lowest cost, rather than the quality or condition of what they get. "Many developing countries are increasingly dependent on donor assistance to meet the equipment needs of their health care systems. However, because not all important parameters are taken into consideration, donations sometimes do not achieve their intended objectives, and could even constitute an added burden to the recipient health care system" [2]. Furthermore, the equipment providers may come from a variety of different countries. This results in exposure to a larger number of manufacturers and models, equipment requiring different power sources, lack of or different language operator, and service manuals. Medical facilities in the LMIC are littered with inappropriate medical devices that will never

Fig. 10.1 The majority world is littered with inappropriate medical devices that will never function in the environment to which they were sent

function in the environment to which they were sent (Fig. 10.1). "Few documented case histories are available to tell us what actually happens to used health care equipment that arrives in developing nations. However, the sense among some biomedical engineers and health care professionals who have extensive work experience in these countries is that less than 30%, perhaps as low as 10%, of used equipment ultimately becomes operational" [3]. This is the sad reality facing many visiting surgeons when they reach the place of service. Encountering inappropriate medical technology (equipment), a lack of medical devices, and broken equipment should be expected.

Procuring appropriate medical technology, training the staff on proper setup and usage, and having a maintenance support system remain a low priority and commitment for most organizations and LMIC healthcare facilities. "Economic changes and financial problems, and a growing burden of disease have contributed to an increasing dependence on donor assistance in the area of health care for many developing economies. This assistance usually includes physical equipment and spare parts, and in some countries, nearly 80 percent of health care equipment is funded by international donors or foreign governments. The introduction, utilization and maintenance of health care equipment require substantial financial, organizational and human resources. Often, this is either not recognized, or not enough attention is paid to it. In the Sub-Saharan Africa region, for example, a large proportion (up to 70 per cent) of equipment lies idle due to mismanagement of the technology acquisition process, lack of user-training and lack of effective technical support" [4].

Even without these realities, normal wear and tear on medical equipment is going to result in a need for regular service. The lack of biomedical technicians or any other technical support often leaves the clinical staff and surgeons responsible for repairing the equipment they are using. They are too often untrained and not up to the task. Anticipating these problems and being prepared to address them will help the surgeon respond quicker and more effectively to the needs.

Pre-trip Planning

Do not assume that the healthcare facility which you are going to will have all the required equipment, accessories, and supplies that you will need. Determine what equipment you will need, and contact the facility to verify what is already there and if the condition of the equipment is functional. Also, ensure that they have the required accessories and any spare accessories and/or supplies. Obtaining an accurate answer will be a challenge because most healthcare facilities in the LMIC do NOT maintain an active equipment inventory. Knowing what accessories are available and the condition of the equipment and accessories is an even greater challenge. If there is any doubt, arrange to have the needed equipment and accessories provided and/or plan to take some with you when you go.

Correcting the Failure

Despite your best efforts, your equipment has failed. Now what? Just as patient history is vitally important in diagnosing the medical problem, asking the correct questions and gathering historical information on the equipment and events leading up to the failure will better assist you with determining what exactly is wrong and how to correct it. Avoid making quick assumptions and carefully think through proper troubleshooting steps.

> When it comes to troubleshooting medical equipment failures, there is a tendency to jump to wrong assumptions and miss what might otherwise be the real problem. This is especially true in some limited resource settings where parts are not readily available and biomed training or troubleshooting skills have not been taught. Before jumping to conclusions and tearing into a medical device that does not appear to be working correctly, it is best to begin with the most obvious and likely problem areas. Taking a medical device apart should be the LAST step in troubleshooting the problem. [5]

Equipment problems and/or failures will almost always fall under one of the following four areas: **p**ower, **p**rocedure, **p**atient accessories, and **p**arts. Worldwide

Table 10.1 The four P's of troubleshooting

Power	The problem is related to some form of power issue. Loss, incorrect, etc.
Procedure	The problem is related to an operator error or incorrect procedure
Patient	The problem is related to a patient accessory or interface device
Parts	The problem is related to a failed internal part/component

Biomedical Charitable Services (WBCS) refers to these as "Rick's four P's of troubleshooting" (Table 10.1). Troubleshooting will become much easier to remember and perform if you use the four P's in your approach.

As a clinician, you know that a proper diagnosis of the patient not only includes the patient history but often access to the proper diagnostic tools and equipment as well. Likewise, when you are troubleshooting the medical equipment, you will need some basic tools and test equipment. It should be possible to carry a few small items if you are going to an environment that does not have those on site. The minimum tools would include regular and Philips screw drivers and needle nose pliers. The minimum test equipment should include a small multimeter that will read AC and DC voltage and impedance (resistance). Obviously, the greater assortment of tools, test equipment, spare parts, and disposable accessories you take, the better off you will be.

You've heard the saying "you are only as good as your tools" or "the right tool for the right job!" Successful troubleshooting and repair will require these. Finding these items when you reach your place of service will be difficult. Identify suggested tools and a multimeter that can be purchased locally before you leave (Figs. 10.2 and 10.3).

Fig. 10.2 Small basic tool kits come in handy while serving internationally

Fig. 10.3 Low cost meters can be found in stores

Power Problems

Always begin the troubleshooting process by checking all aspects of the power. Inspect power cords for connection, both at the power outlet and at the back of the device. Insure that the plugs are firmly seated at both ends. Also check the actual condition of the cords and plugs – if they appear worn, cut, or kinked near the ends, replace them. Power plugs from the UK that have three flat blades often contain fuses inside the power plug. These internal fuses occasionally blow and must be checked with a meter or the power cord substituted to verify it is good.

Verify the actual power condition and availability (voltage, frequency, stability, etc.). Is there even power at the outlet and is it at the proper voltage? Poor power sources may be poorly regulated, running too high or low, and can damage the equipment. Also verify that the power requirement of the device matches the power it is being plugged in to (the destruction of a 110 V piece of equipment is usually instantaneous if it is plugged into a 220 V system). It is common to find incorrect power plugs forced into outlets or inappropriate adaptors being used. This occasionally results in cords being plugged into the wrong voltage outlets (Figs. 10.4 and 10.5).

If the power outlet and power cord have been verified to be good and the device is still not coming on, check for blown fuses. Some fuses are easy to find and remove for inspection. Some will require a small screw driver to remove from the plug or fuse holder and others may be located inside the device and require the cover to be removed. Some glass fuses can be visually inspected and it is obvious when they are blown. Others, however, may not be visible or may even appear to be good, but are not. It is always best to verify with an ohm meter if one is available or simply replace the fuse.

Fig. 10.4 Power outlets will vary not only in styles but in voltage and frequency. Always make sure the device is plugged in to the correct power source

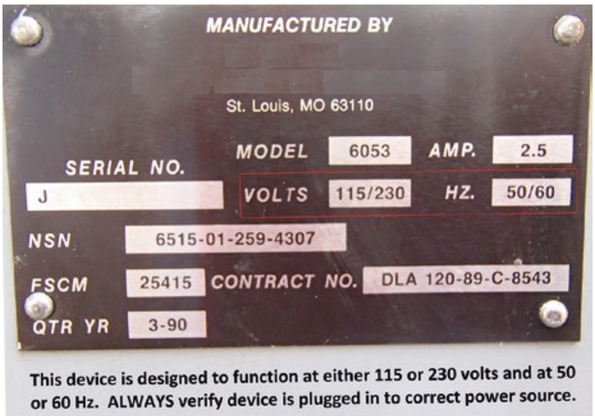

Fig. 10.5 Always check the equipment nameplate to verify the input power requirement

If a blown fuse is found and replaced and the device blows the fuse again, this is an indication there is a defective component inside the device. The device should be taken out of service and given to a qualified technician to inspect and repair. It is not uncommon to find insect or rodent nests and damage internally. Urine has been known to corrode contacts, components, and wiring, which can burn out power supplies or circuit boards. Chewed wires are also common. This type of damage is typically not repairable without further technical assistance and parts.

If the device is battery operated, check the condition of the batteries and ensure that they are properly installed. Batteries installed backward (or upside down) are a common problem and cause the device to not work. Rusted and/or corroded battery contacts inside the device will also result in failure, even when new batteries are installed. Do not make assumptions with batteries, but verify condition and proper installation. Replacement, if you are uncertain, may be the best way to check.

Keep all air filters clean, fans unblocked, and items off and away from the equipment to prevent overheating of the power supply. Proper air ventilation on some devices is critical.

Procedure Errors

User or operator errors are something no one likes to admit, but it happens especially when trying to use a piece of unfamiliar equipment. Because it is a difficult subject to address and safety has been compromised when users do not want to admit or attempt to cover up errors, the US health systems now refer to them as "procedure errors." The important thing is not to lay blame, but to correct the error and to prevent future errors. In the limited-resource environment where there may be limited numbers or no equipment user manuals available or where they are in a different and unfamiliar language, operator or procedure errors are more likely to occur. This problem is also exaggerated when the clinical users have not received proper training on the usage of the device.

It is vitally important, therefore, that questions are asked and procedures checked to verify the problem is not simply a problem of improper usage. Do not assume that the user is infallible. If you or the other clinical users don't know how the equipment functions, ask or find out how to operate the equipment correctly. If you are working in an environment with Internet access of sufficient quality, many times the user manual can be downloaded from the manufacturer or other technical websites.

Lack of proper handling of the equipment is also considered a procedure problem and referred to as equipment abuse in the US health systems. Equipment abuse results in more failures than most people realize and should be addressed when encountered. Additional details on abuse are covered under the patient accessories troubleshooting step.

Patient Accessories/Interface Failures

Damage from lack of care or abuse of the equipment often results in broken accessories or parts. Patient accessories or interface devices such as patient cables, blood pressure hoses, and pulse ox sensors are the weakest link in medical equipment. These parts receive the most stress, wear and tear, and will eventually all wear out and fail, even if the users give exemplary care. However, not handling these devices carefully will shorten their life expectancy.

Unless you have basic test equipment such as a multimeter and/or a patient simulator, verifying that the problem is in the patient accessories can be difficult. Your primary method of troubleshooting may be limited to visual examination and swapping out accessories. Closely examine cables, wires, hoses, sensors, or other small parts for kinks or worn areas. In limited-resource settings where single-use items are frequently used multiple times, worn-out accessories is a common problem. It is often obvious where the problems are located. Worn-out single-use sensors, electrosurgical pencils and patient return pads, and even electrocardiogram electrodes are frequently used beyond their ability to conduct signals. When in doubt, replace them.

Finding spare or replacement accessories is a frequent problem. Unfortunately, it is common to discover that the healthcare facility does not have or does not know where any spare accessories are located. You may be faced with equipment being placed out of service while waiting for new patient accessories to arrive. Therefore, as mentioned earlier, it is a good practice to arrange for or take spare accessories with you when you travel.

The lack of troubleshooting and repair skills is a frequent problem in the limited-resource environment, but it can be a politically and culturally sensitive area to address. National maintenance personnel often struggle with a lack of tools, test equipment, spare parts, and other proper repair resources. Moreover, a lack of troubleshooting training and experience often results in ineffective service attempts in most limited-resource environments. This is often manifested by the quick and haphazard repairs that use a variety of different tapes or materials to patch together broken wires and accessories. When patient accessories are found taped together, it is usually a safe assumption that the connections are insufficient. Replace these accessories as soon as possible.

To reiterate the previous quote, "Taking a medical device apart should be the LAST step in troubleshooting the problem" [5]. It is critical that these common causes and failures mentioned above be checked prior to opening the equipment and checking for internal part failures.

Parts Failure

Although most people assume the contrary, internal component failures are actually the least likely problem. Carefully check the other three "P's" of troubleshooting before determining the problem is a failed part inside the device. If it has been determined that the device has a failed internal part, consider the possible appropriate service options before disassembling the equipment. These options include repairing the device on site, waiting for a qualified service tech to come for a repair, and sending or taking the equipment to a location where it can be properly serviced. Disassembling the equipment by an inexperienced person who does not have diagnostic equipment and spare parts available is more likely than not to result in a non-fixable mess.

Equipment is often not repairable on-site without proper replacement parts. However, if qualified service personal are available and parts are available, then it is appropriate to have them check for and replace any missing or defective parts.

Unless the clinical staff member has electrical and/or mechanical aptitude, choose one of the following options:

- Leave a detailed note describing the problem or failure with the equipment so the qualified service people will know why it was taken out of service.
- If the service personnel are available, meet with them to discuss the problem. Service on equipment is most successful when the users discuss the details of the problem with the service techs.
- The last and often most appropriate option is to send the equipment out for repair or wait for qualified help to arrive. If you do not have the proper tools and test equipment (basic meter and/or simulator) to troubleshoot the device, you should not open it and make a bad problem worse. Asking another unqualified hospital staff person to service the equipment is equally dangerous or ineffective. A qualified service person will know their limitations (abilities AND resources) and will seek outside assistance if needed. Disassembling and fiddling with defective equipment when there are no parts to repair it only results in further damaging the equipment.

Common Failures

Because similar parts vary from one manufacturer and model to another, the list of general parts that will work in every device will be limited. Spare parts such as batteries, fuses, filters, light bulbs, electrical connectors, and patient accessories vary from device to device. Unless the healthcare facility where you are going has completed an inventory and evaluation of the medical equipment you will need to use, it will be close to impossible to anticipate what parts you should take with you to address problems. If, on the other hand, they evaluate their needs, you might be able to obtain a list of the parts to take. Therefore, asking for this information in advance is the only hope of obtaining appropriate spare parts to carry with you.

There are eight more common/critical devices that a surgeon will depend upon (Table 10.2). Three are specific to the operating room (OR) or surgery area (anesthesia, electrosurgical unit, and sterilizer), and the others will be found in the OR, postanesthesia care unit, ward, and/or other areas of the hospital.

Troubleshooting Examples

The following two troubleshooting examples occurred in 2015 in two African countries and illustrate how to follow the four P's of troubleshooting.

The first example was a nerve stimulator in Uganda that the anesthesiologist simply said "is not working." Although the handheld stimulator had no power cord, one should still begin with the evaluation of the first "P" – power. It still requires

Table 10.2 Common failures

Problems	Solutions
Anesthesia machine	
Pneumatic leaks	Check all patient circuits, hoses, gaskets, connectors/fittings
Incorrect readings	Check sensors, electrical cables and connectors, batteries
Patient monitor	
Poor ECG signal	Check skin prep and electrode condition
Poor or incorrect BP readings	Check hoses, connectors, and patient cuff
Poor or incorrect SAO_2 reading	Check condition of finger sensor
Electrosurgical unit	
Alarm going off	Check patient plate wires, connectors, and contact with patient
Poor cut and/or coag	Check proper patient plate contact with patient skin
No cut or coag	Check footswitch and/or pencil condition
Oxygen concentrator	
Low airflow	Check all filters (external and internal)
Low O_2 percent (meter needed)	Check filters, proper power source, age of concentrator
Suction pump	
No or low suction	Check filters, hoses, suction adjustment
Running slow and/or hot	Check proper power source (specifically the frequency)
Defibrillator	
Will not operate if unplugged	Battery low or dead
Poor ECG signal or display	Check skin prep, electrodes, and patient cable
Pulse oximeter	
Will not operate	Check battery condition
No or poor patient signal	Check finger (SAO_2) sensor (connector, cable, sensor)
Sterilizer	
Will not come on or heat	Check power source. Check steam generator
Will not sterilize	Check door gasket, steam traps, and piping for leaks

power to operate. Therefore, the 9 V battery was removed and checked with a meter. The battery was indeed low (4.5 V) and needed replacement. The second “P” (procedure) troubleshooting step was not evaluated because the doctor was known to be experienced in the proper operation of the stimulator. However, as a reminder, it is not logical or safe to always assume the user fully understands the operation of the device. The third “P” (evaluation of the patient accessories or interface) was then undertaken. In the case of this stimulator, it was designed with two lead wires that connect the stimulator to the patient. One of the two wires was broken and needed repair. The stimulator was now returned to full function. After following the four P’s approach to troubleshooting, it was discovered that the stimulator failure was both a power problem and patient interface problem, and it was quickly and easily repaired and returned to service.

The second example was a patient monitor in South Sudan. The initial complaint by the clinical staff was a very poor ECG signal and display on the monitor. The QRS signal was barely visible and consisted of mostly interference or artifact. Since the monitor was on and all other parameters are functioning well, and it was a monitor designed to work on both 110 V 60 Hz and 220 V 50 Hz, it was assumed that the first P, power, was good. The next P, procedure, is often a problem with when there is a poor QRS signal on monitors. Therefore, the lead setting on the monitor and the lead placement on the patient were checked and found to be okay. However, the clinical staff admitted that the skin prep on the patient was not completed correctly when the electrodes were applied. Additionally, the patient electrodes were old and dried out. Once the skin was prepped correctly and new electrodes were installed, there was an improvement on the signal on the display. Nevertheless, the signal still had a significant amount of artifact. The next P, patient interface, was checked, and it was determined by the use of a simulator that the patient cable and lead wires were found to be good. At this point, it was assumed the final P, part, had failed in the monitor. Before concluding that the problem was an internal failure, there was one last attempt to troubleshoot the problem by going into the "advanced settings" mode of the monitor. This will not be easy if you are not familiar with the monitor and don't have a manual available. Fortunately, this function was found, and upon investigation, it was found to have a software setting to set the monitor for 50 Hz or 60 Hz operation. The monitor was set for 60 Hz but was plugged in to the typical 50 Hz African power source. Once the monitor setting was reset for 50 Hz, the frequency interference disappeared, and the monitor had a clean QRS display. Therefore, the problems were primarily procedures which included poor skin prep, an improper power setting, and patient interface (dried electrodes).

Preventing the Failure

The Essentials

- *Everyone (admin, clinical, technical, and support staff) can help prevent failures.*
- *Appropriate technology procurement is the first step in preventing failures.*
- *Proper usage and handling of equipment is the next step in preventing failures.*
- *Developing and following an equipment management plan prevents most failures.*

Preventing future equipment failures and problems are often not considered or are left up to maintenance personnel. However, users and clinical staff play an important role in preventing a variety of failures. The three basic prevention steps include

Table 10.3 The three P's of prevention

Proper care	Handle the equipment carefully and keep clean
Performance check	Verify proper operation and performance before every use
Preventive service	Replace worn accessories and parts before they fail

proper care and use of the equipment, evaluating the performance of the equipment each time it is used, and performing basic preventive service before the failures occur (Table 10.3).

Proper care of the equipment starts with proper cleaning and careful handling. All filters should be checked and cleaned on a regular basis. Some are designed to be blown out and/or washed, and some are disposable and will need to be replaced. Failure to keep air filters clean may result in equipment overheating and component failures. Dirty air filters on oxygen concentrators will also affect the oxygen output, and concentrators typically have both internal and external filters that will need cleaning and replacing. Some equipment, such as sterilizers, also have water and/or drain filters that must also be checked and cleaned on a regular basis. One very common failure with suction pumps can be traced directly to the filters. The most common filter problem on pumps is with bacteria filters that may appear to be just fine, but become clogged and prohibit airflow. A defective bacteria filter can be easily verified by simply bypassing the filter to test.

Being proactive with your facility by encouraging the addition and regular use of protection devices against "bad" electricity can go a long way toward prevention of unwanted damage from bad power. A simple inexpensive surge protector can reduce or eliminate damage caused by short-term spikes coming into your medical equipment's power cord. Lightning and other surge currents caused by "noisy" equipment being used nearby can send thousands of volts of a very short duration that may not blow the protective fuse, but will damage delicate electronics contained within your ultrasound machine or patient monitor. These simple plug-in devices isolate your medical equipment from spikes simply by clamping the incoming current at a manageable voltage.

Sustained low voltage (commonly called "brownouts") forces many medical devices to try and compensate by increasing their draw of current from the line. This generally overheats your suction pump motor or compressor unit. Voltage correction transformers sometimes called regulators are step-up/step-down transformers that can maintain the proper operating voltage when your source becomes lower or higher than normal. These units cost more but will pay for themselves many times over. Brownouts are common in LMIC and can be as dangerous as unprotected power surges to electronic equipment.

The ultimate power protection device is an uninterruptible power supply (UPS). These devices contain a storage battery and inverter that produce their own power that is clean and carries you through both "brownouts" and complete power losses. The UPS will continue to operate until the battery loses its charge. This gives the clinician time to complete the surgery case or the ultrasound study without

Fig. 10.6 This electrosurgical unit/Bovie pencil connector was damaged from an improper cleaning solution

interruption. These UPS units must be sized according to the load being provided but are generally available in many developing countries city centers. They are the most expensive solution and can be bulky, but properly sized, they can provide clean power for everything from cell phone chargers to CT scanners.

Cleaning should be performed for obvious reasons, including infection control and damage from dust and dirt. Make sure the cleaning materials or fluids are appropriate and will not cause damage to the device or accessories. Improper cleaning procedures or materials could result in damage such as the electrosurgical unit pencil connector (Fig. 10.6). The contacts corroded because the users plugged in the pencil when it was still wet with a corrosive cleanser, and this resulted in a poor connection between the pencil and the device.

Proper care and handling of the equipment and accessories is essential. The patient accessories or interface devices are the weakest link in medical equipment. Therefore, all users must treat the devices and accessories with respect and understand they are susceptible to easy breakage. An example of how not to care for the patient accessories is shown in Fig. 10.7. Pulling on cables, hoses, and wires and/or wrapping them too tightly will cause internal breakage of wires that cannot be seen or leaks in hoses and connectors. Clinical staff should be trained and reminded of the importance of proper care.

Fig. 10.7 This is not the correct care and handling of patient accessories. Note the kinked blood pressure hose near the connector

Encourage the Development of a Medical Equipment Management Plan

US healthcare regulations require regular performance and safety (PAS) inspections. This is not optional in the USA and insures patient safety and properly operating equipment. PAS inspections and tests can be performed by both the users of the equipment and biomedical technicians. These inspections fall primarily on the clinical staff in most limited-resource countries where there are no available biomed techs. Prior to using a medical device on a patient, the user should visually and functionally inspect the device and verify it is performing properly.

US healthcare regulations also require regular preventive maintenance (PM). This is also occasionally referred to as planned preventive maintenance (PPM). Although PMs are typically carried out by biomedical technicians, preventive service can and should be performed by the clinical staff when biomed techs are not available. Preventive maintenance means replacing parts before they fail. These types of parts are typically mechanical parts that wear out, for example, clogged filters, and/or the patient accessories that wear out over time and usage. Lubrication of mechanical parts is also considered a PM. The lack of ready availability and the expense of replacing a part that is "still working" make this difficult to implement in limited-resource areas and cultures.

Procurement of appropriate technology (medical equipment, parts and accessories) is one of the most effective ways of preventing problems. Whether or not you are personally involved with procuring medical equipment, parts, or accessories or you have the opportunity to make recommendations to the healthcare facility where you are working, make sure you know the source of the equipment or parts. As mentioned earlier, "a large proportion (up to 70 per cent) of equipment lies idle due to mismanagement of the technology acquisition process" [4]. This is a result of using donors or providers that are not familiar with appropriate technology transfer to LIMC environments. Even though the provider has good intentions and wants to help, their available equipment and/or parts may not be suitable for the environment to which it will be sent.

One way to ensure you are obtaining the most appropriate technical resources and support is by utilizing organizations and individuals that adhere to quality standards and have experience working in LMIC environments. Technical Exchange for Christian Healthcare (TECH) is one example of an association of many healthcare organizations and individuals who follow quality standards. "Sharing their resources, knowledge, and expertise, TECH members are committed to providing functioning, appropriate, sustainable medical equipment. Believing that our work reflects our Christian testimony, TECH members are attentive to the quality of items sent to the mission field" [6]. These "standards" [7] help insure the technology will be most appropriate for the environment and application it will be sent to and that all aspects of the transfer (packing, shipping, installation, training, parts and manuals, etc.) will be carefully considered. For a list of the current TECH members with links to their websites, go to www.techmd.org/membership/. These members include:

- Chosen http://www.chosenima.org/
- International Aid http://www.internationalaid.org/
- Samaritan' Purse http://www.samaritanspurse.org/

Summary

Anticipate and plan for equipment problems before and during your time of service. Plan ahead and take any critical devices, accessories, or supplies that you anticipate needing if there is no guarantee that they will be available on-site when you arrive. Expect that you will encounter existing problems and some will develop while you are there. Follow the four P's of troubleshooting to ensure a quick and most effective resolution to these problems.

Prevent future problems by performing preventive service and encouraging the national staff or hospital management to seek appropriate future procurement and service.

Lastly, seek help from those with international medical technology support experience. This should be done before, during, and after your travel to the field. Encourage hospital leadership to manage their technology correctly the first time and not put Band-Aids on their problems.

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Frugal and Reverse Innovations in Surgery

11

Matthew Prime, Yasser Bhatti, and Matthew Harris

Overview of Frugal and Reverse Innovations and Relevance to Surgery

The Essentials

- *Drivers for healthcare in low-income countries are converging with those in high-income countries.*
- *Frugal innovations offer potential for low-cost and high-quality global surgery.*
- *Reverse innovations diffuse solutions from low-income to high-income contexts.*

In this chapter we outline emerging trends in innovation, specifically frugal and reverse innovations, and their relevance to global surgery for both high-income and low- and middle-income countries (LMICs). Increasing attention is being afforded to bending the growth cost curve by developing new solutions or drawing from different solutions in LMICs.

M. Prime, MBBS, BSc, MRCS (✉) • Y. Bhatti, DPhil, MSc, Mot, FHEA
Division of Surgery & Cancer, Institute of Global Health Innovation, Imperial College London, 10th Floor, QEQM building, St. Mary's Hospital, Praed Street, London W2 1NY, UK
e-mail: mprime@imperial.ac.uk; yasser.bhatti@imperial.ac.uk

M. Harris, DPhil, MBBS, MSc FFPH
Division of Surgery & Cancer, Institute of Global Health Innovation, Imperial College London, 10th Floor, QEQM building, St. Mary's Hospital, Praed Street, London W2 1NY, UK

Department of Primary Care and Public Health, Reynolds Building, St Dunstans Road, London W6 8RP, UK
e-mail: m.harris@imperial.ac.uk

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Escalating demand for healthcare and constrained resources has traditionally been seen as challenges limited to LMICs. However slower economic growth rates and soaring healthcare costs particularly in the USA and the UK are contributing to unsustainable spending. Economic challenges combined with social challenges reflected by, for instance, the increasing prevalence of the burden of noncommunicable disease suggests the convergence of challenges facing global healthcare systems. While consideration for quality healthcare has been paramount in high-income countries (HICs) and affordability as an added metric has been considered important for the socially and economically disenfranchised, both are now becoming equally important for everyone, even the socially and economically well off.

As global healthcare leaders wrestle with the problem of how to improve competitiveness while simultaneously reducing costs and improving quality, the idea of developing frugal innovations or adopting reverse innovations as a way of tackling these challenges is gaining prominence. Popular examples of frugal innovations in surgery include Narayana Heart Hospital, Aravind Eye Care System, Jaipur or ReMotion knee prosthetics, and hernia repair using mosquito net mesh.

Frugal innovation and reverse innovation are often conflated, yet there is a clear distinction. Frugal innovations entail affordability as a key characteristic and have traditionally been associated with LMICs or emerging markets [1–3]. Reverse innovations are associated with diffusion of such low-cost or frugal innovations from low-income to high-income settings [4]. Once frugal innovations are identified or developed, they can then be assessed for reverse ability from low- to high-income contexts.

Frugal Innovation

By taking out costs and increasing efficiency, transforming care delivery, expanding access to quality care, improving patient outcomes, and increasing the sustainability of the health system, frugal and reverse innovations have the potential of beneficially disrupting current and sometimes outmoded health system practices.

Frugal innovation gained much global traction from mainstream publication in The Economist in 2010, which presented several healthcare innovations, both product and process, including the GE's MAC 400 ECG machine, a medical device reengineered to focus on simplicity and cost reduction available for $800 [5]. The definitions of frugal innovation prevalently found in existing literature are governed by concerns for low cost and sourcing from developing or emerging market countries and have relevance for global surgery. In the management consulting literature, Ernst and Young (2011) define frugal innovation as the economical use of resources to provide products affordable to those on a lower income [6]. In academic literature, scholars call frugal innovation as simply "toned down" and "good-enough products" [7] or low-cost products [8, 9]. Definitions by Gupta and Wang [10], Zeschky et al. [11], Tiwari and Herstatt [12], and George et al. [13] are familiar to those found in Govindarajan and Trimble's work on reverse innovation. The process of frugal innovation may redesign products [11], reconfigure value chains [14], or rebuild entire ecosystems [15, 16]. In essence frugal innovation is a label that captures a range of heterogeneous activities, which cut across different sectors [17].

Drawing from extensive study of what entails frugality in innovation, we see frugal innovations as "means and ends to do more with less for many" [18]. Frugal innovation can be more affordable for the producer, provider, or patient, but should ideally have potential impact on a global scale for population-wide or system-wide benefit. Our adopted definition of frugal innovation is hence broad, such that it encompasses examples where inputs and outputs are less costly but also where things are done more efficiently or where innovations provide wider access to larger populations through their scalability [19].

People often equate frugality with poor quality, especially if its sources are unconventional, and this makes the diffusion or adoption of the innovation particularly challenging in healthcare where quality and patient outcomes are key metrics of success. Indeed frugality is about affordability, but in moving beyond early perspectives of frugal innovations as simply "good-enough" or "no-frills" products, we must recognize frugality is also about adaptability and accessibility – key issues confronting healthcare professionals challenged with improving access to care while simultaneously reducing costs and improving quality.

Reverse Innovation

Reverse innovation is defined as "any innovation that is adopted first in the developing world" [20]. This means learning from, or diffusion of, the innovations that low-income countries have themselves developed and perhaps even scaled to high-income countries. Woolridge in The Economist refers to both frugal and reverse innovation in mainstream practitioner outlets, by writing "Frugal innovation radically redesigns products and services to make them much cheaper for the emerging middle class – and then re-exports them to the West" [5].

In healthcare circles, this has become somewhat of a movement. In 2012, an ongoing thematic series in the journal *Globalization and Health* set out to explore and promote "reverse innovation." In 2013, the Ivey International Center for Health Innovation issued an open call to invite proposals for "reverse innovations" that could address Canada's health system challenge [21]. The International Partnership for Innovative Healthcare Delivery (IPIHD), recently renamed Innovations in Healthcare (IIH) formed out of a partnership between the World Economic Forum, Duke University, and McKinsey & Company, operates a "reverse innovation" working group to address how successful innovations in healthcare delivery from low-income settings can be replicated in high-income settings. In 2016, the US Commonwealth Fund commissioned case studies of frugal innovations for applicability to the US health system.

Some reasons for this shift in emphasis on the directionality of learning include the North-South model of development, rooted in postcolonial assistance, which has been heralded as archaic [22]. Development has been called into question as an industry that is often self-serving [23–25] and failing to demonstrate significant change [26, 27]. Also, the global health landscape has changed dramatically. Power and influence are more diffuse with a proliferation of significant new actors [28, 29], and emerging economies continue to challenge established markets. There are many examples of impressive health innovations originating from LMICs. These have the potential to disrupt health systems in the Global North; indeed there are many reasons why the bloated healthcare economies of high-income countries could benefit from leaner innovations and out-of-the-box thinking.

Relevance to Surgery

Surgical procedures that embody frugality and innovation offer potential for disruptive cost reduction and global accessibility. Examples of frugal innovations in surgery are diverse ranging from additive manufacturing or 3D printing to produce surgical tools to lean manufacturing and task shifting techniques to achieve economies of scale such as at the Narayana Heart Hospital or in the Aravind Eye Care System [30–32]. Other examples include the Jaipur prosthetic knee, the Arbutus Drill Cover for orthopedic surgery, and hernia repair using mosquito net mesh. An understanding of these cases and their relevance to the surgical field can help offer lessons in developing high-impact and cost-effective solutions that address the intensifying challenges of burgeoning budgets, financial accountability, and finite resources.

Dr. Devi Shetty is a renowned Indian cardiac surgeon and founder of Narayana Health, who at his hospital in Bangalore has been able to decrease the cost of cardiac surgery to $1,500 per operation, compared with $144,000 in the USA, $27,000 in Mexico, and $14,800 in Colombia while at the same time maintaining quality (1.4% 30 day mortality from coronary artery bypass surgery vs. 1.9% in the USA). In effect his organization has evolved cardiac surgery to a production line: maximizing the number of operations while improving quality through procedure repetition [5, 30].

Aravind Eye Hospital has been on a mission since 1976 to end blindness in India seeing 2.5 million patients a year [32]. Today Aravind is the largest eye surgery provider in the world. Among its highly touted technical and social achievements are dropping the imported price of intraocular lenses from $200 apiece to locally produced $5 apiece. It costs $10 to conduct a cataract operation that lasts just 20 min, and currently around 300,000 eye surgeries are completed each year. Aravind achieves a gross margin of 40% despite the fact that 70% of patients receive free or heavily subsidized rates. By comparison, the average cost for this eye procedure in the USA is about $1,650. The hospital's Aurolab, which pioneered the production of high-quality, $5 low-cost intraocular lenses, produces 700,000 lenses each year, of which three-quarters are exported all over the world. However, the lenses are not exported to the USA since Aravind cannot afford the costly US-FDA clinical approval process [31]. With less than 1% of the country's ophthalmic manpower, Aravind accounts for 5% of the ophthalmic surgeries performed nationwide [32]. The hospital network uses broadband for rural screenings. "We are going from village to village to provide eye care to the unreached," says Aravind's chairman, Dr. P. Namperumalsamy [31].

Narayana and Aravind have successfully scaled in home contexts, but are finding replication elsewhere challenging. Although more evidence is available on the efficacy and safety of mosquito mesh for hernia surgery, advocacy for the diffusion for global surgery is limited to resource-constrained contexts [33]. Howitt et al. (2012) advocate that policy makers and the medical establishment still need to act quickly in order not to repeat the delay seen in the adoption of oral rehydration therapy [34]. Even with lack of prevailing evidence, the scale of economic and social advantages of alternative surgical techniques in low-income countries may outweigh the minimal clinical disadvantages [35]. See the section in “Chap. 3 The Economic Case for Surgical Care in Low Resource Settings” that speaks to the financial calamity resulting from not investing in essential surgery.

Surgery entails products and processes. But products or processes of frugal innovation are not mutually exclusive – in fact they are interdependent and complimentary – but the delineation helps to provide a helpful starting point for investigating the different challenges and in identifying the kind of frugal innovations that are likely to have the biggest impact. However, research suggests to move beyond the focus on technology innovation and think also along social innovation and institutional innovation as well as needs and motivations of users or innovators such as user driven, efficiency driven, challenge driven, and social driven [17].

We know little about the motivations and strategies of frugal innovators and how clinicians and engineers and designers can better work together to co-develop frugal and reverse surgical innovations. Interdisciplinary design spaces such as Helix at Imperial College London provide a place for interaction and lives up to Donald Schön’s work on reflective practice (1983), where the joint practices of clinicians and designers come together and can be critically assessed by scholars [36].

This interdisciplinary approach informs healthcare but also other sectors. While some frugal approaches to process innovation have been inspired by the techniques and philosophy of lean production, first developed in the car industry, frugal approaches to produce surgical innovation may have the potential to in turn inform the car industry in how to design automobiles.

Identifying and Understanding Methods for Frugal and Reverse Innovations in Surgery

The Essentials

- *Frugal innovations need to be identified beyond case analysis*
- *Strategies to evaluate the “reversibility potential” of innovations from LMICs must be developed*
- *Innovators are using various methods to achieve frugality*

Current academic literature identifying examples of frugal innovations in healthcare is limited, and authors have often drawn on the examples of Narayana Healthcare [17, 37, 38] and the Mac 400 ECG4 [11, 38, 39] to build theories or illustrate conclusions. Although these examples are important, their impact is limited to the specific conditions and problems they were developed for. Current work suggests that innovators are widely embracing the concept of frugality to solve a variety of different healthcare challenges [40].

Identifying Frugality

In order that frugal innovations can be evaluated, studied, and disseminated into the health sector, they must first be identified or assessed as "frugal innovations." Unfortunately, in-depth case study analysis of all new innovations is not practical; therefore, tools must be developed to help healthcare leaders more easily scan for promising frugal solutions; the authors at Imperial College London have developed an empirically derived frugal identification tool based on the key definitional components of affordability, adaptability, and accessibility outlined by Bhatti [17]; subsequent testing has identified a cohort of frugal innovations in healthcare, many of which are applicable to the field of global surgery [40] (Table 11.1).

Assessing Reverse Ability

For healthcare systems in developed countries to benefit from innovations conceived in resource-poor contexts, strategies must be developed to identify and stratify innovations with the greatest potential. Govindarajan and Trimble [20] state that "reverse innovations can flow uphill by penetrating marginalized markets after a delay during which trends close the gap between rich-world and poor-world needs." In other words the more deprived areas of a developed economy have challenges more aligned with developing economies, as such the innovations are more applicable. Further, they propose a framework based on how an innovation demonstrates convergence in five "needs gaps": performance, infrastructure, sustainability, regulatory, and preference. However, further research is required in healthcare to evaluate how such frameworks might be used in practice.

Methods Used in Frugal and Reverse Innovations

Understanding the fundamental dimensions employed by an innovation to "do more with less, for many" [19] will help innovators identify important strategies to foster their own creative efforts. Initial work by Prime et al. (2016) has shown that for frugal product development, the concept of simplification and user-centered design is critical [40]. A group from Arbutus Medical, based at the University of British Columbia (UBC), Canada, working in 14 developing nations worldwide, has developed the Drill Cover Hex (Fig. 11.1), an ingenious solution to allow surgeons to safely use a low-cost hardware drill for surgical procedures, by only sterilizing a drill bit and attachment instead of entire drill, dramatically reducing the cost.

Table 11.1 Frugal innovations for healthcare [40]

Frugal innovation	Innovation description
Arbutus Drill Cover	Arbutus Medical has developed a $400 alternative to $30,000 surgical drills, allowing safe and effective treatment of patients in resource-constrained settings
BRACI Smart Ear	BRACI is a product and platform which is able to detect a wide range of sounds in the environment and deliver a notification about that sound to any medium the user has specified, for example, in the form of a message on a screen
eACCESS	The eACCESS initiative aims to make critical care specialists available round the clock in order to provide high-quality care to patients in the ICU
Fosmo Med	Fosmo Med is changing the paradigm of pre-filled IV bags by utilizing innovative forward osmosis technology to create sterile intravenous solutions at the point of care
JANMA	JANMA by AYZH is a US$3 clean birth kit containing six simple tools recommended by the World Health Organization (WHO) to ensure sanitation and sterility at the time of childbirth
Miroculus	Miroculus has developed an accurate, easy to use, noninvasive, and affordable microRNA detection platform that can radically improve the ability of life science research and healthcare providers to diagnose, treat, and monitor diseases at a molecular level through the examination of microRNAs
Mother's Delivery Kit	Mother's Delivery Kit contains sterile products a woman needs during childbirth to avoid potentially fatal neonatal complications, such as tetanus due to a lack of clean blades and sepsis caused by delivering children in unsanitary conditions
PEEK vision	Peek – the portable eye examination kit – makes eye tests affordable and easy anywhere in the world by leveraging smartphones with specialist adapters and software
Possible	Possible is a nonprofit healthcare company that, using an innovative health system model, delivers high-quality, low-cost healthcare to the poor
Pro Mujer	Pro Mujer's "Integrated Women's Empowerment and Healthcare Model" ties the delivery of healthcare services to the delivery of microfinance services to increase coverage and access among low-income women in Latin America
Pumani BCPAP	The Pumani BCPAP is a low-cost respiratory support device used in the treatment of respiratory illness in infants and young children
Robohand	The need for affordable, functional upper limb replacements is immense. Robohand components are 3D printed using polylactic acid (PLA), derived from renewable resources such as corn starch, tapioca roots, chips or starch, or sugarcane
Smile Train	Smile Train is an international children's charity with a sustainable approach to a single, solvable problem: cleft lip and palate
SughaVazhvu Healthcare	SughaVazhvu trains underutilized AYUSH (alternative Indian medicine) physicians to provide evidence-based primary care using clinical protocols developed in association with the University of Pennsylvania
Ziqitza Healthcare Limited (ZHL)	Ziqitza Health Care Limited (ZHL) operates 1,280+ ambulances, with 6,000+ staff, in 17 states across India and the UAE. They use a tiered pricing, user-fee-based business model in India wherein patients are charged based on ability to pay based on the patient's destination

Fig. 11.1 The Drill Cover Hex (formerly the Arbutus Drill Cover) developed by Arbutus Medical (Image courtesy of Arbutus Medical, a medical company that spun out of UBC)

Fig. 11.2 "Portable eye examination kit" (Image courtesy of Peek Vision)

Prime et al. (2016) also saw that harnessing emerging technologies such as digital platforms and 3D printing could achieve more with less [40]. For example, a UK team focused on reducing blindness has produced a "portable eye examination kit" called PEEK, using a smartphone application and lens adapter (Fig. 11.2). A validation study has demonstrated that image quality is comparable to a standard desktop retinal camera, furthermore, they suggest that the ease of image capture will allow community health workers (CHWs) to perform critical tests to identify the avoidable causes of blindness in underserved rural communities, which makes this an attractive public health intervention [41].

As well as employing user-centered design to understand the needs of frontline health workers, Prime et al. (2016) also report the importance of supporting grassroots innovators, such as the South African pioneers behind a 3D-printed prosthetics company [40]. In May 2011 the founder suffered a woodworking accident severing all the fingers on his right hand. During his recovery, he discovered that there were no suitable finger prosthetics and that other limb prosthetics were largely unaffordable for the everyday South African citizens. Using his engineering and entrepreneurial skills, he formed Robohand, a company which now produces customizable, affordable, 3D-printed prosthetics. Impressively, the designs have been open-sourced to decrease the barriers to access.

Critical to providing improved surgical care to underserved communities is advances in service delivery. Prime et al. (2016) demonstrate that care providers can consider multiple ways to achieve more with less [40]. The economies of scale approach, as championed by Narayana Healthcare (NH) and the Aravind Eye Care System (AECS), is a well-known model and has well-documented cost reduction benefits. However, both NH and AECS employ several other strategies within this model to achieve their results. For example, AECS uses a cross-subsidization strategy, where service provision is supported by revenue from manufacturing ophthalmic lenses. Ziqitza Health Care Limited also use a cross-subsidization model; however, rather than supporting services from a separate revenue stream, they supplement the cost of transport to public hospitals with higher charges for those going to private hospitals [40].

A current popular organizational strategy to decrease human resource costs and combat skills' shortages is to adopt task shifting or task sharing, whereby tasks are delegated, if appropriate, to less specialized health workers. For example, surgeons operating at NH and AECS concentrate their efforts in the operating room, while the nursing staff provides pre- and postoperative care. Prime et al. (2016) suggest that in most cases, "task shifting" is supported by a protocol or product, which makes the previously complex task easier and safer [40].

It is hoped that widespread system adoption of frugal innovations will contribute to current efforts by healthcare leaders to bend the cost curve. However, like any innovation there are enablers and barriers to the diffusion process; many of these solutions originate from nontraditional sources, and as such we should anticipate that the pathway for adoption will be challenging.

Barriers and Challenges to Frugal and Reverse Innovations

The Essentials

- *Diffusion of innovation is complex, and learning from low-income countries is even more complicated.*
- *Frugal and reverse innovations face social and cognitive barriers to adoption mainly associated with source.*
- *A culture of collaborative innovation is vital to overcome challenges to adopting frugal innovations from low-income countries.*

Diffusion of innovation in healthcare is not linear; its pathway is chaotic and thorny [42]. The "standard" attributes of an innovation ripe for adoption should have a relative advantage, be compatible with the norms of the adopter context, be perceived as uncomplicated with observable benefits, and, finally, hold potential for reinvention [43]. Creating space and time for learning, but also being able to remove old ways of working, delayering so that new processes do not accumulate are all important [44].

Innovations from low-income countries are developed in very different regulatory environments to high-income countries, and this, on its own, challenges their spread into other contexts. However, learning from low-income countries and adopting their innovations into high-income countries is complicated further by issues related to social and cognitive biases associated with the source of the innovation. The role of the innovator context in the spread of the innovation is an important consideration and one which is of particular importance in reverse innovation.

Learning from and adopting innovations from low-income countries has certain complexities arising from the fact that these countries may be considered, by some, to be "unusual" sources of innovation [45]. There can often be preconceptions regarding the relevance of, and likelihood that learning will come from, low-income countries [21, 45]. A legitimate source is therefore important for innovation diffusion, but little is known about how legitimacy is defined or perceived. The diffusion of innovation literature is curiously silent on whether one's view of the source of an innovation matters in the diffusion process. Greenhalgh et al. (2004) mention that the innovator context should be a "legitimate" source but then does not explain what constitutes "legitimate" [43].

Source as Barrier

The effect of source has been well documented in the marketing literature. Bilkey and Nes (1982) showed that consumers tend to rate products from their own countries more favorably and that consumer preferences are positively correlated with the degree of economic development of the source country, probably evoked by the lower price cue of low-income country products [46]. Up to 30% of the variance of consumer product ratings can be attributed to the product's country of origin [47] and respective regulatory environments. Products developed abroad in general are perceived as "riskier" than products developed in one's own country. Overall, country of origin has significant effects on consumer brand attitudes [48], and the country of origin of a product serves as a conflated, stereotyped measure for other product attributes [47].

In practice, although much emphasis is given to assessing the quality of the research, we know little about how we individually value the research. We may each reach a different conclusion as to whether research presents strong evidence and whether we consider the research useful. There is some evidence to suggest that these issues of source may be playing out in practice in healthcare research. A rigorous randomized control trial (RCT) may convince a surgeon to change a certain practice, but may not have the same effect on a primary care physician [42]. Communities of practice develop "ways of working" (clinical, intellectual, professional) that can be relatively inaccessible to nonmembers of the group. McGivern and Dopson (2010) refer to this as "epistemic communities" and is a barrier to the transfer of knowledge, expertise, and experience between groups [49].

Even in research, the issue of source may be influencing researchers' interpretation of evidence. Ideally, research findings ought to be judged on the strength of the evidence and their relevance. However, there is some subjectivity involved in interpreting research [50]. Research certainly does not "speak for itself" – we give it a voice, and how we judge whether one piece of research constitutes evidence or not is complex and messy. Harris et al. (2015) found that there is some evidence to suggest that the country of origin matters in research evaluation and publication [51]. In their randomized, controlled trial, they showed that a source from a low-income country negatively influenced US public health professors' opinion of research abstracts in some instances. Participants were more likely to refer one abstract, of the four abstracts that were included in the study, to a peer if the source was from a high-income country compared to a low-income country (OR 1.28; 95% CI 1.02–1.62), all things being equal [51]. Although the effect size was small under experimental conditions, it may be "clinically" significant considering how much research is published and consumed on a daily basis.

Although the regulatory contexts and practice environments are very different in a low-income country, compared to a high-income country, at a granular level, the differences are unlikely to be more than with any other high-income country. All contexts will have cultural, regulatory, economic, and financial differences, and it can be as challenging to adopt an innovation from a neighboring hospital as from another country. In the case of reverse innovation, low-income contexts are *perceived* to be very different, and this perception can influence one's view of the country as a potential source of innovation. Cultural relevance is a significant issue and is as relevant in high- to low-income country diffusion as the other way round.

How to Overcome This Challenge

Reverse innovation is a complex and fragmented process: one with no particular institution in charge and with blurred lines between supply and demand. Following Rogers (2003), DePasse and Lee (2013) suggest that due to these unique challenges, reverse innovation requires a particular type of "crossover" from low-income country early adopters to high-income country innovators [52, 53]. A culture of collaborative innovation will be vital to overcome challenges to adopting frugal innovations from low-income countries. Reverse innovation requires "spannable social distances" bridged by policy makers, entrepreneurs, and health system leaders and utilizing diverse channels such as conferences, learning collaboratives, and online resources [53]. The actors driving this process may include innovation think tanks, health policy organizations, and foundations, and their work is to create demand – demand for the innovation and demand for local service providers interested (or persuaded) to pilot or adopt the innovation. The recent emergence of "curator" organizations that collate frugal innovations from around the world, including low-income countries, is potentially important actors in spanning these social distances. Curator organizations identify frugal innovations of potential value in home country contexts and are able to identify innovations from low-income countries that are "off the radar" of more traditional knowledge sources, such as the peer-reviewed medical literature. Research is needed to explore the degree to which these knowledge bases help to persuade a greater adoption of healthcare innovations, whether frugal, reverse, or otherwise. More research is needed to better understand the specific challenges related to adopting global innovations and specifically those from low-income countries.

If we are to see greater adoption of frugal and reverse approaches, we have to make the case that innovations from low-income countries are as legitimate as from anywhere else. Such convincing can be achieved by supporting teams of frugal and reverse innovation champions who are tasked and equipped to fit into the health system. The teams can be comprised of disease identification and system champions, to evaluation of evidence of impact and cost, to overcoming regulatory and legal barriers. A culture of collaborative innovation is vital to address the challenges that lie ahead for effective and sustainable healthcare systems. But the dearth of "evidence" that accompanies the diffusion potential of frugal innovations – whether that's because the evidence is distrusted because of its source or because of a lack of methodological rigor – needs to be overcome through cultural change.

Conclusion

Affordable and quality healthcare is needed not only for the socially and economically disenfranchised but also at more sustainable levels for the socially and economically well off. In particular, surgical innovations that embody frugality while upholding standards of quality and safety can be transformative for both developing and developed healthcare systems. But there are challenges of leveraging frugal innovations from development to reverse diffusing them to high-income countries, particularly in the healthcare sector. While global surgery can leverage evolving models of frugal innovation for the benefit of global populations and markets, this effort also presents an opportunity for the practical and policy discourse in frugal and reverse innovation to benefit from experimentation and evidence collection that may inform other sectors beyond healthcare. We are only beginning to understand these issues, and there has been some headway in collecting evidence of the potential benefits of frugality in healthcare innovations as well as obstacles to their adoption in LMICs. Yet we need further research on the development, adaptation, and adoption of frugal innovations and efforts to diffuse evidence-based policies among decision-makers worldwide to reduce inequalities in global surgery for generations to come.

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12 Getting Started: Connecting to Global Surgical Opportunities

Domenech Asbun, Lena Lea Kassab, and Horacio J. Asbun

Background

There are seemingly endless different settings across the globe in which one can practice surgery. For individuals seeking to participate in global surgical efforts, the general idea of volunteering abroad is bound to have appeal. In the setting of increased global awareness of the unmet surgical need worldwide [1], the motivation for such efforts aligns with the willingness to serve that is inherent to medical professionals. It is no surprise that interest in global surgical opportunities continues to grow [2, 3]. Surgical associations are becoming increasingly involved in humanitarian surgical missions, and American surgical training has accredited resident elective rotations with a focus on global surgery [4]. The structure of these international efforts generally consists of surgeons and healthcare providers from high-income countries (HICs) looking to mobilize resources and manpower to aid and develop surgical capacities in low- and middle-income countries (LMICs) [5].

Amid the excitement, it is important to consider the details that constitute different efforts at humanitarian surgical development. It is imperative to be clear about ones objectives, research which groups will best help achieve those objectives, and

D. Asbun, MD
Department of Surgery, Kern Medical, 1700 Mt Vernon Avenue, Bakersfield, CA 93306, USA
e-mail: domenechasbun@gmail.com

L.L. Kassab, MD, MBA
Department of Family Medicine, Mayo Clinic,
4500 San Pablo Road S, Jacksonville, FL 32224, USA
e-mail: kassab.lena@mayo.edu

H.J. Asbun, MD, FACS (✉)
Department of Surgery, Mayo Clinic Florida,
4500 San Pablo Road S, Jacksonville, FL 32224, USA
e-mail: asbun.horacio@mayo.edu

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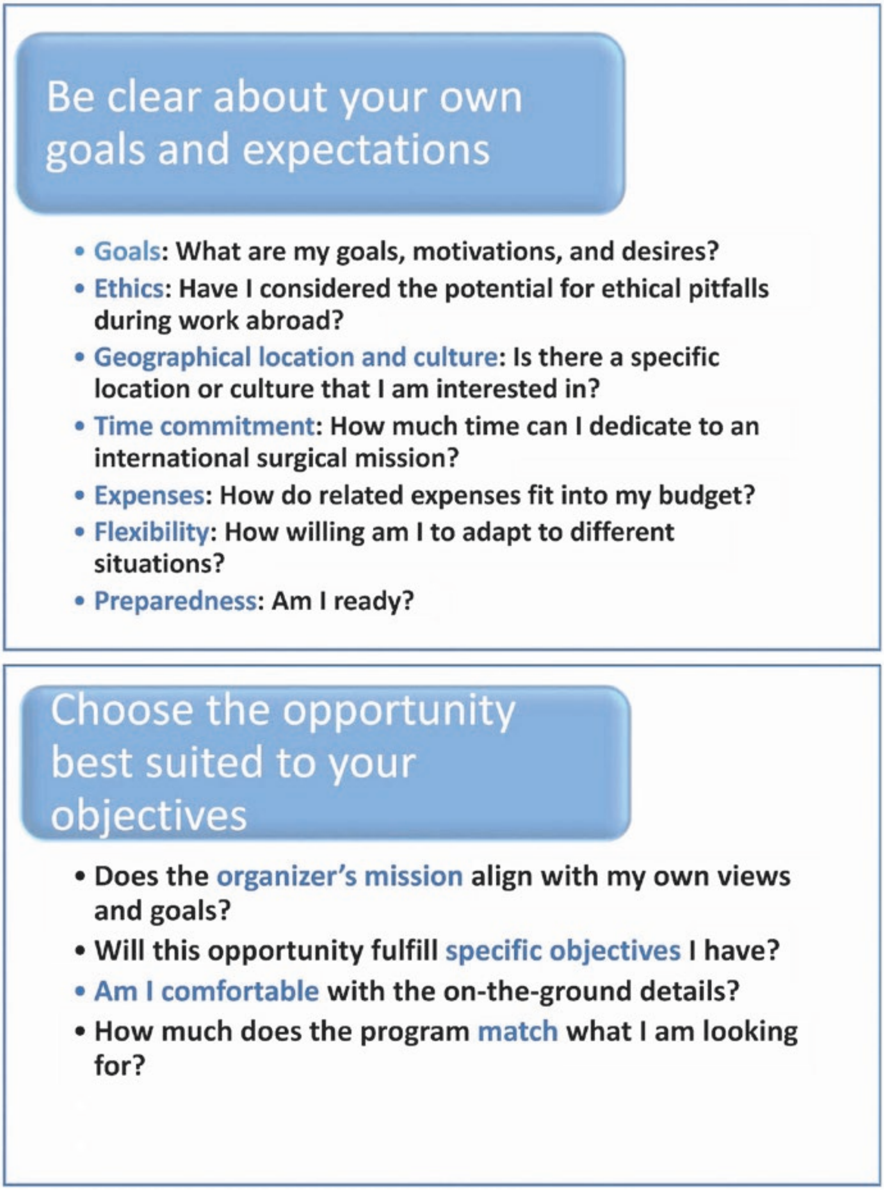

Fig. 12.1 Questions to ask yourself and the programs you are considering

recognize how the efforts impact the local community. This understanding begins with a good deal of introspection and is further complemented by careful selection of a program or organization that best matches one's objectives. Relevant questions are further explored in the following section (Fig. 12.1).

Be Clear About Your Own Goals and Expectations

The Essentials
- *Individuals should outline their goals and motivations.*
- *Thought must be given to ethical issues surrounding global surgery.*
- *Preparing for a trip includes both logistic and personal preparation.*

In order to know what to seek out in a program, interested individuals must assess their personal mind-set, expectations, and level of commitment. The following questions lead to pertinent answers.

Goals

- **What are my goals, motivations, and desires? How do I learn more about global surgery, and how can I contribute? Am I primarily interested in: 1) performing surgeries to alleviate the disease burden in underserved areas; 2) gaining clinical exposure to surgical diseases that I do not usually encounter; 3) or becoming a part of policymaking/program development in the field of global surgery?** Many programs concentrate on the clinical aspect of volunteering abroad, especially those offering short-term involvement. However, there are also opportunities for individuals more interested in formulating policies, gathering data for research, and other nonclinical efforts. Different factors serve as the motivation behind both the creation of global surgery health organizations and individuals' participation with them (Fig. 12.2). Other details to consider are whether one wishes to work for academic credit, be on call for disaster response, remain at a single site versus being mobile, gain specific clinical or procedural experience, teach a particular topic, etc. By answering these questions early, one can begin to focus and narrow the list of options.

Ethics

- **Have I considered the potential for ethical pitfalls during work abroad?** There are complex ethical and moral issues related to international surgical trips, which by no means guarantee only positive impacts on local communities [5, 6]. Surgical practice in LMICs may be perceived by visitors from HICs as being less developed or less organized and may be held to lesser standards. Those seeking to engage in GS service are bound by a personal responsibility to uphold sound medical ethics abroad. These include the well-known concept of non-maleficence ("first, do no harm") along with beneficence (medical practice should benefit the patient) and patient autonomy when making medical decisions. Equally important are issues surrounding the patient's right to informed consent, dignity, and

Fig. 12.2 Global surgery initiatives. Getting started: connecting to global surgical opportunities. © 2010 Intermountain Healthcare (Used with permission)

privacy/confidentiality. Although there are bound to be cultural barriers and differences between the visitors and the local population, it is imperative that the visitors seek to communicate thoroughly with the patient and fellow healthcare providers, safeguarding their trust. The visitors must "seek to understand before seeking to be understood" and realize that a cultural difference in practice or mentality does not indicate an inferior practice or mentality. Visitors must also maintain up-to-date knowledge and technical skills to provide the standard of care, contingent upon local resources. Simply put, the high standards of practicing medicine in HICs must be upheld in LMICs.

Geographical Location and Culture

- **Is there a specific location or culture that I am interested in? How comfortable am I in different cultural settings?** Although global surgical initiatives are inherently altruistic, one should not shy from considering interests that are more personal in nature. Surgical mission trips should include a component of bidirectional learning in which the volunteer contributes to development and also gains from the experience. Seeking out a particular culture or region of interest can potentiate this learning. Furthermore, a baseline knowledge and understanding of a culture can be a valuable addition to a team of visitors.

Time Commitment

- **How much time can I dedicate to an international surgical mission? Am I looking to be involved in the short or long term?** It is important to be realistic about the time one is able and willing to dedicate to a global surgical trip. International efforts with a focus on self-sustainable developments in infrastructure and surgical capabilities are generally advocated over shorter mission trips centered on performing surgeries during a limited time and then departing. The former is considered a more durable way to create change and has been shown to be more cost-effective. However, the latter can still be beneficial if there are no better options [5, 7, 8]. There are many short-term (a few weeks) opportunities in programs dedicated to implementing long-lasting developments, but individuals should realize that the ability to substantiate greater changes is generally related to longer time commitments.

Expenses

- **How do related expenses fit into my budget? What resources do I have available to raise funds if needed?** It is hard to predict the cost associated with individual involvement in global surgical efforts. Expenses vary widely depending on the scope of the trip, the location, and the level of involvement of the individual. One study investigating costs associated with four Operation Smile mission trips in India found that the largest expense was air travel, accounting for 48.8 % of the total expenses [9]. One can generally expect that air travel will be one of the single most significant expenses for individuals involved in surgical mission trips. Attention must also be paid to other expenses related to preparing for a trip (purchasing equipment, paying for visas, payments to organizations), expenses during a trip (food, lodging, local travel, management of ongoing expenses at home), and unplanned expenses (prolonged stays, emergency flights).

Flexibility

- **How willing am I to adapt to a situation that may be physically uncomfortable, require long hours of work, and pose unseen challenges? Am I willing to work in a country or setting that differs from what I originally envisioned?**

One can benefit much from developing the ability to adapt to unusual environments and unexpected circumstances. It is impossible to know definitively what specific situations will be encountered during humanitarian work, and often details are different than anticipated. The safety of the team should always be a priority, but other basic comforts such as running water, electricity, and a comfortable place to sleep may be difficult to secure. Past travel experience, mental preparedness prior to travel, and adequate social support will all influence a person's ability to adapt to unusual or stressful circumstances. Individuals should earnestly consider to what degree they are willing to accept these uncertainties and discomforts and keep those thoughts in mind when considering a list of service options.

Preparedness

- **Am I ready? What adjustments do I need to make in my personal life?** Take time to consider issues that may arise after a prolonged absence from home. These issues may arise from responsibilities to people, work, school, pets, etc. Be sure to make necessary arrangements well in advance. The arrangements should be flexible to accommodate any possible unexpected circumstances. Assure up-to-date passports with sufficient pages, necessary vaccinations, weather- and culture-appropriate clothing, other supplies for travel and daily living, etc. Many surgical residents arrange for elective rotations with accreditation from the Accreditation Council for Graduate Medical Education (ACGME) (further discussed below), and arrangements often take months to complete.

Identify Your Strengths

- Individuals may possess certain qualities that can contribute significantly to a group involved in global surgery initiatives. These include linguistic abilities, cultural sensitivity and awareness, ability to work with others, professionalism,

✓ Realistic, deep-seated motivation to contribute to the program's success
✓ Technical capabilities/specialized training in an area useful to the ultimate mission of the visiting group
✓ Team player, maintains ultimate goals of the team as central priorities
✓ Adaptability to unusual environments
✓ Has access to appropriate social and emotional support
✓ Foreign language capabilities, and a thorough understanding of certain cultures
✓ Availability for future endeavors in local community or other similar settings

Fig. 12.3 Qualities that serve as assets during international work

and potential to contribute to long-term or future endeavors. If appropriate, these qualities can be emphasized when applying to work with international groups, as they become assets during international work (Fig. 12.3).

Choose the Opportunity Best Suited to Your Objectives

The Essentials

- *Explore the details surrounding global surgical opportunities.*
- *Relate these findings to the personal objectives and viewpoints previously determined.*

There are likewise specific questions worth asking about the program or organization responsible for the mission abroad.

Program Details

My Goals vs Organizer's Goals

- **Does the organizer's mission align with my own goals? Does its approach to humanitarian outreach align with my own views?** An understanding of how different organizations approach surgical development is important, as it will define expectations. Individuals should review and scrutinize an organization's mission statement, website, informational literature, and testimonials from those who have worked with the group. The answers to the ethics questions above must be kept in mind and used as a litmus test for determining if one agrees with an organization's outlook.

Will It Fulfill My Objectives?

- **Will this opportunity fulfill specific objectives I have?** These objectives may include contributing to a specific philanthropic cause, gaining academic credit, gathering data for research, establishing a relation with a major organization, learning a language, etc. It may be useful to make a list of priorities and decide which opportunities accomplish the most important goals. It is also helpful to determine which goals one is willing to forfeit, if necessary.
- For surgical residents looking to gain academic credit for an international elective rotation, the ACGME has outlined specific requirements that are available online at www.acgme.org [4]. The application process includes multiple requirements, including verification that the facility can provide a 2-week rotation with evaluation of the resident's performance, which includes an outpatient experience, and that the trainee will have access to educational resources (library, online resources, etc.).

Comfort Level

- **Am I comfortable with the on-the-ground details?** This pertains to an individual's assessment of **flexibility** and analyzes the proposed living situation, work environment, and travel details. One should also examine how the group interacts with the local community, the size of the group, and efforts to integrate into the local culture and economy. These details have a direct effect on the experience of the visitors.
- **How much does the program match what I am looking for?** This should be a final recapitulation of the information gathered about a specific opportunity in global surgery. Individuals should compare and contrast various programs at once. It is best to keep many viable options open and understand that there are always benefits to an experience that one can only discover after commencing the work.

Dos and Don'ts

The Essentials

- *Approach different cultures with an open mind, and attempt to understand different perspectives.*
- *Maintain a respectful attitude toward cultural and social differences.*
- *Be aware of the possibility of mistrust and corruption.*

Don't Patronize

Often the hardest prejudices to eliminate are also the subtlest. The visiting group must reflect on its own perspectives and be sure to avoid a patronizing attitude toward the local group, which may be unintentional or difficult to identify. Regardless of the experience and expertise of the members of the visiting group, there are always opportunities for growth and learning for members of all parties involved. The more open that visitors are toward new information and bidirectional learning, the more beneficial the interaction will be.

Do Learn Medical Politics and Local Culture

Adequate research is paramount, as is always maintaining a curious and open mind. The visiting organization should have a thorough understanding of how the local government functions, how knowledge is disseminated, and how locals perceive foreign involvement in healthcare. It is also important to seek out and understand subtle cultural differences early on in the trip. Other subtle nonmedical cultural differences are important to learn early in the process. For example, people of certain cultures may be drawn toward someone who uses physical contact to communicate agreement and amiability, while others may find it unpleasant or offensive. Directly asking questions as to how certain things are perceived, no matter how trivial, may be the only way to fully gauge their general receipt.

Don't Assume Perceived Needs Always Match Real Needs

Although programs are set up in HICs to address specific issues in LMICs, the local perception of problems in the LMICs may be different from what the visiting surgeons believe. Possible discrepancies between what different groups think are important. They must be sought out early and addressed directly to avoid misconstruing of the intent behind international efforts.

Do Maintain a Small, Healthy Dose of Skepticism

Identifying motivation for international projects and partnerships is as important as qualifying the type of motivation. Typically, surgeons from HICs represent the visiting group and the locals contacted are from LMICs. The disparities present in surgical capabilities between the two groups often mirror other stark differences in economic well-being and lifestyle between the two groups. Some agenda oriented toward monetary gain is a very real possibility that cannot be ignored. When assessing the amount of motivation in the local group, it is important to assure that the ultimate goal is to improve surgical care in their community. Personal gain as the main driving force may be present at any level of an organization, and the aforementioned disparities may attract individuals with less noble intentions. A certain degree of suspicion is justifiable to better assure that the members of the local group have full commitment to benefit their community and share what they have learned.

Acknowledge Corruption

Corruption is a problem endemic to healthcare systems across the globe. The comprehensive *Global Corruption Report 2006* released by Transparency International estimated that "hundreds of billions of dollars" from the funds spent on health worldwide are lost to corruption every year [10]. This affects countries at all levels of income and is conducted by people at all levels of society, from centralized governments to individual practitioners or patients.

A history of corruption in an area and its setting should be understood. The details are incorporated into the information gathered on a given site or country. Instead of being considered objectively wrong, in many places bribery or fraud may be seen as an unavoidable part of the socioeconomic system. In such settings one may consider such practices to be the local norm or a means to an end. However, the visiting group should not readily accept or be part of it and should instead look for solutions to deal with corrupt practices. In the setting of limited funds – as applies to most surgical missions abroad – it is unacceptable to sacrifice financial sustainability on the basis of acceding to corrupt customs. Doing so also contradicts efforts to have a positive influence on the local community.

Specific Global Surgical Opportunities

The Essentials

- *International surgical programs offer work in many different settings, including academic partnerships, as part of higher education, short- and long-term volunteering, and disaster relief.*
- *There are countless different organizations coordinating surgical trips abroad; consider the many options thoroughly before making a commitment.*
- *There are abundant opportunities within the United States to contribute to the needs of underserved American communities.*

The search for a program that can best fit ones expectations can be confusing and complex. One option is to turn to major academic centers, residency programs, and surgical societies. For example, the American College of Surgeons website for Operation Giving Back serves as a comprehensive resource for physicians seeking involvement in surgical volunteer opportunities [11].

Academic Partnerships

In response to the growing acknowledgment of the global surgical disease burden, many academic medical centers have established affiliation with teaching hospitals in LMICs. These partnerships have served not only to promote development of surgical capabilities but also to promote bidirectional educational experiences, research collaborations, and development of cultural, social, and economic understanding. They can foster longitudinal commitment to development in an area, prioritizing local education over that of the visitors, and provide a framework of promoting surgical development that may be useful for wider application in the future [12]. Examples of academic partnerships include Harvard with Partners in Health in Haiti and Rwanda; Massachusetts General Hospital and Mbarara Regional Referral Hospital in Uganda; University of California, San Francisco (UCSF), with the Bellagio Essential Surgery Group and with Makerere in Uganda; Vanderbilt with Kijabe Hospital in Kenya and with Baptist Medical Group in Nigeria; and the University of Toronto with the Ministry of Health in Botswana.

Surgical Residency Electives

International electives for surgery residents in the United States have been shown to benefit residents' education and are associated with increased interest in international work after residency [13, 14]. A study conducted in late 2013 found 21 of 246 general surgery residency programs offered global health training programs [15]. Of these, 14 programs offered elective-based activities (<6 weeks), 12 offered research programs, 5 offered extended curriculum-based training (>6 weeks), and 2 offered "other activities." Programs were established in most World Health Organization regions of the world. A survey in 2015 found the overall number increased to 34 surgery residency programs offering global surgery rotations, with 25 of them being approved by the ACGME [16].

Although under more constraints than some other global surgery opportunities, surgical electives are excellent options for surgical residents who are interested in furthering their understanding of global surgery and want to contribute to surgical development where it is most needed. Residents are referred to the ACS Operation Giving Back website for a comprehensive list of current electives listed: http://www.operationgivingback.facs.org/content2271.html.

Options for Non-American Surgeons

Surgeons with residence and nationality outside of the United States have a handful of options regarding organizations that coordinate global surgical efforts (Table 12.1) [11].

Table 12.1 Some organizations in the United States that coordinate global surgical efforts [11]

Organization	Website URL
China Mission	http://china-mission.org
Community Coalition for Haiti	http://cchaiti.org
CURE International	www.cureinternational.org
Doctors On Call for Service	www.docs.org
Global ENT Outreach	www.geoutreach.org
Global Medical Foundation	www.globalmedicalfoundation.org
Healing the Children – Southwest Chapter	www.htcsw.org
International Medical Assistance	www.ima-missions.org
Medical Ministry International	www.mmint.org
Operation Smile	www.operationsmile.org
Palestine Children's Relief Fund	www.pcrf.net
Partnership in Mission	www.paxjoliet.org/missions
Rotaplast International	www.rotaplast.org
Society of Philippine Surgeons in America	www.spsatoday.com
Solidarity Bridge	www.solidaritybridge.org
Surgical Volunteers International	www.surgicalvolunteers.org

Table 12.2 Some organizations that specialize in the field [17]

Organization	Website URL
Relief Web	www.reliefweb.int
The Center for International Disaster Information	www.cidi.org
The Center for International Humanitarian Cooperation	www.cihc.org
The Harvard Humanitarian Initiative (HHI)	http://hhi.harvard.edu
International Committee of the Red Cross (ICRC)	www.icrc.org
International Medical Surgical Response Team (IMSuRT)	http://www.phe.gov/Preparedness/responders/ndms/teams/Pages/imsurt.aspx
InterAction	www.interaction.org/work/disaster-response
The Sphere Project/Sphere Handbook	www.sphereproject.org/content/view/27/84
Society of Critical Care Medicine: Disaster Resources	www.sccm.org/Disaster/Pages/default.aspx
Urban Humanitarian Response Portal	www.urban-response.org

Disaster Relief

Being part of the immediate medical response to disasters provides a unique working environment. Individuals involved are usually part of an organization that responds to major disasters within a certain area or globally. The need for surgeons is unpredictable, and as such physicians involved must be flexible and highly adaptable to different situations. Disaster response situations are generally more dangerous and stressful than other more planned trips, and extra preparation is necessary for safe and efficient participation. For those interested in disaster relief, the resources in Table 12.2 can provide access to information and organizations that specialize in the field [17].

Other Organizations Involved in Global Surgical Development

The number of organizations facilitating international surgical missions is constantly changing. Table 12.3 is a list of a large number of organizations with activity throughout the world, in all surgical specialties.

Domestic Unmet Needs: Opportunities to Contribute Within the United States

An analysis of surgical capabilities within the United States in 2009 found that over 4,500,000 Americans live in a predefined Health Service Areas (constructed using ZIP codes and Medicare data) without surgeons [18]. These needs have been detailed in interactive maps which can be found here: http://www.acshpri.org/maps.html.

Table 12.3 Organizations with activity throughout the world in all surgical specialties

Organization	Website URL
A Glimmer of Hope	www.aglimmerofhope.org
Adventist Development and Relief Agency	www.adra.org
Africa Inland Mission	www.aim-us.org
Amazon-Africa Aid Organization (3AO)	www.amazonafrica.org
American Refugee Committee	www.archq.org
Ann Foundation Inc.	www.annfoundation.org
Bairo Pite Clinic	http://bairopiteclinic.tripod.com
Board of World Mission of the Moravian Church	http://mcnp.org
Cameroon Baptist Convention Health Board	http://www.cbchealthservices.org
CardioStart International	www.cardiostart.org
Catholic Medical Mission Board	www.cmmb.org
CB International	www.cbi.org
CHANGE	http://www.changeinc.org
Child Family Health Institute	www.cfhi.org
Children's Cross Connection, International	www.cccinternational.org
Children's Surgery International	www.childrenssurgeryintl.org
China Mission	www.china-mission.org
Christian Medical & Dental Associations/ Global Health Outreach	www.cmds.org
Clinica Evangelica Morava, Ahuas, Honduras	http://www.ahuasclinic.com
Commission on Overseas Missions. Mennonite Church	http://www.mennonitemission.net
Commonwealth Health Center	www.mtccnmi.com/community/CHCSaipan/hospital.htm
Community Coalition for Haiti	www.cchaiti.org
CRUDEM Foundation	www.crudem.org
Curamericas	www.curamericas.org
CURE International	www.cure.org
DePauw University Winter Term in Service	www.depauw.edu/univ/hartman/wtis.htm
Doctors of the World	www.doctorsoftheworld.org
Doctors on Call for Service Foundation	www.docs.org
Doctors Without Borders (Medecins sans Frontieres)	www.doctorswithoutborders.org
Esperanca	www.esperanca.org
Evangelical Free Church	www.efcm.org
FAMI (Filipino-American Medical Inc.)	www.ifami.org
FIENS Foundation for Int'l Ed in Neuro Surgery	www.fiens.org
Friends of Good Samaritan	www.test.friendsgoodsamaritan.org
Friends Without a Border	www.fwab.org
Fundacao Esperanca	www.amazonafrica.org

Table 12.3 (continued)

Organization	Website URL
Global Pediatric Surgery	www.stage.globalpaediatricsurgery.org
Global Volunteers	www.globalvolunteers.org
Grace Ministries International	www.gracem.org
Hackett Hemwall Foundation	www.hacketthemwall.org/welcome.html
Hands Together	www.handstogether.org
HBS Foundation, Inc./Hopital Bon Samaritain	www.hbslimbe.org
Healing the Children Midlantic	www.users.nac.net/htcmid
Healing the Children Northeast	www.htcne.org
HealthCare Nepal	www.healthcarenepal.org
Health Teams International	www.healthteamsintl.org
Health Volunteers Overseas	www.hvousa.org
Hillside Health Care Center, Belize	www.hillsidebelize.net
Honduras Outreach, Inc.	www.hoi.org
Hope Worldwide	www.HOPEww.org
Hopital Albert Schweitzer Haiti	www.hashaiti.org
Hospital San Carlos	www.hospitalsancarlos.org
Interactive Voluntary Development Network (IVDN)	www.intvolnetorg.org
Intercristo	www.jobleads.org
International Cooperation for Development	www.ciir.org
International Health Exchange (IHE)	www.ihe.org.uk
International Medical Assistance	www.chosenima.org
International Medical Corps	www.imc-la.org
International Service Learning	www.ISLonline.org
International Relief Teams (IRT)	www.irteams.org
International Rescue Committee Overseas	www.intrescom.org
Interplast	www.interplast.org
IVUmed	www.ivumed.org
Lalmba Association	www.lalmba.org
LIGA International	www.ligainternational.org
Medical Ministry International	www.medicalministrytrips.org
MEDICO (Medical, Eye and Dental International Care Organization)	www.medico.org
Mercy Ships	www.mercyships.org
Mexican Medical Ministries	www.mexicanmedical.com
Maryknoll Mission Association of the Faithful	www.maryknoll.org
Medecins sans Frontieres (Doctors Without Borders)	www.doctorswithoutborders.org
Medical Benevolence Foundation	www.mbfoundation.org
Medical Ministry International	www.mmint.org
Medicine for Peace	www.medicineforpeace.org
Mexican Medical Ministries	www.mexicanmedical.com

Table 12.3 (continued)

Organization	Website URL
Mountain Mover's Mission International	www.mountainmovers.org
Nicaraguan Children's Fund	www.nicachildfund.com
Northwest Medical Teams International	www.nwmedicalteams.org
Omni-Med	www.omnimed.org
Operation Blessing	www.ob.org
Operation Rainbow	www.operationrainbow.org
Operation Smile	www.operationsmile.org
Palestine Children's Relief Fund	www.pcrf.net
Partnership in Mission	www.paxjoliet.org/missions
Peacework	www.peacework.org
Physicians for Peace	www.physiciansforpeace.org
Pioneers	www.pioneers.org
PRAY (Project Rescue of Amazon Youth)	www.praymission.com
Project AmaZon (formerly PAZ International)	www.projectamazon.org
Project HOPE	www.projhope.org
RAO Hospital	www.raocoop.org/hospital.html
Red Cross	www.icrc.org
Rotaplast International	www.rotaplast.org
RSVP (Reconstructive Surgeons Volunteer Program)	www.plasticsurgery.org
SEE International (Surgical Eye Expeditions International)	www.seeintl.org
Seventh-Day Adventists Church World Headquarters	www.health20-20.org
The Simeus Foundation	www.simeusfoundation.org
Society of Philippine Surgeons in America	www.spsatoday.com
Solidarity Bridge	www.solidaritybridge.org/#sbhome
South American Missionary Society of the Episcopal Church (SAMS)	www.episcopalian.org/sams
St. Jude Hospital	www.stjudehospitalslu.org
Surgical & Medical Assistance Relief Teams	www.teresasearcy.wix.com/smart
Surgical Volunteers International	http://www.surgicalvolunteers.org
Surgicorps International	www.surgicorps.org
TEAM (The Evangelical Alliance Mission)	www.teamworld.org
Uplift Internationale	www.upliftinternationale.org
Vellore Christian Medical College Board (USA), Inc.	www.vellorecmc.org
Volunteer Missionary Movement	www.vmmusa.org
VSO Canada – Voluntary Service Overseas	www.vsocanada.org
Wesleyan World Missions	www.mgonet@wesleyan.org
World Medical Mission	www.samaritanspurse.org
World Mission Prayer League	www.wmpl.org
World Surgical Foundation	www.worldsurgicalfoundation.org

Table 12.4 Some organizations providing humanitarian surgical relief within the United States [19]

Organization	Website URL
Access OC	www.accessoc.org
Arlington Free Clinic	www.arlingtonfreeclinic.org
Beach Health Clinic	www.beachhealthclinic.org
Chesapeake Care	www.chesapeakecare.org
CommunityHealth	www.communityhealth.org
Defense Medical Readiness Training Institute	www.dmrti.army.mil
Fresh Start Surgical Gifts	www.freshstart.org
Good Samaritan Health and Wellness Center	www.goodsamhwc.org
Health Care Access Clinic	www.healthcareaccess.org
Judeo Christian Health Clinic	www.judeochristianhealthclinic.org
Mission Cataract USA	www.missioncataractusa.org
Operation Access	www.operationaccess.org
Operation Blessing	www.ob.org
Physicians' Innovation Network	www.physiciansinnovation.org
Primary Care Access Network	www.pcanorangecounty.com
St. Elizabeth's Health Center	www.ccs-soaz.org/St.-Elizabeth-s-Health-Center.html
Surgery on Sunday	www.surgeryonsunday.org

This necessity for surgical capacity is the focus of many humanitarian organizations. (Table 12.4). [19]

Conclusion

International efforts to further global surgical capacities continue to gain momentum, and it is as opportune a time as ever to become involved. Participation in such opportunities takes careful planning, a thorough understanding of the ethics of volunteerism, and an open mind. There are myriad global surgery resources available, and individuals are encouraged to spend time investigating their options. Through hard and intelligent work, both the visiting and the local group can enjoy the fulfillment of contributing to surgical development in areas of need.

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Part IV

On the Ground: The Clinical Essentials

General Surgery Essentials

13

Sherry M. Wren and Micaela M. Esquivel

Introduction

General surgical conditions span a wide variety of disease states. This chapter will focus on emergent or urgent general surgical conditions and their management in low- and middle-income countries (LMICs). In resource-limited settings, barriers to care are significant and include acceptability, accessibility, availability, and affordability. Patients often present in late stages of their disease states, which impacts perioperative considerations and management. Providers are often required to diagnose surgical conditions without the laboratory and imaging studies that are typically used in high-resource settings. It is prudent to understand available resources, drugs, personnel, instruments, supplies, blood, and postoperative care setting, and factor these into decision-making. It is also vital to understand the local context and culture. Situational ethics often come into play for procedures that carry possible reproductive consequences, amputations, and informed consent. The primary decision-maker must be identified and may include a male spouse (especially for procedure with reproductive consequences), family elder, or village leader. Additional factors such as the financial obligations of the

S.M. Wren, MD, FACS, FCS (ECSA) (✉)
Stanford University School of Medicine, Department of Surgery,
G112 PAVAHCS 3801 Miranda Avenue, Palo Alto, CA 94304, USA
e-mail: swren@stanford.edu

M.M. Esquivel, MD
Stanford University School of Medicine, Department of General Surgery,
300 Pasteur Drive H-3691, Stanford, CA 94305, USA
e-mail: mesquive@stanford.edu

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patients for the care must be taken into consideration. Often, patients will be asked to purchase and obtain supplies for a procedure including drugs, IVs, sutures, and dressings as well as pay a fee upfront for any care. Patients and their families' decision-making can include declining lifesaving procedures due to financial constraints. Practicing general surgery in the global setting requires full consideration of all elements to successfully treat each patient; contextual understanding is vital in this process.

Initial Assessment of the Surgical Patient

The history and physical exam is of primary importance in the global setting as laboratory and imaging resources may not be available to aid in the diagnosis. Key portions of the history for all general surgery patients include, but are not limited to, nutritional status, HIV status, diabetic history, and social considerations such as ability to adhere to treatment or follow-up. It is also common that patients present with anemia due to chronic conditions making a preoperative hemoglobin of 7–8 gm/dl not uncommon. This must be factored into operative decision-making. These and other conditions/factors may impact the surgical care and outcomes of each patient.

Differential Diagnosis

An expanded differential is important to consider in these settings, as conditions are often encountered in limited resource settings that are not commonplace in Western practice. Differential diagnoses must include consideration of surgical manifestations of infectious diseases and presentations of diseases in a younger age group than commonly seen in the developed world. These conditions may be far along in their disease state, and more urgent surgical intervention may be required.

Procedures

For all invasive procedures, it is imperative to keep in mind that patients may have diseases that can be transmitted through needlestick or other bodily fluid exposure. Patients in some LMICs may have a much higher incidence of diseases such as TB and HIV; therefore, it is the surgeon's responsibility to make sure that they and their team are as prepared as possible. Personal protective equipment is not as readily available in many settings, so consideration should be given to bringing eye protection, N-95 masks, and needlestick prophylaxis kits for HIV.

Skin and Soft Tissue

The Essentials

- Subcutaneous abscesses, pyomyositis, and intramuscular abscesses are common.
- Many patients are malnourished and may be immunocompromised.
- Use of ultrasound is valuable to differentiate cellulitis, abscess, and pyomyositis.

Infectious soft tissue conditions comprise a larger surgical burden in LMICs compared to high-income settings where antibiotics and primary care are more readily available. In LMICs, patients have frequent injuries from walking without shoes and farming activities. In LMICs, deeper infections and multifocal locations are more commonly seen. A common pitfall is incomplete drainage and irrigation of abscess cavities.

Abscess

Compared to high-income settings, there is a larger etiology of soft tissue abscesses in LMICs, and many organisms can be involved. Patients often present with pain, tenderness, warmth, and swelling at the site of infection. Laboratory studies are often not required for diagnosis; though the use of ultrasound (US) can help distinguish between a superficial abscess and pyomyositis. It is also more common to see abscesses in young children, often in the neck or head area (Fig. 13.1). Adequate incision and drainage with copious irrigation is the mainstay of treatment. Decisions about use of local anesthetics, conscious sedation, or general anesthesia need to be made on a case-by-case basis. Often the site of the incision can be determined by palpation of fluctuance or the point of maximal tenderness, but US can assist in locating the cavity as can needle aspiration. If possible, send the fluid for culture.

Fig. 13.1. (**a**, **b**) Show an abscess of the right neck of two children. (**c**) Shows an abscess of the posterior scalp of a child

The most common organisms are *Streptococcus* and *Staphylococcus*, and starting antibiotics before or after drainage can assist in resolution. Though wound care is difficult in LMICs, a common pitfall is making the incision too small and not adequately breaking up and draining the cavity. To ensure continued drainage, placement of a drain and use of a cruciate incision can be useful. Close follow-up exams and wound care are needed initially to ensure resolution. If the abscess cavity is completely drained and surrounding cellulitis resolved, continued antibiotics are not warranted. If a patient does not improve, re-exploration of the wound is required [1].

Pyomyositis

The Essentials

- Pyomyositis is an infection of the skeletal muscle.
- Other considerations: infected hematoma post trauma.
- Diagnosis: tense painful muscle – aspiration and/or US can be helpful.
- Treatment: systemic antibiotics and drainage of the muscular abscess.

Definition

Pyomyositis, also known as tropical pyomyositis or myositis tropicans, is a bacterial infection of the skeletal muscles that eventually results in a pus-filled abscess. It can account for approximately 5% of hospital admissions in tropical areas, and in patients with HIV, the incidence can be as high as 31% [2]. *S. aureus* is the most common organism cultured, but other organisms including streptococci and gram negatives can also be responsible. It is also not uncommon to have "sterile pus" and no organisms identified [2]. The etiology is not well characterized and is thought to be possibly due to hematogenous spread of bacteria to a muscle area that may have been damaged by previous trauma, parasite infection, or malnutrition that allows for bacterial growth in skeletal muscle which is typically infection resistant.

Signs and Symptoms

The muscles most commonly affected are the quadriceps, glutei, pectoralis major, serratus anterior, biceps, iliopsoas, gastrocnemius, abdominal, and spinal muscles [3]. Typically a single muscle group is infected, but patients can present with infection in more than one site up to 20% of the time [4]. The disease presents in three stages depending on the time to presentation to the clinic or hospital [5].

Stage 1: This is characterized by systemic complaints of fever, malaise, and muscle pain and swelling. The muscle group may feel woody and indurated. There is no overlying cellulitis and no abscess can be palpated or seen on ultrasound. If recognized at this stage, oral antibiotics with good staph coverage may treat the infection, but patients should be monitored because abscess formation is still possible. Approximately 2% present at this stage.

Stage 2: Almost 90% of patients present in this, the suppurative phase. It is typically 1–3 weeks after the initial presentation of muscle pain and is characterized by fever, exquisite muscle tenderness, and edema. The muscle over the abscess is tense and painful. But there is often no erythema visible and no skin signs of the deep-seated infection making the diagnosis of deep abscesses challenging. Aspiration with or without ultrasound typically demonstrates pus and confirms the diagnosis. If left untreated, the infection can progress to sepsis and bacteremia.

Stage 3: This is the least common presentation and is characterized by systemic toxicity from untreated worsening muscle infection, bacteremia, and septic shock and its attendant complications.

Diagnostic Tests

Needle aspirate the muscle group at the site of maximal firmness. Since the abscess is usually quite deep, a longer needle may be necessary to reach the cavity. Ultrasound can be helpful to identify if a deep abscess is present and assist during aspiration.

Special Considerations

Have a high index of suspicion in HIV-positive patients; if no abscess is present on presentation, patients should be observed on antibiotics for a few days to make sure that an abscess does not form.

Treatment

Administer systemic antibiotics with excellent staph/strep coverage combined with incision and drainage of the abscess. Traditionally, surgical incisions were done to allow packing of the cavity, but now with the experience of successful percutaneous drain placement via radiographic guidance in high-resource settings, it is time to consider the use of smaller incisions to allow for drain placement and removal of all pus in the low-resource setting. If the abscess responds to drain placement via an incision, this would save the difficulty of handling an open wound in the low-resource environment. If the patient did not improve, then more extensive incision and drainage could be done.

Necrotizing Soft Tissue Infections

Necrotizing soft tissue infections are most often caused by mixed gram-negative and gram-positive organisms, often gas producing, which are rapidly evolving and can quickly track either in the subcutaneous space or along fascial planes (fasciitis) and even involve the muscle. On physical exam, the characteristic finding is pain out of proportion to what would be expected, especially when not directly over the obvious site of infection. Crepitus over the involved tissue, and gas on plain x-ray imaging, is diagnostic of a necrotizing soft tissue infection that requires prompt attention. Other skin changes such as necrotic areas and bullae can also be present. Necrotizing infections often require extensive tissue debridement to healthy tissue, though even with these measures, septic shock is the most common cause of death. In LMICs, full laboratory services are likely not readily available so reliance on history and physical exam will guide diagnosis and management. When in doubt, an operative exploration is indicated to distinguish between cellulitis and a necrotizing soft tissue infection. Care for these patients can be very challenging in resource-limited environments due to the lack of critical care and ventilation capabilities. Such resource limitations may factor into survivability of the patient and should be discussed with the family.

Treatment should commence with immediate broad-spectrum systemic antibiotics to cover both gram-positive and gram-negative organisms. Older medications such as penicillin G, clindamycin, and gentamycin are effective agents and should be administered if the more modern antibiotic regimens with extended spectrum penicillins and vancomycin are not available. Simultaneous fluid resuscitation with isotonic crystalloids should be administered while setting up the operating room for an emergent debridement. It is imperative to remove all involved skin, soft tissue, and when involved the fascial layer and involved muscle. Tissue usually has a grayish discoloration and does not bleed. "Dishwater"-appearing fluid leaks out from the affected tissues. Debridement should occur until bleeding and live tissue is reached (Fig. 13.2). Patients may require additional operative debridements to fully control the infection. Initially patients should be placed in the highest monitored setting available due to risk of ongoing septic shock. Repeat examinations of margins of the debrided wound to ensure no progression should occur often in the first 24–48 h until the extent has been fully declared. Decisions to return to the OR for additional debridements should be based on clinical parameters of improvement or the lack thereof.

Gangrene (Amputations)

Patients with peripheral arterial disease and/or uncontrolled diabetes can develop serious sequela that span the spectrum from severe soft tissue infection to gangrene (tissue necrosis). This commonly impacts the distal extremities, mostly the

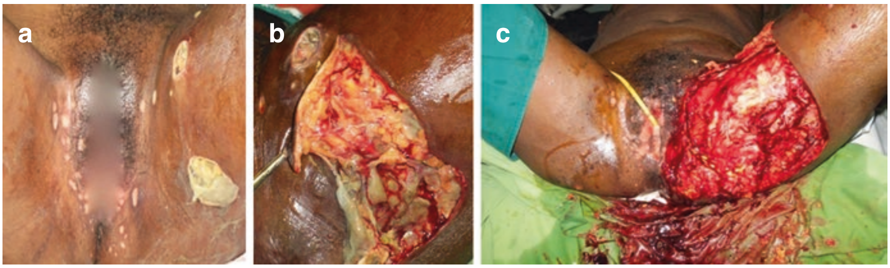

Fig. 13.2. This figure shows a necrotizing soft tissue infection of the left medial thigh. (**a**) Depicts the patient at presentation; (**b**) shows first stage of debridement; (**c**) shows the complete initial debridement

feet, toes, and calf, and sometimes the hands, as they are farthest from the heart. In addition, gangrene can be seen due to untreated traumatic fractures of the extremities. There are two main types of gangrene: dry and wet gangrene. In any patient with gangrene, a thorough exam of all upper and lower extremity pulses is absolutely necessary. In addition, an ankle-brachial systolic pressure index (ABI – the ratio of the ankle systolic blood pressure divided by the brachial systolic blood pressure) should also be performed at the bedside when possible. The ABI can assist in better understanding the severity of a patient's peripheral arterial disease and how they may recover from surgical intervention [6]. If patients have pulses that are too weak to calculate an ABI, they likely have severe peripheral arterial disease. Patients should also have a blood glucose obtained to determine if they have hyperglycemia since they may not know they have the disease, or even when they are known to have it may be untreated due to lack of access to diabetic medications.

Dry gangrene tissue is hard, shrunken, with a dry texture, and a clear demarcation between live tissue and necrotic tissue (black) (Fig. 13.3). Eventually, the line of separation from necrotic tissue and viable tissue will be complete, and the gangrenous tissue will eventually slough off. Acute surgical intervention for dry gangrene is not warranted.

Wet gangrene has a moist appearance with swelling, and the demarcation between viable and necrotic tissue can have an area of pink, soft, and wet tissue in between. This is a sign of an active infection and is a surgical emergency. Wet gangrene has a much worse prognosis and can quickly lead to sepsis. Due to high

Fig. 13.3. Both are examples of dry gangrene from trauma, as shown by the black necrotic tissue. (**a**) Is the scalp of a child and (**b**) is the left arm of a teenager

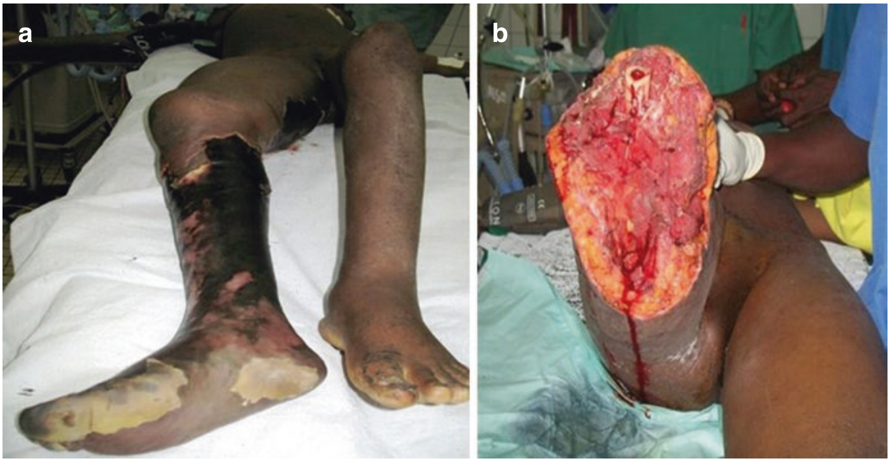

Fig. 13.4. (**a**) Shows wet gangrene of the right lower extremity; (**b**) shows treatment by guillotine amputation to healthy noninfected tissue

mortality of wet gangrene, an emergent salvage (or guillotine) amputation of the affected limb is often necessary (Fig. 13.4) [6].

This will help limit the systemic impact of the infection and allow time for the infection to be treated with antibiotics. In general, the safest course for acute infection is to leave the amputation site open to allow for control of infection with subsequent stump revision and closure. The site for a guillotine amputation should be at the most distal site not involved in severe infection that allows for removal of the infected area. Preservation of uninfected tissue is necessary for the future revision to optimize stump creation for the remote chance of a future prosthesis.

For gangrene secondary to peripheral vascular disease, patients should be counseled to stop smoking to try to prevent future problems. If they have any access to a higher level of care, discussion about a complete vascular workup should be done and a referral instituted. Diabetic foot education can also be considered as a preventative service. Nightly foot inspection can help prevent some of the infections from punctures that result in severe foot infections.

Tetanus

Tetanus is caused by the exotoxin elaborated by *Clostridium tetani* that affects the nervous system causing patients to develop reflex muscle spasms and rigidity. Tetanus infections are more common in LMICs as tetanus vaccines are not readily available. In LMICs, it is important to give tetanus toxoid when able to all those who present with an open wound or infection. Tetanus should be suspected in any patient complaining of spasm of the muscles of the jaw or "lockjaw." In addition, there can be painful spasms in other muscle groups in the neck, trunk, and extremities and by generalized, seizure-like activity in severe cases (Fig. 13.5).

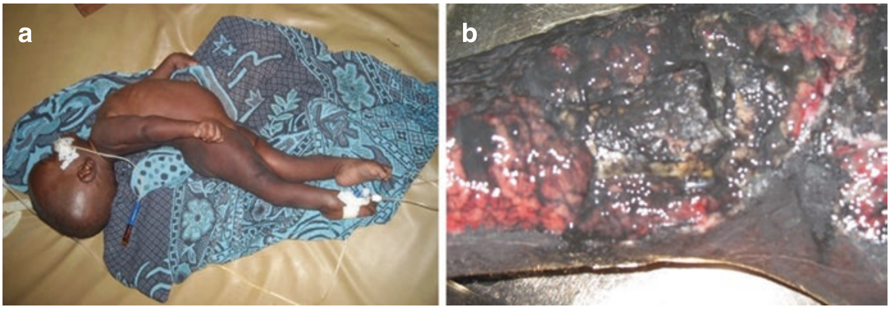

Fig. 13.5. (**a**) Depicts a small child with opisthotonus caused by tetanus; (**b**) shows an extensive wound in the lower extremity of an adult tetanus patient

The clinical course is variable and dependent on whether the patient has any prior immunity, the amount of toxin present, and the age and general health of the patient. The majority of neonatal tetanus cases are due to contamination of the umbilical stump and unfortunately are often fatal. Child and adult tetanus should be treated when possible with wound cleansing, removal of any necrotic tissue, administration of tetanus toxoid, and administration of human tetanus immune globulin (TIG) both for passive immunization and for therapy. When available, TIG (500 units as a single IM dose) should be administered as well as antibiotic treatment with metronidazole. Patients should be kept in quiet rooms with minimal stimulation; spasms can be controlled with benzodiazepines and intravenous magnesium sulfate. Patients can have respiratory issues and if possible should be transferred to a tertiary care center for mechanical ventilation; this is often not possible. Supportive care with IV fluids, nutrition, and observation for the time of significant spasm (1–2 weeks) can result in complete recovery [7]. Postoperative tetanus, though uncommon, may result from both exogenous and endogenous sources and can develop within 24 h after an operation [8].

Perirectal Abscesses

Perianal and ischiorectal abscesses often present with pain, an indurated perianal mass, discomfort with defecation, and possibly fever. Infection is thought to be due to obstructed cryptoglandular anal glands that then become infected. The infection then travels the path of least resistance into perirectal spaces and then abscess formation occurs. The main types of perirectal abscesses include perianal, ischiorectal, intersphincteric, and supralevator (Fig. 13.6). If the abscess is supralevator in location, it can be difficult to diagnose since it cannot be palpated on rectal exam and may not have as clear cut symptoms as the other abscess locations. Diagnosis is made by history and then perineal examination. The area should be inspected for redness, tenderness, and fluctuance; a digital rectal exam must be performed to assess for tenderness and abscess palpation. Needle aspiration can be helpful to try and identify pus if there is some question on exam. The primary treatment is

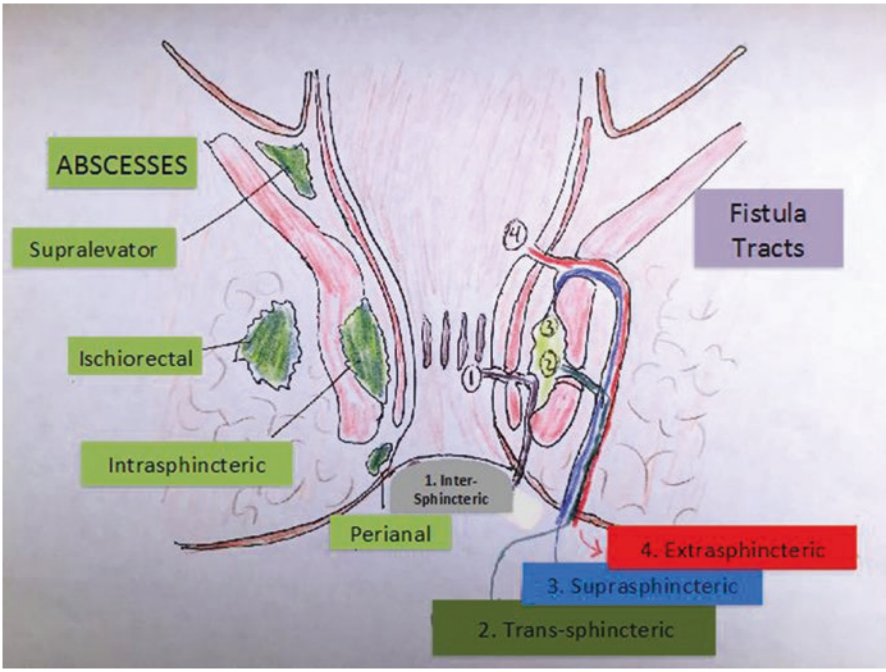

Fig. 13.6. Image depicting location and types of perirectal abscesses and fistula tracts

incision and drainage of the entire abscess cavity. Antibiotics are adjunctive and should be used until the cellulitis has resolved. Daily sitz baths, as well as after defecation, is an excellent way to manage the wound and avoid daily packing. Undrained collections should be considered if the patient does not improve markedly and still complains of pain.

It is imperative to maintain continence during incision and drainage, and multiple procedures may be necessary to allow drainage of the pus or to better identify a possible anal fistula. Anesthesia beyond local anesthesia is sometimes necessary to completely drain and treat perianal infectious diseases.

Perirectal Fistulas

Due to the pathology of disease of perianal abscesses, fistula tracts are common and about one-third of patients with an abscess requiring drainage suffer the end result of an anal fistula. These fistulas can be identified in the majority of patients at the time of abscess drainage. There is no clear consensus on whether or not to treat the fistula at time of abscess drainage. Long fistula tracts should have a seton placed, which will allow better identification of tract trajectory and sphincter involvement. Once these details are known, a more definitive plan for treatment can be determined with the key objective of maintaining continence. When forming a treatment plan, one must consider the location of internal opening, the course of the fistula tract, and therefore the amount of sphincter involved.

The classification of anal fistula guides choice of the most appropriate fistula treatment options (Fig. 13.6). Typical treatment of intersphincteric and low transsphincteric fistulas is a simple fistulotomy to unroof the tract and allow it to heal. Care should be taken to preserve as much of the sphincter complex as possible to diminish the risk of postoperative incontinence. Suprasphincteric and transsphincteric fistulas involve much more of the anal sphincter, carry a higher risk of incontinence, and are a real challenge in the low-resource environment. If the surgeon has knowledge and experience in rectal advancement flaps or the LIFT procedure (ligation of intersphincteric fistula tract), these approaches can be considered. Both techniques have been shown to be successful in complex fistula disease but require specific procedural training and experience for success and to avoid risks of incontinence or recurrence. Cutting and non-cutting setons are commonly used in low-resource settings. Setons can be made of many materials including umbilical tape, silk, rubber bands, and even cable ties [9]. The seton is placed through the fistula and cinched down over time to slowly divide the subcutaneous tissue and sphincter. This approach requires multiple visits and has a risk of incontinence.

Breast

The Essentials

- Lack of screening and access to care cause patients to present late in their disease stage.
- Pathologic evaluation of biopsies is not always available, causing many to be lost to follow-up while awaiting diagnosis or treating patients with a presumptive diagnosis..
- Adjuvant treatments such as chemotherapy, hormonal therapies, and radiation therapy may be nonexistent in LMICs and may not be used as part of treatment plans.

Breast Cancer

Breast cancer is not as prevalent in LMICs as in high-income settings, but mortality rates for breast cancer may be higher in the former. In addition, with Westernization of these regions, breast cancer rates are increasing. Due to numerous barriers to screening and diagnosis, only 20–50% of women in LMICs are diagnosed in early stages (I and II), compared to over 70% diagnosed in these early stages in high-income settings. There are additional delays after diagnosis to treatment, called “provider interval,” with LMICs having an interval from diagnosis to treatment over four times longer than high-income countries [10].

LMICs have minimal access to chemotherapies, hormonal therapies, and radiotherapies for the treatment of breast cancer. Even without these therapies, early identification and timely surgical intervention can save lives. The Breast Health Global Initiative (BHGI) has led in the development of "Guidelines for International Breast Health and Cancer Control" for LMICs. If adjunctive therapies are not available for patients, breast-conserving surgical interventions are not recommended, and modified radical mastectomy is indicated, even for early stages [11]. Unfortunately, breast cancer often presents as a fungating obvious cancer with palpable nodes either from metastatic spread or from associated infection. If cellulitis is present, the infection should be treated with antibiotics and wound care prior to undertaking resection. As outlined above, modified radical mastectomy is the recommended treatment with excision of breast tissue and involved axillary nodes. In the setting of a large fungating cancer, resection leaving an open wound may be necessary followed by reconstruction after the wound bed has granulated with a split thickness skin graft. If at all possible, the tissue should be sent for pathology, and estrogen/progesterone status should be determined. This is often impossible either due to the lack of money to pay for the tests or the lack of a pathologist. Tamoxifen, if available, could be empirically considered for adjuvant treatment.

Breast Abscess and Mastitis

Breast infections are common in LMICs and management is similar to high-income settings. Infections can be both lactation and non-lactation associated. Non-lactation mastitis can occur in multiple age groups including infants (<2 months), children, adolescents, and adults. Lactation mastitis is very common because of high-multiparous mothers and prolonged breastfeeding. Mastitis can lead to abscess formation if left untreated, or the primary presentation may be abscess with overlying cellulitis.

Mastitis typically presents with swelling, erythematous skin, tenderness, induration, and warmth. Pus may or may not be expressed through the nipple but if present can be cultured or examined if resources allow. Antibiotic treatment initially targeted at staph and strep should be initiated and broadened to cover gram negatives if there is no response to the cellulitis in 24–48 h. Analgesics with nonsteroidal anti-inflammatory agents (e.g., ibuprofen) can be helpful and used in lactating and non-lactating patients. Breastfeeding can continue even with the infected breast, and women should be encouraged to make sure the breast empties as much as possible with each feeding. A breast abscess presents as a fluctuant mass and is a common sequela of mastitis; however, it can also present without any previous history of mastitis. Abscesses can occur in any age or gender but are more common in women. Palpable fluctuant masses are often noted on exam, and if ultrasound is available, the breast can be imaged to better identify size and depth. Initial management includes antibiotics and percutaneous abscess aspiration as long as the skin is intact over the abscess and the abscess is <6 cm. Up to three aspirations are often required for complete resolution. Surgical incision and drainage treatment is used for abscess with overlying skin compromise or frank necrosis, large abscesses, abscesses just beneath the skin, or in failed aspiration patients. Local anesthesia can be used and excision of any necrotic skin as well as drainage of the cavity should be done. The wound can be left covered and not packed and irrigation done until the wound closes [12]. If an infection is not resolving with antibiotics and drainage, the diagnosis of inflammatory breast cancer needs to be considered and investigated via a biopsy if possible.

Hernia Disease

The Essentials

- The burden of hernia disease is high in LMICs.
- Inguinal hernias are more common in men, while femoral hernias are more common in women.
- Incarcerated hernias are the leading cause of bowel obstruction in LMICs.
- Type of repair depends on resources available – it is imperative to be prepared to perform primary tissue repairs as well as the use of mesh herniorrhaphy.

The high burden of hernia disease in LMICs was highlighted in the Disease Control Priorities the Third Edition of Disease Control Priorities (DCP3); Volume on Essential Surgery concluded that over 14,000 deaths due to hernias could be averted each year if basic surgical care could be provided in LMICs [13]. Several studies have shown that the burden of hernias and the associated morbidity and mortality is higher in sub-Saharan countries than in higher-income countries [14, 15]. Due to delay in definitive surgical care of symptomatic hernias in resource-limited countries, patients often have larger hernias and a higher severity of symptoms.

Of all hernias, groin hernias have the highest rate of incarceration and strangulation [16]. Though inguinal hernias account for over 95% of all groin hernias, femoral hernias are more likely to present strangulated (Fig. 13.7). It is important to complete a hernia exam on all patients, particularly those presenting with obstructive symptoms, as hernia is the leading cause of bowel obstruction in LMICs.

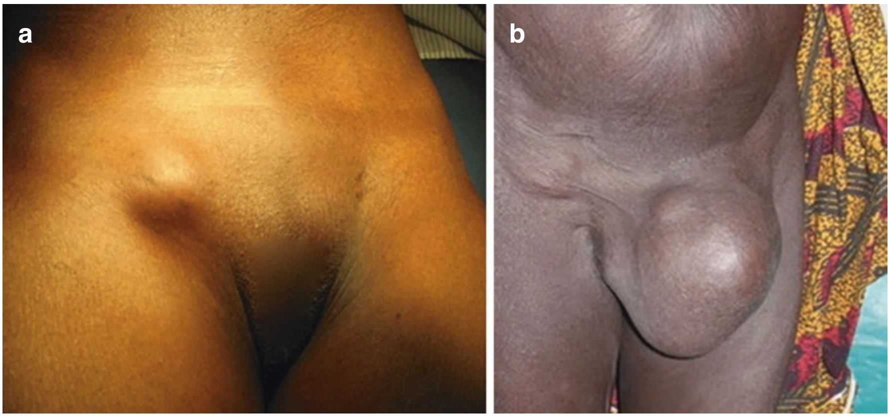

Fig. 13.7. (**a**) Depicts an incarcerated femoral hernia in a female. (**b**) Shows a female with bilateral hernias, the left incarcerated and the right reducible

Groin Hernias

All symptomatic inguinal hernias should be repaired due to risk of incarceration/strangulation. Notable increase in size over time is common, as heavy labor is common for people in LMIC. Mesh repair is preferred due to the lowest risk of recurrence. If commercial mesh is not available, the use of sterilized polyester or nylon (100%) mosquito net can be used as the hernia mesh [17]. When hernia mesh is not available, procedures such as the McVay (Cooper's ligament) repair with relaxing incision can be performed for femoral hernias and Shouldice or Bassini repairs for indirect and direct hernias. Each of these repairs share the following common operative steps [18]:

1. Skin incision superior to the pubic tubercle and inguinal ligament.
2. Division of soft tissue to the external oblique aponeurosis.
3. Opening of the external oblique aponeurosis from the external inguinal ring extending laterally past the internal ring.
4. Mobilization of the cord structures from inguinal canal.
5. Division of the cremaster muscle to identify an indirect hernia sac and examination of the floor for evaluation of a direct hernia sac.
6. Mobilization and reduction of hernia sac(s) – ligation not usually necessary. For large scrotal hernias, an indirect sac can be transected in the inguinal canal, and the anterior wall opened as far as possible distally to prevent hydrocele.
7. Open the transversalis fascia from the internal ring to the pubic tubercle.
8. In the McVay and Bassini repair, the transversalis fascia combined with the transversus abdominus fascia, the aponeurosis, and the internal oblique muscle is sewn either to Copper's ligament (McVay) or the shelving edge of the inguinal ligament (Bassini). In the McVay repair after the initial closure to Cooper's ligament, the repair transitions to the shelving edge at the level of the femoral vein.
9. The repair is continued just past the internal ring.
10. A vertical or hockey stick relaxing incision through the anterior rectus sheath starting just above the pubic tubercle and superiorly – the distance necessary is based on the degree of tension in the repair.

Ventral Hernias

Anterior abdominal wall hernias can be epigastric, umbilical, periumbilical, or incisional. Epigastric hernias often only require surgical intervention if symptomatic, while we recommend surgical repair of all periumbilical hernias due to higher rates of incarceration. Umbilical hernias are quite common in children and should not be repaired until the child is >2 years old because the vast majority will close on their own. Since the incidence of complicated umbilical hernias in children in LMICs is not known, there are some recommendations that defects >1–1.5 cm in children age 3 and above are closed when possible [19]. Incisional and ventral

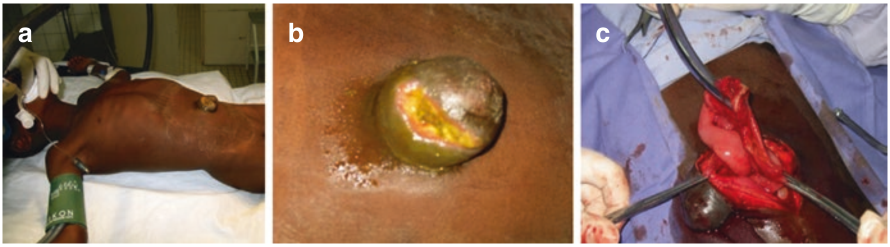

Fig. 13.8. (**a**) Umbilical hernia in a child with bowel fistula formation due to untreated incarceration and bowel obstruction; (**b**) show exam findings on presentation; (**c**) shows intraoperative findings of small bowel fistula

hernias are common in LMICs and can be challenging to repair when >4 cm because of the relative lack of prosthetic meshes. Hernias can be closed with primary fascial closure but may have significant chances of recurrence if large. An excellent alternative technique is a component separation to allow for a tension-free primary tissue repair. Briefly, skin flaps are raised exposing the anterior rectus and external oblique fascia. The external oblique fascia is incised 2 cm lateral to its border with the rectus and the external oblique muscle mobilized bluntly upward off of the internal oblique muscle. This allows for midline movement of the rectus and laxity to primarily close the defect. Drains are recommended where the skin flaps were mobilized to diminish the chance of seromas. This is an excellent alternative when prosthetic mesh is not available. Patients will need to be observed for development of seromas, skin flap compromise, and wound infections. Abdominal binders, if they can be found, can be used to help support the abdominal wall during recovery. Patients should be counseled to not resume heavy work after hernia repairs, but this may not be possible; therefore, recurrence is not unusual after repairs in this setting (Fig. 13.8).

Incarcerated/Strangulated Hernias

One of the most common emergencies seen is an incarcerated/strangulated hernias of any anatomic location. Patients present with a tender painful mass, possibly with bowel obstruction, or even peritonitis depending on how long it took to reach the hospital. Reduction should only be attempted if there are no signs of bowel compromise such as fever, overlying skin changes, or peritonitis. If the hernia is reduced, admission for observation followed by elective repair should be done if at all possible to prevent future bouts of incarceration. If signs of strangulation are present, immediate surgery through an incision directly over the hernia is warranted. It is important to inspect the involved bowel, which may require enlargement of the hernia defect of laparotomy. Bowel resection with primary anastomosis may be necessary if there has been vascular compromise (Fig. 13.9). Primary tissue repair can then be completed and the patient observed postoperatively.

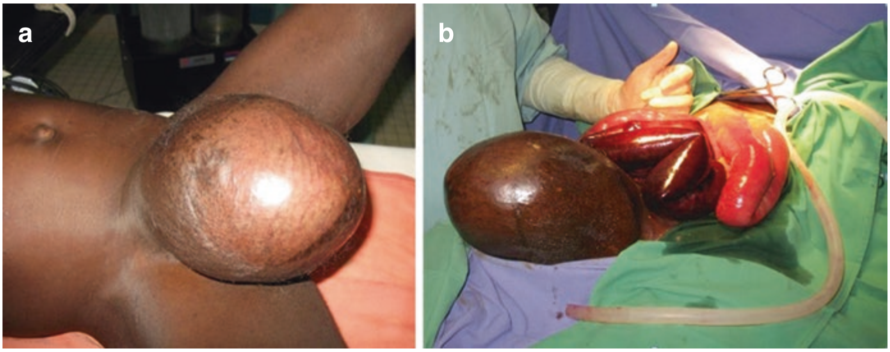

Fig. 13.9. (**a**) Strangulated right inguinal; (**b**) intraoperative findings of ischemic small bowel requiring bowel resection

Gastrointestinal (GI) Emergencies

The Essentials

- The differential diagnosis is broad; one must be familiar with the epidemiology of the region they will be serving.
- Imaging and lab studies are limited – rely heavily on thorough history and physical exam to guide care.
- Patients present late in their disease process and, therefore, assume dehydration, malnutrition, anemia, and electrolyte abnormalities on arrival and resuscitate and optimize the patient prior to the operation as able.

Patients in LMICs often present later in the disease process, thus making the history and physical exam even more crucial for prompt determination of management. A recent study showed that 72,000 people in India died from acute abdominal conditions in 2010, most in their home and most in rural areas [20]. Due to late presentation, many patients with GI emergencies are in poor clinical condition, with severe anemia, dehydration, poor nutrition, and possible electrolyte abnormalities. It is imperative to attempt to correct severe anemia (Hgb <6) and dehydration prior to any operation. In addition, in many of these settings, laboratory facilities are not readily available, and determination of electrolyte abnormalities is not possible. Recall, patients with persistent emesis often have metabolic alkalosis and hypokalemia. Though less likely in patients with an acute surgical abdomen, patients with profound diarrhea may have hyperchloremic metabolic acidosis, also often with hypokalemia.

Due to cultural and language differences, obtaining an accurate history may be difficult. Open-ended questions are preferred when initially obtaining a history, though ensuring specific information is obtained may require directed and pointed questions. For example, some patients may describe the pain as "recently" coming on, though when asked specifically, the pain started "two weeks ago." In every setting, a thorough review of systems is important, with particular focus on gastrointestinal and genitourinary systems. Standard history questions about quantity, frequency, character of emesis, or bowel movements must also be expanded to include questions about the presence of blood or worms. It is important to include a detailed history of urinary and vaginal symptoms, as a common cause of abdominal pain in women can be due to severe urinary tract infections or pelvic inflammatory disease. For all patients, always specifically ask if they have had any previous abdominal surgery.

The physical exam is of critical importance as a thorough history may be difficult to elicit. Much information can be gained from examining the eyes and mouth. Sunken eyes may be a sign of dehydration, icteric sclera may be a sign of liver disease, and pale conjunctiva may be a sign of anemia. The tongue will also be dry when patients are dehydrated. The abdominal exam must be thorough and must include evaluation for distention, guarding, fluid, rigidity, rebound, and masses. Additionally, even if not included in the history, always examine for umbilical, inguinal, and femoral hernias. Rectal exam is also almost always indicated. Female patients may require a pelvic exam to rule out gynecologic causes of pain such as uterine rupture or pelvic inflammatory disease, which is noted with cervical motion tenderness on exam.

Appendicitis

The Essentials

- Appendicitis is one of the most common causes of an acute abdomen across the globe.
- Imaging and laboratory studies are limited, rely on clinical diagnosis, and do not delay operation if suspicion is high.
- Prepare for open appendectomy, as laparoscopic availability is limited.

Appendicitis is one of the most common indications for urgent/emergency surgery across the globe [21]. Often, due to lack of resources, the diagnosis of appendicitis is clinical, without supporting imaging or laboratory studies. The negative appendectomy rate may be higher in low-income settings, which, due to high morbidity and mortality of delayed diagnosis in these settings, is acceptable. Early surgical intervention is recommended in the presence of high clinical suspicion.

The natural history is unclear, and there appears to be a subset of patients who are more at risk for perforation and that this is not a time-dependent phenomenon. Children are at higher risk of perforation than adults. Recent data exists that demonstrate early uncomplicated appendicitis (non-perforated or gangrenous) can be successfully managed in most cases with antibiotics, but this may not be a good strategy in LMICs since there is a significant risk of recurrent appendicitis in the next year; thus, definitive management at presentation is recommended.

Table 13.1. The elements and scoring of the Alvarado score for diagnosis of acute appendicitis [22]

	Features	Score
Symptoms	Migration of pain	1
	Anorexia	1
	Nausea/vomiting	1
Signs	Tenderness in right lower abdomen	2
	Rebound tenderness	1
	Elevated temperature (≥37.3 °C)	1
Laboratory test	Leukocytosis	
	Neutrophilic left shift	
Total score		10

Clinical Findings

Abdominal pain is the most common symptom and is often the first symptom. The pain usually starts in the periumbilical region then migrates to the right lower quadrant. The often described "four symptoms of acute appendicitis" includes right lower quadrant pain, anorexia, nausea, and vomiting. The Alvarado score can assist in determining the likelihood of acute appendicitis (Table 13.1) [22]. A score of 5 or 6 is compatible with acute appendicitis; 7 or 8 is probable appendicitis, while 9 or 10 is extremely probable appendicitis.

Special Considerations

Diagnostic tests, such as US, CT, and MRI scans, or laboratory studies are limited and should not be required to make a clinical diagnosis. The physical exam findings are more classic with pain at McBurney's point (in the right lower quadrant) with an anterior appendix; retrocecal appendicitis tends to present later. Physical exam maneuvers such as psoas and obturator signs and a digital rectal exam can all be helpful in aiding the diagnosis. Appendicitis is generally more difficult to diagnose in females, due to ovarian pathology, pelvic inflammatory disease, or ectopic pregnancy.

Treatment

If the appendicitis is complicated, meaning that the base of the appendix is perforated (or highly inflamed) or the appendix is gangrenous or grossly perforated, a partial or full cecectomy is often warranted. This is still possible through a standard right lower quadrant appendectomy incision, though enlarging the incision will likely be necessary and thorough irrigation is imperative. In this instances and when possible, a partial cecectomy should be done since this will only require suture closure of the cecum and not an ileocolic anastomosis.

Antibiotics should be initiated once the diagnosis of appendicitis has been made and should be continued on all patients through the operation. Postoperative antibiotic recommendations vary for complicated versus uncomplicated appendicitis and rely on intraoperative findings to guide timing. With complicated (gangrenous or perforated) appendicitis, patients are at higher risk for abscess and continued infectious complications, and antibiotics are warranted for 3–5 days postoperatively [23]. For uncomplicated appendicitis, in patients with mild or moderate inflammation, antibiotics can be stopped postoperatively. If the patient is highly febrile or has signs of sepsis preoperatively, even with technically uncomplicated appendicitis noted intraoperatively, antibiotics should be continued for at least 1–3 days [24].

Cholecystitis

The Essentials

- The burden of gallbladder disease varies dramatically across regions – be familiar with the epidemiology of your local setting.
- Patients often present late and may have acute on chronic cholecystitis and scarred gallbladders.
- Abdominal ultrasound is the most useful imaging modality; suggestive findings of acute cholecystitis include positive sonographic murphy's sign, thickened gallbladder wall >4 mm, pericholecystic fluid, and visualization of impacted stones.
- Open cholecystectomy is the mainstay of treatment in LMICs.

The burden of gallbladder disease, gallstones, and subsequent cholecystitis varies dramatically across regions and across different ethnic groups. Regardless of region or race, women are impacted by gallbladder disease more frequently than men worldwide. Unexpected pathologies such as ascaris or salmonella typhi causing cholecystitis also occur in LMICs.

Signs and Symptoms

Patients with acute cholecystitis often have pain in the right upper quadrant, epigastric pain, nausea, fever, and emesis. Additionally, these patients frequently have a history of similar episodes in the past where their symptoms were less severe and resolved on their own, indicative of biliary colic. Patients will frequently be tachycardic and may have a fever. A positive Murphy's sign (arrest of inspiration upon deep palpation of the right upper quadrant) is often present with definite acute cholecystitis, though not necessary for the diagnosis. These symptoms can also occur with amoebic and bacterial hepatic abscesses and without preoperative US; definitive diagnosis can occur in the operating room.

Diagnostic Tests

If laboratory studies are available, a complete blood count (CBC) is useful to identify those with leukocytosis (as well as anemia). Patients who present severely jaundiced usually do not just have cholecystitis. Other diagnoses such as common bile duct obstruction (stone, worm, tumor), primary liver disease, and hemolytic anemias must be considered and caution used before proceeding with operative treatment; surgery may not be indicated. Liver function tests (LFTs) can assist in establishing these diagnoses but are often not available.

Abdominal US is often the most accessible and useful imaging modality to assess gallbladder disease, particularly in resource-limited countries. An abdominal US can evaluate gallbladder size, wall thickness, presence and size of gallstones, pericholecystic fluid, and the size of common bile duct. Though abdominal US has high sensitivity and specificity for stones in the gallbladder, it can miss smaller stones in the common bile duct. The majority of LMICs will not have the availability of CT, magnetic resonance cholangiopancreatography (MRCP), nor hepatobiliary iminodiacetic acid (HIDA) scans. Additionally, utilization of endoscopic retrograde cholangiopancreatography (ERCP), which can be both diagnostic and therapeutic, requires specialized training and facilities, and therefore access is limited.

Treatment

The Essentials

- Open cholecystectomy: recommended treatment option in most settings. When laparoscopic equipment and supplies are present, this would be the preferred procedure.
- Open subtotal cholecystectomy: many patients will present late in their disease progression and anterior wall inflammation may be too great to complete a full cholecystectomy. Drain placement is critical due to chance of postoperative bile fistula.
- Open common bile duct exploration: to relieve blocked common bile duct.
- Cholecystostomy tube: will ultimately require subsequent cholecystectomy. Should rarely be considered unless there are no other treatment options.

For definitive treatment of acute cholecystitis, we recommend open cholecystectomy. This open approach allows for common bile duct exploration as needed and remains the most commonly used method for gallbladder removal in low-resource countries. In the highly unusual scenario of a critically ill patient too unstable to undergo a general anesthetic, a cholecystostomy tube insertion under local +/− sedation may be performed for gallbladder drainage. For severe ascending cholangitis, t-tube drainage of the CBD can be considered to temporize the patient prior to definitive treatment. Though nonoperative management and treatment with fluid resuscitation and antibiotics is a temporizing option, in resource-limited countries, patients are often far along in their disease process and are frequently lost to follow-up; therefore, definitive treatment is recommended.

Small Bowel Obstruction

The Essentials

- Etiology: hernias, adhesions, Ascaris, volvulus, intussusception, strictures, cancers, and foreign bodies.
- Patients will present late and will be dehydrated – attempt to resuscitate prior to surgery.
- Always complete a rectal exam and palpate for hernias (including groin).

As mentioned in detail in the introduction of this section, patients are more likely to present late in the disease process, and attempts at resuscitation and correction of anemia and electrolyte abnormalities should be attempted prior to surgical intervention. The differential diagnosis for small bowel obstruction is broad, but the same principles apply to all patients and include a thorough history and physical exam. Always complete a rectal exam and palpate for hernias (even if no history of hernias), especially groin hernias.

Hernia

Many patients will present with a tender or tense mass at a known hernia site. This may be less reliable in elderly patients, particularly elderly females with femoral hernias. If the patient presents 6 h or less from the initiation of symptoms, then attempts at external reduction may be attempted. If the patient presents over 6 h since the initiation of symptoms, they have an increased risk for compromised or ischemic bowel that requires resection. When attempting reduction, ensure the patient is supine (can place cushions under the legs for reducing abdominal hernias to further relax the abdomen), position in slight Trendelenburg, and administer IV pain medications if available to treat the patient's pain. A general principal of reducing hernias is to not attempt to "push" the mass in; rather slowly "squeeze" the herniated mass, which will push out edema and with slight pressure will often result in successful reduction. If reduction is not successful or the patient has additional symptoms of diffuse abdominal pain or peritonitis, urgent operation is warranted for examination of bowel and repair of hernia defect.

Ascaris

Ascaris lumbricoides is a giant roundworm that infects humans who ingest fertilized eggs. The larva can penetrate the wall of the duodenum and enter the blood stream to then reach other organs, such as the liver, heart, and lung. The larva can then be coughed up and swallowed by which means the adult worms return to the small intestine where they grow and can obstruct the small intestine. *A. lumbricoides* is a large public health concern, and it is estimated that 62 million people suffer from this roundworm infection worldwide [25]. In addition, *Ascaris*-related bowel obstruction is seen in 730,000 people worldwide each year and accounts for 11,000 deaths each year [25]. The adult roundworms can be found as high as the duodenum but generally live in the jejunum and ileum [26]. Patients can present with acute or subacute symptoms [27], and many have a history of worms in their feces or emesis. An abdominal x-ray will not only show signs of obstruction but can reveal worms. For further detail, please refer to Chap. 15.

Small Intestine Volvulus

Patients with volvulus of the small intestine generally present with acute onset abdominal pain and emesis. Abdominal x-rays can assist with the diagnosis and differentiate from other obstructive pathology, such as *Ascaris* obstruction. This requires urgent surgical intervention and attempts to release adhesions, bands, or an internal hernia. Bowel resection may be required.

Intussusception

Young children often present with the history of intermittent abdominal pain, distension, and "currant jelly" stools, and those under 2 may pull their knees to their chest with the pain episodes (Fig. 13.10). In addition, intussusception can be seen in adults due to abdominal tuberculosis, tumors, and *Ascaris* infections. The use of ultrasound is particularly useful for diagnosis and can see a "target" sign. LMICs do not have ready access for enema reduction and radiology confirmation; thus, minilaparotomy is often necessary. In children, the intussusception can be reduced by milking the bowel, not pulling the bowel due to risk of tear. Tumors are a possible cause in adults, and if found intraoperatively, the involved bowel should be resected.

Cancers and Strictures

Cancers are not a common cause of small bowel obstruction in LMICs. In addition, inflammatory bowel disease is also rare, though strictures could be due to abdominal tuberculosis. These should both be considered on the differential diagnosis, and regional variation should be taken into consideration.

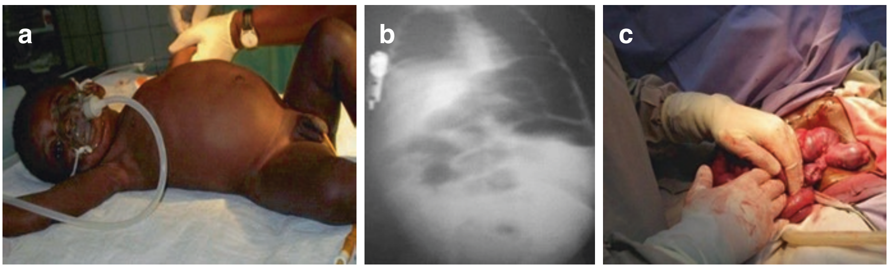

Fig. 13.10. Ileocolic intussusception. (**a**) Depicts a young child at presentation with abdominal distension; (**b**) x-ray findings at presentation; (**c**) the intraoperative findings of the ileocolic intussusception

Perforated Ulcer Disease

The Essentials

- Ulcer disease is an extremely common cause of peritonitis.
- Should be suspected with history of dyspepsia, often due to Helicobacter pylori.
- Treatment: omental patch repair for perforation and postoperative treatment with therapy for H. pylori.

Perforated ulcers are a common cause of peritonitis and acute GI emergencies in LMICs. The incidence has been shown to be as high as four out of five patients with peritonitis [20]. The patients often have a long history of dyspepsia. Unlike typhoid perforations, patients do not have several weeks of fever, headache, or fatigue. Patients will often present with acute onset abdominal pain, and by the time they seek medical attention, they may have a rigid abdomen with rebound tenderness and guarding. Undiagnosed and untreated *Helicobacter pylori* infections are often the cause. As with all patients with perforation, resuscitation prior to surgical intervention is imperative. Treatment includes exploratory laparotomy, identification of the perforation, and omental patch repair. Often, definitive diagnosis of *H. pylori* may not be possible, though postoperative therapy for eradication is indicated. Omental patch seems to have displaced the older treatments that included a truncal vagotomy and a drainage procedure, but there have been no comparative trials in LMICs especially in the context of inability to often treat the *H. pylori* infection. Control of the infection through laparotomy and washout and coverage of the leak site appears to constitute adequate treatment though higher perioperative mortalities are present than in Western series [28, 29].

Colonic Volvulus

The Essentials

- Sigmoid volvulus in young men is prevalent in Africa unlike typical age groups in HICs.
- Early presentation of sigmoid volvulus may be amenable to sigmoidoscopy for reduction of sigmoid volvulus, though sigmoidectomy is warranted for prevention of recurrence.

The most common sites for colonic volvulus are the cecum and the sigmoid. Colonic volvulus is a common cause of large bowel obstruction globally and particularly in LMICs [30–32]. It occurs when a segment of large bowel twists about its mesentery, creating a closed-loop obstruction. Volvuli are at high risk to cause ischemic bowel due to the twisting of the mesentery and subsequent vascular compromise.

Sigmoid Volvulus

This occurs due to an air/stool filled loop of sigmoid that twists around the mesentery. Sigmoid volvulus is the most common colonic volvuli and most often occurs in the Western setting in the elderly or patients over 70 years of age. In Africa, the disease epidemiology is very different than in Western countries and is predominately a disease seen in young males (25–40 years old) [33]. The exact pathogenesis is unknown but may be due to redundant sigmoid colon, very high-fiber diet, or chronic constipation. A recent examination of deceased fetuses in KwaZulu-Natal suggested that there was a possible congenital elongated narrow sigmoid colon which predisposes to volvulus [34]. Those with sigmoid volvulus may have a more insidious onset of abdominal pain and distension, with emesis being a late symptom. Some do present with acute symptoms of obstruction. On physical exam, abdominal distension and tympany are common, with signs of peritonitis raising concern for perforation or ischemic bowel. An abdominal x-ray will often show a U-shape of the distended sigmoid colon, from the pelvis to the right upper quadrant; and air will be absent in the rectum. Though sigmoidoscopy is likely not available in many settings in LMICs, it can be used to reduce the volvulus followed by an elective sigmoidectomy to prevent recurrence. For emergent treatment, both single stage resections with re-anastomosis or classic two stage procedures with colostomy and Hartmann's procedure have been reported. There are also substantial differences in operative treatment reported in African countries for emergent treatment of volvulus even when gangrenous intestine is found. Mixed results with the single stage approach have been found, but it can be safely performed in selected candidates [35, 36]. Creation of a stoma in a low-resource setting has substantial consequences since stoma appliances and bags are almost impossible to find in many areas. If a colostomy is done, reversal at the earliest time should be considered to lessen the impact of the stoma [33].

Cecal Volvulus

In cecal volvulus, the cecum and ascending colon rotate around the mesentery. The pathogenesis is due to a redundant and mobile cecum and ascending colon, which maybe be a congenital development. Cecal volvulus in general occurs in younger patients. There are three types of cecal volvuli; these include type 1 (clockwise axial torsion), type 2 (counterclockwise axial torsion), and type 3 (folding upward of the cecum (bascule)). Type 1 and 2 are the most common. The presentation is also variable, as some patients have more insidious onset of symptoms, while others have acute onset of obstructive symptoms. An abdominal x-ray with cecal volvulus may show an air-filled "coffee bean" cecum that is usually displaced medially and superiorly [35]. Open right colectomy or ileocecal resection is recommended as the definitive treatment for cecal volvulus [35]. Though cecopexy or colpopexy has been described [37], there may be a higher risk of recurrence, and those in LMICs already have decreased access to surgical care.

Due to lack of imaging studies (particularly CT), definitive diagnosis of either type of colonic volvulus may not be possible, and diagnosis will often be confirmed at exploratory laparotomy.

Obstructing Colon Cancer

The Essentials
- Colon cancer is much less common in LMICs, though is increasing due to globalization.
- Due to lack of screening in LMICs, patients often present with obstruction, perforation, or anemia secondary to bleeding.

Colorectal cancers in LMICs is much less common than high-income settings (five to ten times less common), though this is changing fairly rapidly due to globalization and changes in diet [38]. Most cancers are adenocarcinomas, and due to lack of colonoscopies and screening, patients present much later in the disease process, often with obstruction, perforation, or anemia from chronic blood loss. It is rare to have a patient with an asymptomatic colon cancer. Due to lack of pathology and CT imaging, diagnosis of colorectal cancer may be made during exploratory laparotomy. Adjuvant therapies are also limited as is monitoring for recurrence. Colon resection elective or emergent colon resection follows the same principles as in the Western setting except the anastomosis is typically sutured since there are usually no staplers available in the OR.

Liver and Splenic Abscess

The Essentials
- Symptoms for both hepatic and splenic abscesses are often nonspecific.
- Abdominal US is effective for diagnosis and follow-up.
- Antibiotics can be used successfully for small bacterial abscesses of <3 cm.
- Amebic abscess most often respond to medical treatment and do not require drainage until they are >10 cm.

Hepatic Abscess

Bacterial
Symptoms of a bacterial liver abscess are often vague, with right upper or epigastric pain, and can be insidious and nonspecific. Causes of these abscesses can range from biliary obstruction, prior bacteremia episodes, or preceding intra-abdominal infection. Abscesses are very common in Asia but can be found worldwide. Laboratory findings may show a leukocytosis, though liver enzymes may be within reference ranges. Though abdominal CT with contrast has the highest sensitivity, abdominal US is effective in making the diagnosis. Initial

management includes IV antibiotics alone for small abscesses (<3 cm) and percutaneous drainage under ultrasound guidance if available. Percutaneous aspiration can also be considered for abscesses 3–5 cm in size. There are no uniform recommended antibiotic regimens. In general coverage against broad spectrum, organisms (gram negatives/positive and anaerobes) include 2 weeks of IV antibiotics followed by 1–1.5 months of oral antibiotics [39]. Patients who do not improve on treatment should be re-imaged if possible for multiple or loculated abscesses that require drainage or aspiration. It may be difficult to obtain these resources and ensure patient compliance. If percutaneous drainage is not available, and repeat US shows continued abscess, surgical intervention with open abscess drainage is warranted.

Amebic

Amebic liver abscesses are most commonly seen in endemic areas such as Mexico, Africa, India, and Central and South America and are due to an *Entamoeba histolytica* infection. *E. histolytica* is a protozoan that enters the liver via the intestines and portal system. It most commonly affects young men, and symptoms of abdominal/epigastric pain and fever usually occur several months after infection [40]. If laboratory services are available, eosinophilia and a leukocytosis may be seen. Abdominal ultrasound is often required for a diagnosis, and a hepatic lesion consistent with an abscess is seen. Diagnosis is based on clinical and US exam with clinical suspicion based on endemic geographic location and, if available, serology. Empiric treatment with metronidazole to see if the patient improves could be tried in endemic areas, or small needle aspiration to distinguish frank pus from a pyogenic abscess versus the typical "anchovy paste" aspirate of the amebic abscess can be completed. The mainstay of treatment is oral metronidazole for 7–10 days, though if this fails, percutaneous aspiration/drainage is recommended and has been found to mostly be necessary in larger abscess >10 cm in size [39, 41]. Open surgical drainage of amebic liver abscesses is not generally warranted.

Splenic Abscess

Splenic abscesses are generally due to hematogenous spread of bacteria and, as expected, are more commonly seen in immunocompromised patients. Similar to liver abscesses, symptoms of splenic abscess can also be vague and often include fever and abdominal pain. Though patients may not complain of left upper quadrant pain, splenomegaly can sometimes be noted on physical exam or abdominal US. Patients also often have a leukocytosis. Splenectomy is the mainstay of treatment for splenic abscesses. Access to image-guided percutaneous drainage of the splenic abscess is limited in LMICs, though studies have found this is a viable option if done with IV antibiotics [42]. Though difficult in LMICs, it is important to try to ensure patients receive post-splenectomy vaccine prophylaxis, including polyvalent pneumococcal, meningococcal, and *Haemophilus* b vaccines.

Tuberculosis Peritonitis

The Essentials

- Tuberculosis peritonitis is uncommon though increased in patients with HIV, diabetes, and malignancy.
- Ascites is seen in vast majority of patients at presentation.
- Symptoms are insidious and often include abdominal pain, weight loss, and fever.
- Minilaparotomy may be required for diagnosis, though medical treatment with an antituberculosis regimen is the mainstay of management.

Tuberculosis peritonitis is caused by *Mycobacterium tuberculosis* (TB) via hematogenous spread from the lung to the peritoneum. Infection generally occurs due to reactivation of latent TB, though it can also occur in active pulmonary TB. At the time of diagnosis, over 90% of these patients present with ascites. If ascites is not present, it is a sign of more advanced disease [43]. The symptoms are insidious and include weeks to months of abdominal pain, weight loss, and fever. This is a difficult diagnosis as patients often do not know of a diagnosis of TB, and signs of TB are often not present on chest x-ray. The gold standard of diagnosis is culture of *Mycobacterium* from the ascitic fluid or peritoneal biopsy. TB peritonitis should be on the differential in all patients with unexplained ascites. Diagnosis can be made visually with a minilaparotomy as one can see the peritoneum studded with white nodules. Biopsies of these nodules will show caseating granulomas and be positive for acid fast bacilli. Treatment is nonsurgical and requires initiating a full anti-TB treatment regimen (discussed in Chap. 15). Fever, ascites, and abdominal pain all generally improve after several weeks of medical treatment. Those with delayed treatment can develop abdominal adhesions due to the TB peritonitis and are at risk for obstruction in the future – this risk, as well as signs and symptoms of obstruction, should be communicated with patients.

Abdominal Masses

The Essentials

- Pediatric:
  - Abdominal masses are most common in children under 5 years old.
  - The older the child, the more likely the mass is to be malignant.
- Adult:
  - Abdominal masses and cancers are commonly infection related in LMICs (e.g., hepatocellular carcinoma related to chronic hepatitis B and/or C).
- Surgical resection of abdominal masses in children and adults is the mainstay of management.

GI Masses by Age

Abdominal masses vary by age, though the majority of masses in both the pediatric and adult populations ultimately need to be surgical removed. The work up may be more limited in LMICs as the use of CT, MRI, bone scans, laboratory tests, and pathology may not be readily available these settings. This makes history and physical exam even more important in aiding in the diagnosis. It is critical to obtain information on rate of growth, location in abdomen, and mobile versus fixed mass. An abdominal US is useful in determining the site of the mass and can help determine cystic versus solid masses. The most common abdominal masses by age groups and general management considerations are reviewed below.

Pediatric

Abdominal masses in the pediatric population are most common in children under 5 years of age, with most masses in neonates occurring in the retroperitoneum (renal origin). Older children are more likely to have masses that are malignant. The most common diagnoses are Wilms tumor, neuroblastoma, ovarian and liver tumors, and involvement of nodes or organs with lymphoma or leukemia. Please refer to Chap. 20 Essential Pediatric Surgery for more details.

Adult

Abdominal masses in adults may not be symptomatic or palpable, though patients may experience symptoms that narrow the differential diagnosis. Hepatic and splenic abscesses can cause an abdominal mass and must be considered along with malignant etiologies. While obtaining the patient's history, it is also important to seek information on family history of cancer and social history including alcohol and tobacco use. Colorectal cancer, though less common in LMICs compared to high-income countries, is increasing in incidence due to changes in diet and is also diagnosed in very late stages due to lack of screening [38]. Many abdominal masses and cancers in LMICs are related to infectious causes and can be seen in the liver, stomach, and cervix [44, 45]. Liver cancer has a high incidence in developing countries due to chronic hepatitis B and C virus infection and lack of hepatitis B vaccination in childhood [4]. Gynecological cancers can also present as abdominal masses (Fig. 13.11). US is an excellent tool to try to rule out infectious causes of abdominal masses such as liver abscess, echinococcus, kala-azar, or tropical splenomegaly (covered in Chap. 15). If a mass lesion is discovered, primary treatment for most abdominal masses in this setting is surgical resection, with stage of disease determining need for additional therapies such as chemotherapy and radiation therapy. The diagnosis is commonly made at the time of the operation, and resection is completed to remove the mass when technically feasible. Lack of pathology is common, and concrete diagnosis and stage is often unable to be determined (Fig. 13.11). Benign etiologies such as mesenteric cysts can occasionally be found and easily treated by surgical resection (Fig. 13.12). It is not unusual to identify patients with widely metastatic cancer to the liver and/or peritoneum; unfortunately, there are often no good options for treatment or palliation, and long-term survival is uncommon (Fig. 13.13).

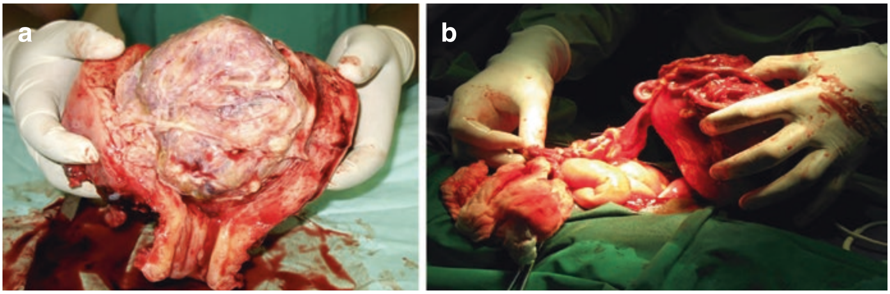

Fig. 13.11. Lower abdominal masses: (**a**) uterine mass; (**b**) ovarian mass

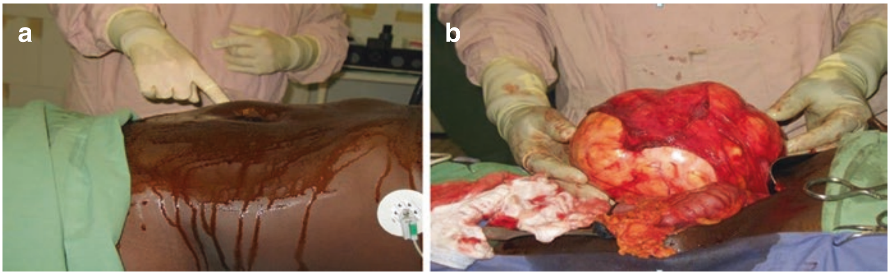

Fig. 13.12. 42-year-old female presenting with right mid-abdominal mass. (**a**) Visible and palpable large abdominal mass; (**b**) operative finding of large mesenteric cyst found at the root of the mesentery

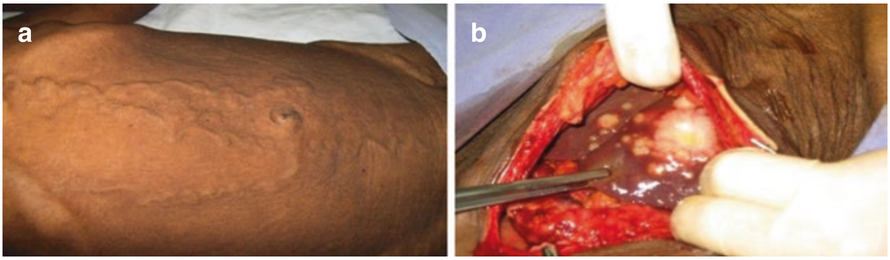

Fig. 13.13 A 47-year-old man presenting with upper abdominal mass. (**a**) Distended abdomen with collateral veins at presentation; (**b**) mini-diagnostic laparotomy revealed probable metastatic cancer throughout the liver

Proper selection of patients should be performed; preoperative hemoglobin, nutritional state, and HIV state need to be carefully considered. In general, operations should be avoided in end-stage HIV cases since the recovery and survival potential is very low. Palliative procedures can also be considered, such as intestinal bypass when extensive tumor is found that cannot be safely resected.

Summary

In summary, general surgical conditions seen in LMIC can be similar to conditions seen in high-resource countries but tend to present later in the disease course. In this setting, it is also necessary to consider that conditions may represent surgical presentations of infectious diseases not commonly seen in high-income countries except in immigrants. Evaluation of the patient with special attention to nutritional status, anemia, and HIV status must be done as well as a consideration of the resources on hand and the patient's ability to afford and participate in the care being proposed. Surgical treatment may be lifesaving and often requires innovative solutions to some of the practice challenges found in these environments.

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Essential Anesthesia

14

Mark J. Harris

Background

Over the last 40 years, the evolution of modern anesthesia in high-income countries (HICs) has led to a 40-fold improvement in perioperative patient safety. Over a similar timeline in low- and middle-income countries (LMICs), anesthesia care has remained poorly equipped, ill funded, and understaffed, with a persistently high morbidity and mortality [1]. When such statistics are available from LMICs, anesthesia is commonly in the top five causes of avoidable death (along with hypertension, hemorrhage, and sepsis) [2]. Most of the anesthesia-related deaths occurred in rural hospitals, and 90% of them were avoidable [3]. Estimates of avoidable anesthesia-related mortality rates in the developing world are scarce and variable [4], but all are at least tenfold greater than in high-income countries [1].

Shortages of trained personnel hamper efforts to improve anesthesia services. The USA has over 24 anesthesia providers per 100,000 population [5], while many low-resource countries have less than 1 provider per 100,000 [6]. Moreover, the majority of these providers are not physician anesthesiologists [6] but nurse anesthetists and “trained on-the-job” noncredentialed providers. Nurse anesthetists in low-income countries have a similar training pathway to their counterparts in the USA. However, “trained on-the-job” practitioners can range from high school graduates formally trained over several years to anesthetist “assistants” who took over the anesthetizing responsibilities when the anesthetist left the post or died. This demonstrates the issue that with a severe deficit of trained personnel, not only is the surgical capacity limited, but individuals are forced to perform procedures for which they may have no training. In some low-resource countries [2], there are disproportionately fewer anesthesia providers than surgeons, making anesthesia personnel the “rate-limiting factor” in unmet surgical need.

M.J. Harris, MD, MPH
Department of Anesthesiology, Rm 3C444, University of Utah Medical Center,
50 North Medical Drive, Salt Lake City, UT 84132, USA
e-mail: mark.harris@hsc.utah.edu

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Standard medications are often in short supply in low-resource regions, e.g., antibiotics and opiates [7]. Access to modern anesthetic drugs is limited, and our colleagues in poor countries must use medications, such as sodium thiopental, long abandoned by wealthier nations.

The majority of institutions in low-resource countries do not meet the World Health Organization (WHO) emergency and essential surgical and anesthesia standards: adequate blood reserves, an oxygen source, a pulse oximeter, and essential medications available at every facility performing surgery [8–10]. Of the equipment that is present, 80% of it is donated [11]. Within a year, less than 30% of donated anesthesia equipment remains functional [12]. Trained maintenance personnel are in short supply, as are spare parts for the wide assortment of donated equipment.

Most surgeries in LMICs are done under spinal or ketamine anesthesia [13]. There may be cases where a general anesthetic is desirable, but unless appropriate equipment, drugs, and personnel are available, this should be avoided. As always with healthcare delivery in the low-resource world, if you are relying on the resources of the local institution, you should do nothing that is not normally done at that institution. If, however, you have brought on your trip the personnel, monitors, equipment, and drugs that you would normally use in your home institution, then your normal procedures and protocols would be appropriate.

Disclaimer

The intent of this chapter is not to instruct a surgeon on how to administer an anesthetic. It may be tempting in straitened circumstances to provide both anesthetic and surgical care. However, performing surgery precludes simultaneously providing vigilant anesthetic care. Even with a stable patient under an established anesthetic, close monitoring must be sustained to ensure continued safety – impossible while operating. It is estimated that 7% of avoidable anesthesia-related mortality is due to the same individual operating and providing anesthesia [14].

Studies of anesthesia-related deaths and near misses reveal that most are avoidable and, when avoidable, usually involve human error. There are several common factors associated with human error, most of which are intensified in the global health environment (Table 14.1).

This chapter will describe the conditions under which your anesthetic colleague is functioning and the potential consequences on your procedure. It is hoped that

Table 14.1 Potential exacerbations of human error

Factors associated with human error	Global health exacerbation
Inadequate preparation	Haste to complete cases in limited duration of mission
Inadequate experience or training	Unfamiliarity with hospital, equipment, anesthetic procedure, or surgery
Environmental limitations	Language difficulty between patient/anesthetist/surgeon/nurses
Physical and emotional factors	Fatigue, illness

with a greater understanding of these limitations, you will help mitigate some of the potential human error in your own practice and in that of your teammates.

Additionally the information in this chapter may facilitate your assistance should your anesthesia partner require it.

Monitors and Equipment

Most facilities in LMICs have limited access to the monitors and equipment that we in HICs would consider vital. The hardware with which you might be familiar may not be available at all, be of a different class, and/or be partially functional.

The following is a brief overview of the monitors and equipment that may or may not be available in the operating theater.

Stethoscope

As simple as it sounds, a stethoscope is a vital piece of equipment in a low-resource operating room. By placing the bell on the suprasternal notch, it can be used to simultaneously and continuously monitor the presence and quality of ventilation and the heart rate and cardiac output.

Sphygmomanometer

In combination with a stethoscope, this is a must-have monitor. Most operating theaters in the low-resource world will have a manual sphygmomanometer. Automatic ones are few and far between.

Pulse Oximeter

If used continuously during surgery, a pulse oximeter can provide timely notice of hypoxia, hypovolemia, and imminent cardiac arrest. The World Federation of Societies of Anæsthesiologists and the WHO recommend routine oximetry use for all patients undergoing anesthesia [15, 16]. Thanks to the decrease in oximeter costs and the efforts of organizations such as Lifebox [17], pulse oximetry is increasingly available in low-resource settings.

Ventilator

A ventilator delivers oxygen to and removes carbon dioxide from an apneic patient. Therefore, if a mechanical ventilator is unavailable, and the anesthesia provider is unable to manually ventilate a patient for many hours, apnea is minimized by avoiding prolonged pharmacological paralysis. This has implications for those surgical procedures where muscular relaxation is helpful.

Anesthesia Machine

An anesthesia machine is used to deliver anesthetic gases by inhalation to the patient. In the low-resource world, there are a broad range of such machines of varying ages, design, and functionality. The anesthetic agents deliverable by these devices will vary from hospital to hospital and even between operating rooms within a single institution.

Capnometry

Monitoring the partial pressure of exhaled carbon dioxide has become an important physiologic and safety monitor. Unfortunately the availability of capnometry in LMICs is limited by the expense of the machines. Although this cost is decreasing as it did for pulse oximeters, a capnometer is still beyond the budget of most low-resource operating theaters.

Anesthetic Gas Analyzer

These analyzers provide the ability to monitor the level of an anesthetic agent in the patient's lungs and therefore extrapolate to levels in the blood and brain. Such information is important for ensuring adequate anesthesia and also for evaluating perturbations in the patient's physiologic state. Unfortunately, the cost of these analyzers is beyond the budget of most low-resource institutions. Consequently, patients often ricochet between "too deep" and "too light" as the anesthetist responds to the patient's hypotension and movement.

Anesthetic Techniques

Ketamine Anesthesia

Ketamine is an inexpensive phencyclidine derivative that produces "dissociative anesthesia" by disconnecting the limbic and cortical systems. Although the patient may appear to be awake with open eyes and purposeful movements, they are non-communicative and experiencing an intense analgesia and amnesia. Ketamine can be administered by intravenous, intramuscular, oral, rectal, subcutaneous, epidural, or transnasal routes. Bioavailability varies considerably between these methods. An intravenous bolus of ketamine has an onset time of 1–5 min. This is slower than most other intravenous anesthetic agents. The duration of action depends on the route of administration (20–30 min for intramuscular and 10–15 min for intravenous).

One reason for ketamine's popularity in low-resource settings is that alone, and when given slowly, it does not produce significant ventilatory depression. This means that an intense analgesic state can be induced without the need for ventilatory support. This is, of course, very important in an environment where there may not be the equipment or personnel to intubate or provide ventilatory support. Ketamine is commonly used for [18]:

- Abscess drainage
- Appendectomy
- Burn and general wound care
- Chest tube insertions
- Cesarean sections – alone or in combination with a patchy or diminishing spinal
- Dilation and curettage
- ENT foreign body removal
- Exploratory laparotomy
- Hysterectomy
- Inguinal herniorrhaphy
- Laceration repair
- Orthopedic procedures:
  - Amputation
  - Dislocation reduction
  - Fracture reduction
  - ORIF
- Prostatectomy

Unlike many other induction and sedation agents, ketamine acts as a sympathetic nervous system stimulant, masking its cardiodepressant effects by the stimulated release of catecholamines. Care should be taken with its use in critically ill patients who may have depleted their endogenous catecholamine stores such as trauma patients. In these individuals ketamine's direct myocardial depressant effects may be unmasked with resultant decreases in systemic blood pressure and cardiac output.

Ketamine increases salivary secretions, and an antisialagogue is often included in preoperative medication.

Many adult patients report unpleasant hallucinations, while under ketamine, premedication with a benzodiazepine is often used to mitigate such recall.

Ketamine crosses the placenta. When ketamine is used for Cesarean sections, newborns will be partially anesthetized and should be cared for accordingly.

Ketamine is included on the WHO List of Essential Medicines [10] but is considered a drug with abuse potential, so steps must be taken to limit unauthorized access.

Spinal Anesthesia

All of the neuraxial techniques (i.e., spinals, epidurals, and caudals) involve injecting local anesthetic into the spinal canal to act upon nerve roots. With a spinal anesthetic, the medication is injected directly into the thecal sac, and with an epidural or caudal, the medication bathes the nerve roots in the epidural space. A spinal technique produces a more intense block, and the administration has a more objective technical end point (i.e., the presence of cerebrospinal fluid in the spinal needle).

Spinal blocks are usually administered at L1 or below and therefore, as a primary anesthetic technique, have proven most useful for lower abdominal, inguinal, urogenital, rectal, and lower extremity surgeries. Upper abdominal procedures (e.g., cholecystectomy) can be performed with spinals, but it is difficult to achieve a sensory block adequate for patient comfort while avoiding the complication of a high spinal.

In addition to sensory blockade, spinals produce a dense skeletal muscle blockade. This can be vital in a region that may have limited ability to provide prolonged muscular paralysis with a general anesthetic.

Benefits of Spinal Anesthetic

- Blunts the stress response to surgery.
- Decreases intraoperative blood loss.
- Lowers the incidence of thromboembolic events.
- Decreases the morbidity and mortality in high-risk surgical patients. Perhaps the greatest impact on mortality has been in Cesarean sections, where spinal anesthesia decreases mortality by half compared with general anesthesia [19].

Regardless of the local anesthetic used, most patients will experience onset of a spinal block within minutes of injection. Time to peak effect varies with the medication used and ranges from 10 min (lidocaine) to 20 min (bupivacaine). Spinal blocks do not end abruptly but recede from cephalad to caudad. There is an important distinction between the duration of surgical block and recovery of normal function. These vary depending on the specific anesthetic, the dose, and any adjuvant medications added to the injectate. For example, lidocaine can last between 40 min and 4 h, while bupivacaine can last between 1.5 and 6 h (Table 14.2).

Complications of Spinal Anesthesia

Complications can be thought of as resulting from the needle or the local anesthetic. Below are the more common complications and those with which you may be able to help.

Table 14.2 Contraindications to spinal anesthesia

Absolute	Relative	Controversial
Patient refusal	Uncooperative patient	Communication difficulty
Infection at injection site	Sepsis	Complicated surgery:
Coagulopathy	Pre-existing neurological conditions	Prolonged procedure
Severe hypovolemia	Severe spinal deformity	Major blood loss
Increased ICP	Stenotic valvular heart lesions	Compromised ventilation
Severe aortic or mitral stenosis		

Needle

Backache – localized inflammatory response to the tissue insult from the needle. Up to 30% of patients receiving only general anesthesia also complain of postoperative backache. Can potentially be a symptom of spinal hematoma.

Post-dural puncture headache – thought to be due to decreased intracranial pressure as cerebrospinal fluid leaks from the thecal sac through the hole left by the spinal needle. Typically the pain is constant, bilateral, frontal, and occipital and associated with photophobia and nausea. Classically it is relieved by lying down and exacerbated by sitting or standing. Usually resolves in a few days to a week.

Spinal hematoma – usually occurs in the setting of a coagulopathy. Rapid surgical decompression is the treatment of choice.

Local Anesthetic

Urinary retention – blockade of the S2–S4 nerve roots decreases bladder tone and inhibits the voiding reflex. More pronounced in male patients, urinary catheterization is recommended for all but the shortest of blocks.

High/total spinal anesthesia – occurs when local anesthetic travels high enough to block the entire spinal cord, resulting in severe hypotension, bradycardia, and respiratory insufficiency. Onset is usually rapid, and treatment consists of ventilatory and cardiopulmonary support.

Cardiac arrest – patients with a high vagal tone are at risk of cardiac arrest during a spinal anesthetic. Commonly, arrest is preceded by a gradual decline in heart rate and blood pressure. Rapid, aggressive treatment of bradycardia, and hypotension minimizes the risk of arrest.

Epidural Anesthesia/Analgesia

As mentioned above, an epidural technique involves injecting local anesthetic into the epidural space where it bathes the nerve roots thus producing its effects. The major differences between spinal and epidural techniques include:

- Correct placement of an epidural needle can be more technically challenging than that of a spinal needle. This is because the epidural space is smaller and potentially harder to find than the intrathecal space.
- Unlike spinal anesthesia, an epidural can be placed at any intervertebral space. Sacral epidural anesthesia is referred to as a caudal block.
- A catheter can be placed in order to facilitate prolonged delivery of medication with either spinal or epidural techniques. It is more common to place a catheter with an epidural technique.
- An epidural technique produces a more focused region of anesthesia and/or analgesia. This is one of the main reasons to use an epidural technique. The zone of effect can be dictated by the level of placement of the epidural needle and the volume and components of medication injected.
- Epidural anesthesia is slower in onset (10–20 min) and less dense than a spinal block.

- Because of the site of placement of an epidural needle and/or catheter, a test dose must be administered before an epidural is used. This test dose is intended to detect intravenous or intrathecal placement of the epidural. The most common test dose is a 3 ml combination of local anesthetic and epinephrine (5 μg/ml). If the epidural is in an epidural vein, the epinephrine will produce tachycardia (an increase of at least 30 bpm) and/or hypertension (an increase of at least 20 mmHg) in the patient. If the epidural is intrathecal, the local anesthetic will produce readily identifiable spinal anesthesia.

Given the possibility of targeting specific dermatomes with an epidural technique, they can be very effective for postoperative or labor analgesia. Minimizing reliance on opioids, and facilitating coughing and ambulation, can dramatically reduce the incidence of postoperative pneumonia and speed recovery [20]. However, in the low-resource setting, equipment for placement and personnel to monitor an epidural can be scarce. Many high-resource organizations will equip their surgical missions with epidural kits sufficient to provide postoperative analgesia for their patients.

General Anesthesia

There are five components of general anesthesia:
1. Unconsciousness
2. Amnesia
3. Analgesia
4. Immobility
5. Mitigation of autonomic responses to noxious stimulation

Production and maintenance of these components is a complex and fluid process. Different portions of the surgical procedure will require emphasis on different constituents of the anesthetic. For example, during skin preparation and draping, emphasis will be placed on amnesia rather than analgesia, whereas during a peritoneal dissection, emphasis will be placed on immobility, analgesia, and sympathetic attenuation. Many of the medications used in anesthetic practice can achieve more than one of these components. For example, opiates can deliver analgesia and autonomic attenuation, while ketamine can provide unconsciousness, amnesia, and analgesia.

Course of a General Anesthetic

Induction of Anesthesia

1. Monitors applied and patient's cardiopulmonary condition are confirmed adequate for conduct of planned procedure.
2. Preoxygenation/denitrogenation. The lungs can be thought of as the oxygen supply tank for the body. Normally, our lungs contain 21% oxygen (i.e., the oxygen content of room air), with the remainder mostly being nitrogen. Once we have rendered a patient unconscious and unable to breathe for themselves, they are

entirely reliant on us to breathe for them (i.e., remove carbon dioxide from the lungs and replace it with oxygen using a bag-mask apparatus or an endotracheal tube). Until we can fulfill this ventilatory requirement, their cells are dependent on the oxygen supply in their lungs. Therefore. the more oxygen there is in their fuel tank, the longer they will be able to survive without ventilation. Three minutes of spontaneous breathing of 100% oxygen will replace the nitrogen and increase the oxygen concentration of the lungs to 95%. Consequently, this will extend to 10 min, the time taken for an apneic patient to drop their saturation to 90%. Ten minutes is usually long enough to successfully intubate a patient. If unsuccessful 10 min is long enough for an induction agent to wear off and a short-acting neuromuscular blocker to be metabolized.

3. Medication administration. The particular choice of medication will be dependent on the nature of the surgery, the nature of the patient, and the drugs available. However, as discussed above, given that the requirements for an anesthetic include unconsciousness and immobility, these drugs will usually include a sedative hypnotic (e.g., sodium thiopental, propofol) and a neuromuscular-blocking drug (e.g., succinylcholine, rocuronium). These paralytic medications usually have a longer onset time than the sedative hypnotics, and so, once rendered unconscious, the patient will usually be mask ventilated while waiting for neuromuscular blockade to occur.
4. Intubation. Placement of an endotracheal tube (ETT) is the procedure most identified with anesthesia providers. It fulfills two functions. The cuff on the ETT seals the trachea and protects the lungs from inflow of fluids from the upper airway, e.g., stomach contents, blood, or pus. Secondly, the cuff on the ETT enables the anesthesia provider to generate intermittent positive pressure in the lungs and therefore ventilates the patient rather than relying on them to breathe spontaneously. In any patient who has been adequately fasted prior to surgery (i.e., no food or drink for longer than 4 h), this intubation process can take place in a standard, stepwise fashion as described above. If the patient has not been adequately fasted or has a disease process that increases their chance of aspiration (e.g., diabetes mellitus, pregnancy), then a "rapid sequence induction" must occur. This is an adaptation of the standard induction process that minimizes the duration of time during which the patient's airway is unprotected and minimizes the insufflation of air into the stomach. The neuromuscular blocker is given at the same time as the sedative hypnotic, and there is no mask ventilation while waiting for paralysis. A difficult airway, expected or not, is a challenging event even in a high-resource institution. In a low-resource setting, with limited preoperative evaluations, relatively poorly trained, inexperienced staff, and few airway adjuncts, it can rapidly lead to a patient's demise. Therefore, in case a surgical airway is required, the most experienced surgeon should be in the operating room during induction and intubation.

Maintenance of Anesthesia

During the surgical procedure, the anesthesia provider will monitor the patient's cardiopulmonary status and modify the anesthetic to provide the five components of a successful general anesthetic (see Sect. 3.5 above). Moreover, resuscitative efforts may be required depending on the patient's preoperative physiological condition and the events of surgery.

Most anesthesia machines in LMICs do not have functioning ventilators. Therefore, either the anesthesia provider will manually ventilate the patient (unlikely for a prolonged surgery), or the patient will spontaneously breathe. If the latter, there will be no muscular paralysis. This may increase the difficulty of the procedure.

Emergence/Extubation

Before a patient can be safely extubated, they must demonstrate a return to normal function:

1. Spontaneous ventilation. Is the patient exhibiting the ability to breathe an appropriate tidal volume (i.e., 6–8 ml/kg) in a regular pattern (i.e., eight to ten breaths per minute)? Only one of these is insufficient – both must be present. Most modern anesthesia machines have the ability to measure tidal volume and ventilatory rate. If this is absent in the operating room, tidal volume can be estimated from the degree of deflation of the ventilation bag, excursion of the chest wall, and abdomen movement. Assessing ventilatory rate is a simple matter of counting. Estimations can be misleading, as inadequately low ventilatory rates often seem normal.
2. Airway protection. Having mitigated the patient's autonomic reflexes for the duration of the surgery, it is important to confirm that they have appropriately returned before restoring airway protection responsibility to the patient's medulla.
   (a) Strength. Has the patient's muscular strength returned to the point where they are able to generate a sufficiently strong cough? The textbook method for assessing such strength is to have the patient hold their head off the bed for 5 s. This reveals the strength of the patient's abdominal musculature, i.e., the source of the power behind an adequately forceful cough. If the patient is unable or unwilling to follow such commands, a similar assessment of their strength can be gained by observing their movements as they emerge from anesthesia.
   (b) Coordination. Having the strength to generate an airway-clearing cough does not necessarily mean that the patient is fully able to protect their lungs. In addition they must have the coordination to take a breath, close their glottis, tense their abdominal and thoracic musculature, and open their glottis in the correct order and with the correct timing. Such coordination is a higher-level function and can be assessed by the patient's ability to follow commands or demonstrate deliberate movements, for example, reaching for the ETT as opposed to simply writhing nonproductively.

Once the patient has demonstrated adequate ventilatory function, normal strength, and productive reflexes, the airway should be suctioned to minimize any potential for aspiration of secretions and the ETT removed. The patient should then be supplied with 100% oxygen by mask for a brief period to ensure maintenance of ventilatory function and exclude airway obstruction by soft tissue or laryngospasm. If all remains well, the patient can be taken to the postanesthesia care unit with a simple oxygen mask in place.

Postanesthesia Care Unit

The early postoperative phase is characterized by a relatively high incidence of potentially life-threatening cardiopulmonary complications (Table 14.3). In HICs, postanesthesia care units (PACUs) have significantly reduced the incidence of early postoperative deaths. In fact the success of extended care in PACUs inspired the development of modern intensive care units.

In LMICs where there is a shortage of manpower and equipment throughout the hospital, close observation during the early postoperative time in close proximity to the most appropriate personnel and equipment is vital to avoid unnecessary morbidity and mortality. The availability of personnel and monitors to adequately run a PACU is a vital part of any surgical endeavor. If these resources do not exist at the institution in which you intend to work, then you should bring them with you.

Table 14.3 PACU complications

Pulmonary complications	**Airway obstruction** (7% of PACU complications)	Hypotonic tongue	
		Laryngospasm	
		Secretions	
		Wound hematoma	
		Edema	
	Hypoxemia	Atelectasis – lasts 7–10 days	
		Pulmonary edema	
		Pneumonitis	
		Pulmonary embolism – air/thrombus/fat	
		Pneumothorax	Intubated patients with high airway pressures
			Trauma patients with rib fracture
			Surgery near diaphragm
		Hypoventilation	Drug induced
			Intrapulmonary abnormality
			Airway obstruction
			Splinting due to pain
			Residual neuromuscular blockade
	Hypercarbia	Malignant hyperthermia (see below)	
		Thyrotoxicosis	
		Rebreathing	
		Pulmonary embolism	

(continued)

Table 14.3 (continued)

Cardiovascular complications	**Ischemia/ infarction**	75% of perioperative infarcts have no pain		
		Tachycardia greatest risk factor for ischemia		
	Dysrhythmias	Sinus tachycardia (100–150 bpm)	Usually benign	Sympathetic discharge
				MI
				Hypoxemia/ hypocarbia
				Hypovolemia/ anemia
		Sinus bradycardia (<60 bpm)	Treat if:	Opioids/ beta-blockade
			<45 bpm	Athletes
			Hypotension	Vagal reflexes/ high spinal
			Slow ventricular response	Hypoxemia
				Elevated ICP
		Premature atrial complexes	Usually benign	
		Premature ventricular complexes	Treat if:	Hypoxemia
			>6/min	
			Multifocal	
			Salvos	Hypokalemia
	Hypotension (3% PACU complications)	Hypovolemia		
		Anemia		
		MI		
		Left ventricular failure		
		Dysrhythmias		
		Low peripheral vascular resistance (e.g., sepsis/spinal)		
	Hypertension	Pain/anxiety		
		Bladder distension		
		ETT		
		Stress response to surgery		
		Hypervolemia		
		Hypoxemia		
		Missed antihypertensive medication		

Malignant Hyperthermia

Malignant hyperthermia (MH) is a rare inherited myopathy with an incidence of between 1:10,000 and 1:250,000 anesthetics. It is associated with abnormal calcium channel receptors and modulators in the sarcoplasmic reticulum. There appears to be no ethnic difference in incidence or pathology. Children under 15 years of age comprise 52% of all incidents, but it presents in all age groups. Patients with central core disease, multi-minicore disease, central nuclear myopathy, and King-Denborough syndrome are all predisposed to MH [21].

MH usually ensues following induction of a "triggering" anesthetic but can rarely occur without an inciting event. It can occur immediately following or hours after the inciting event. "Triggering" anesthetic agents associated with MH are the halogenated volatile anesthetics (e.g., halothane, isoflurane) and succinylcholine. Avoiding these triggering agents can avert MH, even in a known susceptible individual.

MH is characterized by an acute hypermetabolic state, signs of which include hyperthermia, tachycardia, tachypnea, increased CO_2 production, increased O_2 consumption, acidosis, hyperkalemia, muscle rigidity, and rhabdomyolysis. One of the earliest and most sensitive indicators of MH is the unanticipated two- or threefold increase in end-tidal CO_2.

Untreated, MH has a mortality of 100%. With treatment, mortality can be as low as 5%.

Treatment of an acute MH crisis consists of:

- Immediate discontinuation of all triggering agents.
- Hyperventilation (to a minute ventilation of greater than 10 l/min).
- Administration of dantrolene (2.5 mg/kg repeated as required – titrate to heart rate, body temperature, and end-tidal CO_2).
- Cooling by all routes available (intravenous cool saline, topical ice to all exposed areas, peritoneal exchange).
- Hyperkalemia should be managed in the standard fashion using glucose, insulin, bicarbonate, and hyperventilation.

The preparation and administration of dantrolene is a labor-intensive and time-consuming process. Therefore, this is one of those situations in which your anesthesia colleague will require assistance while they are managing the patient's rapidly deteriorating physiology.

After the acute episode, there are three complications of MH:

1. Recrudescence. There is a 25% relapse rate within the first 24–72 h [21].
2. Disseminated intravascular coagulation. This should be managed in the standard fashion.
3. Myoglobinuric renal failure. This should be treated with bicarbonate to protect kidney tubules and mannitol to maintain >1 ml/kg/h urine output.

Due to the relatively low incidence of MH, and the relative expense of dantrolene, operating theaters in low-resource settings rarely stock dantrolene. However, as it is the mainstay of MH treatment, if your anesthesia colleague is planning on using triggering agents, particularly on children, dantrolene should be included in your medication supply.

The Malignant Hyperthermia Association of the United States has a resource-rich website with treatment cards and discussion boards – http://www.mhaus.org/healthcare-professionals. In addition they have a hotline to assist in the acute management of an MH crisis (within the USA 1-800-644-9737, outside of the USA 209-417-3722).

Table 14.4 Approaches to postoperative pain management

Route	Medication		Administration: Preop	Intraop	Postop
Oral	Acetaminophen/paracetamol		✓		✓
	NSAIDs		✓		✓
	Opiates		✓		✓
Intravenous	NSAIDs		✓	✓	✓
	Opiates		✓	✓	✓
	Ketamine		✓	✓	✓
	Lidocaine [24]			✓	✓
Regional	Nerve block	Lidocaine/bupivicaine/ketamine/clonidine	✓	✓	✓
	Spinal		✓		
	Epidural/caudal		✓	✓	✓

Postoperative Pain Management

Inadequately treated pain increases short- and long-term morbidity and mortality. Despite acceptance that access to pain treatment is a human right [22], many LMICs lack even the most basic pain medications (e.g., opioids, nonsteroidal anti-inflammatories) that are on the WHO List of Essential Medicines [10]. Even with this deficit, there are still many possible approaches to managing your patient's postoperative pain (Table 14.4) [23].

Summary

Surgery is a team sport. Given the personnel and equipment surpluses in the high-income world, the necessity for such cooperation is less acute than in the low-income world. Whether you are operating with a trusted colleague from your home institution or a local anesthesia provider with whom you are unfamiliar, the willingness and ability to collaborate in a low-resource environment will prove vital for the provision of safe surgical care for your patient.

Appendix

In the event that your anesthesia colleague requires analytical or interventional assistance with an unstable patient, here are a few diagnostic aids to assist with managing common perioperative events.

Hypoxemia

Defined as oxygen saturation less than 90% or a decrease of more than 5%

Until proven otherwise, low oxygen saturation indicates hypoxemia.

Table 14.5 Differential diagnosis of hypoxemia

Decreased delivery	Decreased FiO_2
	Circuit tubing or ETT kinked
	Leaks in system
	Low O_2 flows (masks)
	Inadequate ventilation
	Obese patient
	Low tidal volume/respiratory rate
	Right main stem intubation
	Bronchospasm
	Pneumothorax
	Ventilation/perfusion mismatch
	Atelectasis/pneumonia
	Aspiration/secretions
	Pulmonary embolus
	Pulmonary edema
	Cardiac shunts
Decreased transportation	Low cardiac output/hypotension
Artifacts	Blue dyes (e.g., methylene blue)
	Electrocautery
	Cold hands/Raynaud's/decreased perfusion

Management

- Increase O_2 delivery to 100%.
- If available, check $ETCO_2$ and peak airway pressure.
- Hand ventilate with large volumes.
- Look at chest and auscultate breath sounds.
- Check endotracheal tube and circuit.
- Suction airway.
- Check pulse oximeters and color of patient (Could it just be machine artifact?).
- Should the patient be reintubated?
- Table 14.5.

Hypotension

Defined as a decrease in mean arterial pressure of more than 20% below baseline (Table 14.6).

Initial Checklist

- Verify BP (e.g., is someone leaning on blood pressure cuff?).
- Check other vital signs (heart rate, CO_2, oxygenation).
- Check blood loss or persistent surgical venous compression.

Table 14.6 Differential diagnosis of hypotension

Preload	Afterload	Contractility
True hypovolemia:	1. Neuraxial anesthesia/ spinal shock	1. MI/ischemia
1. Ongoing hemorrhage	2. Release of aortic cross-clamp	2. Dysrhythmias
2. Inadequate resuscitation	3. Anaphylaxis/transfusion reaction	3. Congestive heart failure
3. Fluid sequestration	4. Systemic inflammation/sepsis	4. Hypothermia (<32 °C)
4. Vomit/diarrhea	5. Liver failure	5. Hypothyroidism
5. Osmotic/diuretic polyuria	6. Rewarming	6. Malignant hyperthermia/ sepsis
6. Pre-existing hypertension (i.e., chronic volume depletion)	7. Hypothyroid	7. Hypocalcemia
	8. Drugs:	8. Severe acidosis/alkalosis
Relative hypovolemia:	(i) Antihypertensives	9. Drugs:
1. Positive pressure ventilation	(ii) Antidysrhythmics	(i) Anesthetics
2. Tension pneumothorax/ cardiac tamponade	(iii) Anticonvulsants	(ii) Antidysrhythmics
3. Caval compression (e.g., pregnancy, tumor, surgical packing)	(iv) Induction/inhalational agents	(iii) Calcium/adrenergic blockers
4. Pulmonary hypertension/ pulmonary embolism		(iv) Local anesthetic toxicity (especially bupivacaine)
5. Valvular disease		
6. Head-up position		

Initial Treatment

- Intravenous (IV) wide open (crystalloids).
- Decrease or stop anesthetic.
- Increase FiO_2.
- Administer inotropes/vasopressors (ephedrine/phenylephrine/epinephrine/vasopressin).
- Consider:
- Head-down position.
- More/larger IV access.
- Give colloids/blood.
- Table 14.6.

Hypertension

Defined as an increase in blood pressure more than 20% above baseline.

Initial Checklist

- Verify BP (e.g., is someone leaning on blood pressure cuff?).
- Check other vital signs (heart rate, CO_2, oxygenation).
- Check sources of anesthetic (IV, vaporizer).

Initial Treatment

- Increase anesthetic (vaporizer/epidural/local).
- Labetalol – 5 mg increments.
- Nitroglycerine – 0.1–2 mcg/kg/min.
- Nitroprusside – 0.1–3 mcg/kg/min.
- Nifedipine – 10 mg sublingual.

Differential Diagnosis of Hypertension

Pre-existing Disease

- Hypertension/heart failure
- Early acute myocardial infarction/aortic dissection
- Autonomic hyperreflexia (spinal cord transection at or above T7)
- Increased intracranial pressure
- Autonomic instability
- Alcohol withdrawal
- Endocrine (hyperthyroid/hypoglycemia/pheochromocytoma/carcinoid)
- Preeclampsia
- Bladder/colon/stomach distension

Surgical

- Aortic cross clamping
- Prolonged tourniquet time
- Post-myocardial revascularization
- Post-carotid endarterectomy (denervation of carotid baroreceptors)
- Hypervolemia (TURP syndrome)

Anesthetic

- Pain/light anesthesia
- Increased temperature (malignant hyperthermia)
- Hypoxemia/hypercarbia/metabolic acidosis
- Hypervolemia/vasoconstriction
- Blood pressure cuff too small
- Emergence delirium

Drugs

- Vasopressors
- Systemic absorption of vasoconstrictors
- Monoamine oxidase inhibitors/tricyclic antidepressants
- Cocaine/ketamine
- Naloxone (reverses opiates)
- Intravenous indigo carmine dye
- Rebound (i.e., clonidine/β-blocker cessation)

Table 14.7 Differential diagnosis of prolonged emergence

Prolonged drug action	Metabolic causes	Neurologic injury

Overdose
Hypothermia (<33 °C)
Increased sensitivity
Decreased protein binding
Redistribution
Drug interaction
	Hypoxia/hypercarbia
	Organ dysfunction:
	  Hepatic
	  Renal
	  Endocrine
	Hypoglycemia/hyperglycemia
	HONK/diabetic ketoacidosis
	Electrolyte imbalance:
	  Hyponatremia
	  Hypocalcemia
	  Hypomagnesemia
	Hypothermia (<33 °C)
	Sepsis
	Alcohol
		Intracranial:
		  Hemorrhage
		  Contusion
		Cerebral embolus
		Cerebral ischemia
		Seizure:
		  Subclinical
		  Postictal state
		Raised ICP
		Pneumocephalus

Prolonged Emergence

Defined as unexpected failure to regain consciousness 30–60 min after cessation of general anesthesia (Table 14.7).

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WHO Anæsthetic Infrastructure and Supplies List – http://www.who.int/entity/surgery/publications/s15983e.pdf?ua=1

WHO Guidelines for health care equipment donations – http://apps.who.int/iris/bitstream/10665/70806/1/WHO_ARA_97.3_eng.pdf

Tropical Infectious Disease Medicine for Surgeons: A Primer

15

Bruce C. Steffes and R. Gregory Juckett

Introduction

The Essentials

- *In LMIC environments, that which appears to be "surgical" may not be.*
- *Diagnostic and therapeutic options may be at a minimum putting a premium on the history, physical exam, and knowledge of the disease.*
- *Algorithms for diagnosis and treatment are different in the LMIC.*
- *Do not to fail to prepare or to take care of yourself.*

Surgery in the tropics requires more than just the right set of surgical skills. It is also vital that the surgeon understands the various local infectious diseases and how they present. This is consistent with the aphorism that the best surgeon is the internist who cuts. What may first appear to be "surgical" may not be. The differential diagnosis in this new area of practice involves all the usual suspects plus the local tropical diseases; thus, "tropical" algorithms for care must supplant the familiar ones from home. Conditions caused by infectious disease will often change the operative risk and confuse postoperative conditions. The challenge is to provide the same level of surgical care in an environment where resources are limited, little if any backup is available, and many patients suffer from malnutrition.

Conditions caused by infectious disease change the operative risk. Severe immunosuppression from HIV-AIDS and/or malnutrition are common, and both

B.C. Steffes, MD, FACS, FWACS, FCS(ECSA) (✉)
Pan-African Academy of Christian Surgeons, c/o Christian Medical and Dental Associations, 504 Old Jonesboro Road, Bristol, TN 37620, USA
e-mail: bruce.steffes@paacs.net

R. Gregory Juckett, MD, MPH, FAAFP C TropMed
Department of Emergency Medicine/Family Medicine, West Virginia University School of Medicine, 390 Birch Street, Morgantown, WV 26506, USA
e-mail: gjuckett@hsc.wvu.edu

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conditions may be exacerbated by parasitic infection or concomitant tuberculosis. Anemia, from malaria or hookworm, seems ubiquitous in low- and middle-income countries (LMICs). Many such areas report anemia in 50–98% of children and 27–49% of women. Twenty percent of these anemia cases are severe [1]. The Advanced Trauma Life Support (ATLS) "rule" of giving two liters of crystalloid (or two boluses of 20 mL/kg) and then type-specific blood presumes a normal starting hematocrit. Blood may be needed well before then in the anemic patient who already has a severe deficit in oxygen carrying capacity.

Blood transfusions to correct anemia pose a major challenge in global health. A severely anemic patient facing surgery requires blood immediately. However, such transfusions are often unavailable and are certainly not without risk. The presence of HIV and hepatitis B and C in the donor supply may make the risk of transfusion even greater.

Medical students in the Global North may be taught that the causes of postoperative fever are the "5 Ws" of wind, water, walking (vein), wound, and wonder drugs. In the Global South, it's often the "3 Ms" of malaria, malaria, malaria and maybe only later the "5 Ws." Students in the North are taught the law of parsimony in making a diagnosis ("No matter how you push and squeeze, the symptoms have to fit just one disease."). In less-developed areas, it seems that everyone has two or three diseases.

The prevalence of infectious disease and its consequences brings into play Bayesian probabilities, i.e., hoofbeats here really can be zebras. In some regions, intestinal nematodes, not small bowel adhesions, may be the leading cause of small bowel obstruction. That changes diagnostic and care algorithms. Similarly, depending on where you are, jaundice may be more often related to worms or flukes than to gallstones. A patient with hematuria may have schistosomiasis rather than kidney stones. On the other hand, it is equally important to remember that tropical hoofbeats may still be horses: not all cases of dysentery are due to ameba or shigellosis.

Diagnosis is often difficult in the austere clinical environment of the tropics. Advanced laboratory techniques are neither available nor affordable, and even the most basic microbiology lab is a distinct luxury. Decisions often must be made quickly with a minimum of laboratory support. Treatment is more likely to be empiric with trials of the most appropriate medications available at the time.

Basic assumptions, like universal tetanus immunization, are also challenged in these settings. The surgeon in the global health environment should never forget the risk of tetanus. Patient immunization status may be uncertain, and many, if not most, patients are inadequately immunized – even if they have records of having received it. Tetanus immune globulin is hard to come by, so vaccination at the first thought of tetanus risk is the best option.

The surgeon who is preparing to work in tropical medicine would be well advised to prepare adequately. If time and degree of involvement permit, there are some excellent courses in tropical medicine and humanitarian surgery which range from day courses to those of several weeks or months in length. A good printed or electronic general patient care manual and some critical smartphone apps or URLs are

Table 15.1 Suggested print and electronic resources for tropical medicine

Print and Kindle Allman K, Wilson I. Oxford Book of Anaesthesia, 2016
Auerbach P, Constance B, and Freer L. Field Guide to Wilderness Medicine. 2013
Brent A, Davison R, Seale A. Oxford Handbook of Tropical Medicine. 2014
Cahill K. Tropical Medicine: A Clinical Text. 2011
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Magill A, Ryan E. Hunter's Tropical Medicine and Emerging Infectious Disease, 2012 (also online access)
Palmer D, Wolf C. Handbook of Medicine in Developing Countries. 2014
Print only
Sanford CA; Jong E. The Travel and Tropical Medicine Manual 2016
King, M. Primary Surgery – Volume 1 (Non-Trauma; 1993); Primary Surgery – Volume 2 (Trauma, 1993); Primary Anesthesia (1986). Only available from www.talcuk.org
Internet sources
Open Library – Rockwood, Green and Wilkins' Handbook of Fractures https://openlibrary.org/works/OL14849703W/Rockwood_Green_and_Wilkins'_handbook_of_fractures
Open Access ENT text: http://www.entdev.uct.ac.za/guides/open-access-atlas-of-otolaryngology-head-neck-operative-surgery/
PAACS Principles of Reconstructive Surgery: http://www.paacs.net/involved/paacs-resources/
Urology textbook: http://www.urology-textbook.com/
Surgical Care at the District Hospital – WHO Manual. Free download from http://www.who.int/surgery/publications/scdh_manual/en/index.html
Semer Nadine, "Practical Plastic Surgery" Philadelphia: Hanley and Belfus, 2001 PDF downloadable from http://www.practicalplasticsurgery.org/docs/PPS_complete.pdf
Maurice King's Primary Surgery wiki (Courtesy of the Canadian Network for International Surgery) has many chapters downloadable as PDFs. Volume 1 http://www.cnis.ca/what-we-do/african-information-program/primary-surgery-wiki/ and Volume 2 https://www.ghdonline.org/surgery/discussion/primary-surgery-trauma-volume-2-2/

strongly recommended to help treat both surgical and nonsurgical infectious disease (see Table 15.1). Once in the tropics, locally experienced clinicians provide a gold mine of information and their opinions should be sought and respected.

It is critical that the surgeon also prepare to take care of his own health. While in the planning stage, consult with a travel health expert before departure for his or her advice on antimalarial prophylaxis, vaccinations, and necessary prescriptions for antibiotics. Allow enough time to complete the longer vaccination protocols (e.g., 6 months for hepatitis). Study the Centers for Disease Control and Prevention (CDC) recommendations for travelers to those countries. Ensure that you have a supply of freshwater or have a high-quality portable water filter. Take necessary precaution against insect bites (including high-quality mosquito repellents and nets). As much as possible, wear the appropriate personal protective equipment. In the operating room, always wear splash guards or protective eyewear, double-glove, and use "no touch" methods in passing sharps. Ensure that you will have access to the drugs necessary for postexposure prophylaxis for HIV.

Malaria

The Essentials

- *Knowledge of the common strains and treatment of malaria in your area of service is critical.*
- *Single-drug therapy of malaria is not recommended.*
- *You should use a good antimalarial prophylaxis regimen and avoid insect bites since prophylaxis does not actually prevent contacting the disease.*
- *You should know your G6PD status if you are serving in an area where P. ovale and P. malariae are common.*
- *Tropical splenomegaly patients should be treated for a prolonged period with antimalarials before considering surgery.*
- *Splenectomy in tropical splenomegaly due to visceral leishmaniasis (kala-azar) is reserved for cases of severe hypersplenism (uncommon) and drug resistance.*

Introduction

Malaria continues to be a major scourge in many LMIC (especially those in sub-Saharan Africa) and should be considered in the differential diagnosis of any febrile patient, including post-op patients. Many surgical cases present with malarial coinfection, and it is common for some patients to have several different diseases. Mosquitoes are such a problem in developing nations that many unscreened hospitals must enforce the use of bed nets to prevent nosocomial malaria infections in surgical patients. About half a million African children are thought to die of malaria every year, down from one to two million in the recent past. For those who survive their childhood encounters with this disease, malaria becomes a debilitating recurrent illness resulting in chronic anemia and fatigue. Besides Africa, other key regions for malaria include South and Southeast Asia (especially during the monsoon), the Amazon, and Oceania (Papua New Guinea, Solomon Islands, and Melanesia) [2].

Life Cycle and Species

Anopheles mosquitoes spread malaria by injecting sporozoites when they bite. These multiply in the liver, reemerging as merozoites which attack red blood cells. Merozoites become trophozoites, the feeding form of the parasite, feasting on the host's hemoglobin and soon destroying infected red cells to release yet more merozoites and repeat the cycle. It is the lysis of RBCs (erythrocytes) and release of cytokines, eventually occurring in synchrony, which is responsible for the shaking chills (rigors) and periodic fevers of classic malaria. Female *Anopheles* mosquitoes become infected when they take up the reproductive cells, gametocytes, in their

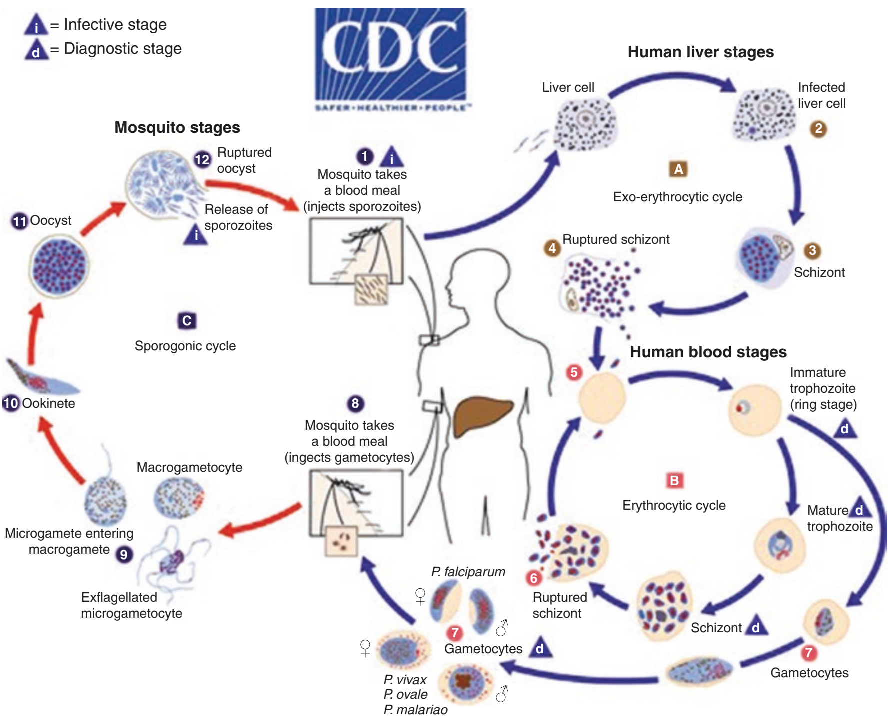

Fig. 15.1 Life cycle of malaria [3] (Figure courtesy of DPDx and CDC site http://www.cdc.gov/malaria/about/biology/)

human blood meal, with the sexual aspect of malaria's life cycle occurring in the mosquito gut with subsequent dissemination to the salivary glands (Fig. 15.1) [3].

The most serious form of malaria, *Plasmodium falciparum* (malignant tertian), produces febrile episodes every 48 h and is associated with the dreaded complications of cerebral malaria (coma and death), "blackwater fever" (hemoglobinuria and kidney failure), algid malaria (cold clammy skin, vomiting, diarrhea, or dysentery), and noncardiogenic pulmonary edema. Red cells infected by *P. falciparum* develop surface knobs, causing them to sludge and eventually obstruct capillary networks in the brain and kidney. This form of malaria predominates in sub-Saharan Africa but may be found throughout the tropics. Falciparum malaria is also the most resistant to drugs. It is usually resistant to chloroquine outside of Central America and Haiti and has also developed resistance to mefloquine in much of Southeast Asia.

Vivax malaria ("benign tertian," caused by *P. vivax*) is the other common malaria species, also causing fever every 48 h. It is more tolerant of cold and can be found at higher elevations, or in temperate climates, as well as tropical areas. Although a serious debilitating infection, it is far less likely to be fatal, although splenic rupture may occasionally result in death. This malaria can persist in the liver as hypnozoites, or "sleeper cells," allowing it to survive unfavorable conditions in the host and permitting multiple relapses. In that case, patients stressed by surgery can relapse even without reexposure to malaria. Black Africans are relatively resistant to *P. vivax* since they lack the Duffy antigen, the receptor which allows vivax malaria to penetrate the RBC membrane.

Vivax malaria has developed resistance to chloroquine in Indonesia and Papua New Guinea. Both the blood and liver forms of vivax must be treated to effect a cure. So, in addition to typical malaria treatment to eliminate merozoites, patients with *P. vivax* must also be treated with primaquine phosphate if relapse is to be prevented. As primaquine provokes hemolysis in patients with G6PD (glucose-6-phosphate dehydrogenase) deficiency, all patients should be screened for this prior to its administration. Surgeons who work in areas known to have endemic vivax malaria are advised to know their own G6PD status.

The remaining two species of human malaria are far less common. *P. ovale* (also termed "benign tertian" malaria) is found in W. Africa and sporadically around the globe. It is very similar to *vivax* but easily infects African blacks. It too must be treated with primaquine to eradicate the liver phase and thereby remove the risk of eventual relapse. *P. malariae* ("benign quartan malaria," causing fever every 72 h) is the rarest and least virulent malaria species and can persist for long periods in the blood with minimal symptoms, making this the most likely malaria to be spread by blood transfusions. It is also the malaria species most likely to result in nephrotic syndrome.

P. knowlesi is a lesser known type of malaria affecting primates in SE Asia. It was recently described as causing zoonotic infection in humans. It is a virulent disease clinically resembling *P. falciparum* and is treated in the same manner.

Presentation

Malaria begins with a flu-like illness with nonperiodic fever and sweats. Synchronous fever only develops later in the course of the disease after the red blood cells start lysing in unison to produce a diagnostic febrile pattern. Therefore, malaria must be suspected with any febrile illness (periodic or not) in an endemic area and with any travel history to an endemic area. The classic malaria presentation of shaking chills (rigors) followed by high fever, headache, and myalgias on alternating days, while typical, should never be considered necessary for diagnosis. Patients on inadequate prophylaxis may have more subtle symptoms with a resultant dangerous delay in diagnosis. Hemolysis often results in significant jaundice (unconjugated hyperbilirubinemia) superficially resembling clinical hepatitis. Splenic enlargement produces abdominal discomfort in the left upper quadrant. Falciparum malaria has innumerable presentations with cerebral, renal, pulmonary, and gastrointestinal versions mimicking many other diseases. Malaria causing dysentery with fever may be mistaken for Shigella infection. Headache with fever may be caused by either meningitis or malaria, and both conditions must be excluded, especially in the meningitis belt of Africa. In a population which is generally partially immune, recurrent disease may be a sign of immunosuppression – look for a secondary process (e.g., pneumonia, urinary tract infections, HIV-AIDS, etc.). The immunosuppression of trauma or surgical insult can cause recurrence of malaria.

Children more commonly have convulsions, coma, hypoglycemia, metabolic acidosis, severe anemia, and neurodevelopmental sequelae. Adults are more likely to have severe jaundice, acute renal failure, and acute pulmonary edema.

Diagnosis

Malaria may be diagnosed with rapid diagnostic tests (RDTs) or with thick and thin blood smears. Blood smears remain the gold standard. However, antigenic testing (RDTs) of the right type for the malaria in the region can not only provide rapid diagnosis but also identify the malaria species. Limitations may include persistent reactive titers from prior infections, cost of the test, and the inability to determine the level of parasitism. The thick blood smear determines if malaria is present, while the thin smear helps identify the malaria species. In many African countries, where 98% of all malaria is due to *P. falciparum (vivax* being unlikely in the black population), the thick smear is often the only test performed. Thin smears are essential to speciate the malaria parasite, determining if it is *P. falciparum*, *vivax*, *ovale*, or *malariae*. Only blood smears can determine the level of parasitism and gauge the effectiveness of therapy. A smear may be initially negative, especially if obtained between febrile episodes, and up to three specimens 8 h apart may be necessary to confirm a diagnosis. Malaria should be suspected before fever periodicity develops and prompt treatment can be lifesaving [4]. If parasitemia is greater than 2% on the thick smear, the patient most likely has *P. falciparum* (or *P. knowlesi*). This is true because *P. vivax* and *P. ovale* only infect reticulocytes; therefore, the parasitemia is about 1–2%. (Fig. 15.2a, b) [5].

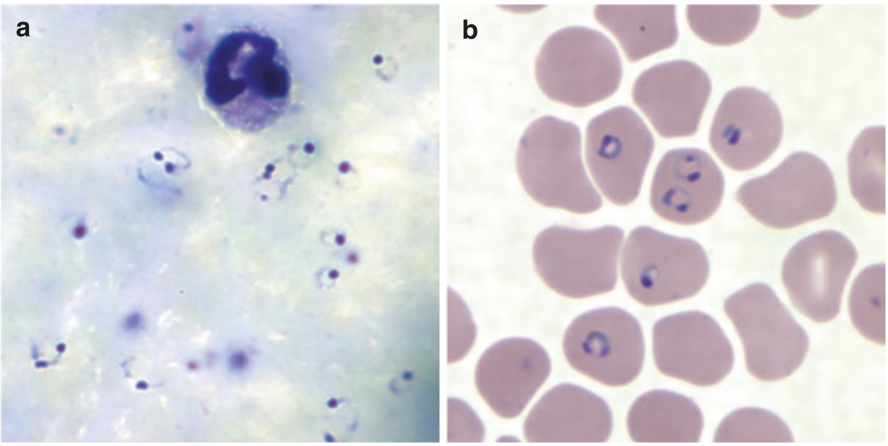

Fig. 15.2 (**a**, **b**) Ring forms of *P. falciparum* in thick smear (*left*) and thin smear (*right*) *[5]* (Photos courtesy of DPDx and CDC site http://www.cdc.gov/dpdx/malaria/gallery.html#pfalringformtrophs)

Treatment

Uncomplicated falciparum and other malarias are often treated with artemisinin combination therapy (ACT). The Ministry of Health in many countries have often selected one or more types of combination drugs and the others are not available, so asking one's co-workers or pharmacist can be helpful. Perhaps the most common option is artemether-lumefantrine (*Coartem*, *Riamet*) which can be given as a 3-day course (for nonimmune travelers) or as a 2-day course for those with prior malaria exposure (immunity is never complete with malaria even in those exposed frequently). *Coartem* is available in the USA as well. Atovaquone-proguanil 250/100 (*Malarone*) is another reasonable option, given as four tablets daily × 3 days. Older regimens include quinine and doxycycline (multiple side effects), mefloquine (neuropsychiatric side effects), or sulfamethoxazole-pyrimethamine (less effective). Chloroquine therapy is now reserved for only Central America, the island of Hispaniola, and the relatively few areas still sensitive to this drug. For *vivax* and *ovale* malaria, primaquine phosphate 15 mg two tablets daily × 2 weeks should be prescribed for terminal treatment, to prevent later relapse. G6PD deficiency should be excluded before primaquine is used [6].

Complicated or severe infection in the nonimmune patient (severe defined as a parasitemia >2%) with *falciparum* malaria (including its cerebral, renal, GI, and pulmonary complications) must be treated with IV artesunate or quinine (or quinidine in the USA, where IV quinine is unavailable) [7, 8]. Artesunate is now the drug of choice for complicated malaria as it clears the malaria parasite more rapidly than quinine.

Recidivism is high when artemisinins are used either orally or parenterally as monotherapy, and therefore as soon as oral medication can be taken, doxycycline or clindamycin should be started as a complete course. In the event IV quinine is used, it should always be given with dextrose 10% infusion and every 2 h blood sugar checks to prevent hypoglycemia. Hypoglycemia is particularly a problem in children and pregnant women. The Centers for Disease Control and Prevention (CDC) – USA) maintains a 24 h hotline to assist clinicians with difficult malaria cases [9].

Prevention

Prevention of malaria is through the use of permethrin-treated bed nets and the appropriate use of prophylactic drugs (chloroquine, mefloquine, atovaquone-proguanil, or doxycycline). Insect repellents after dusk and bed nets are very helpful [10]. Natural immunity to malaria achieved by frequent exposure to the infectious mosquito is at best short-lived and disappears in as little as 6–12 months after going to a non-malarial region. For a nonnative, attempting to acquire malaria immunity through natural infection is an untenable strategy. As Philip Briggs in the Bradt Travel Guide for Uganda states "Some travelers prefer to acquire resistance to malaria rather than take preventative tablets, or they twitter on about homeopathic cures for this killer disease. That's their prerogative, but they have no place expounding this ill-informed drivel to others. Travelers to Africa cannot acquire any effective resistance to malaria, and those who don't make use of prophylactic drugs risk their life in a manner that is both foolish and unnecessary" [11].

Tropical Splenomegaly

All forms of malaria can lead to splenomegaly, but some chronic malarial infections are thought to result in the "tropical splenomegaly" syndrome (synonym: hyperactive malarial syndrome). It is unclear whether it is a property of the disease or the patient's response to the disease or a combination. This condition is characterized by massive enlargement of the spleen (10 cm below costal margin), high IgM levels (>2 standard deviations above local mean), and high malaria antibody titers. Documented malaria parasitemia is rare in these patients, however. Tropical splenomegaly is especially common in malnourished patients found in Eastern Indonesia and Papua New Guinea. The liver can also be enlarged with lymphocytic infiltration of the hepatic sinusoids (Fig. 15.3).

Symptoms include massive splenomegaly with abdominal swelling, discomfort, and anemia. The differential diagnosis of splenomegaly includes non-cirrhotic portal fibrosis (common in India), kala-azar (leishmaniasis), schistosomiasis, lymphoproliferative disorders, typhoid, TB, thalassemia, and Felty syndrome.

Treatment is with antimalarial drugs for at least 1 year. Despite the size, splenic rupture is uncommon as is portal hypertension and ascites. Splenectomy is a last resort and should be performed only if long-term antimalarials fail and the patient is uncomfortable and suffers from hypersplenism. Vaccination against pneumococcus, meningococcus, and *H. influenzae* B should be carried out before splenectomy. Asplenic patients must be vaccinated as well and treated aggressively for infections [12].

Fig. 15.3 A young boy in West Africa with tropical splenomegaly

The massive splenomegaly of visceral leishmaniasis (kala-azar) usually causes hypersplenism, but unless it is severe, splenectomy is reserved for massive splenomegaly in the face of drug-resistant kala-azar [13, 14]. The mechanisms for increased sensitivity after splenectomy is unclear. Liposomal amphotericin B, antimony, and miltefosine (oral) are all used to treat kala-azar. Miltefosine is the drug of choice for kala-azar in South Asia where resistance to antimonials is common.

Enteric Fever (Typhoid and Paratyphoid)

The Essentials

- *A disease of poverty and fecal contamination of water, it is more common in dry season.*
- *The commonly available Widal test is of little practical help.*
- *Typhoid vaccination, whether oral or intramuscular, is not fully protective.*
- *Antibiotic resistant typhoid is on the rise.*
- *Steroids are only used in very severe disease,* e.g.*, coma, obtundation, or shock, and may go the way of steroids in other cases of septic shock.*
- *GI hemorrhage is more common than perforation, but perforation is the most common indication for surgery.*
- *The proper surgical treatment is still debated for some cases, but resection is preferable for multiple perforations close together. Second-look laparotomy may be indicated.*
- *Acute typhoid cholecystitis is more common in children.*

Typhoid fever is caused by *Salmonella enterica*, serotype Typhi. Milder paratyphoid fever is a similar infection caused by other *Salmonella enterica* serotypes Paratyphi A, B, or C. Enteric fever, which refers to both typhoid and paratyphoid, is a global disease of less-developed regions with poor hygiene, with typhoid having the higher mortality (10–20%) if not treated. One-third of the world's population is at risk. Children in South and Southeast Asia are the most frequently affected, but the disease is also found throughout sub-Saharan Africa and parts of Central and South America [15]. Carrier states may develop in some patients, especially those with chronic cholecystitis or urinary schistosomiasis.

Presentation

Symptoms of typhoid fall into four 1-week stages, following a prolonged incubation period (up to 30 days after exposure). The first stage is characterized by progressive

Fig. 15.4 (**a**, **b**) Young Togolese boy with typhoid facies (**a**) and evidence of obtundation, abdominal distension, and previous treatment (lettering on abdomen) by a national healer (**b**)

fever, headaches, abdominal discomfort, constipation, and weakness. The second stage is marked by high sustained fever (38–40 °F), often with relative bradycardia (Faget's sign). Cough and rhonchi at this stage resemble bronchitis. Light-skinned patients may develop "rose spots" on their chest and abdomen, which are actually bacterial skin emboli. Pea-soup diarrhea with a foul odor often replaces constipation in the second stage, and the abdomen is usually distended and tender. Delirium with high fever is common. The so-called typhoid facies is evident at this point (see Fig. 15.4a, b). The third stage is characterized by continued fever and debility with potentially fatal complications: intestinal hemorrhage, metastatic abscesses, and distal ileal perforation. The Peyer's patches in the distal ileum are prone to hemorrhage, and this area also becomes subject to perforation, resulting in peritonitis and free air in abdomen. Operative intervention at this stage is lifesaving. Recovery usually occurs slowly in the fourth week of illness [16, 17].

Atypical manifestations of typhoid fever include cholecystitis, acute lobar pneumonia, isolated arthralgias or myalgias, urinary symptoms, severe jaundice, or fever alone. Some patients present primarily with neurologic manifestations such as isolated severe headaches that may mimic meningitis, delirium, or, in extremely rare cases, parkinsonian symptoms, Guillain-Barré syndrome, or acute transverse myelitis [18]. Other unusual complications include pancreatitis, orchitis, osteomyelitis, and abscesses anywhere on the body.

Diagnosis

The diagnosis of typhoid and paratyphoid is based on blood or bone marrow cultures, with the latter being the most accurate. Stool cultures are the least accurate. Blood cultures are typically positive in the first and second weeks. The old-fashioned Widal test (anti-O and anti-H antibodies) becomes positive only in the second week of illness and is less useful, since empiric therapy should be started before the Widal is available. Also, false positives from prior typhoid infections limit the value and usefulness of this antiquated test. Platelet counts may drop later in the disease.

Prevention

Typhoid is spread through fecal-oral contamination; thus, it is preventable through proper sanitation, food handler hand hygiene, and control of flies. There are two typhoid vaccines but both provide only about 70% protection. The live oral vaccine (*Vivotif Berna Oral Typhoid*®) consists of four capsules, taken once every other day, with a 5-year protective effect. It can be used in nonpregnant, immunocompetent patients >6 years of age. The injectable killed vaccine (*Typhim VI*®) is effective for only 2 years. It can be given to children >2 years.

Treatment

Treatment has traditionally been with chloramphenicol or trimethoprim-sulfamethoxazole in the developing world. Ciprofloxacin soon became the antibiotic of choice, but quinolone resistance, particularly in South Asia, limits its use today. Azithromycin 500 mg daily (pediatric dose 20 mg/kg/d) × 7 days has now replaced ciprofloxacin as the most effective treatment [19]. Ceftriaxone is an injectable option but may be less effective than azithromycin. A super multidrug-resistant typhoid (H58) strain originally from South Asia is now replacing sensitive strains in Africa and Asia. Although plasmid-mediated drug resistance is nothing new for typhoid, the H58 strain incorporates antibiotic resistance into typhoid's permanent genome and is now at near epidemic levels in many areas [20]. More recent advanced antibiotics can be effective against typhoid but often unavailable or too expensive for routine use in LMIC.

Typhoid is one of the few infections where steroids might be beneficial, but only in very severe disease, such as coma, obtundation, or shock [21]. This was based on a single Indonesian study [22] and remains somewhat controversial (dexamethasone 3 mg/kg followed by 1 mg/kg every 6 h for a total of 48 h). Of the very sick patients treated with steroids, there was a 10% case mortality rate in those treated with dexamethasone compared to 55.6% in the placebo group. Steroid treatment beyond 48 h may increase the relapse rate. Note that a subsequent 1991 steroid trial with hydrocortisone showed no significant difference [23], and this treatment should be reserved for only the most ill typhoid patients.

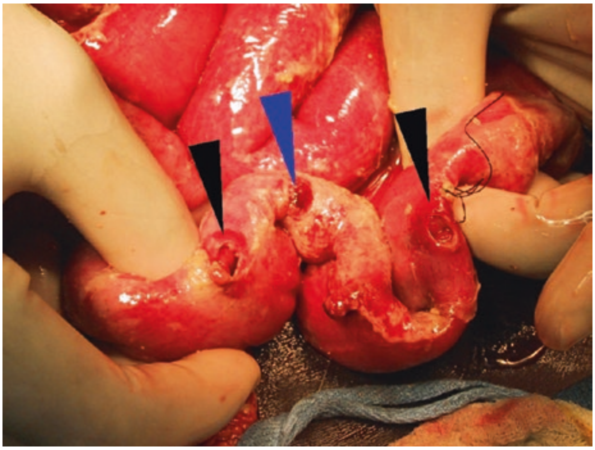

Fig. 15.5 Two punched out perforations of the terminal ileum are indicated by *black arrows*. The *blue arrow* points to a Peyer's patch that is necrotic. Notice the moderate fibrinopurulent peritonitis

Surgical Interventions

As mentioned, surgery for carrier state is NOT a usual indication, despite the notoriety of "Typhoid Mary Mallon." Normally, the indication for surgery is the same as it is for the treatment of any chronic cholecystitis per se; ablation of the gallbladder doesn't always work for the carrier state.

Although actually more common, gastrointestinal hemorrhage is not as dramatic and rarely life-threating. Anywhere from 1.5% to 10% of patients may bleed, usually in third or fourth week and usually presents like a small intestinal hemorrhage. It may be very hard to localize if the bleeding site is indeed in the small intestine.

Perforation is the best known complication of enteric fever. Occurring in only 1–5% of the stricken, it mostly commonly occurs in the second and third weeks of illness. Perforation in males is more common than in females in most series [24, 25]. Some patients perforate without an obvious prodrome. Even with prompt surgical treatment, mortality for perforation is high (14–100%) for advanced disease in various series [25–27]. It seems to be dropping overall during the past two decades [2, 5, 27–31]. The operative mortality is affected by many factors common in resource-poor environments – varying surgical, anesthetic, and nursing skill, delayed presentation, number of perforations, malnutrition, and immunosuppression among them.

The indications for surgical intervention are (Fig. 15.5):

- Pneumoperitoneum on x-ray (may require left lateral film to see it)
- Ultrasound showing free fluid in the context of an acute abdomen
- Persistent palpable mass (especially with erythema of abdominal wall)
- Diffuse peritonitis or positive peritoneal tap
- Persistent sepsis/failure to improve on medical therapy

Many patients present in such a way that the suspicion of abdominal catastrophe is great but the x-rays are negative. In that case, frequent examinations by the same or equally experienced examiner and repeat x-rays (despite the expense) are indicated. They should be done every 6 h at first until improvement or perforation is evident. In this setting of high suspicion and high likelihood of the disease, a negative laparotomy is rare and better tolerated than a missed perforation.

Many typhoid patients present with hypovolemia due to dehydration or sepsis. They should be adequately resuscitated with crystalloid and given appropriate antibiotic coverage (covering intestinal aerobic and anaerobic flora including *Salmonella typhi*) prior to being taken to the OR.

Perforations are most often in the distal ileum (rarely proximally and sometimes in the cecum) and are found on the antimesenteric border. They are usually single (70%) but can be multiple (one paper reporting 24 in a single patient) [32]. Oversew the perforations with interrupted vertical mattress sutures (Lembert sutures) if one to three perforations are found. Some argue that all perforations should be resected [33]. The need to freshen the tissues by excision of the ulcer edges is debatable but probably wise if in doubt. Look for discrete areas on the mesenteric border that are "about to perforate" and consider plicating those. Resection (either enterectomy or, less commonly, a right hemicolectomy) is advised if multiple lesions are found close to each other or tissue quality at the perforation site is poor [31, 34]. As with other causes of fibrinopurulent peritonitis, there is debate about the value of aggressive peritoneal debridement and irrigation of peritoneal cavity, but the author (BCS) tends to aggressively debride, copiously irrigate, and consider second-look laparotomy. A small minority of surgeons have suggested exteriorization of the perforation, which is usually reserved for the extremely ill [31, 35]. Meier and Tarpley have suggested ileostomy for severe disease [36]. Visual examination of the gallbladder is warranted before closure to rule out concomitant disease.

Always consider the wisdom of a controlled abdominal closure to prevent abdominal compartment syndrome. In a low-resource setting, one must often be inventive to accomplish it. There remains debate over the use of retention sutures in these malnourished and critical ill patients. Whether the abdomen is closed primarily or not, the surgeon should strongly consider a second-look operation and repeat peritoneal irrigation in 24–72 h.

The most frequent postoperative complications from perforated typhoid are infectious in nature (including wound infection, wound dehiscence, and intra-abdominal abscess). Empyema, bleeding diathesis, and psychosis can occur. Fecal fistula can be a catastrophic complication [34].

Acute cholecystitis due to typhoid is very uncommon and may present separately or accompanying ileal perforations [37]. The low index of suspicion for this manifestation of typhoid fever often leads to delayed diagnosis, advanced disease (gangrene or perforation), and very ill patients [37–39]. For reasons not well understood, it is more common in children (Ayite reports an incidence of 0.6% in Togo) [40] and very rare in adults [41–43]. Non-advanced cases may be treated nonoperatively but complicated cases are treated operatively.

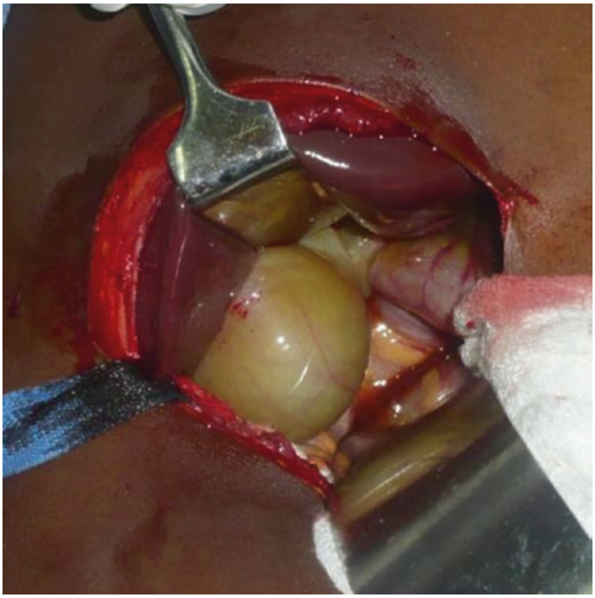

Fig. 15.6 Typhoid cholecystitis (Photo courtesy James Brown)

Once one suspects the disease, the diagnosis and treatment parallels that of more routine acute cholecystitis (Fig. 15.6). A surgeon is wise to look at the gallbladder during a case of enteric perforation, and during a case of acute cholecystitis in a setting where typhoid is likely, look at the small intestine (especially in the pediatric age group).

Filariasis (Nematodes)

The Essentials

- *It is very common but surgery is palliative and uncommonly indicated.*
- *The timing of the blood draw is important in diagnosis.*
- *Diethylcarbamazine (DEC) is a treatment for filariasis but contraindicated in onchocerciasis (Mazzotti reaction).*
- *The treatment of filariasis is aimed at nonoperative treatment of lymphedema.*
- *Acute retroperitoneal lymphangitis is a rare cause of acute abdomen. It is the complication of the disease but should not be operated upon.*

Life Cycles

Filarial worms may infect the lymphatic system (*Wuchereria bancrofti*, *Brugia malayi*), or the skin (*Onchocerca*, *Loa loa*, *Dracunculiasis*). Elephantiasis describes

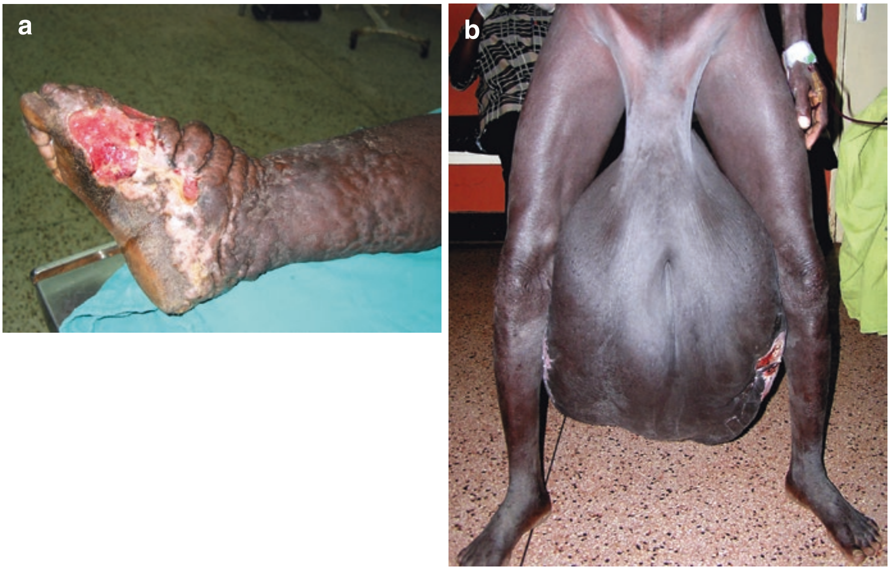

Fig. 15.7 (**a**, **b**) Filarial-induced lymphedema of right foot (with chronic ulcer) and of scrotum (Photo (**b**) courtesy Peter Bird)

swelling of the lower extremities or scrotum (hydrocele) from lymphatic obstruction. Lymphatic filariasis is widespread in Africa and Asia and may be found in a few areas of South America and in Haiti. “Mossy foot” or podoconiosis describes a noninfectious elephantiasis caused by volcanic soil absorbed through plantar fissures in habitually barefoot farmers. It is limited to certain volcanic areas, such as the Ethiopia highlands, and may be prevented through wearing shoes. Radical surgical debulking procedures have been attempted with varying success and have again lost favor compared to nonoperative treatment of lymphedema through foot hygiene, emollient, bandaging, exercise/massage, and wearing of socks and shoes [44] (Fig. 15.7a, b).

The agents of elephantiasis (*Wuchereria* and *Brugia*) are filarial infections spread by mosquitoes. *Wuchereria* is distributed throughout the tropics while *Brugia* is limited to South Asia. Microfilaria (larval worms) exits the mosquito mouth parts and penetrates the site of the bite, maturing in the host’s lymphatics. Lymphatic inflammation develops, gradually resulting in lymphedema. Microfilaria is only active in the bloodstream at night (nocturnal periodicity) when the mosquito vector is most active, retreating to the lymphatics by day. Several species of mosquitoes around the world may serve as vectors.

Onchocerciasis can manifest either as river blindness (most common in dry savannah settings) or as sowda or craw-craw, a pruritic skin disease in forested regions. It is predominantly a disease of West Africa with foci in Central and South America. Both variants of this disease are spread by black flies of the genus *Simulium*. The microfilaria are active in the skin rather than the blood, causing intense itching. The adult worms live in subcutaneous nodules under the skin.

The African eye worm (*Loa loa*) is a migratory filarial worm of West Africa, residing in subcutaneous tissue. It is called "eye worm" since adult worms occasionally travel under the conjunctiva of the eye, where they resemble clear motile Asian noodles. Victims often have migratory hives (termed Calabar swellings) and eosinophilia, both of which represent an allergic response to the parasite. Unlike onchocerciasis, however, eye worm does not cause blindness. The eye worm vector is the diurnal deer or antelope fly; thus, its microfilaria is only detectable in blood samples drawn during daytime (diurnal periodicity).

The Guinea worm (*Dracunculus*) is another subcutaneous filarial worm now found in only a few remote African locations (e.g., Sudan). This parasite lodges under the skin of an extremity. When this painful inflamed limb is immersed in water, the worm releases innumerable eggs which are ingested by water fleas. Drinking water containing these fleas transmits the infection to new human hosts. There are several easy ways to interrupt the cycle: filtering drinking water to remove water fleas, treating the water (*Abate*), or preventing infected people from entering and contaminating the water supply. Due to these three measures, this parasite is now on the verge of eradication [45].

Diagnosis

Wuchereria infections are asymptomatic in the early stages, but swelling or discomfort in an extremity is usually the first manifestation of infection. Ultrasound using a 7.5 MHz or 10 MHz probe can often visualize a "filarial dance" in the lymphatics. Treatment early on will prevent elephantiasis or hydrocele. However, after extensive lymphedema develops, surgical intervention will also be needed. Secondary bacterial lymphangitis is common [46].

Onchocerciasis presents with subcutaneous nodules containing the adult worms. Onchocercal skin disease (OSD) manifests with depigmentation on shins ("leopard patches"), "hanging groin" (redundant inguinal skin), and intense allergic itching due to microfilaria in the skin (craw-craw). River blindness is due to inflammation resulting from the release of bacterial antigens by microfilaria in the anterior chamber. Both manifestations may occur in the same patient, but eye disease is much less common outside of the African savannah [47].

African eye worm is characterized by migratory hives ("Calabar swellings") and the pathognomonic "eye worm" appearance if an adult worms visit the eye.

Guinea worm causes a painful extremity with inflamed skin and a burning sensation. This motivates the victim to soak the extremity in water, permitting the parasite to release its eggs.

Filarial infections are diagnosed by identifying the characteristic microfilaria in a blood or skin sample. The time when the blood is drawn is important. Late night (10 PM–2 AM) blood samples detect *Wuchereria* and *Brugia* microfilaria, although a small provocative test dose of diethylcarbamazine (DEC) 2 mg/kg (50–100 mg) will trigger their emergence during the day [48]. Blood should be drawn 30–40 min subsequent to DEC administration. Loa microfilaria are normally active in diurnal blood samples), since this is when their vector is most active. Onchocerciasis is diagnosed by obtaining snips of iliac crest skin (a needle elevates a small tent of skin to be snipped off with a scalpel) and then examined for microfilaria after incubating overnight in warm saline solution. Keys for microfilarial identification are available, based on the presence or absence of a sheath and/or nuclei in the tail. Serologic tests for various filarial infections are now available from the CDC for confirmation.

Treatment

Microfilaria are much easier to eradicate than adult worms, which resist treatment. Diethylcarbamazine (in the USA, available only from the CDC) is the treatment of choice for *Wuchereria*, *Brugia*, and *Loa*, although DEC treatment should be started at low doses and increased gradually to avoid allergic reactions from dying microfilaria in the blood [6]. Steroid pretreatment minimizes this risk. Onchocerciasis is best treated with episodic ivermectin, which prevents transmission [6]. DEC is contraindicated in onchocerciasis, and this disease must be excluded in African patients prior to its use as it may cause severe ocular and skin exacerbations (Mazzotti reaction). The adult parasites survive DEC treatment but can be rendered sterile with doxycycline, which kills the symbiotic *Wolbachia* bacteria, necessary for parasite fertility [49]. DEC treatment of Loa infections must be given with caution if microfilarial levels are >2,500/m^{2}due to an increased risk of encephalitis, which pretreatment steroids do not always prevent (http://www.cdc.gov/parasites/lymphaticfilariasis/health_professionals/dxtx.html). Guinea worm resists all medical treatment. However, the end of the worm may be lured out by immersion in water, grasped with forceps, and then incrementally removed by winding the worm on a stick.

Surgical Interventions

Surgery for filariasis should be avoided if possible. Nodulectomy to remove the adult parasite of onchocerciasis can result in cure only if excision eliminates all adult worms. It must be combined with proper chemotherapy. Thus, this is not a practical choice in patients with multiple nodules or in patients in whom nodules are not clinically evident. There is no role for surgery in the removal of the guinea worm but occasionally is necessary to drain abscess along the tract, especially if the worm ruptures with too forceful extraction methods.

The treatment of filariasis should be aimed at the nonoperative treatment of lymphedema. Usually elephantiasis due to filarial involves the pelvic girdle or the lower extremities, but it can involve the arm and breast. Chyluria may occur if the perinephric lymphatics are involved.

Fig. 15.8 (**a**, **b**) Filarial lymphedema. A giant hydrocele with excoriation of the scrotum (**a**) and involvement of the left breast (**b**) (Photo (**a**) courtesy Harold Adolph) (Photo (**b**) courtesy Warren Cooper)

The general indications for surgery include the presence of disability due to the size of the limb, recurrent cellulitis, cosmetic reasons (rarely), and the inability to wear shoes (causing disability or economic consequences). Throughout the years, many surgical procedures have been tried – and none work well. Omental and intestinal transfers, creation of lymphovenous shunts in the groin, and Thompson's operation (dermal lymphatics brought closer to the deeper lymphatics through implanting of a de-epithelialized skin flap) have been used to try to increase lymphatic flow from the limb. Various debulking procedures such as the Sistrunk procedure (excision of the skin and subcutaneous tissue on lateral aspect of the leg with primary closure), Homans' operation (similar to the Sistrunk procedure with more tissue removed), and Charles's operation (excision of all skin and subcutaneous with skin grafting directly on the fascia) have all been used with mixed results (Fig. 15.8a, b).

The large hydrocele, giant scrotum, and "hanging groins" with filarial can cause significant deformity, and since the surgery does not address the core problem, surgical cure is rare, and complications and recurrence are to be expected. The "classic" hydrocele of filariasis is manifested by a thickened tunica vaginalis, amber fluid with old blood clots, cholesterol crystals, and "calcium dust," but it is not always present. The epididymis is often scarred. You find microfilariae in the fluid if it is examined under the microscope or you may find adult worms in the cord and epididymis (Fig. 15.9).

Fig. 15.9 "Hanging groins" of onchocerciasis (Photo courtesy Warren Cooper)

Onchocerciasis is known for "hanging groins" – redundant skin caused by inguinal adenopathy. Surgery should be done only for severe functional, hygiene, and cosmetic purposes. There is no standardized surgical approach to this condition; there are no large series of cases to direct therapy. Most operations are "made up" at the time using established principles, but are complicated by poor healing.

Chylothorax is an uncommon but annoying consequence of filariasis. Rupture of the occluded posterior mediastinal lymphatics is the mechanism. Other causes must be ruled out. Fifty percent will close with nonoperative treatment. Eventually, in the rest, obliteration of the pleural space is indicated because of persistent leak, nutritional or metabolic complications, or the inability to fully expand the lung (and drain the loculations). Thoracic duct ligation is the standard treatment (if leak can be found). Pleurectomy is a treatment option, but pleurodesis does not work well in this benign disease. Pleuroperitoneal shunts can be successful, but are often complicated by infection and obstruction.

There is one condition which appears surgical but which is not. Surgery should be avoided. Acute retroperitoneal lymphangitis is rare and manifests as acute abdominal pain over large areas associated with shock and collapse. The exam is more benign than the presentation might suggest – there is not board-like rigidity. The condition is due to toxins from the filarial plus those of B-hemolytic Streptococcus and Staphylococcus. It is essentially an immune-mediated response to dying worms and is the consequence of the cytokines and tissue factors released. There is a high mortality, which is not helped by surgical exploration. Don't operate if you can make the diagnosis beforehand.

Cestode Infections (Hydatid Disease)

The Essentials

- *This is endemic in areas with dogs, cattle, and sheep.*
- *Cystic echinococcosis (CE) is more frequent and more common in younger adults and acts more benignly. Alveolar echinococcosis (AE) is generally found in older patients and requires resection to treat and have a high chance of recurrence.*
- *Biliary contamination (leaks) of the liver cysts must be ruled out before using some common scolicidal agents.*
- *Extra-abdominal disease can cause pulmonary, bone, and CNS disease.*
- *Spillage of the cystic fluid can cause anaphylaxis and/or seeding of the abdomen.*
- *PAIR (percutaneous aspiration, injection, and reaspiration) therapy is most successful on single superficial unilocular cysts.*
- *Treatment preoperatively and postoperatively with benzimidazole carbamates* (e.g., *albendazole) is indicated for primary surgery.*

Life Cycle

The canine tapeworm (*Echinococcus granulosus*, *E. multilocularis*, *and E. vogeli*) larvae affect humans as an accidental intermediate host. The canine (dog, fox, hyena, wolf, coyotes, and jackal for *E. granulosus*, fox and rarely wolves, coyotes, lynxes, cats, and black bears for *E. multilocularis*) has the adult tapeworm which passes the eggs in the feces. The eggs are ingested and turn into an invasive metacestode in the intermediate host (deer, camels, pigs, sheep, cattle, goats, horses, and many other animals for *E. granulosus*; eight families of rodents, including mice, rats, hamsters, gerbils, and squirrels for *E. multilocularis*). The intermediate host is eaten by the definite host and the metacestode is released and develops into the tapeworm (cestode).

This canine zoonosis is endemic in sheep and cattle-grazing areas of the Mediterranean countries, the Middle East, the southern part of South America, Iceland, Australia, New Zealand, and southern parts of Africa; the latter five are intensive endemic areas. The incidence of cystic echinococcosis (*E. granulosus*) in endemic areas ranges from 1 to 220 cases per 100,000 inhabitants, while the incidence of alveolar echinococcosis (AE; due to *E. multilocularis*) ranges from only 0.03 to 1.2 cases per 100,000 inhabitants. Infestation with *E. vogeli* is the rarest form of echinococcosis and is reported mainly in the southern parts of South America.

Presentation

Most common sites of involvement in human disease are liver (70%), lung (20%) [50], and soft tissues with the bone and brain being rarely involved in humans. The following discussion largely concerns cystic echinococcosis (CE), the most prominent form of the disease.

Most disease has a long incubation period (20–30 years before becoming symptomatic) and 25% of infected people are asymptomatic. CE tends to be a disease of younger adults (30–40 years old) and AE tends to be in older adults (50–60 years old). Untreated hydatid cysts result in death of 15% of patients. Other symptoms are nonspecific – abdominal or chest discomfort, dyspepsia, vomiting, weight loss, and biliary obstruction. Bronchopleural fistulae and chest wall deformity can occur in pulmonary disease. Pathological fractures or spinal compression can occur from bone disease. CNS disease occurs from cyst-induced pressure on surrounding structures and can include paralysis and death [51].

Volume-related complications occur from the cyst; toxic complications occur from the treatment. The most common serious complications include rupture, secondary infection, and biliary fistulas.

Larger, peripheral cysts of the liver and lung will most commonly rupture, usually following minor or major trauma. The sudden spill of parasitic antigen into the peritoneum or pleura may cause anaphylactic shock, especially with abdominal cysts. Nonlethal rupture can cause disseminated intraperitoneal or pulmonary disease.

Secondary infection can occur in 5–10% of cases and is most commonly due to hematogenous seeding of a liver cyst causing a liver abscess [52]. The bacterial infection will kill the scolices and the germinal membrane. External drainage and antibiotics and ultimate obliteration of the cavity are required.

Cyst rupture into the larger ducts can cause biliary colic, intermittent obstructive jaundice, and recurrent cholangitis. Small biliary radicals can open into the cyst cavity – if unrecognized, they can cause small postoperative biliary leaks which normally heal spontaneously. Larger biliary fistulas should be sutured if recognized at the time of surgery. Major surgical reconstruction of the ducts may be necessary.

Nonsurgical Treatment

Benzimidazole carbamates (mebendazole or preferably albendazole) for 3–12 weeks are usually effective in killing the parasite and decreasing the size of liver hydatids [53]. Alopecia, hepatitis, glomerulonephritis, neutropenia, and failure to respond are all problems of long-term treatment with this class of drugs. Praziquantel has been recommended by some for adjunctive therapy pre- and post-surgery.

Invasive radiological techniques have been developed. “PAIR” is the *p*ercutaneous *a*spiration of cysts under radiological guidance, followed by *i*njection of scolicidal agent and *r*easpiration after scolicidal treatment. It is most effective on superficial unilocular cysts. It may not work well with multilocular cysts and recurrence is a problem. Contamination of the peritoneal cavity and anaphylaxis is always a risk.

Surgical Interventions

Most disease will respond to treatment with benzimidazoles. Surgery is generally indicated if there are:

1. Large, symptomatic, subcapsular cysts in young patients.
2. Large, viable cysts especially if peripheral and prone to rupture.
3. Complicated cysts (e.g., infected, intrabiliary leak, extraperitoneal rupture, anatomically difficult).
4. Multilocular cysts.
5. Pulmonary hydatids have high risk of intrabronchial rupture and should be operated upon.
6. Brain, spinal, and bone cysts (Fig. 15.10a–d)

Patients over 65 years of age have high risk of surgery and low prevalence of viable cysts (especially if they are calcified); surgery should be avoided if possible. Small (<4 cm), deep cysts should not be operated upon if possible because the risks outweigh the benefits.

The best advice for the global surgeon is to ask somebody locally who knows how to handle these cases and to scrub with them. If surgery is primarily indicated, treatment with benzimidazole carbamates is started 4 days preoperatively and lasts for 1 month to diminish the risk of secondary echinococcosis.

Intraoperatively, it is very important to select the most appropriate scolicidal agent and to avoid peritoneal contamination. Only a few scolicidal agents may be available to you. Possible options include:

- 0.5% silver nitrate solution (risk of caustic injury to bile ducts).
- Hypertonic saline (3% [54]–20%) – cerebral demyelination due to rapid hypernatremia is a potential problem with the higher dosages.
- 2–5% formalin (risk of caustic injury to bile ducts).
- 70–95% ethanol.
- 1%, 5%, or 10% povidone-iodine.
- 0.5% cetrimide (alkyltrimethylammonium bromide).
- Hydrogen peroxide 3%.
- 0.5% sodium hypochlorite if bilious aspirate; 3.75% if non-bilious.

Control of contamination is very important to avoid anaphylaxis and peritoneal implantation. The area is packed with scolicide-soaked packs around the cyst or a suction cone apparatus is used [55, 56] and the cyst fluid aspirated. Take care to avoid any spill and carefully note whether there is bile staining – if it is bilious, it may affect choice of scolicides as above to avoid damage to the biliary ducts. The chosen scolicides is instilled and allowed to sit for a few minutes – often twice, 5 min apart with aspiration of the solution after each installation (Table 15.2).

The cyst is then opened and packed within using scolicide-soaked sponges. After a few minutes, the sponges are removed and the cyst wall germinal layer is removed

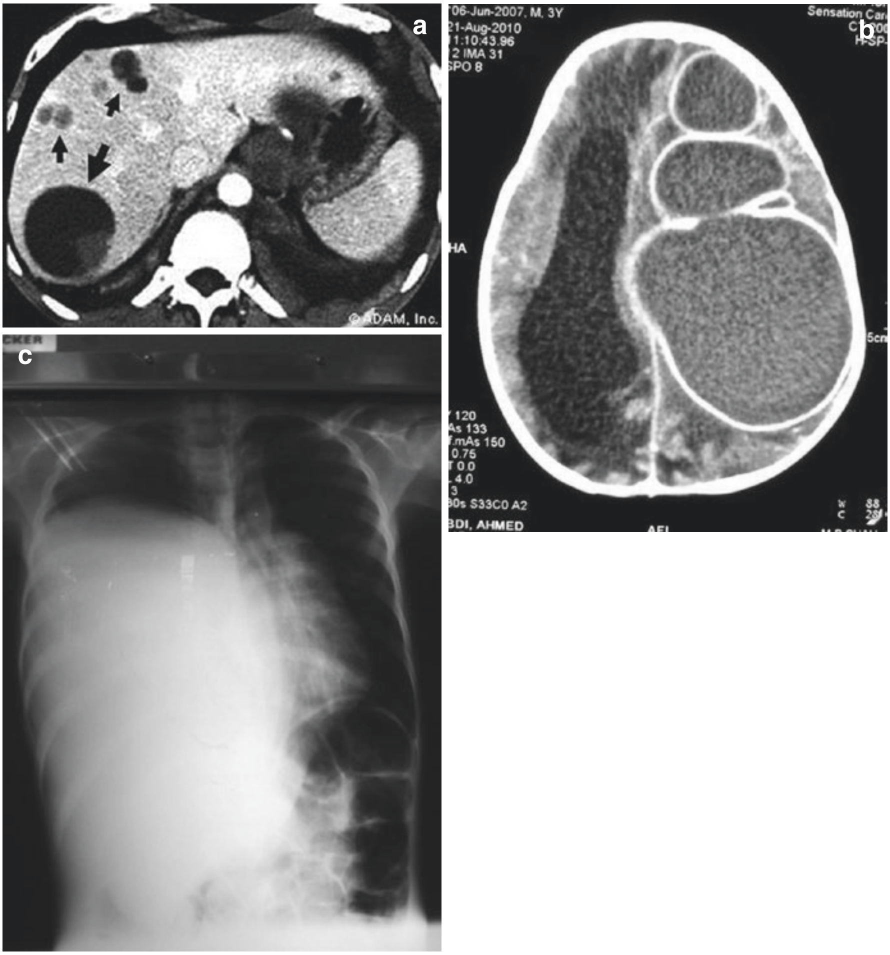

Fig. 15.10 (**a**–**d**) The posterior subcapsular liver cyst shown on the *top left* (**a**) should probably be resected. Definitely, the cysts in the brain (**b** *top right*) should be removed (Photos courtesy Michael Matlak). (**c** *bottom left*) The chest x-ray of a patient with a huge right pulmonary hydatid cyst and the CT (**d** *bottom right*) which shows that it is predominantly one huge cyst (Photos courtesy Dan Poenaru)

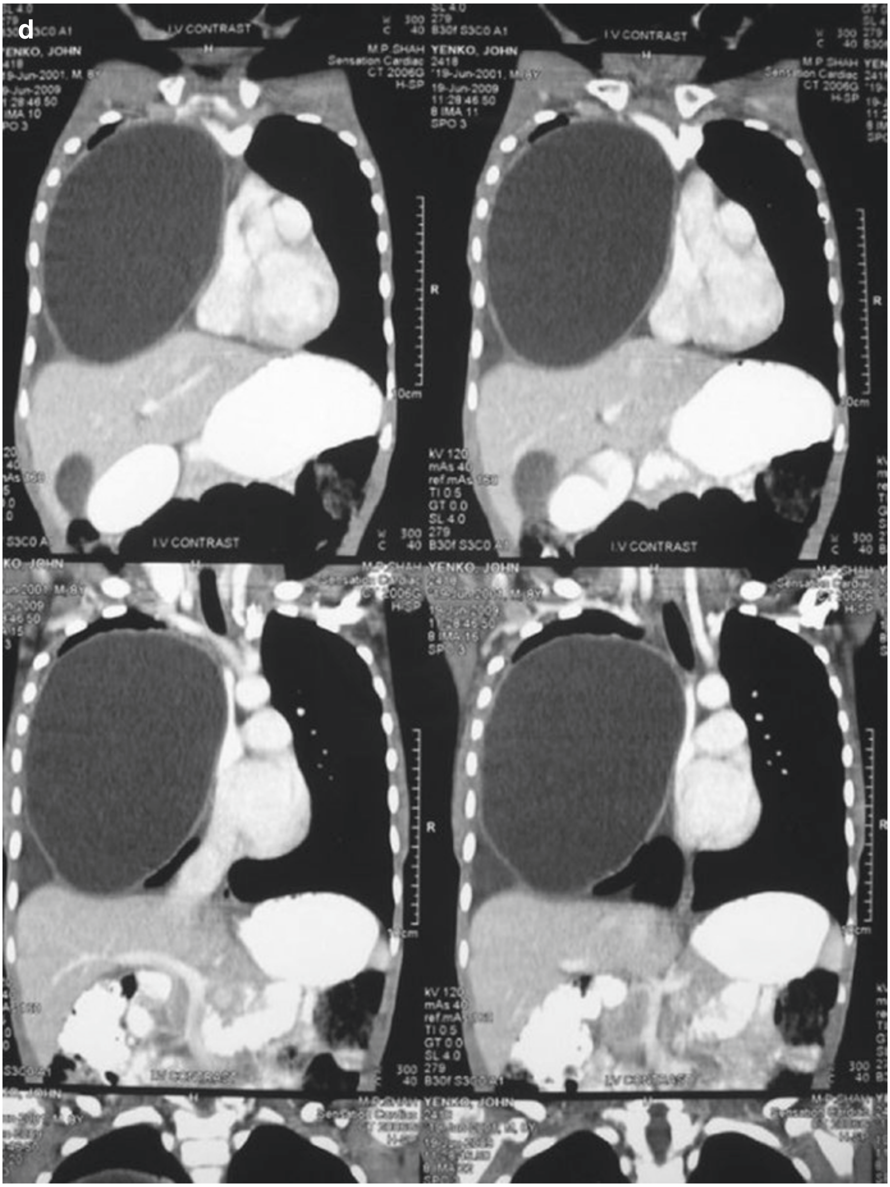

Fig. 15.10 (Continued)

Table 15.2 Scolicidal agents that can be used if there is bile staining of the fluid or a known biliary leak

1. Hypertonic saline (3% [54]–20%)
2. 70–95% ethanol
3. 1%, 5%, or 10% povidone-iodine
4. 0.5% cetrimide
5. Hydrogen peroxide 3%
6. 0.5% sodium hypochlorite

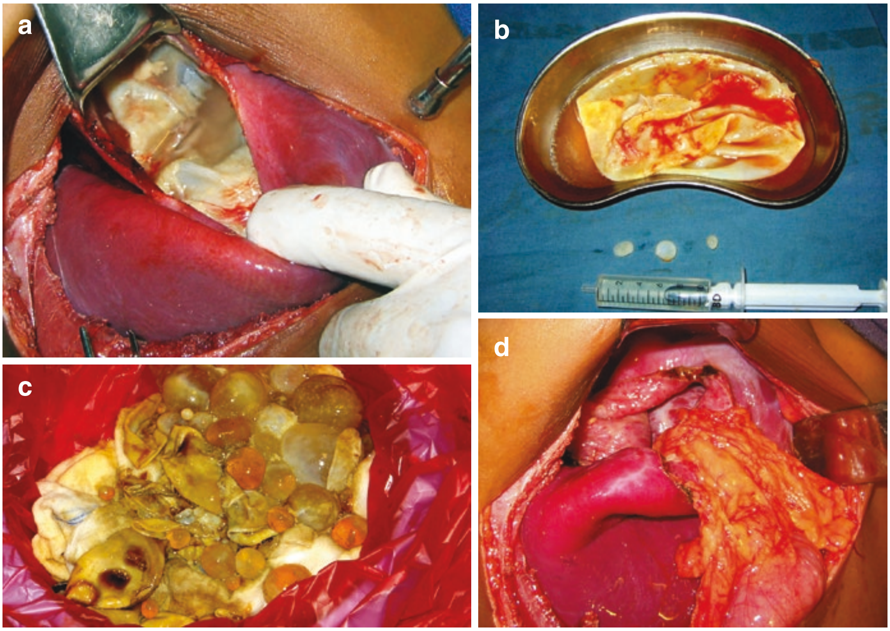

Fig. 15.11 (**a**–**d**) *Top left*: The decompressed echinococcal cyst is seen in the liver cavity. *Top right*: The germinal layer has been removed and small daughter cysts seen on the towel. The number of cysts can be much greater as seen in another case (see *bottom left*). *Right*: Cavity of the first case filled with pedicled omentum (omentoplasty) (Photo (**a**, **b**, and **d**) courtesy Dan Poenaru) (Photo (**c**) courtesy Barbara Okamoto)

(removing all scolices and the entire germinal layer, often piecemeal). Small, pendulous cysts can be excised totally. Infected hydatids are usually dead and can be externally drained (Fig. 15.11a–d).

Management of the residual cyst cavity is the next step but no method is totally satisfactory. Suture any biliary communications with absorbable suture. The choices of handling the residual cavity include filling the cavity with pedicled omentum (omentoplasty), [54, 57] suturing ("overlapping" and "capitonnage") of both the lung and liver which may be possible in flexible cysts but is not always satisfactory, marsupialization, the use of fibrin sealant or installation of normal saline, and closure of the cyst (often over an indwelling urinary catheter which is removed in 1–3 weeks).

A more radical approach (cystectomy and pericystic liver resection) has been shown to be safe and effective in retrospective studies, but there has not been a prospective study to confirm it [57–59].

A laparoscopic approach can be done for simple noncomplicated cysts in suitable locations [60].

Complications of surgery for CE include:

1. Anaphylaxis (should be rare)
2. Biliary fistula (up to 50%)
3. Abscess
4. Recurrence (5–25%)

Alveolar echinococcosis (AE) disease is an uncommon but aggressive and invasive form of hydatid disease caused by *E. multilocularis*. It usually requires radical hepatic resection for cure if that is possible, but often extensive involvement of surrounding tissues makes this impossible. Orthotopic liver transplantation may be necessary. Prolonged chemotherapy is indicated.

Helminth Infections (Ascaris, Trichuris, Hookworm) and Biliary Flukes

The Essentials

- *Until recently, roundworms could be treated reliably with albendazole or mebendazole and flatworms with praziquantel (Fasciola hepatica is an exception). There is some emerging albendazole resistance.*
- *Modern sanitation can prevent all of these.*
- *Small bowel obstruction due to roundworms can be treated with piperazine or albendazole (mebendazole). A minority of physicians advocate no anti-helminthic treatment.*
- *The stress of surgery may increase the risk of migration by the Ascaris.*

Life Cycles and Presentation

Intestinal worm infections include roundworms (nematodes) and flatworms (flukes and tapeworms). Three intestinal nematodes – the roundworm (*Ascaris*), whipworm (*Trichuris*), and hookworms (*Necator*, *Ancylostoma*) – affect over a billion people [61]. Many children may be coinfected by all three of these worms which stunt both their physical and intellectual development [62].

Ascaris infections are abundant in areas of poor sanitation, where human feces contaminate the soil. Roundworms are acquired by ingesting embryonated eggs. These eggs hatch in the stomach, and the larvae must first migrate through the lungs (producing a transient wheezing bronchitis known as Löffler's syndrome) before finally maturing in the small intestine. Children are prone to heavy infections, which occasionally obstruct the intestine. Migration of these worms into the bile ducts or pancreas may occasionally result in cholecystitis or pancreatitis.

Trichuris or whipworm infections commonly accompany *Ascari*s infections but develop in the large intestine without passing through the lungs. They are common causes of colitis, bloody stools, and rectal prolapse. The prolapse is caused by edema in the rectal mucosa. The risk of appendicitis is also increased as worms at the ileocecal junction increase bacterial infection risk.

Hookworm infections (*Necator americanus* and *Ancylostoma duodenale*) persist for decades and result in iron-deficiency anemia and fatigue. Chronic anemia is a major problem for infected children. Hookworm larvae living on the ground penetrate the skin, causing a "ground-itch" rash. They then migrate to the lungs, are coughed up and swallowed, and attain maturity in the small intestine where they survive for decades.

Liver flukes (fascioliasis) parasitize the biliary tract. These include the Chinese liver fluke (*Clonorchis*), *Opisthorchis*, *Fasciola hepatica*, and *Dicrocoelium.* Although light infections are asymptomatic, complications necessitating surgery may include cholangitis, biliary lithiasis, and cholangiohepatitis or hepatic abscess.

Diagnosis

The standard method for diagnosing the ascariais, whipworm, hookworm and liver fluke infections is by identifying the eggs in a stool sample using a microscope. Because eggs may be difficult to find in light infections, a concentration procedure is recommended. Repeated stool examinations may be needed.

Treatment

Single-dose albendazole 400 mg or mebendazole 500 mg q 6–12 months is effective for reducing roundworm infections in children [63]. Piperazine causes a flaccid paralysis of worms which is helpful in obstruction. Pyrantel pamoate should be avoided, since it causes a spastic, rigid paralysis which can precipitate bowel obstruction. Albendazole resistance is emerging, necessitating an urgent need to develop new drugs. The newest alternative drug is tribendimidine, which was approved in China in 2004 [64]. Flukes and other flatworms can be treated with praziquantel (*Biltricide*) 25 mg/kg divided into three doses given over 1 day [6]. However, *Fasciola hepatica* is the exception as its thick integument resists praziquantel. It is treated with bithionol, available in the USA through the CDC.

Prevention

Public health education is vital. Transmission of all of these helminths is prevented by modern sanitation, which prevents fecal contamination of soil. Proper use of latrines is the best means of control. Shoes will reduce but not prevent hookworm infection since any contact of the skin with infected soil poses a risk. Regular deworming of all school children with benzimidazoles is a practical interim solution in high-incidence areas.

Surgical Interventions

In the LMIC, the prevalence of diseases causing bowel obstruction is markedly changed. Adhesions, diverticular disease, and colon cancer are less common causes of obstruction, but roundworm obstruction is more common in small bowel obstruction. Amebiasis can increase the risk of colocolonic intussusception.

In a thin child, a palpable abdominal mass ("ball of twine") is usually a bolus of *Ascaris*. Plain and contrasted x-rays can demonstrate the worms; water-soluble contrast may be more likely to break up the obstruction.

Nasogastric decompression and antihelminthics are indicated. A minority of physicians prefer to use no antihelminthic treatment at all.

Bowel obstruction may warrant surgical removal, although usually this condition can usually be managed medically. If medical treatment with albendazole or piperazine is ineffective, and surgery is indicated, the worm bolus can often be milked down into the colon. The last resort is transverse enterotomy and primary closure (under broad spectrum antibiotic coverage). If the worms are still alive, the stress of surgery seems to increase their willingness to migrate, and penetration of the suture line by the live worm is known to occur (Fig. 15.12a–c).

In some patients, the weight of the worm bolus can cause volvulus and gangrene of the involved loop. This potential catastrophe must always be kept in mind.

Migration of these worms into the bile ducts or pancreas may occasionally result in cholecystitis or pancreatitis. Endoscopic retrograde cholangiopancreatography (ERCP) with extraction followed by a single dose of antihelminthics is necessary for worms in the biliary tract (Fig. 15.13a, b).

Surgical treatment of biliary flukes is either removal of the fluke with endoscopic techniques or the standard treatment of the complication.

Schistosomiasis

The Essentials

- *Three types of blood flukes are known, each with differing appearances to the eggs they pass and each with differing clinical presentations.*
- *Acute schistosomiasis in nonimmune travelers is known as Katayama fever, an immune response to the egg production.*
- *The surgical presentation is uncommon but very broad in its scope. Surgical treatment is palliative. Medical treatment (praziquantel) is effective but may not avoid the sequela.*

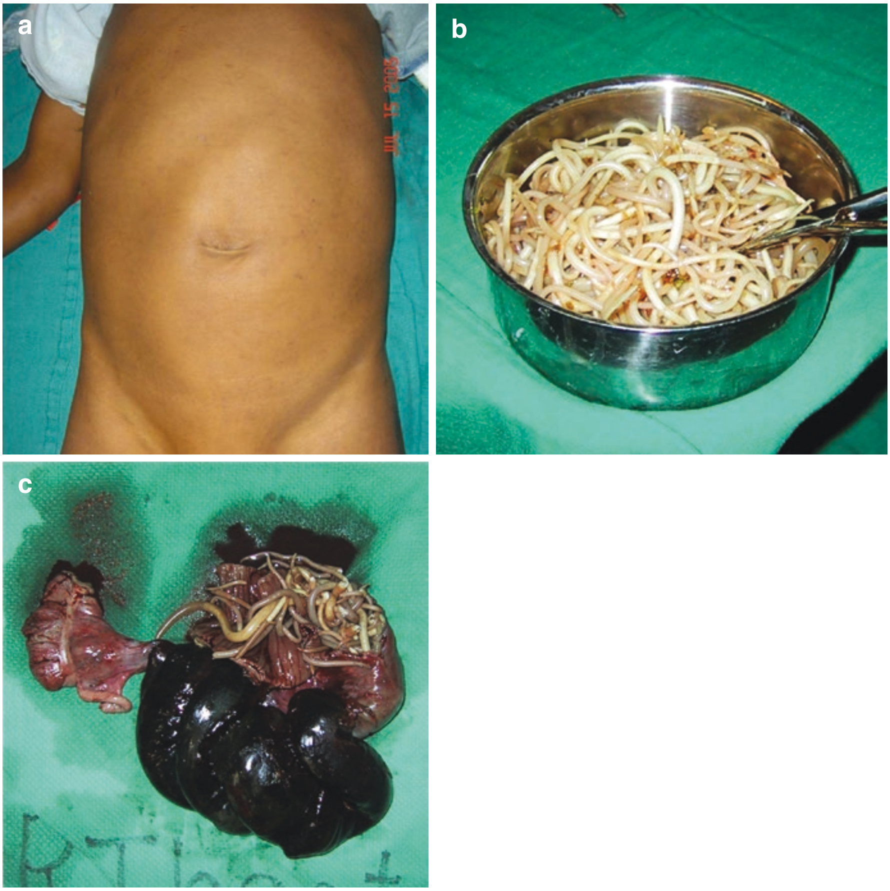

Fig. 15.12 (**a**) (*top left*) Kenyan child with visible distended loops. He did not respond to nonoperative treatment and was explored. The mass of worms in the picture on the *top right* (**b**) was removed via an enterotomy (Photos courtesy Russell White). (**c**) (*bottom right*) – This child presented with an acute abdomen and small bowel obstruction. A right hemicolectomy was necessary

Life Cycles and Presentation

Schistosomiasis or bilharzia (from Theodor Bilharz, who first described it) afflicts over 200 million people, but most of its victims (97%) reside in Africa [65]. Three species of these blood flukes are medically important: *Schistosoma haematobium*, residing in bladder vessels and causing urinary schistosomiasis (63% of all cases); *S. mansoni*, residing in the greater mesenteric vessels, the cause of intestinal schistosomiasis (35%); and *S. japonicum* (1%), also known as Asian intestinal schistosomiasis, residing in the lesser mesenteric vessels [66].

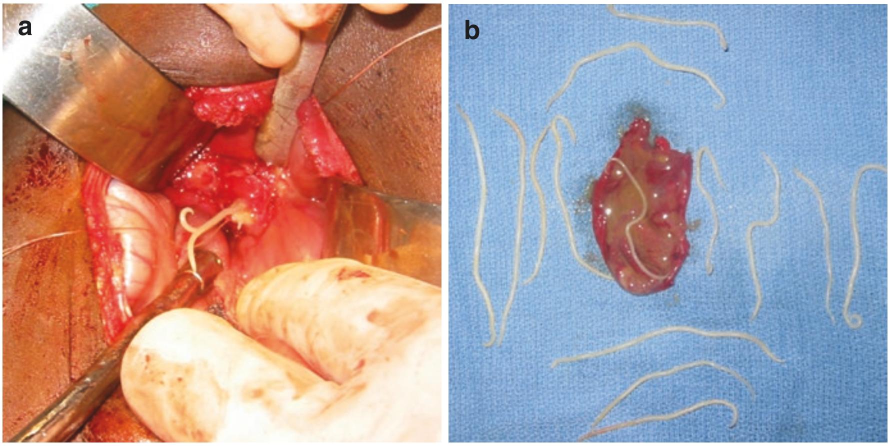

Fig. 15.13 (**a**, **b**) Ascariasis-induced acute cholecystitis. Thirteen worms were found in the common duct and one in the gallbladder (Photo courtesy Russell White)

Schistosomes depend on their intermediate host, freshwater snails, to complete their life cycle. When human excreta enter water, the eggs hatch into miracidia which seek out snails to parasitize. Snails then release larval flukes or cercaria which swim about in shallow water until they contact and penetrate human skin. Sensitive individuals often develop a nonspecific rash or "swimmer's itch" at the site of penetration. Cercaria lose their tails to become schistosomules and then migrate through the lungs and liver, making their way (depending on species) to either the bladder or mesenteric vessels, where they mature into long-lived adults that persist for decades. Symptoms are usually slow in developing and are a consequence of chronic inflammation from the enormous numbers of spined eggs that accumulate in the walls of the bladder and bowels. Many eggs eventually penetrate through to be excreted in the urine or feces, but most remain trapped in the body. In the case of *S. haematobium*, this results in gross hematuria ("male menstruation"), bladder granulomas, and squamous cell cancer of the bladder. Obstructive uropathy (hydronephrosis) may result in renal failure. With *S. mansoni*, egg granulomas of the intestines and liver lead to colitis, hepatosplenomegaly, hepatic fibrosis, portal hypertension, splenomegaly, and even hepatocellular carcinoma [67]. *S. japonicum* is the most pathogenic species (as it produces far more eggs than the others) and has been associated with neurologic disease, colorectal polyps, and carcinoma. Nonimmune travelers may develop acute schistosomiasis. This febrile illness, known as Katayama fever, is due to an immune response to the parasite's egg production.

Schistosoma species are identified by the spine's location on the egg (terminal in *haematobium*, lateral in *mansoni*, absent in *japonicum*). *S. haematobium* eggs are excreted in the urine and *S. mansoni* in the stool (and identifiable on rectal biopsy specimens).

Diagnosis

Examination of stool and/or urine for ova is the primary method of diagnosis for suspected schistosome infections. The choice of sample to diagnose schistosomiasis is dependent upon the area to which the patient lives or has visited, since the species have highly specific preferences. Adult stages of *S. mansoni*, *S. japonicum*, *S. mekongi*, and *S. intercalatum* reside in the mesenteric venous plexus of infected hosts, and the eggs erode through the intestinal mucosa and are shed in feces; *S. haematobium* adult worms prefer the venous plexus of the lower urinary tract and eggs are therefore shed in the urine.

Some areas of the world may have more than one species present. In some areas of sub-Saharan Africa, both *S. mansoni* and *S. haematobium* are endemic. Patients from those areas should have both stool and urine samples examined for eggs.

Testing of stool or urine can be of limited sensitivity, particularly for travelers who may have lighter burden infections. To increase the sensitivity of stool and urine examination, three samples should be collected on different days.

Serologic testing for antischistosomal antibody is available to determine previous infections. Commonly used serologic tests detect antibody to the adult worm. For new infections, the serum sample tested should be collected at least 6–8 weeks after likely infection, to allow for full development of the parasite and antibody to the adult stage. Serologic testing determines only previous exposure and cannot determine between active and previous infections. A test which can determine the presence of the active presence of antigen is under trial.

Treatment

Praziquantel as a single dose (40 mg/kg/d) is the most effective treatment for schistosomiasis [6]. The Schistosomiasis Control Initiative (SCI) has controlled this disease in many endemic areas, such as Egypt, through mass drug administration (MDA) efforts [68].

Surgical Interventions

The treatment for schistosomiasis (Bilharzia) for the majority of symptoms and problems is medical. There are complications of the disease which may be seen by a surgeon:

1. Obstructive uropathy and bladder cancer, including chronic renal failure which may require a transplant.
2. Spinal involvement (usually responds to chemotherapy alone).
3. Massive splenomegaly with hypersplenism, symptomatic discomfort due to bulk or cirrhosis. It does not respond to medical treatment in established cases. Portal-systemic shunt may be performed in conjunction.

4. Portal hypertension (including bleeding varices, ascites, or liver failure, including those who need a transplant).
5. Splenic giant follicular lymphoma associated with hepatosplenic bilharziasis.
6. Ruptured ectopic pregnancy.
7. Abdominal pain or bloody diarrhea.
8. Colorectal polyps and carcinoma (especially with *S. japonicum*).

The principles of the palliation or treatment of these diseases are similar to the same conditions due to other etiologies.

Tropical Ulcers: Cutaneous Leishmaniasis (CL), Buruli Ulcer, Phagedenic Ulcer, and Cutaneous Anthrax

Infectious ulcers in the tropics coexist with the other more common causes of ulcers found throughout the world. Ulcers due to venous hypertension, lymphedema, and ischemic arterial disease are unchanged from their presentation and treatment in the rest of the world, but may be more advanced upon presentation. The incidence may change, however, especially in areas where filariasis has caused lymphedema. In LMIC, social expectations may make elevation and rest hard to comply with, especially for women. The lack of angiography and of experienced vascular surgeons may make ischemic ulcers beyond diagnosis and treatment.

Leishmaniasis

The Essentials

- *Sandflies are the vector. The species and the presentation vary between the Old World and the New World.*
- *The clinical presentation also varies – it can be cutaneous, mucocutaneous, or visceral.*
- *Biopsy of the edge of the ulcer is most productive.*
- *Medical treatment is prolonged and can be expensive but is preferred to any surgical treatment.*

Life Cycles

Leishmaniasis is caused by intracellular protozoal parasites of the genus *Leishmania*, which are spread by various sandflies: *Phlebotomus* subspecies in the Old World and *Lutzomyia* subspecies in the New. These infections are most often found in Central and South America, South Asia, the Mid-East, the Mediterranean, and East Africa [69]. Some species of *Leishmania* are limited to humans, whereas others are zoonotic infections, with the primary reservoirs being rodents or dogs.

Leishmaniasis presents as three different clinical syndromes: cutaneous leishmaniasis (CL), mucocutaneous leishmaniasis (MCL), and visceral leishmaniasis (VL). Which type develops is dependent on the heat tolerance of the species involved. Cutaneous leishmaniasis spp. are limited to the skin, while more heat-tolerant species can invade the viscera (VL). Mucocutaneous leishmaniasis (MCL) or "espundia" (Portuguese for "sponge"), caused by *Leishmania braziliensis*, seems to be intermediate between these two [69].

Once introduced to the body, Leishmania parasites lose their flagella to become amastigotes. Surprisingly, they thrive after being consumed by the body's first line of defense, the macrophages, and develop into one or more persistent skin ulcers. The slightly raised ulcer margin is very well demarcated, and such ulcers are often described as having a "pizza-like" appearance. They last many months before healing with significant scarring. Regional names for CL include Baghdad boil (Iraq), Ciclero's ulcer (Brazil), uta (Peru), or saldana (Iran).

Most cutaneous leishmaniasis ulcers will eventually heal after many months; however, New World ulcers caused by the *Braziliensis* species only appear to heal, permitting them to metastasize years later as *espundia* or the mucocutaneous form of the disease. *Espundia* starts as chronic nasal congestion but the infection may eventually destroy the nasal cartilage, resulting in a characteristic "tapir nose."

Visceral leishmaniasis is caused by the *Donovani* species complex (*L. donovani*, *L. infantum*, *L. chagasi)*. In the Indian subcontinent, VL is known as kala-azar ("black disease" in Hindi) and manifests with fever, weight loss, splenomegaly, anemia, and (sometimes) darkened skin. Untreated cases are often fatal without treatment, with a >75% case fatality rate [69]. *L. infantum* is found in Southern Europe, with a canine reservoir, and it usually infects children or immune-compromised patients (IV drug abusers and AIDS patients). *L. chagasi* may be only a South American variant of *L. infantum*.

Diagnosis

Cutaneous leishmaniasis can be diagnosed with a biopsy of the ulcer edge, but the amastigotes of the many species cannot be differentiated by pathology. Monoclonal antibody testing may be required for species identification, especially if multiple species exist in an area. Polymerase chain reaction (PCR) testing is the best option for species identification if available.

Treatment

The mainstay of traditional leishmaniasis therapy has been pentavalent antimony (sodium stibogluconate) given parentally over 20–28 days. Sodium stibogluconate is unavailable in the USA (except from the CDC) and has toxic side effects [69]. Shorter 10-day courses may be used for cutaneous disease such as *L. major* (Baghdad boil), *L. tropica*, and *L. mexicana*. Liposomal amphotericin B (*AmBisome*) × 5 days is safer but cost limits its use to developed countries. Indian VL can be treated orally with miltefosine 100 mg each day for 28 days [6]. VL in this region is now likely to be resistant to antimonial compounds [69].

More than 90% of CL will eventually heal after several months, so treatment is not always necessary [69]. However, ulcers caused by *L. braziliensis* should always be treated due to the risk of it later relapsing into *espundia*. Other CL therapies include intralesional pentavalent antimony injections, itraconazole, ketoconazole, paromomycin ointment (unavailable in the USA), cryotherapy, and heat treatments.

Surgical Intervention

Other than biopsy for making the diagnosis, there is little role for surgery in most cases of leishmaniasis. Plastic reconstructive procedures may be needed after mucocutaneous leishmaniasis infection is well controlled and the tissues have healed and resumed normal elasticity (Fig. 15.14).

Buruli Ulcer

The Essentials

- *Painless ulcerative disease caused by Mycobacterium ulcerans.*
- *Diagnosis is usually clinical; culture is slow and of low sensitivity.*
- *Preoperative treatment with rifampin and streptomycin is indicated before any surgical resection.*
- *Antibiotics alone may be effective with small Category 1 lesions.*

Fig. 15.14 Espundia, or mucocutaneous leishmaniasis, is most often found in South and Central America but occasionally seen in West Africa as was this case

Fig. 15.15 (**a**–**c**) (**a** *top*) Note that this Class II Buruli ulcer has undermined edges and central necrosis. Many Buruli ulcers look like clean granulation but will not heal as is shown in the *middle* (**b**) photo. The Somali boy in (**c**) was biopsy proven to have mycobacteria, but the disease became progressive, invading the retroperitoneum, and the patient died (Photos (**a**, **b**) courtesy Terry Treadwell) (Photo (**c**) courtesy Erik Hansen)

Life Cycle

Buruli ulcer is a severe but painless ulcerative disease caused by *Mycobacterium ulcerans*. It primarily afflicts children. It is primarily found in West Africa, but may occur elsewhere in the wet tropics, including coastal Australia. Seventy percent are in children under 15 years of age. It typically begins as a subcutaneous nodule on the extremities (80%) or diffuse swelling of the extremity that quickly develops into an extensive painless, nonhealing undermined ulcer with a central slough due to an immunosuppressant mycolactone cytotoxin produced by the organism [70]. It is unclear exactly how the infection is transmitted, but swimming in natural stagnant bodies of water, especially if abrasions or insect bites are present, appears to be the major risk factor [70] (Fig. 15.15a–c).

Diagnosis

Most ulcers are diagnosed clinically. Culture is slow and of low sensitivity. Ziehl-Neelsen staining has only 40% sensitivity because numbers of mycobacteria are few, they are not uniformly distributed within the lesion, and the numbers decrease over time. Even biopsy has only sensitivity about 80–90%. PCR, if available, is a standard means of confirming the diagnosis.

Buruli ulcer must be differentiated from the more unusual tubercular ulcer which is ragged and shallow with bluish overhanging edges. The base is less vascular and more fibrous. This tubercular ulcer will not improve with usual tropical ulcer therapy, and the patient should receive antitubercular chemotherapy.

Treatment

The treatment of Buruli ulcer used to depend on surgery but there was a high risk of relapse. Surgery as a primary treatment has a 16% recurrence rate as opposed to a 2% if antibiotics are included. Since 2004, the WHO has recommended that all Buruli patients first receive a course of rifampicin 10 mg/kg and injectable streptomycin 15 mg/kg (contraindicated in pregnancy) administered daily × 8 weeks [71]. Pregnant patients can be treated for the same length of time with the same dosage of rifampicin plus clarithromycin 7.5 mg/kg twice daily. There is presently an ongoing trial (by the University of Amsterdam and World Alliance of Wound and Lymphedema Care) of rifampicin and clarithromycin which, being oral drugs, would avoid hospitalization. Changes in wound care recommendations now include debridement of necrotic tissues, moist dressings changed twice a week, and modified compression dressing to control edema. Completing this treatment is likely to heal the ulcer and minimizes the need for and size of skin grafts (Treadwell Terry, 23 Sept 2015, "personal communication"). Antibiotic treatment quickly reverses the mycolactone immune suppression and often produces a misleading inflammatory reaction, making it appear the condition is worsening rather than improving.

Buruli ulcers can be divided into three categories: Category I includes small lesions (nodules, papules, plaque, ulcers <5 cm), Category II includes single ulcers 5–15 cm, and Category III includes extensive ulcers >15 cm, any ulcers on the face or neck, or disseminated forms, including osteomyelitis. Median rifampin and streptomycin healing times for Categories I, II, and III are 8, 10, and 20 weeks, respectively [72]. Dense scarring and contracture may occur.

Prevention

The regular use of insect repellents may reduce the risk of Buruli ulcer by half, but it is impractical to keep rural children from playing in the water [73]. Unfortunately, bacille Calmette-Guerin (BCG) vaccination used in tuberculosis has not been very effective in preventing *M. ulcerans* infection.

Surgical Intervention

Category 1 lesions should have 4 weeks of therapy plus simple excision and immediate closure. Antibiotics alone are curative in 47% of cases, especially smaller lesions. Category 2 lesions should have antibiotic therapy for up to 8 weeks if the ulcer is stable or improving. These are more likely to require skin grafting to speed healing. If the ulcer deteriorates during treatment, debridement is necessary. Wide surgical "clean" edges do not improve results, but only increase tissue loss. Category 3 lesions should have antibiotic therapy first and debridement and skin grafting as necessary. Avoid surgery in the area of the orbit, face, and genitals.

Tropical Phagedenic Ulcer

The Essentials
- *Mixed infections which include spirochetes and fusiform bacilli.*
- *Usually occur in malnourished patients and may be painful.*
- *Consider antibiotics and myocutaneous flaps (rather than skin grafts).*

Tropical ulcers are mixed infections that usually develop on the foot or ankle subsequent to minor trauma. Spirochetes and fusiform bacilli are usually present. They typically occur in malnourished rural patients and, unlike Buruli ulcers, are more likely to be painful [74]. Poor nutrition leads to a rapid sloughing of tissue (*phagein* in Greek means to eat) and chronic difficult-to-treat draining ulcers. Advanced ulcers can appear malignant and neglected lesions can become malignant (a Marjolin's ulcer). Treatment is through a combination of antibiotics, surgery, and skin grafting. Myocutaneous flaps are superior to split skin grafts, which often break down in chronic ulcers.

Cutaneous Anthrax

The Essentials
- *Do not debride the coal-black eschar – this can result in lethal systemic infection.*
- *Treat with penicillin and doxycycline or ciprofloxacin for weaponized strains.*
- *Airway compromise may require a surgical airway.*

Bacillus anthracis, the source of anthrax, is an endospore-producing gram-positive rod bacterium acquired by skin contact with spores, spore inhalation, or ingestion of infected meat. Anthrax may produce cutaneous (hide porter's disease), pulmonary, or gastrointestinal symptoms. The bacteria are present throughout the world, but the disease is rare in developed countries and uncommon even in the LMIC. The exact prevalence in the LMIC is unknown. Cutaneous anthrax is often the result of contact with infected animal hides, and several recent cases have resulted from these hides being used in drum manufacture. Skin inoculation with anthrax spores produces a painless ulcer with a central black scab (eschar) surrounded by purplish edematous skin ("malignant pustule"). Anthrax, meaning "coal" in Greek, takes its name from this coal-black eschar. *WARNING:* The eschar should never be debrided or excised as this can result in systemic spread of the infection with fatal consequences [75]. Most treated cases of cutaneous anthrax will recover however. Anthrax treatment is with penicillin and doxycycline, but ciprofloxacin is currently recommended for potentially weaponized strains. Surgical intervention is important in cases of airway compromise (Fig. 15.16).

Fig. 15.16 The black eschar of cutaneous anthrax. Do not debride it (Photo courtesy Carol Spears)

Other Infections with Surgical Implications: Ludwig's Angina, Trachoma, Madura Foot, and Tuberculosis

Ludwig's Angina

The Essentials

- *Ludwig's angina is usually caused by abscesses of the lower molars. An early dental consult is advised. Extraction is often required at some point in the treatment.*
- *Ludwig's angina can spread rapidly along the planes of the neck, compromising the airway. Consider prophylactic intubation or surgical airway.*
- *Two-thirds of cases will require drainage. A CT, if available, can help plan the best approach.*

Ludwig's angina (angina Ludovici) is a serious, potentially life-threatening cellulitis, or connective tissue infection, of the floor of the mouth, which can abscess or spread as necrotizing fasciitis through the neck and upper thorax. It is due to oral streptococcal subspecies (anaerobic), *Staphylococcus*, and *Bacteroides*.

Ludwig's angina usually starts from an abscess of the second and third lower molars. The submandibular space is the primary site of infection, but the pus can

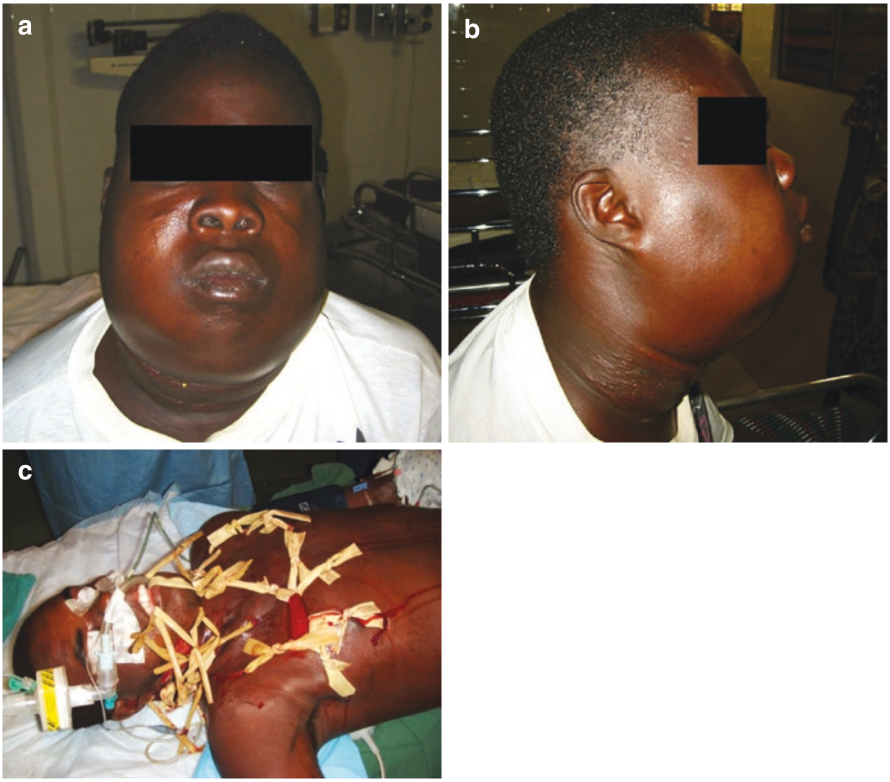

Fig. 15.17 (**a**–**c**) (**a** *top left*) and (**b** *top right*): Presentation with Ludwig's angina caused by dental abscess. (**c** *bottom right*) Necrotizing fasciitis of the neck and upper chest after late treatment for Ludwig's angina

spread contiguously to the sublingual space. Infection can also spread contiguously to involve the pharyngomaxillary and retropharyngeal spaces, thereby encircling the airway. The tongue may be protruded. It can progress down onto the chest as a necrotizing fasciitis (Fig. 15.17a–c).

The diagnosis is usually obvious on exam but ultrasound or CT with contrast will give the most detail in planning the best approach to drainage. Prophylactic intubation or surgical airway may be needed and is best done sooner than later since this disease can progress very rapidly within hours.

The infection is treated with high-dose penicillin, metronidazole, and/or clindamycin. Approximately two-thirds of cases will require drainage. Multiple drains through multiple incisions may be necessary. An early dental consult is advised. Be aware of the risk of the development of associated mandibular osteomyelitis.

Trachoma

The Essentials

- *Remember the 6 Ds (dryness, dust, dirt, dung, discharge, and density) and the 5 Fs (flies, feces, faces, fingers, and fomites).*
- *Eyelid surgery is considered when at least one eyelash rubs on the eyeball – before corneal scarring occurs.*
- *SAFE therapy (surgery, antibiotics, face washing, and environmental improvements) is a good strategy in fighting the disease.*

Trachoma is a bacterial eye infection caused by *Chlamydia trachomatis*, contributing to at least 15% of blindness in the developing world [76]. Trachoma is most common in dry, poverty-stricken regions, where flies and poor sanitation result in repeated eye infections in children. Eventually, this results in eyelid scarring and inward-turning eyelashes (trichiasis) which permanently damage the cornea. The term trachoma refers to the rough appearance of the upper tarsal conjunctiva (trachoma means "rough" in Greek). Environmental conditions fostering trachoma are characterized by either the "6 Ds" (dryness, dust, dirt, dung, discharge, and density) or the "5 Fs" (flies, feces, faces, fingers, fomites).

The World Health Organization has developed a trachoma screening picture card (depicting the everted upper lid or tarsal plate) that helps grade the clinical severity of the condition [77]. The earliest or first stage is trachomatous follicular inflammation (*TF*) with >5 visible follicles in the upper tarsal plate followed by trachomatous intense inflammation (*TI*) where the thickened tarsal conjunctiva obscures over half of the deep tarsal vessels. The third stage is trachomatous scarring (*TS*) where white tarsal scar tissue is evident. This scar tissue retracts, eventually resulting in entropion, where the lid margin is pulled toward the eye. Trachomatous trichiasis (*TT*) is the fourth stage in which at least one eyelash rubs on the eyeball or there is evidence of recent eyelash removal. This is the stage when eyelid surgery is indicated. The final stage is corneal opacity (*CO*), by which time vision has already been impaired.

The International Trachoma Initiative (ITI) has formulated a comprehensive strategy for trachoma control (SAFE – surgery, antibiotics, face washing, environmental control) [76]. In the SAFE strategy, "S" signifies surgery to correct trichiasis. A small horizontal incision is made in the upper eyelid through the tarsal plate 3 mm from the lid margin, and then the skin retracted is to evert the eyelashes. Everting mattress sutures are placed to ensure the lid margin stays permanently everted. "A" stands for antibiotic therapy, specifically single-dose azithromycin 20 mg/kg (up to 1 g), which has replaced tetracycline ointment as the most effective *Chlamydia* therapy [78]. "F" refers to regular face washing. "E" is for environmental improvements such as access to clean water and latrine use to curtail fly populations. Mobile teams travel to remote villages to first screen for trachoma and then apply the SAFE strategy to treat existing cases and hopefully prevent future ones (Fig. 15.18a–d).

Fig. 15.18 (**a**–**d**) (**a** *top left*) – Blind Maasai woman with trichiasis and corneal scarring, worse on the right than the left. (**b** *top right*) – Classic Herbert's pits located at the corneal-scleral junction (limbus). These depressions in the cornea are likely secondary to involution of limbal follicles active earlier in the disease. (**c** *bottom left*) – Classic trachoma finding of "Arlt's line," a white band of conjunctival scarring on the palpebral conjunctiva of the upper lid when everted. (**d** *bottom right*) – Quadruple lid rotations performed by the ophthalmic nurse brought dramatic relief to her chronic pain and discomfort. Later, cataract surgery in the left eye restored vision to this blind woman. Cataract surgery in the right eye was deferred due to the trachomatous scarring of the cornea (Photos courtesy John Cropsey)

Madura Foot (Mycetoma)

The Essentials

- *A chronic fungal infection of the subcutaneous tissues of the foot, diagnosed by swelling, sinus tracts, and grains in the discharge.*
- *Treatment of actinomycetomas is easiest and most effective (trimethoprim-sulfamethoxazole and/or doxycycline and in some protocols, gentamicin).*
- *Eumycetomas require long-term antifungal therapy.*
- *Surgery (with antimicrobial therapy) may be appropriately used to excise small lesions and debulk large lesions.*

Madura foot is a challenging chronic subcutaneous tissue infection of the foot or occasionally the hand. The foot develops a painless tumorlike swelling that eventually bursts open to reveal sinus tracts that drain black (fungal) or yellow (bacterial or fungal) granules. It is this characteristic triad of swelling, sinus tracts, and colored granules (grains) in the discharge that establishes the diagnosis. Biopsy and culture can confirm the diagnosis. Madura foot typically occurs in farmers or rural people whose skin is inoculated with contaminated soil. It is endemic in areas of Africa, India, and Central America. There are two basic types: actinomycetomas (bacteria resembling fungi) and eumycetomas (true fungi) [79].

Treatment is easier with actinomycetomas, which usually respond to extended trimethoprim (TMP)-sulfamethoxazole (SMZ) and/or doxycycline treatment. A two-step regimen has also been described in India. An intensive 1-month treatment with twice daily IV gentamicin and oral SMZ-TMP is followed by SMZ-TMP and doxycycline twice daily [80]. Eumycetomas are treated with very long-term itraconazole or other systemic antifungals for 12–24 months with follow-up for at least 2 years. In the developing world, it is often more practical to excise small lesions and debulk large ones, but always with medication both before and after excision to prevent recurrence (Fig. 15.19a, b).

Tuberculosis

The Essentials

- *Tuberculosis is increasing in frequency and can involve any organ system, although diagnosis can be difficult. It should be part of any differential diagnosis of fever.*
- *Lymphatic involvement (scrofula) represents one-third of the cases in LMIC.*
- *Surgery can reverse neurologic deficits in Pott's disease.*
- *Many cases of extrapulmonary tuberculosis are not associated with active pulmonary disease.*
- *For abdominal presentations, surgery is reserved for diagnostic conundrums, significant obstruction, and the occasional perforation. Avoid adhesiolysis and consider stricturoplasty over resection.*

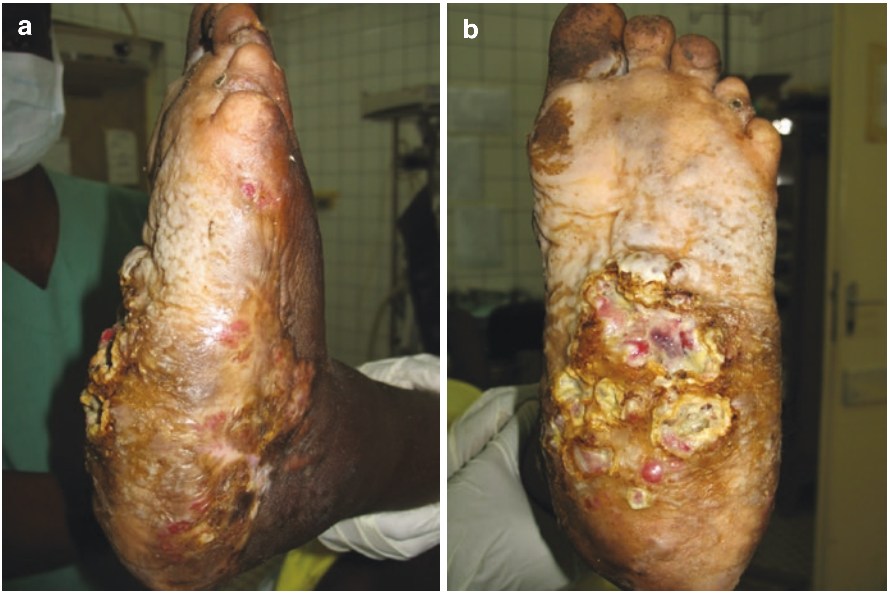

Fig. 15.19 (**a**, **b**) Madura foot side and plantar (Photos courtesy Sherry Wren)

Presentation

Tuberculosis (TB) is part of the "big three" diseases found in the developing world: TB, HIV/AIDS, and malaria. Increasingly, TB and HIV are found as coinfections. Although usually thought of as a pulmonary disease, tuberculosis can infect any part of the body: the CNS, bones, joints, pleura, lymph nodes, skin, as well as the gastrointestinal and genitourinary tracts. Symptoms are often insidious, making its diagnosis much more challenging than that of pulmonary TB. Like malaria, non-pulmonary TB requires a high index of suspicion, and it should always be included in any differential diagnosis of fever.

Miliary TB refers to the hematogenous dissemination of TB to any organ. In addition to involving the lungs (in over 50% of cases), it commonly affects the lymphatics, liver, bones, and joints. Consequently, miliary disease is associated with many cases of extrapulmonary TB. The term "miliary" refers to the tiny white nodules resembling millet seeds that characterize this disease. In the lungs, these form a faint diffuse reticulonodular pattern on the chest film. Miliary TB usually has a subacute presentation with fever and night sweats. It can be very challenging to diagnose. Even in the USA, about 20% of miliary TB cases are only discovered on autopsy [81]. Although tuberculin skin testing is the first step, a negative test in no way excludes the diagnosis, and as many as 68% of patients with this condition may be anergic [82]. The differential for miliary TB in the lung includes fungal infections (e.g., histoplasmosis), hypersensitivity pneumonitis, sarcoidosis, metastatic disease, and septic emboli.

Lymphatic disease is very common in the developing world, representing about a third of non-pulmonary cases. Cervical TB adenitis ("scrofula") presents with unilateral, non-tender, rubbery lymph node enlargement. Inflammation is absent. It is frequent in children and young adults, especially in South Asia and Africa. Draining sinuses may develop near the affected nodes. A chest x-ray in these patients may either be normal or may demonstrate hilar or mediastinal LNs. LN biopsy or a fine needle aspirate with culture assists in the diagnosis.

TB bone and joint disease usually starts insidiously with increasing pain, with or without fever. The vertebrae and weight-bearing bones and joints are usually affected. Tuberculosis of the spine (Pott's disease or tuberculous spondylitis) is the most common skeletal form, followed by tuberculosis arthritis (hip or knee joint involvement most likely) and tuberculous osteomyelitis [83]. Pott's disease causes vertebral collapse with a gibbus spinal deformity (kyphosis) and the potential for cord compression and paraplegia. Surgical intervention may be needed for spinal decompression. Pott's patients develop a slow characteristic walk, taking tentative deliberate steps to avoid pain.

Joint involvement of the hip or knee involves escalating pain without any signs of acute inflammation, eventually leading to joint destruction. Synovial biopsy aids the diagnosis, but joint fluid exam is usually not helpful. TB osteomyelitis may affect any bone, with rib involvement (chest wall mass) or lytic bone lesions resembling metastatic disease. Culture of infected bone is usually positive. TB may occasionally cause a rare immune-mediated, inflammatory, symmetrical polyarthritis (Poncet's disease) which resolves with therapy.

Tuberculous meningitis is often associated with miliary disease and poses a major challenge in the developing world. It is usually fatal if not treated in time. TB meningitis classically presents with headache and low-grade fever, but symptoms develop slowly (>7 days), unlike bacterial or viral meningitis. There are often three stages: nonspecific malaise lasting about a week, followed by meningeal irritation (headache, fever, rigid neck) with cranial nerve symptoms, and, finally, seizures and coma. Cerebrospinal fluid (CSF) classically shows high protein, low glucose, and lymphocytosis, although neutrophils may be present early on. Opening pressure is high. CSF culture for *M. tuberculosis* (which takes 4–6 weeks) eventually confirms the diagnosis, but treatment, to be effective, must be instituted much earlier based on clinical suspicion. Culture and sensitivities are important for determining the level of drug resistance, thus guiding long-term therapy. Polymerase chain reaction analysis of CSF, although not yet FDA approved, offers the best hope for rapid diagnosis. CT or MRI scanning, if available, reveal hydrocephalus, parenchymal masses (tuberculomas), and thickened basilar meninges (basal cistern enhancement with contrast). Shunt placement may be necessary for hydrocephalus.

Urinary tract TB classically produces a "sterile pyuria" with hematuria and proteinuria. Cystitis and flank pain are typical symptoms. Urine culture for

M. tuberculosis is usually positive, whereas bacterial culture is negative. Sterile pyuria is also common in miliary TB, with urine TB cultures often being negative in this setting. TB occasionally spreads to the female and male reproductive tracts where it produces pelvic pain, menstrual irregularity, or scrotal pain and swelling.

Gastrointestinal TB causes liver disease, enteritis, peritonitis, and ascites. Hepatic disease presents with RUQ pain, nausea/vomiting, and diarrhea. Miliary liver disease may cause jaundice or pancreatitis. Culture of tissue or ascitic fluid is usually positive; however, evidence of pulmonary disease is missing in at least half of these cases.

"Lupus vulgaris" describes cutaneous tuberculosis, which typically presents in older patients. It appears as yellow or reddish slow-growing skin lesions, which may resemble apple jelly when compressed by a glass slide (diascopy). Biopsy, culture, and PCR are recommended. Many nontuberculous mycobacteria (e.g., *M. marinum* or *M. ulcerans*, the cause of Buruli ulcer) also involve the skin.

Non-pulmonary TB can involve the pleura (pleuritic pain with effusion), the pericardium (retrosternal pain), endocrine and adrenal glands, and indeed any known organ system – hence the need to include TB in the differential for nearly every condition in high-incidence areas.

Diagnosis and Treatment

Key advice for clinicians working with non-pulmonary TB disease includes: (1) do not expect that evidence for concomitant pulmonary disease will be present on chest x-ray (although chest films are mandatory), (2) accept that the response to treatment (especially in resource-poor settings) may be the only way to confirm a tentative TB diagnosis while awaiting culture results, and (3) use culture results and sensitivities to guide treatment. Screening tools include tuberculin skin testing (hampered by false positive readings after BCG vaccination as well as high rates of anergy in immunosuppressed patients), interferon gamma release assays (also prone to false negative results), chest radiographs and CT scans, acid-fast smear and culture, tissue biopsy, nucleic acid amplification tests (GenProbe® and Amplicor®) for sputum specimens, polymerase chain reaction (PCR) testing, and the revolutionary Xpert MTB/RIF assay (a rapid nucleic acid amplification assay to identify the presence of *M. tuberculosis* and its sensitivity to rifampin). Unfortunately, clinicians working in the highest incidence areas have the fewest diagnostic resources. They must rely on a high index of suspicion and a willingness to institute therapy based on incomplete information.

Treatment for non-pulmonary TB is similar to that for pulmonary disease, with isoniazid, rifampin, pyrazinamide, and ethambutol (or streptomycin) for 2 months, then isoniazid and rifampin for 4 months. The exception is tuberculous meningitis which requires at least 12 months of therapy. Immune-compromised patients also require longer courses. Corticosteroids are sometimes used for TB pleuritis, pericarditis, CNS infection (meningitis or tuberculomas), and for spinal cord compression [84].

Surgical Aspects of Non-pulmonary Tuberculosis

There are two common non-pulmonary forms of tuberculosis that might require surgical consultation. Pott's disease (or TB of the spine) has the greatest number of infections located in the lower thoracic spine and upper lumbar spine. Pott's disease manifests as a combination of osteomyelitis and arthritis that usually involves more than one vertebra. The anterior aspect of the vertebral body adjacent to the subchondral plate is usually affected. The infection may spread to adjacent intervertebral disks. In adults, disk disease is secondary to the spread of infection from the vertebral body. In children, the disk, because it is vascularized, can be the primary site. Progressive bone destruction leads to vertebral collapse and kyphosis. Abscesses, granulation tissue, or direct dural invasion can cause spinal cord compression and neurologic deficits. A cold abscess can occur if the infection extends to adjacent ligaments and soft tissues. Abscesses in the lumbar region may descend down the sheath of the psoas to the groin and drain through the skin there. Tubercular disease of the spine occurs in 1–1.5% of all TB patients (more commonly in HIV patients).

The diagnosis of Pott's disease is simpler in children due to lack of other likely possibilities. Scheuermann's disease (self-limited kyphosis in pediatrics due to unequal growth) is one. In adults, tubercular lesions can be confused with many other diseases (pyogenic and fungal infections, secondary metastatic disease, primary tumors of the bone, sarcoidosis, and giant-cell tumors of the bone).

These patients have a history of slowly progressive constitutional symptoms – weakness, malaise, night sweats, fever, and weight loss. Spinal deformity and swelling occur later in the course. Pain is a late sign associated with bone collapse and paralysis. Neurologic signs usually occur late and may wax and wane. Presence of motor function and rectal tone are good prognostic predictors.

Long-term bed rest, with or without cast immobilization, is ineffective. Unfortunately, surgery is expensive and often not available to these people. Open biopsy for diagnosis, debridement, and grafting may be indicated, especially with involvement of more than one vertebral level. In the face of adequate drug therapy, the onset of gradual paraplegia, worsening of paraplegia, presence of motor loss after 1 month, and severe paraplegia after 6 months of treatment are all indications for a surgical approach. Uncontrolled spasticity and the onset of any sudden severe paraplegia are absolute indications. Resistance to chemotherapy and recurrence of disease are also indications. Severe kyphosis with active disease, signs and symptoms of cord compression, progressive impairment of pulmonary function, and progression of the kyphotic deformity are indications. The prognosis is fairly good for surgical intervention; 70–90% of those with paralysis due to Pott's disease will recover with surgery.

The surgical approach varies depending on the surgical skills and access to technology. Harvested ribs, iliac crest, and fibula can be used as grafts, but there is an incidence of late stress fracture. External immobilization is mandatory whenever grafting is done. Posterior fusion in addition to grafting is desirable if available.

Fig. 15.20 Granulomatous peritonitis due to TB (Photo courtesy Rich Davis)

Tubercular enteritis is more common. Abdominal TB is the most common granulomatous gastrointestinal disease of the tropics, affecting 2–5% of all TB patients. Less than 50% of those with abdominal TB have simultaneous active pulmonary TB.

Peritoneal TB is the most common form of abdominal TB. It can be ascetic (wet) or plastic (fibroadhesive). Plastic TB gives the classic "doughy" abdomen on exam. For those patients, 85–90% of the disease is in the ileum and ileocecal areas; the remainder can be found anywhere along the course of the gastrointestinal tract (Fig. 15.20).

TB of the gastrointestinal tract can be ulcerative (60%), hypertrophic (10% – scarring, fibrosis, and masses mimicking carcinoma or combined (30%). There may be caseating granulomas in the lymph nodes or fistulae with circumferential ulcers (long access perpendicular to the axis of the gut). The muscularis layer is usually spared. The Ziehl-Neelsen stain is positive about a third of the time.

Symptoms are nonspecific with symptoms of nonspecific pain, diarrhea, and blood. Approximately two-thirds of these patients have a deep abdominal mass palpable, and two-thirds are constipated.

Complications include hemorrhage, perforation (5–10%), obstruction, fistula formation, and malabsorption. Obstruction from small bowel TB can be the cause of 50% of the cases of small bowel obstruction in some series. Acute TB causes 20% of the obstruction cases; 80% are subacute. Perforations are usual single and proximal to an ileal obstruction.

Surgery is reserved for diagnostic conundrums and significant obstruction. The principle is to resect only complete obstructions and use single or multiple strictuроplasties for significant partially obstructing strictures. Adhesiolysis should be done with great caution to avoid development of fistulae.

Necrotizing Fasciitis (NF)

The Essentials

- *This polymicrobial synergistic infection of gram-positive, gram-negative, aerobic, and anaerobic bacteria can progress very rapidly requiring aggressive and frequent debridement.*
- *Cancrum oris (noma) is an exception to the rule of aggressive debridement – debride but preserve all viable tissue to make reconstruction more feasible.*
- *Don't forget tetanus toxoid, tight glycemic control, and nutritional support.*
- *Reconstruction is considered when the disease is arrested and the patient has achieved positive nitrogen balance.*

Necrotizing fasciitis is a rapidly progressive necrotizing inflammation of skin and subcutaneous tissue and common in all ages in the LMIC [85]. Fournier's gangrene is a form of NF as is cancrum oris (noma, orofacial gangrene); the latter is common in some populations of children [86, 87].

It may start spontaneously in apparently healthy individuals but is often related to conditions causing impaired immunity [85, 88–91]. Known predisposing factors include anemia, malnutrition, HIV/AIDS, specific infections, trauma, diabetes mellitus, and postoperative as well as general conditions like malaria and measles [92, 93]. The trauma required to initiate the infection can be seemingly innocuous including thorns and bug bites.

It is usually a synergistic infection of gram-positive bacteria, gram-negative bacteria, and anaerobes, and up to 80% of cultures are polymicrobial [92].

The natural history of the disease has been divided into stages [93], but the progress of the disease tends to be so rapidly progressive that stages overlap. The presentation and severity depends on the stage at which the patient presents.

Discharge and tissue from the lesion should be gram-stained cultured if possible, including anaerobic culture if available. Efforts should be made to identify and correct any associated cause or complicating factor. Tight glycemic control is critical in diabetics. In many others, there is no rapid reversal of the underlying abetting condition.

Treatment should start early. Any effect of sepsis should be addressed with fluid resuscitation and with parenteral administration of potent broad spectrum antibiotics, including those effective against anaerobic bacteria. Tetanus prophylaxis is necessary in most African settings. Anemia should be corrected and nutritional support will be necessary in most patients. However, the most important concept is early, aggressive surgical debridement. These patients may require returns to the operating room as often as every 12 h to get ahead of the infection. If transfer of the patient is necessary, debridement should precede transfer if at all possible [94].

Fig. 15.21 (**a**) (*top left*) Synergistic gangrene and necrotizing fasciitis in young Togolese boy after injection in the buttock. (**b**) (*top right*) Acute noma in young Sudanese boy (Photo courtesy Dan Poenaru). (**c**) (*bottom left*) Noma patient ready for reconstructive surgery (Photo courtesy Tim Bartholomew)

Cancrum oris is an exception to this rule of very aggressive debridement. While debridement is important, it is important to preserve any viable tissue which will permit better future reconstruction.

Reconstruction will be required after progression of the disease is arrested, the patient is in positive nitrogen balance, and the wound is healing. Closure of the defect may require suturing, skin grafts, or flaps. Healing by secondary intention should be avoided as much as possible to avoid contractures and unsightly scars.

Morbidity and mortality can be high and the long hospital stays can be a financial disaster for the family and village (Fig. 15.21a–c).

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Essential Orthopedics for Global Surgery

16

Michelle Foltz, Richard A. Gosselin, and David A. Spiegel

Introduction

Treatment of musculoskeletal conditions and bone and joint trauma in developing countries is often done by general surgeons at the district and provincial level or by traditional bonesetters, while specialist orthopedic facilities are available only at central, military, training, or NGO hospitals, making the level of care highly variable.

The burden of orthopedic conditions has become a World Health Organization (WHO) priority, but the reality seems quite different on the ground. Injury prevention, having a large behavioral component, doesn't neatly fall into the realm of health but requires coordinated programs crossing many fields as well as the will, organization, and funds to address the problems. The recent, rapid, partial motorization of transport using roads that are inadequate for high speeds and the wide mix of

M. Foltz, MD (✉)
172 Stillwater Loop Road, Columbus, MT 59019, USA
e-mail: michellefoltz@gmail.com

R.A. Gosselin, MD, MPH, MSc, FRCS (C)
Department of Orthopedic Surgery, Institute for Global Orthopaedics and Traumatology, University of California at San Francisco,
643 Ferdinand Avenue, El Granada, CA 94018-1983, USA
e-mail: froggydoc@comcast.net

D.A. Spiegel, MD
Department of Orthopaedic Surgery, University of Pennsylvania School of Medicine, 2nd Floor, Wood Building, Philadelphia, PA, USA

Division of Orthopaedic Surgery, Children's Hospital of Philadelphia,
34th Street and Civic Center Boulevard, Philadelphia, PA 19104, USA

Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA, USA

Orthopaedic Surgery, Hospital and Rehabilitation Centre for Disabled Children,
Janagal, Kavre, Nepal
e-mail: spiegeld@email.chop.edu

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road users has created an epidemic of road traffic injuries, leaving millions permanently disabled from extremity and spinal injuries.

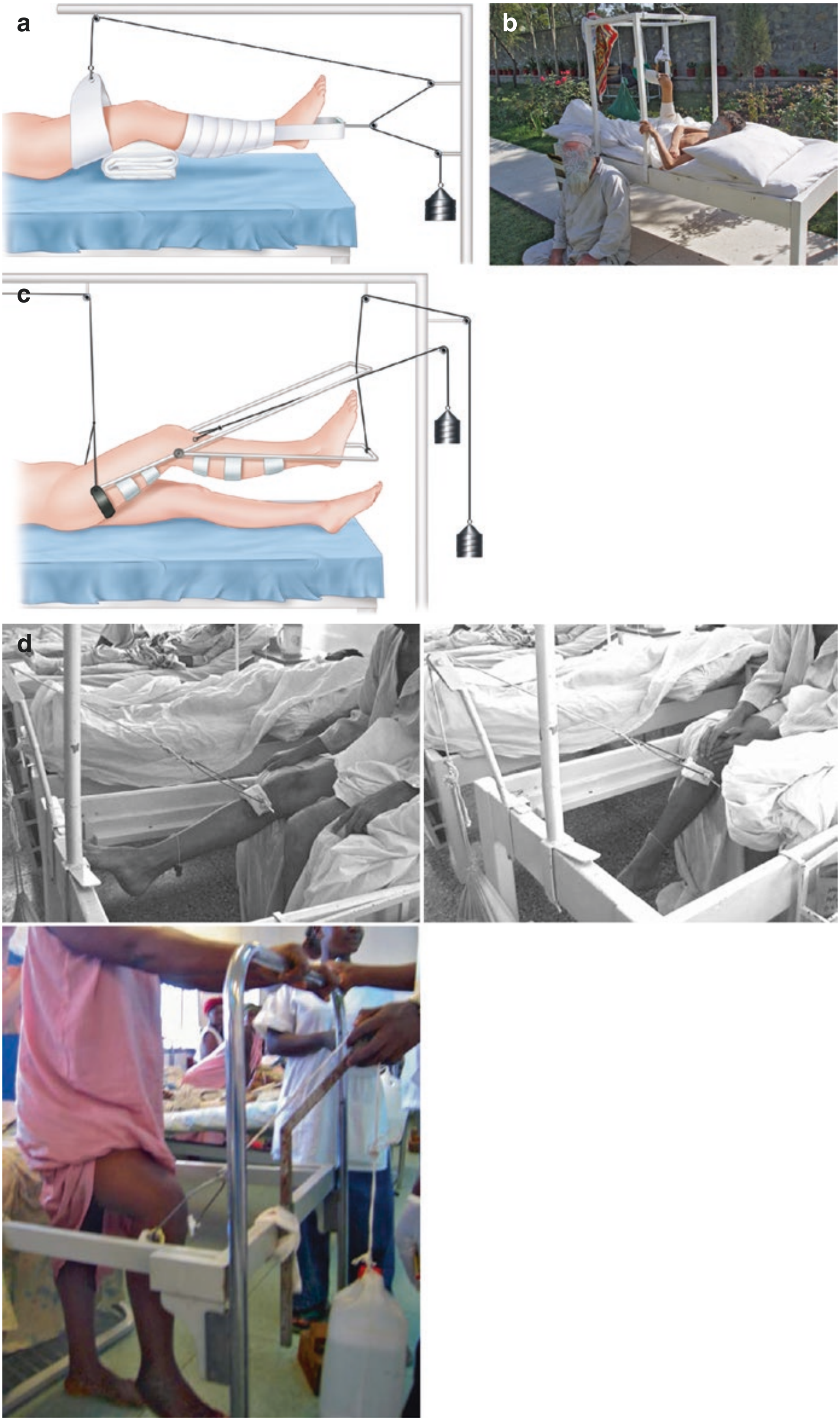
Surgical treatment of orthopedic injuries and end-stage arthritic conditions has long been thought to be too demanding and expensive for the limited human resources and health budgets of most LMICs. Orthopedic training is long and highly specialized; the materials are costly and constantly changing as techniques improve and new therapies evolve. Rehabilitation requires another layer of care, which, if absent, will result in continued disability despite adequate surgical or nonoperative treatment. Even where trauma care is taken seriously, extremity injuries especially of the hands and feet—the small, non-life-threatening, “insignificant parts”—are often overlooked or inadequately treated, resulting in long-term disability. Lengthening life spans and Western lifestyles have added to the orthopedic burden through increased incidence of disabling arthritis with advanced age and the musculoskeletal consequences of chronic diseases such as diabetes.

Neglected or poorly treated trauma is common in austere settings, presenting as chronic dislocation, malunion, non-union, infection, and functional limitation. Taking a useful history can be time consuming, but needs to include an accurate idea of chronicity, the cause of the injury, the specific reason the patient and family have come for consultation, and the results expected after treatment. The latter are not always self-evident and a sympathetic translator needs to be available. A complete exam, including demonstration of activities of daily living, will show functional limitations. Before suggesting surgery, a course of physical therapy and/or serial casting may be suggested as the surgical management of many untreated or poorly treated injuries is prone to complications, and it is often difficult to achieve the desired functional result. A detailed informed consent is mandatory when embarking on these reconstructive cases.

Nonsurgical management of extremity injuries primarily involves external immobilization via plaster of Paris (POP) circumferential casts, plaster slabs, or traction. Fiberglass materials and prefabricated braces are expensive and rare. Plaster supplies and cast padding may be of poor quality, making application cumbersome, inelegant, and often ineffective. Even if dedicated staff are charged with application of POP, patients and possibly x-rays must be checked to ensure proper fit before discharge from the hospital or outpatient department. Though considered safer than surgery, improper splinting or poorly applied casts can cause major problems. Any complaints related to external immobilization must be addressed immediately.

The use of traction is highly dependent on the familiarity of nursing and/or physio staff with the principles of traction and the use of the available devices (Fig. 16.1a–d).

Fig. 16.1 Different forms of traction may be useful in the treatment of upper and lower extremity fractures. For lower extremity fractures, longitudinal traction may be employed through the skin, for example, Russel’s traction (**a**). 90–90 traction involves 90° of flexion at the hip and the knee and can be accomplished by distal femoral pin (**b**). Longitudinal traction may also be accomplished using a proximal tibial traction pin and a Thomas-Pearson splint, but care must be taken to avoid damaging the tibial tuberosity in skeletally immature patients, as this may cause recurvatum deformity from growth disturbance (**c**). In the Perkin’s traction, the lower portion of the bed is removed so that the patient may work on knee range of motion and strengthening exercises while still in traction (**d**) [1] (Reprinted from Fisher et al. [1], with permission of Springer)


a
b
c
d

The skin can tolerate up to 3–4 kg of skin traction and is primarily used in children or in adults to initially keep an extremity comfortable. Skeletal traction may require weights up to 10 % of the patient's weight. Traction pins should be placed using a hand drill as power can thermally necrose the skin and bone. Typical pin sites are the proximal tibia at the level of the tibial tuberosity for the femur, hip, and pelvis injury, distal femur at the level of the proximal pole of the patella for hip and pelvis, and calcaneus for tibia, and olecranon for supracondylar humerus. Avoid proximal tibial pins in children as they can damage the adjacent physis, resulting in recurvatum deformity. Lower extremity traction is used most often with the leg straight or on a padded frame to control rotation. Poorly made or improperly sized traction frames can cause serious pressure sores. Protocols for pin care vary, but should not include deep cleaning with astringent solutions or vigorous digging around the pins.

In this chapter the authors will present some of the more common orthopedic problems found in developing countries and approaches to deal with them; few will involve surgery. When faced with unfamiliar problems, ask for help from your medical, surgical, and nursing colleagues. They can advise on the available equipment, supplies, and local resources.

Adult Orthopedic Trauma

Fractures should be evaluated for associated deformity, swelling, bruising or abrasions, bleeding, fracture blisters, evidence of superficial and deep degloving, vascular injury, and/or neurologic injury. Evaluation of the severity of soft tissue damage in extremity trauma is key to treatment along with knowledge of available treatments and the staff's experience in their use.

Long-bone open fractures are usefully described by the Gustilo classification (Fig. 16.2) and are best left open after tetanus prophylaxis and thorough debridement of all nonviable tissue, including bone fragments without soft tissue attachment, followed by elevation and immobilization in plaster splints or traction with delayed

Gustilo and Anderson Classification of Open Fractures

Type I

Clean wound smaller than 1 cm in size. Assumes a simple fracture pattern

Type II

Soft tissue injury >1 cm but <10 cm without extensive soft tissue damage. Assumes minimal degloving and periosteal stripping and not more than moderate contamination or comminution

Type III

High-energy injuries, with substantial soft tissue injury, periosteal stripping, and/or some degree of crush. Segmental fractures, bone loss, farmyard injuries, high velocity GSW

Type IIIA

Large soft tissue injury or flap, though usually less than 10 cm. Adequate soft tissue remains to cover the bone

Type IIIB

Extensive soft tissue injury, bone loss, devascularization, and/or massive contamination. Inadequate soft tissue to cover bone without a flap

Type IIIC

Fractures with major arterial injury requiring repair

Fig. 16.2 The Gustilo classification [2] (Reprinted from Foltz et al. [2], with permission of Springer) primary closure (DPC), split skin graft (SSG), or flap in 3–5 days. An alternative to plaster or traction management is external fixation (ex-fix), which combines the benefits of easy access to the wound and early mobilization of the patient. It should be viewed as a tool for wound management not for bone healing. While an easy technical procedure in skilled and experienced hands, external fixation can appear daunting to the neophyte, who should not embark on its use without careful consideration of potential harm. Appropriate pin placement is crucial to avoid neurovascular injuries or jeopardize future surgical procedures such as grafting or flaps. In general, the ex-fix should be removed and replaced with splints/POP soon after the wound has healed.

When the presentation is acute, antibiotic prophylaxis for 24 h is appropriate if available. Compartment syndrome can occur in open or closed fractures and in high- or low-energy injuries and is most commonly seen in leg and forearm injuries. The earliest sign is increased narcotic requirements and pain out of proportion to the injury and with passive stretch of the muscle. These are more reliable signs than waiting until pulselessness, pallor, parasthesias, and paralysis have set in, at which point irreversible damage is likely. All bandages, including cotton, should be released while maintaining fracture stability. If the symptoms are not significantly improved, fasciotomies must be considered (Fig. 16.3). In the leg a longitudinal medial incision placed about 2 cm posterior to the medial border of the tibia allows access to both the superficial and deep posterior compartments, each of which must be released. A second anterolateral longitudinal incision placed halfway between the tibial crest and the fibula allows release of the anterior extensor and peroneal muscle compartments. All four compartments must be completely released of constricting fascia. Any muscle that is discolored, of poor consistency, fails to contract when irritated, or does not bleed is nonviable and should be removed. In the forearm both the volar and dorsal

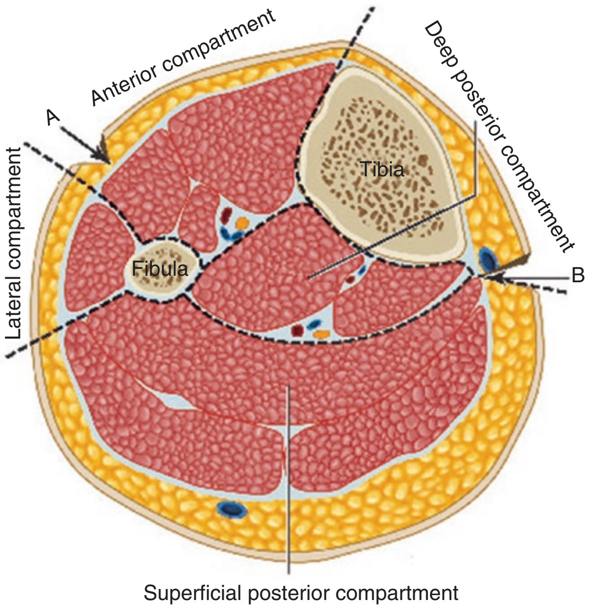


Fig. 16.3 Lower extremity muscle compartments and their release. A–skin incision for release of anterior and lateral compartments. B–skin incision for release of superficial and deep posterior compartments [2] (Reprinted from Foltz et al. [2], with permission of Springer)

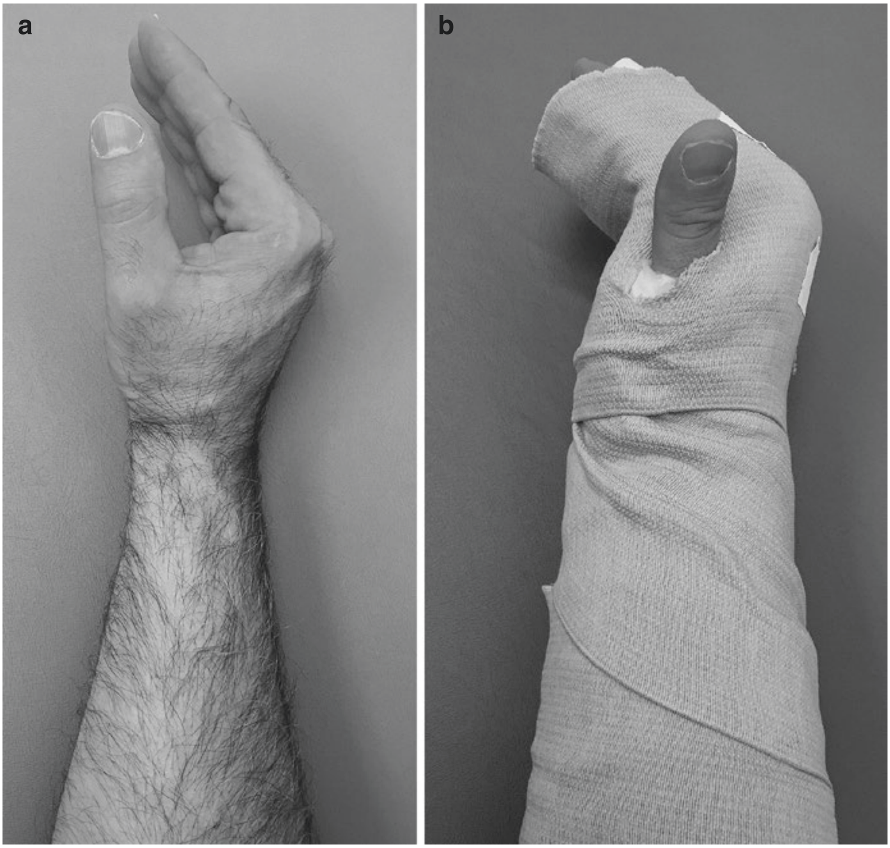


Fig. 16.4 The functional position for splinting the hand involves 30° dorsiflexion at the wrist, 90° flexion at the MCP joints, and full extension at the IP joints

compartments need to be released through separate incisions. Fasciotomy wounds are left open and the extremities stabilized in a bulky dressing with plaster splints and moderate elevation. The wounds are re-evaluated in 3–5 days to determine additional treatment options: further debridement, DPC, or SSG.

Compartment syndromes from injuries that have occurred more than 24 h before admission, such as in crush injuries in natural disasters, should not undergo surgical decompression. By that time ischemia is irreversible and the surgical wounds will likely become infected, often leading to amputation. It is better to splint the extremity in a functional position, accept the residual deficit, and plan for delayed reconstruction. For the hand, the functional position involves extension at the interphalangeal joints, 90° flexion at the metacarpophalangeal joints, and 30° dorsiflexion at the wrist (Fig. 16.4a, b). Long arm splints typically keep the forearm at the midrange of pronation/supination, and the elbow flexed 90°.

No matter the method of treatment, the primary goals are prevention of complications, especially infection, the reestablishment of stability in fractures and motion in joint injury, and the restoration of useful function.

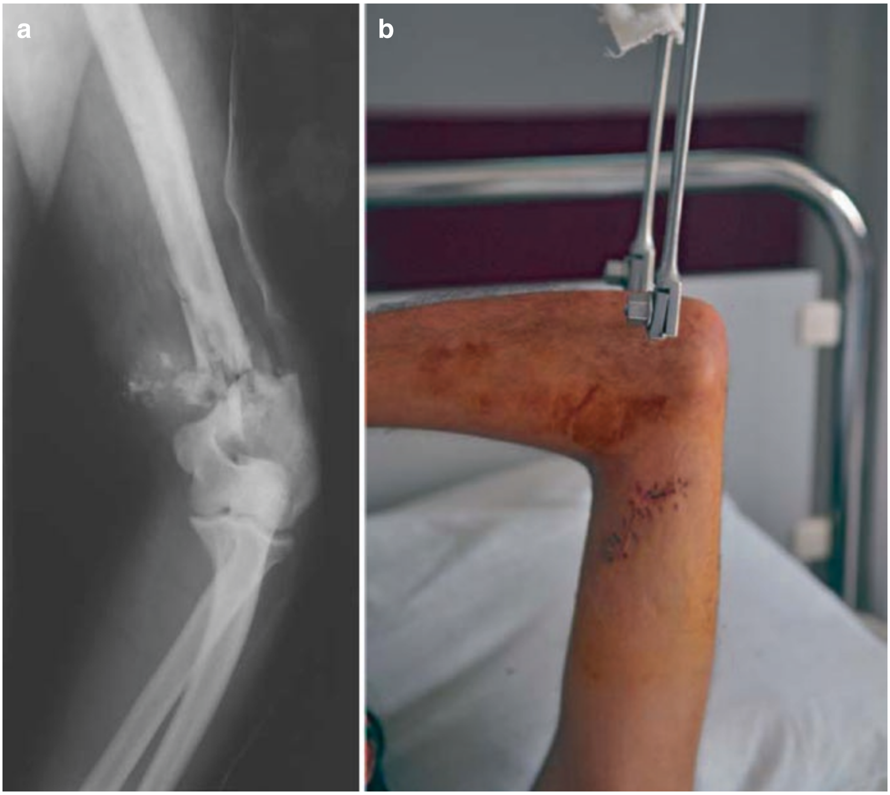


Fig. 16.5 Olecranon traction. Olecranon traction may be used to treat distal humerus fractures, for example, this unstable fracture from a gunshot wound [1] (Reprinted from Fisher et al. [1], with permission of Springer)

Upper Extremity Injuries

Acute anterior shoulder dislocations can usually be reduced with sedation in the emergency department (ED). Those of 2–3 weeks duration may require general anesthesia with relaxation or reduction using the prone position on a trolley and strapping a weight to the wrist. Associated tuberosity fractures usually reduce with the joint relocation and will heal with the shoulder immobilized in a sling for 2–3 weeks. A 3–4 week old dislocation often requires open reduction. Proximal humerus fractures are more common in the elderly and can be treated with a collar and cuff. Humeral shaft fractures heal well in lightweight U-slabs of POP that are changed and tightened every 10–14 days as the edema and swelling decrease. Shaft fractures heal in 6–10 weeks.

Supracondylar humerus fractures in adults are often intra-articular. Unless familiar with the demanding open techniques and with proper equipment and time, these are best treated with olecranon traction until the fracture has demonstrated early healing (no pain with clinical examination) (Fig. 16.5a, b), followed by

Fig. 16.6 Long arm cast

casting or treated with early motion in a removable back slab. Opening such fractures without obtaining adequate stability that allows early motion is not recommended. If elbow dislocations are stable after reduction, apply a back slab for 7–10 days followed by early motion. In general elbows are notorious for loss of motion, even after minor injuries, and any surgical procedures need to be well thought out.

To regain full function, both bone forearm diaphyseal fractures are best treated with plates and screws crossing at least six cortices on each side of the fracture. If this is not possible, a well-molded above elbow cast in neutral rotation will allow healing, though with loss of rotation and probably limited elbow range of motion (ROM) (Fig. 16.6). Monteggia fractures—proximal ulna fracture with radial head dislocation and Galleazi fractures—distal third radius fracture and ulnar head dislocation require open reduction and internal fixation of the fracture to reduce the dislocation. In children these fracture/dislocations can usually be treated closed, without surgery.

Distal radius and ulnar fractures are due to falls on the outstretched arm and can usually be reduced in the ED and splinted. Edema is controlled with elevation of the injured segment above heart level and active finger ROM exercises; an arm sling is not an elevation. While lying down, the shoulder can be externally rotated and pillows placed under the humerus posteriorly to keep the hand and wrist above the heart. In osteoporotic bone, the reduction is often lost, leaving the ulna prominent, but this rarely adversely affects function. Fractures of the hand and fingers are reduced to maintain alignment, length, and rotation and splinted with front slab, back slab, or both that includes the wrist. The functional position for splinting common hand injuries is 20–30° wrist dorsiflexion, 90° metacarpal-phalangeal joint flexion, and interphalangeal joint extension (Fig. 16.4). Buddy taping the noninjured digit(s) to the injured one(s), with gauze or cotton between fingers to prevent maceration, helps maintain the reduction in which the semi-flexed fingertips point to the scaphoid bone. Three- to four weeks splinting is usually sufficient. Mangled hands are difficult to sort out what parts are viable as opposed to what parts will be useful. Seek your colleagues' advice as cultural factors often affect the decisions.

Lower Extremity Injuries

Pelvic fractures are generally high-energy injuries, for example, motor vehicle crashes, and involve a variety of mechanisms including lateral compression and shear forces. They generally heal with nonoperative management, allowing activity and weight bearing as tolerated. In general, shortening of more than 2 cm and angulation greater than 10° in the lower extremity are poorly tolerated. Displaced intra- and periarticular fractures and non-unions lead to significant functional limitations, pain, weakness, and potential compensatory arthritis in adjacent joints.

Hip dislocations usually involve axial loading, and most commonly the hip is flexed at the time of impact, and the dislocation will be posterior. Those that are stable and congruent after a closed reduction can be treated symptomatically; unstable fractures benefit from 2 to 3 weeks of traction in extension and external rotation. Unstable dislocations with large acetabular fractures can be treated with open reduction and internal fixation or prolonged traction to allow the fragments to heal. Femoral neck fractures often progress to non-union and even undisplaced fractures may fail to unite. Low demand patients may be able to get by using a walking aid. Otherwise, replacing the head with a hemi-replacement or complex reconstructive procedures are the options.

Intertrochanteric fractures involving metaphyseal bone can heal with prolonged traction, though older patients may poorly tolerate this. Sub-trochanteric fractures are usually high-energy injuries and like diaphyseal femur fractures can be treated with traction, although shortening and malunion are common. Hip spica casts for adults are cumbersome and are rarely the first line of treatment, but occasionally they can be useful after traction or when biding time between procedures. These casts incorporate the abdomen/pelvis as well as one or both lower extremities and are most commonly used to treat femur fractures in children less than 5–6 years of age.

Unless implants and professional expertise are available for surgery and rehabilitation, injuries about the knee, whether bony or ligamentous, are better treated with 4–6 weeks immobilization, generally in a position of 30° flexion. This results in a stiff, but hopefully stable and pain-free joint.

Tibial shaft fractures can result from either a direct blow or an indirect mechanism involving torsion or lateral bending and can often be reduced and treated in a non-weight-bearing above-knee cast with the knee in 20–25° flexion after the initial swelling has subsided. At 6–10 weeks, when the fracture is "sticky" and painless, the long leg cast is converted to a patellar tendon bearing cast (Fig. 16.7) or

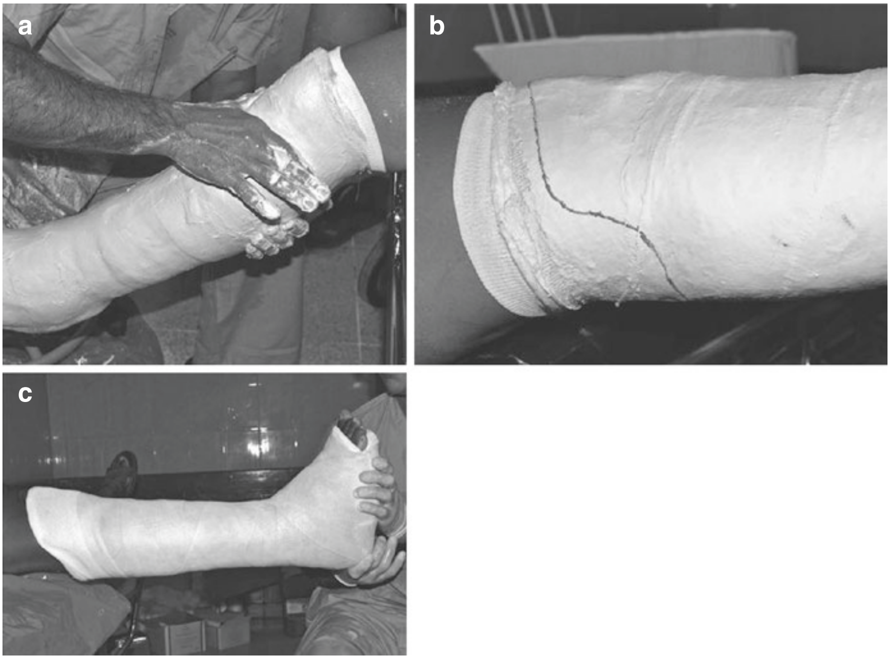


Fig. 16.7 A patellar tendon bearing cast is a variant of a short leg cast in which the initial cast is placed just above the superior pole of the patella and then trimmed down distal to the popliteal flexion crease [1] (Reprinted from Fisher et al. [1], with permission of Springer)

below-knee walking cast. Unstable fractures, and those at or above the level of the proximal third of the tibia, should not be placed in short leg casts that leave the knee free for fear of angulation and non-union due to loss of proximal support. Determining fracture consolidation is subjective. The presence of solid, bridging callus on x-ray, pain-free deep palpation and stress at the fracture site, and pain-free normal gait without limp are good indications of fracture healing.

In many parts of the developing world, the introduction of SIGN nails (Sign Fracture Care International) has revolutionized the treatment of open and closed long bone injuries, allowing dependable and predictable fixation of femur (Fig. 16.8a, b), tibia, and humerus fractures with acceptably low rates of infection, using a solid, locked stainless steel intramedullary nail that requires neither C-arm control or fracture table reduction. A technique manual is freely available at https://signfracturecare.org.

Outcomes for ankle and foot injuries are highly dependent on early reduction to relieve the swollen and deformed soft tissue envelop, while the injured extremity is held with a well-padded back slab, U-slab, or bivalved cast and kept elevated. The goal is a plantigrade or flat foot without excessive inward (varus) or outward (valgus) tilt and full range of dorsiflexion. Fractures and fracture-dislocations of the

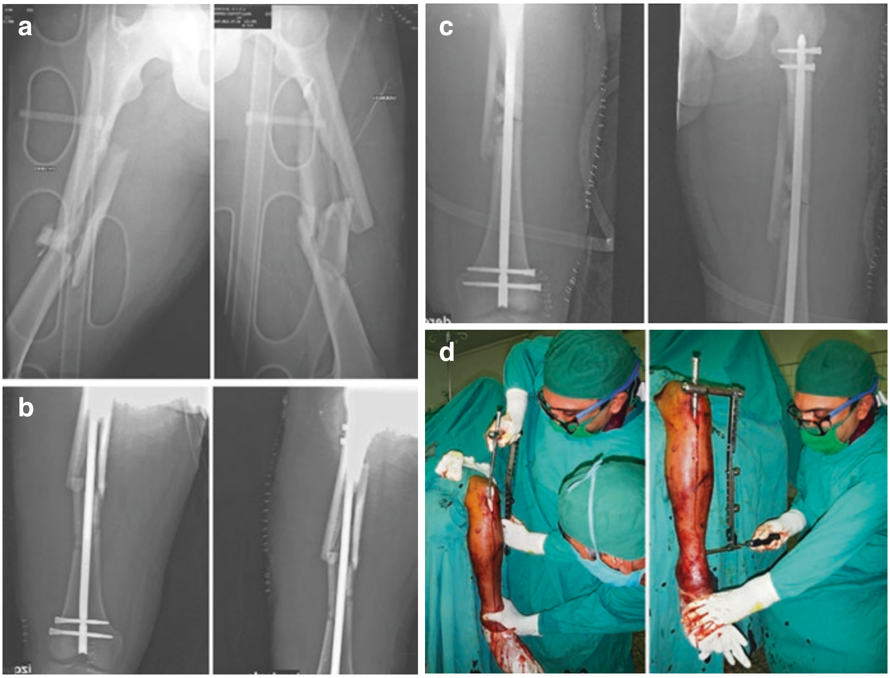


Fig. 16.8 Closed, comminuted femur fracture treated with a retrograde SIGN nail. (**a**, **b**) [3]. A tibial fracture treated by SIGN nailing (**c**, **d**) [4] (**a**, **b** Reprinted from Gosselin et al. [3], with permission of Springer. **c**, **d** Reprinted from Gosselin and Oloruntoba [4], with permission of Springer)

foot are inherently unstable and difficult to hold in plaster. Percutaneous fixation using a K-wire may be needed to hold the reduction. In cultures where shoe wear is optional or minimal, crushed, degloved, and mangled feet often present to the (ED). Thorough debridement with or without pin fixation while allowing the tissues to demarcate may allow useful salvage with only partial foot amputation and avoid higher amputations that would require a prosthesis.

Spinal Cord and Spine Injuries

Spinal cord injury is assessed clinically with a thorough motor and sensory exam including a rectal exam. Inspection and palpation of the back and neck can reveal pain, tenderness, bruising, or step-off to help direct the x-ray exam. Lateral C-spine films should adequately show C7-T1. Key determinants of potential function depend on the neurologic level of the cord injury and the stability of the spine. In resource-poor areas, treatment is usually nonoperative with prolonged bedrest, precautions to prevent pressure sores, and bowel and bladder training.

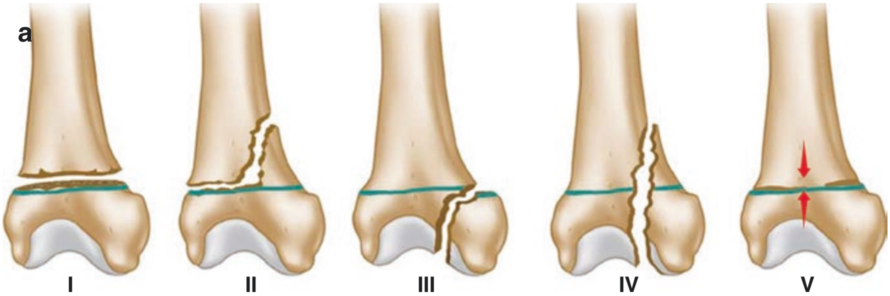


Fig. 16.9 The Salter-Harris classification of pediatric fractures. The Type I fractures go through the physis, while the Type II fractures extend through the physis and then exit out of the metaphysis, leaving a metaphyseal fragment called the "Thurston-Holland" fragment. Type III fractures extend through the physis and then into the joint, while Type IV fractures extend from the metaphysis through the physis and epiphysis, exiting into the joint. Type III and IV are especially at risk for growth disturbance, and joint incongruency can result in arthritis. The Type V fracture is due to compression and is not identified on initial plain radiographs but may present as growth disturbance later. (b) [5] (Reprinted from Spiegel and Banskota [5], with permission of Springer)

Pediatric Orthopedic Injuries

Children make up a disproportionately large population in most developing countries. The majority of extremity injuries can be treated nonoperatively with good outcomes, and as long as rotation and axial alignment are preserved, overriding of fracture fragments is acceptable in most pediatric fractures.

The Salter-Harris classification (Fig. 16.9) is both descriptive and prescriptive for fractures around the physis. Growth plate and metaphyseal fractures have a greater ability to remodel than diaphyseal fractures, especially if the deformity is in line with the adjacent joint's ROM and when significant growth remains. The areas with the greatest remodeling potential are, in descending order, distal femur, proximal tibia, proximal humerus, and distal radius. Remodeling occurs through both physeal growth and new bone formation on the concave or compression side of the bone and resorption on the convex or tension side. Fractures around the growth plates can be problematic, especially in the lower extremities where asymmetric growth can lead to deformity and/or leg length discrepancy. Intra-articular fractures with displacement and/or significant step-off can lead to early arthritis.

Pediatric supracondylar humerus fractures have a bad reputation due to their association with neurovascular injuries (up to 20 % of widely displaced fractures) and compartment syndrome with Volkmann's ischemic contracture (Fig. 16.10). They are the most common pediatric fracture about the elbow, are caused by a fall on the outstretched arm with impact at the hand/wrist (elbow extends and the olecranon causes the fracture), and are usually treated on an emergent basis with closed reduction and percutaneous pinning. Internally stabilizing the fracture allows the elbow to be held in less flexion and less fear of vascular compromise. A long arm splint is usually applied with the elbow in 60–70° of flexion after pinning, and this can be converted to a cast with the elbow at 90° flexion after the swelling has diminished, usually in 3–5 days. Without C-arm, pinning is difficult, and it is better to accept an "improved" closed reduction that maintains general alignment rather than a perfect reduction that might require excessive flexion and vascular compromise.

Patients presenting with a supracondylar fracture with no radial pulse, but whose hand and fingers are pink rarely need vascular exploration. The fracture should be reduced emergently and the vascular status reassessed. An exploration of the vessel is only required if perfusion is felt to be compromised, while close observation can be continued for the pink and well-perfused extremity. Pre- and postreduction neuro assessment is necessary. The anterior interosseous nerve, giving distal interphalangeal flexion to the index and interphalangeal flexion to the thumb, is most commonly involved and usually recovers without further treatment. Fractures that cannot be reduced or adequately held or are highly comminuted may be better treated with overhead olecranon traction. Children with supracondylar fractures often arrive late after treatment by local healers. Treatment depends on extent of deformity and time from the fracture. A moderate deformity with full ROM of the elbow is more acceptable than a well-reduced fracture but an immobile elbow joint. Malunited fractures can be referred for corrective osteotomy if they are symptomatic and/or cosmetically objectionable.

Pediatric femoral shaft fractures may result from low-energy injuries (twisting, falls) or high-energy injuries such as motor vehicle crashes. The fracture patterns reflect the mechanism (torsion, bending axial loading) and the amount of energy. Fractures with comminution or multiple pieces are due to higher energy injuries. The treatment of pediatric femoral shaft fractures depends on

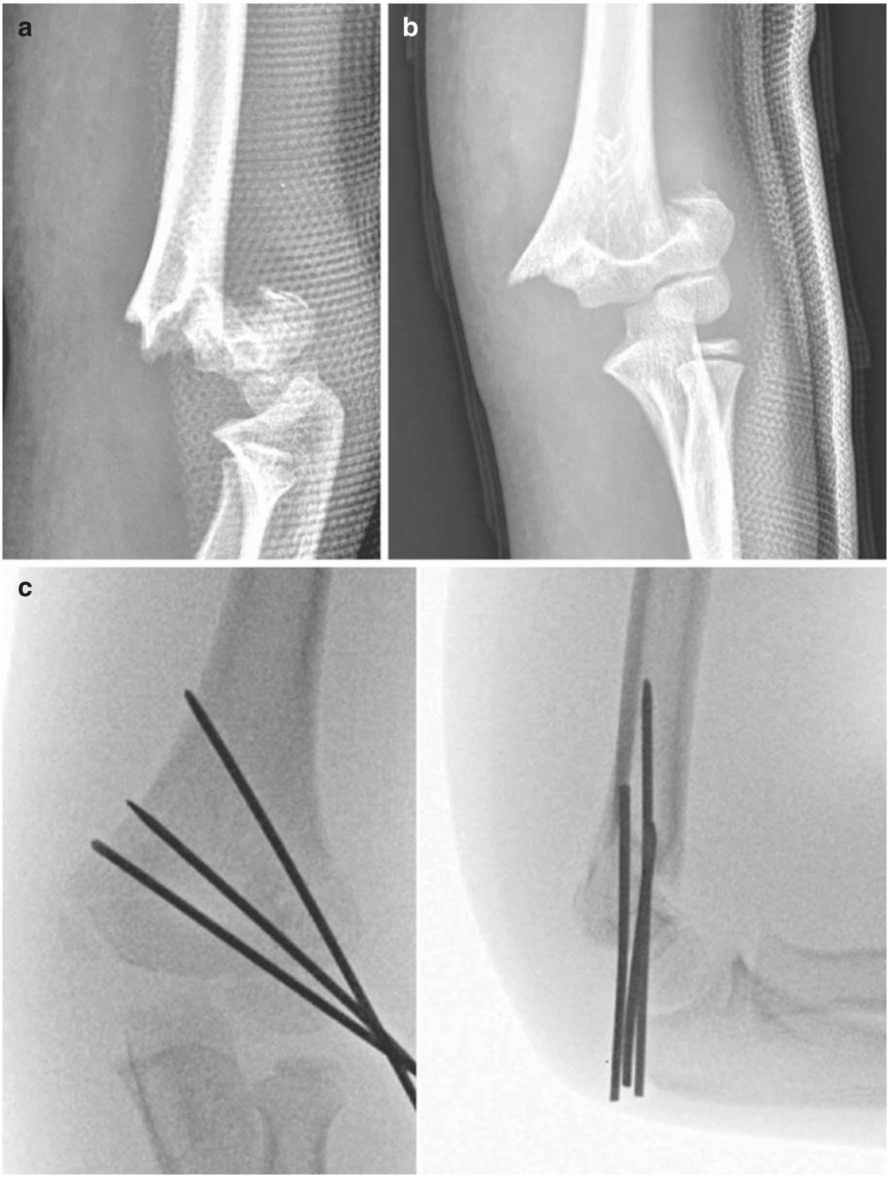


Fig. 16.10 Supracondylar humerus fracture. Supracondylar fractures may be treated by closed versus open reduction and percutaneous pinning (**a**–**c**) or by traction (**d**) [6] (Reprinted from Spiegel et al. [8], with permission of Springer)

Fig. 16.10 (continued)

the age of the patient and local preferences. Between 3 and 8 years, an average 9 mm overgrowth is common and up to 2 cm shortening is acceptable. For patients under 6 years, immediate spica casting or traction followed by spica are the most common treatments with various fixation methods reserved for selected circumstances. Length-stable fractures can be treated in an immediate single-leg or a double-leg spica cast with the foot and ankle free. Mid-shaft fractures are generally immobilized in 45° of flexion of the hip and knee, while proximal fractures may require a greater amount of hip flexion, up to 90°. Fractures that are length unstable (comminuted or with more than 2–3 cm shortening) require traction for 10–21 days prior to applying a spica. Unstable proximal fractures are treated in traction in 90° flexion at the hip and the knee. Older children can be treated as adults with care to preserve growth plates.

Amputations

In low- and middle income countries, amputation for tumors, trauma, infections, and chronic diseases is often the best or only option. Amputation surgery is a process—not a procedure—and needs to address the range of physical, psychological, social, and rehabilitation issues. In some cultures, obtaining consent for an amputation is extremely difficult. No matter the circumstances, a visiting surgeon should request a second opinion from a colleague before proceeding with amputation. Digital photos may also help families make the decision.

An upper extremity amputation should preserve as much distal function as possible, even if limited. The wounds should be healed, and the stump should be painless, sensate, and able to assist as a paddle or claw. Stump length is less of a concern than function, i.e., there is no advantage to preserve the carpal bones that have no muscle padding and add no function while making a cosmetic prosthesis ungainly long. A lower extremity amputation should ideally have a stump that is painless, well padded, and balanced. Disarticulations are end bearing while through-bone amputations bear weight through contact of muscles and various tendons and tuberosities. Before doing any amputation, the surgeon should be aware of the rehabilitation resources available. The prosthetic constraints of a knee disarticulation, for example, may dictate that a less efficient above-knee amputation be performed. Postoperative prevention of hip and knee flexion contractures by prone lying and knee extension exercises is an important step in preparing the patient for prosthetic fitting.

Infections

Musculoskeletal infections are a common cause of disability in economically underdeveloped regions. Early treatment is preferable, although this is unrealistic in most austere environments where patients present with established disease and/or sequelae of sepsis. Besides eradicating the infection, managing the complications of joint destruction, bone loss, pathological fracture, and deformities are long-term projects. Nutritional supplements are important adjuncts in managing all infections.

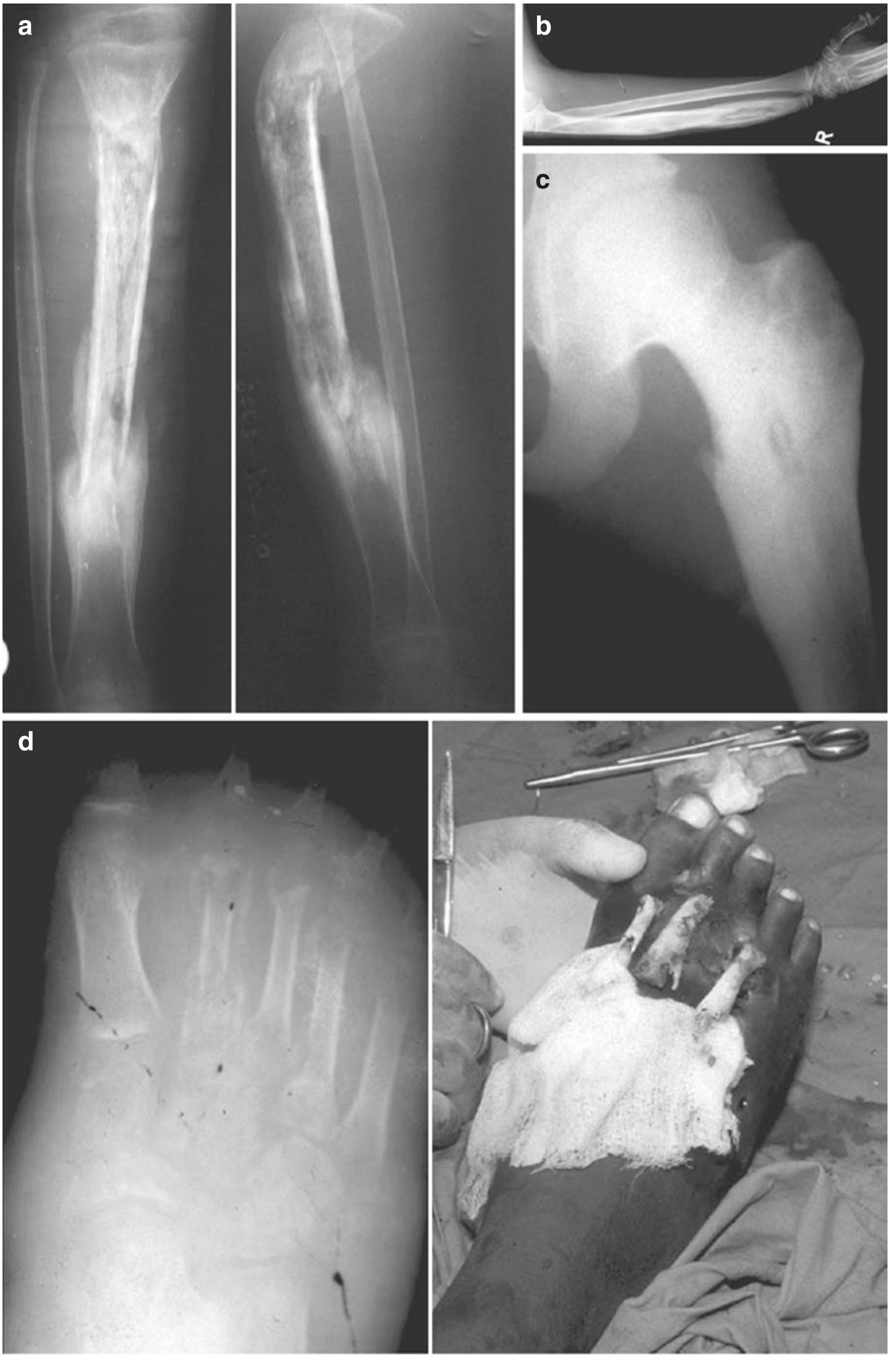
The etiology of most septic arthritis is hematogenous, extension of metaphyseal osteomyelitis, or following surgery. Patients present with joint pain (hip and knee are most common), especially pain with motion, limp, fever, and often a history of other infection. A high index of suspicion leading to prompt surgical drainage and antibiotics should give good results. Damage to the joint surface begins within 18–24 h, and irreversible changes can be present by 4 days, making early diagnosis crucial to prevent permanent damage. While smaller joints may be managed by repeated aspirations and antibiotics, open drainage for larger joints is recommended. Emergent drainage of hip sepsis in children is preferred as there is risk of femoral head avascular necrosis due to vascular tamponade from a tense effusion. Sequelae of septic arthritis are variable and depend on time of presentation thoroughness of treatment, nutritional status of patient, and the ability to prevent of complications.

Acute hematogenous osteomyelitis is commonly a disease of children and presents with localized pain, fever, malaise, and limp. The metaphyses, especially those around the knee, are usual sites of infection with local swelling, warmth, erythema, metaphyseal tenderness, and often a sympathetic effusion, making differentiation between bone and joint infection difficult. Early recognition of infection with surgical drainage and antibiotics gives better outcomes; however, the diagnosis may be masked as there is often a vague history of trauma, and x-rays rarely show bony changes until 10–14 days.

Subacute osteomyelitis involves infection of bone, usually the metaphysis, with an indolent organism in the face of strong host defenses. Patients present with intermittent bone pain, usually at night, and exacerbated by activity with few systemic signs or symptoms. Local discomfort to palpation and mild soft tissue swelling can be present for up to 2 weeks before presentation. The most common radiographic presentation is a Brodie's abscess, a well-circumscribed lytic lesion with a thin sclerotic rim. These lesions may cross the growth plate. Empiric antibiotics are appropriate when the classic radiographic and clinical features are present, but a biopsy should be considered when more aggressive features are present—bone destruction or subperiosteal new bone formation.

Chronic osteomyelitis evolves over months to years from acute osteomyelitis, when organisms become embedded within devitalized material and dead bone (sequestrum), against the body's attempt to resorb these devascularized tissues and retain stability through the formation of new bone (involucrum). Patients present with intermittent bone pain, local tenderness, often a draining sinus, and typical x-ray findings (Fig. 16.11a–d). Treatment is complex, requiring a correct diagnosis, debridement of all infected material, dead space management, and treatment of complications, e.g., pathologic fracture and deformity. Unless there are systemic symptoms, antibiotics are unnecessary; robust nutrition is mandatory for any success. Biopsy may be required as some cases of malignancy can be confused with chronic osteomyelitis, especially when a good history is unobtainable.

Tuberculosis (TB) is still highly prevalent around the world and now kills as many people every year as HIV-AIDS. It should always be in the differential diagnosis of presumed infections or tumors. Ten percent of TB cases involve the musculoskeletal system; 50 % of these involve the spine. TB bone and joint infections require a high index of suspicion as they are usually indolent and slowly progressive with nonspecific constitutional symptoms of low-grade fever, night sweats, weight loss, anorexia, anemia, and malaise. Chemotherapy is effective in 90 % of cases with surgery indicated to establish the diagnosis and treat complications. If a biopsy is not possible, and the clinical signs/symptoms are suggestive and the patient comes from an endemic area, empiric chemotherapy should be started.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Bone and Soft Tissue Tumors

Features suggestive of malignancy include nonmechanical pain, rapid growth, fever, malaise, and weight loss. Prognosis depends on the specific tumor, its grade, size, depth, patient age, medical comorbidities, nutritional status, and available resources for treatment. Patients often present late. In the face of limited imaging, laboratory, chemotherapy, or radiation, palliative amputation may be the only option. If an open biopsy is considered, make a longitudinal incision, cut directly to the lesion to avoid tumor contamination of surrounding tissues, insure adequate hemostasis, and place any drains in line with the skin incision. Specimens from the soft tissue component or extension from an osseous lesion are more likely to be diagnostic. Detailed clinical information must accompany the biopsy when sent to pathology.

Congenital and Developmental Conditions

Clubfoot, congenital talipes equinovarus, affects about 1/1,000 live births. It is most commonly idiopathic, but severe forms are seen in neuromuscular conditions such as myelomeningocele and in arthrogryposis and constriction band syndrome. Pathology is primarily found in the hind foot involving malalignment of the relationships between the calcaneus, talus, and navicular, with associated contractures of the posterior and medial tendons, ligaments, and joint capsules. The basic clinical findings are (1) midfoot cavus, (2) forefoot adductus, (3) hindfoot varus, and (4) hindfoot equinus (Fig. 16.12).

Worldwide treatment of clubfoot is primarily nonoperative using the minimally invasive Ponseti technique, which includes manipulation, serial casting, and usually a percutaneous tenotomy of the Achilles tendon to obtain correction, followed by night bracing for 4 years to maintain the correction. Regional clinics supported by government health services or NGOs are becoming common as the method is disseminated globally, and patients should be referred to these. Older children and adolescents may present with neglected clubfoot or recurrent deformity. They should be referred to specialist centers.

Developmental dysplasia of the hip (DDH) encompasses a spectrum of physical and imaging findings from mild hip instability to frank dislocation. Cultures in which children are swaddled have an increased incidence, while it is little known in Africa, where children are carried with their hips abducted. The instability may be

Fig. 16.11 Chronic osteomyelitis is a sequelae of acute hematogenous osteomyelitis, open fractures, or postoperative infections, in which there are organisms embedded within and around devitalized tissues, giving rise to recurrent episodes of clinical sepsis. An entire segment of a long bone may be sequestered in children (**a**, **b**) [7, 8]. The treatment involves debridement of all devitalized tissues and reconstruction of any bony and soft tissue defects (**c**, **d**) [9] (**a** Reprinted from D'Astous and Harrison [7], with permission of Springer. **b** Reprinted from Penny and Spiegel [8], with permission of Springer. **c**, **d** Reprinted from Harrison [9], with permission of Springer)

Fig. 16.12 Congenital talipes equinovarus (Clubfoot) [10] (Reprinted from Aroojis et al. [10], with permission of Springer)

masked until a limp is found when the child starts to walk. Early treatment by surgeons specialized in DDH treatment offers the best results, as the treatment is technically demanding, and outcomes following a failed reconstruction are worse than no treatment at all.

Angular deformities of the lower extremities can be physiologic (within expected range for age in a growing child), post-traumatic, associated with inflammatory diseases or systemic conditions (malnutrition, rickets), congenital conditions or limb deficiencies, and generalized bone disorders (osteogenesis imperfecta, skeletal dysplasias) (Fig. 16.13). Most will require referral to an orthopedic specialist. The first step is to determine whether the alignment is appropriate for age, and if not where the deformity originates (femur, tibia, foot). Correction is typically by osteotomy with or without fixation. Angular deformities are commonly due to nutritional deficiencies, generalized bone dysplasias, and/or metabolic diseases, and relapse is more likely in the presence of these generalized conditions. Adequate nutritional supplementation is required in most cases.

Fig. 16.13 Angular deformities [11] (Reprinted from Sabharwal and Schwend [11], with permission of Springer)

Neurologic Conditions and Postinjection Injuries

A variety of syndromes and neuromuscular diseases can be encountered with variable influence on the musculoskeletal system, and these are best referred to a center for a diagnosis and orthopedic management to improve function and/or ease of care.

Cerebral palsy is a nonprogressive disorder of movement and posture stemming from damage to the immature brain. The incidence worldwide is 1–2.5 per 1,000 live births. In developing countries the common associations are difficult deliveries at home, jaundice, encephalitis, and meningitis. Musculoskeletal manifestations often progress throughout growth and development in the setting of spasticity and chronic muscle imbalance. Realistic goals must be set for each patient, and treatment will depend on the degree of involvement and local facilities. Handicap International and the International Committee of the Red Cross (ICRC) have family centered rehabilitation programs that can help address some of the challenges in caring for these patients. In selected patients surgery to lengthen or transfer muscles or realignment osteotomies to restore anatomy and maximize function may play a role.

Postinjection paralysis often presents like polio with lower motor neuron signs of foot drop or equinovarus deformity of the foot. The typical history is of a febrile child receiving a quinine injection in the buttock or quadriceps for suspected malaria. Loss of sensation in the first dorsal web space differentiates this from polio, which is strictly a motor disease. Other sequelae of injection injuries include buttock abscess, gluteal fibrosis, and quadriceps fibrosis. Early presentation may respond to splinting and physio; referral to an orthopedic center is recommended. The surgical treatment of equinus contracture is heel cord lengthening, while equinovarus deformity requires heel cord lengthening and a tendon transfer. Gluteal fibrosis is treated by surgical release of the gluteus maximus.

Summary

The world's burden of musculoskeletal diseases is enormous and mostly due to traumatic injuries and infections. Degenerative conditions are emerging as populations age. A majority of the world's population lacks access to an orthopedic surgeon, and when available services are delivered by general surgeons, non-surgeon medical doctors, paraprofessionals, and traditional healers. This chapter briefly covers principles of management for a spectrum of pathology in a setting of limited resources, assuming that an orthopedic surgeon is not available.

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Suggested Reading

Global help (global-help.org) makes available free downloads of books, monographs, and materials which are appropriate for the surgeon working in an austere setting.

Global orthopedics—caring for musculoskeletal conditions and injuries in austere settings. Springer; 2014. Ed. Gosselin, Spiegel, and Foltz. Available as e-book. The text is aimed to give useful advice on orthopedic conditions and treatments for surgeons wanting to work or volunteer in developing countries.

HINARI (www.who.int/hinari/) through HINARI many hospitals and teaching institutions in LMIC have access to a wide selection of journals.

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17 Gynecology and Obstetrics

Morgan Mandigo and Reinou S. Groen

Introduction

All surgeons working in remote settings or hospitals with limited resources will encounter pregnant women, obstetric complications, and gynecologic emergencies. As a surgeon, the call might be split between you and the gynecologist, or there might not be a fully trained gynecologist available. A midwife may serve as the obstetric specialist; however, retained products or cesarean deliveries may require a surgeon. Furthermore, secondary to the limited availability of imaging, the cause of an acute abdomen may be unknown until the laparotomy is performed; therefore, surgeons might encounter ruptured ectopic pregnancies, torsed ovaries, or pelvic inflammatory disease with hydrosalpinx. This chapter provides an overview of gynecologic and obstetric procedures that general surgeons should learn in order to provide women and fetuses/neonates with lifesaving care.

Gynecology

Pelvic Abscess

Tubo-ovarian abscesses can result from untreated pelvic inflammatory disease and can generally be treated with broad-spectrum IV antibiotics. Use a second-generation cephalosporin or carbapenem, metronidazole or clindamycin, and

M. Mandigo, MD, MPH (✉)
Department of Gynecology and Obstetrics, Johns Hopkins Hospital,
600 North Wolfe Street, Phipps 279, Baltimore, MD 21287, USA
e-mail: mmandig1@jhmi.edu

R.S. Groen, MD, MIH, PhD
Alaska Native Medical Center, South Central Foundation,
4320 Diplomacy Drive, Anchorage, AK 99508, USA
e-mail: rsgroen@hotmail.com

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doxycycline for at least 10–14 days. Patients present with fever and pelvic pain and may have foul-smelling vaginal discharge. If fever doesn't resolve with antibiotic treatment, and the abscess is large, surgical drainage is necessary. Pelvic abscesses may also result from septic abortions, as well as following peritonitis, appendicitis, or untreated tuberculosis. Overall surgical management is limited in these cases and may include salpingectomy or hysterectomy. Anatomic planes may not be clear in the setting of pelvic abscesses, and the woman might lose an ovary or her uterus. Therefore, percutaneous or transvaginal drainage is preferred. A transvaginal approach is appropriate if the abscess can be palpated on rectovaginal exam. While visualizing the posterior fornix, a large-bore needle is placed into the abscess and aspirated. If pus is aspirated, a colpotomy should be made to allow for adequate drainage. An opening is made below the cervicovaginal junction with curved mayo scissors. The abscess can then be drained and loculations can be manually removed. A Malecot drain can be stitched in place to allow for continuous drainage. If the abscess cannot be accessed percutaneously or transvaginally, it may be necessary to perform a laparotomy for source control, with irrigation, salpingectomy, and/or hysterectomy as indicated [1].

Abnormal Uterine Bleeding

The differential diagnosis for abnormal uterine bleeding outside of pregnancy is vast, and for the most part, evaluation can be undertaken as an outpatient workup. Pregnancy should always be excluded prior to treating with the therapies mentioned below. Abnormal bleeding may be controlled with oral contraceptive pills (OCPs), high-dose progestins, or a Mirena intrauterine device (IUD). The associated pain is best treated with nonsteroidal anti-inflammatory drugs such as ibuprofen. Occasionally, hemorrhage can result, which poses an emergency. This can be due to hormonal imbalance, adenomyosis, large fibroids or polyps, cancer, coagulopathy, or infection [1, 2].

Resuscitation should proceed with intravenous (IV) fluids and blood transfusion. Twenty-five milligrams of IV estrogen can also be used every 4 h for 24 h to attempt to slow the bleeding. Oral estrogen may also be used at a dose of 2.5–5 mg PO every 6 h for 24 h [2]. Anti-emetics are indicated for nausea associated with high doses of estrogen treatment. A dilation and curettage, polypectomy, myomectomy (removal of fibroids), or hysterectomy may be needed to control intermittent or monthly bleeding (described below).

Polyps and Fibroids

Polyps are overgrowth of endometrium and can be removed by dilation and curettage (see "Care for Miscarriage" section) or with a polyp forceps (*i.e.,* stone forceps). Fibroids are disorganized fibrotic myometrium which can be calcified and can cause excessive bleeding due to the inability of the myometrium to contract adequately during menses.

On physical exam it is possible to visualize prolapsing fibroids or polyps. These can be surgically removed under spinal or general anesthesia, using a ring forceps or Allis clamp to grasp the fibroid while twisting until it is released. The twisting is essential as this controls the bleeding from the feeding vessel(s) of the polyp/fibroid.

Submucosal fibroids (fibroids just under the endometrium) require a hysteroscopic myomectomy when they are the source of abnormal uterine bleeding. If a hysteroscope is unavailable, an operative cystoscope can be used instead [1]. Normal saline and suction can be attached to the cystoscope and fibroids can be grasped with forceps inserted into the operative sheath. Caution should be undertaken to maintain uterine pressure below the mean arterial pressure to minimize fluid uptake into the vasculature. Excess fluid uptake (more than 1 liter) can result in hyponatremia and fluid overload leading to pulmonary or cerebral edema [2].

Abdominal Myomectomy

Large fibroids may also be intramural or subserosal. These fibroids usually cause more bulk symptoms than bleeding symptoms, and their mass effect can cause infertility. Abdominal myomectomy can be considered; however, these procedures are elective and frequently require blood transfusions. Therefore, these surgeries should not be performed in a hospital with limited blood supply or by surgeons without experience in this procedure.

A Pfannenstiel incision (see "Cesarean Section" section) is appropriate for a uterus which is enlarged up to ~14 week gestational age size; thereafter, a midline vertical incision should be considered. To minimize blood loss, the woman should receive 400–600 mcg of cytotec rectally. 20 IU of vasopressin should be diluted in 100 ml of normal saline for injection in the uterus over the incision site. Lastly a uterine tourniquet can be used by creating a window in the broad ligament and then stretching a JP drain tube or Foley catheter tightly around the lower uterine segment to tourniquet the uterine vessels [1, 2]. A large mayo clamp can also be used for this purpose. A midline vertical uterine incision is generally preferable to maximize the number of myomas that can be resected with a single incision. Furthermore, incision of the anterior uterus is preferable to minimize adhesion formation. The fibroid can be grasped with a tenaculum and dissected from the myometrium. Ligate any vessels noted to feed the fibroid prior to its excision. If the endometrium is entered, it should be closed with 4–0 or 5–0 delayed-absorbable suture in running fashion. The myometrium is then closed in layers with 0 or 2–0 gauge suture. A running baseball suture with 4–0 or 5–0 delayed-absorbable suture is used for the serosal closure. After a myomectomy, women should avoid labor and instead deliver via cesarean section [1, 2].

Hysterectomy

The Essentials

- *Indications for a hysterectomy include gestational trophoblastic neoplasm, postpartum hemorrhage, abnormal uterine bleeding due to fibroids or adenomyosis, and endometrial cancer* [1, 2].

Indications for a hysterectomy include gestational trophoblastic neoplasm, postpartum hemorrhage, abnormal uterine bleeding due to fibroids or adenomyosis, and endometrial cancer [1, 2]. Hysterectomies can be done vaginally, laparoscopically, and open abdominally. Vaginal surgery is preferred by experienced gynecological surgeons as recovery is faster and fewer resources are needed; however, this is not recommended without appropriate gynecological training. Abdominally, the surgeon has the choice to perform a total or supracervical hysterectomy; however, given the burden of cervical cancer in limited-resource settings, a total hysterectomy is more appropriate in most situations. However, a hysterectomy performed for postpartum hemorrhage might benefit from a supracervical approach as this is quicker and less risky for the ureters. If the ovaries are taken with the hysterectomy, this will lead to surgical menopause and is not advisable before the woman reaches menopause herself, or age 52 (the average age of menopause). Preparations for a hysterectomy include pre-operative antibiotics (second-generation cephalosporin or clindamycin and gentamycin), Foley catheter insertion, and sterile prep of the abdomen and the vagina.

Entry to the pelvis is easily obtained via a Pfannenstiel incision (see "Cesarean Section" section). A similar incision slightly higher that transects the rectus muscle is called a Maylard and will give more access to the pelvis in the setting of a very broad uterus. A midline vertical incision is needed if the fundus of the uterus is higher than the above-mentioned incisions would be placed and gives optimal access to the pelvis as well as the first half of the upper abdomen. A self-retaining retractor should be placed and the bowel packed cranially. The first step of the hysterectomy is the transection of the round ligament (Fig. 17.1a). Use Kelly clamps to secure the fallopian tube and utero-ovarian ligament at the uterus. Place two transfixing sutures in the round ligament using 0 gauge delayed-absorbable suture. Clamp hemostats to these sutures and cut the round ligament in between, also including 1 cm of the broad ligament inferiorly. Repeat on the other side.

The broad ligament can then be opened by grasping with atraumatic forceps, applying tension, and sharply incising anteriorly toward the vesicouterine fold (Fig. 17.1b). Connect the two incisions in the vesicouterine fold. Identify the ureters bilaterally in the medial fold of the broad ligament. Once the ureters are identified, create a window in the posterior broad ligament and widen this with blunt dissection.

When ovaries are to remain, and when quick action is needed, place two clamps medial to where the tube and utero-ovarian ligament will be transected with the tips in the opening of the broad ligament that was previously created. These structures

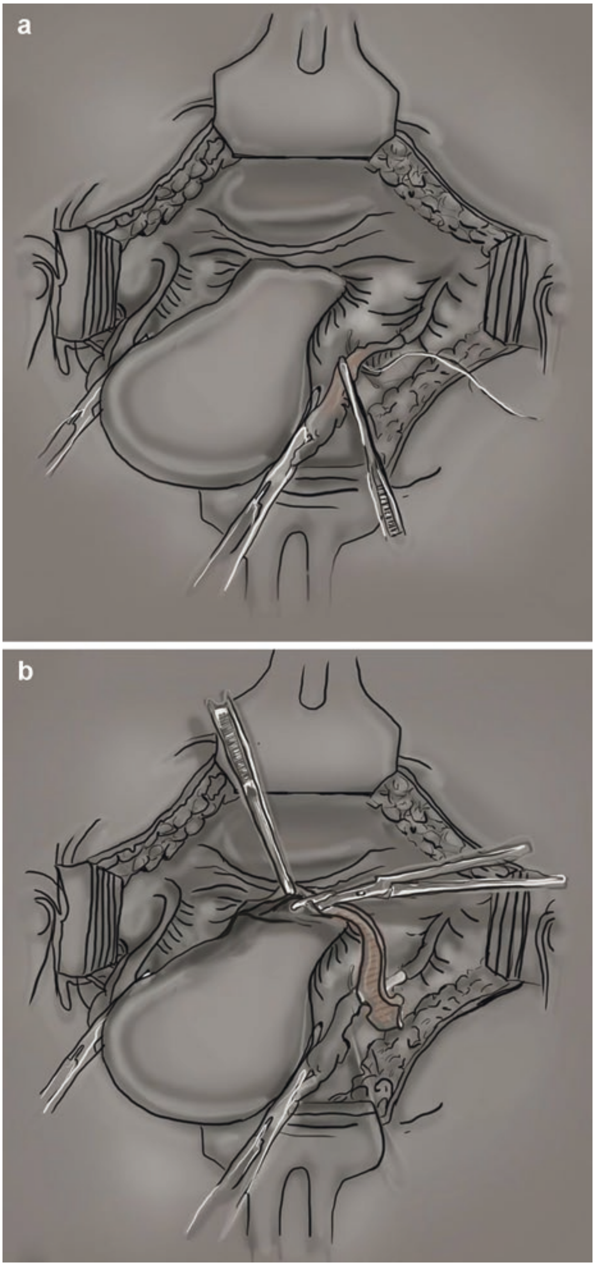

Fig. 17.1 Hysterectomy initial steps. (**a**) Transect the round ligament. (**b**) Open the broad ligament

(containing the broad ligament, tube and utero-ovarian ligament) can then be cut between the Kelly clamp placed earlier and the two additional clamps. A 0-gauge delayed-absorbable suture is free-tied around the lateral clamp and the clamp then removed. A transfixing suture is then placed around the remaining lateral clamp, and the clamp removed as it is cinched. The Kelly clamp at the junction with the uterus should remain since backflow from the uterus will lead to severe bleeding. If there is more time, an alternative method would include removal of the tube. Stepwise, clamp and tie the mesosalpinx just below the ovary, moving toward the previously created opening in the broad ligament.

If the ovaries are to be removed, the two clamps are placed on the infundibulopelvic (IP) ligament that contains the ovarian vein and artery. The IP is lateral to the ovary and the tube. One clamp is placed on the IP ligament near the ovary (the most medial clamp), and two others are placed adjacent to one another laterally, while taking care that the ureter is not included. As above, the IP ligament is cut between the medial clamp and the two lateral clamps. The two lateral clamps are removed as a free tie, and transfixing sutures are serially placed at the most lateral clamps.

Separate the bladder from the lower uterine segment and cervix by bluntly dissecting the connective tissue while applying upward tension on the uterus using the Kelly clamps. Stay in the midline with this dissection as the plane between the bladder and the uterus is avascular; however, the uterine arteries and their branches lie on the sides of the uterus and can bleed heavily. If scar tissue is encountered, sharp dissection may be required. The uterine arteries intersect the uterus where the cervix ends and the uterine body begins (internal os). They are encased in connective tissue that should be dissected off carefully. A Heaney clamp (or two) is placed across the vessels inferior to the transection site, while the uterus is pulled out of the abdomen to prevent clamping the ureters. While placing the clamp, stay 45° to the internal os and slide off the uterus to ensure that the full artery and vein are included. A straight clamp is placed medially to prevent back bleeding from the uterus. The vessels are transected and the uterine arteries are tied with a stitch under the Heaney clamp with the insertion of the stitch at the very tip of the clamp to prevent puncturing the vessels and causing major bleeding. The superior clamp should be left in place. After repeating this on the other side, the medial clamps can be removed since the vasculature to the uterus (uterine vessels and IP or utero-ovarian ligaments bilaterally) should be secured. When performing a supracervical hysterectomy, the uterus can now be amputated from the cervix, and the bleeding from the cervical stump can be controlled with electrocauterization or with figures of eight with absorbable suture.

When performing a total abdominal hysterectomy, the cervix will be removed. The uterine artery has branches along the cervix bilaterally, which much be transected in stepwise fashion. Keep traction on the uterus to increase the distance between it and the ureter. Make sure the bladder is well-dissected off the cervix and place a straight clamp close to the cervix. Next, cut with a knife very close to the cervix, or even slightly into the cervical tissue, and follow with a transfixing stitch. Do this as many times as needed along the cervix; each step provides approximately 1 cm of progress. Place each clamp medial to the prior placed stitches. The last step

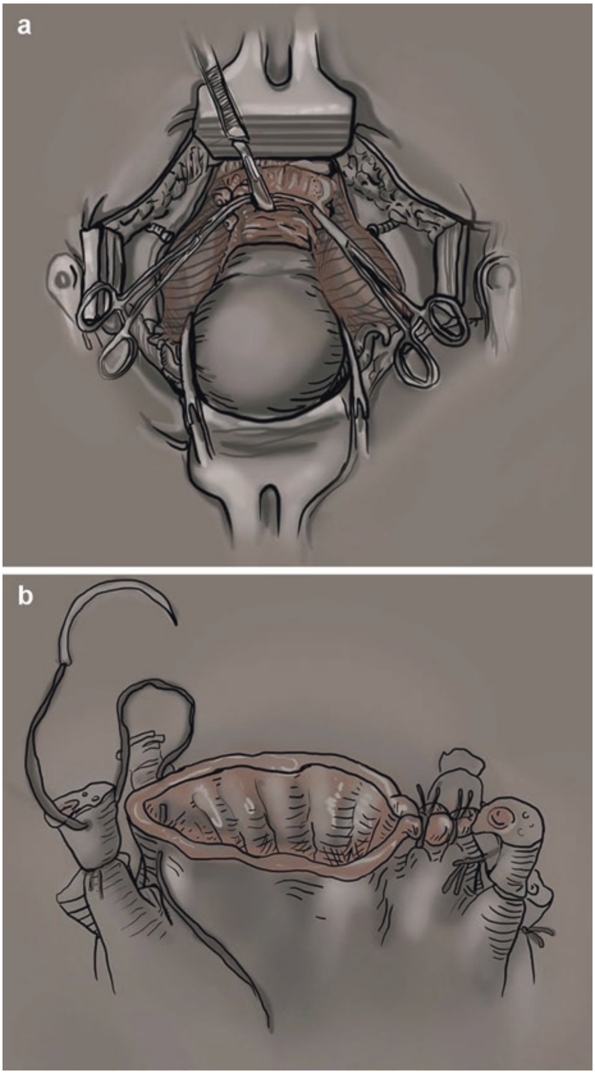

Fig. 17.2 Hysterectomy final steps. (**a**) Create the colpotomy. (**b**) Close the vaginal cuff

includes the cardinal and uterosacral ligaments, which are best visualized with good traction on the uterus and by exposing the posterior uterus and cervix. They are also clamped, divided, and transfixed.

Heaney clamps are then placed under the cervix. The vaginal tissue is incised (or cut with Jorgenson scissors) superior to the clamps, and transfixing sutures are placed at the clamps prior to their removal (Fig. 17.2a). Keep these stitches long and clamp with hemostats, as traction on these sutures will assist in closure of the vaginal cuff. The uterus and cervix have now been removed and the remainder of the vaginal cuff should be closed with 0-gauge delayed-absorbable sutures with figures of eight for good hemostasis (Fig. 17.2b). Include the posterior peritoneum for hemostasis [2].

Adnexal Surgery

Adnexal surgery refers to surgery performed on the ovaries or tubes. This can be done via laparoscopy; however, for large ovarian masses, exploratory laparotomy may be required. Indications include ovarian torsion, ovarian masses, or pelvic pain related to endometriosis/endometriomas. [1]. Ovarian torsion constitutes an emergency and should be on the differential diagnosis whenever a woman presents with acute onset of pelvic pain. She may have a palpable pelvic mass, peritoneal signs, or nausea and vomiting. The pain can be intermittent or constant.

If a torsed ovary is found early enough, it may be possible to save the ovary by untwisting and restoring blood flow. Consider an oophoropexy of the ovary by shortening the utero-ovarian ligament, suturing the ovary to the pelvic sidewall, or suturing the utero-ovarian ligament to the uterosacral ligament in order to prevent future episodes of torsion [1].

If an oophorectomy is required, it is crucial that the ureter is identified and not included in the transection of the IP ligament. The ureter can be identified through the peritoneum coursing over the bifurcation of the iliac vessels, below the ovarian fossa, and crossing about 2 cm under the uterine arteries. The fallopian tube is held on traction to the midline, while the mesosalpinx is clamped and transected toward the uterus until the utero-ovarian ligament can be transected (Fig. 17.3). At this point the ovary can be placed on traction, and the IP ligament can be skeletonized from the broad ligament. The ureter can be identified at this point before clamping the IP ligament.

When performing an ovarian cystectomy, the ovary is incised around the cyst capsule with a knife or Bovie, taking care not to incise the cyst itself. Allis clamps are placed along the edges of the capsule and the cyst is separated from the ovary with blunt dissection. If necessary, sharp dissection may be employed. Use the Allis clamps to apply traction as needed. Bleeding can be coagulated with a Bovie. The ovary can be closed with 4–0 delayed-absorbable suture in a purse-string fashion. The incision is then closed with a running (sub)cortical stitch [2].

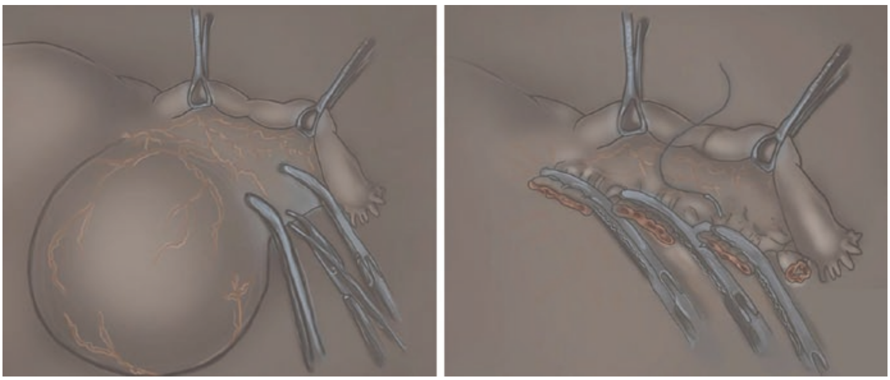

Fig. 17.3 Oophorectomy. Clamp, transect, and ligate the mesosalpinx

Tubal Ligation

A bilateral tubal ligation can be performed postpartum after a cesarean section or with a small infra-umbilical incision after a vaginal delivery. It can also be performed laparoscopically, or via mini-laparotomy. If the procedure is performed outside of pregnancy, a uterine manipulator is advisable to push the uterus to the anterior abdominal wall. A 3–4 cm Pfannenstiel incision (see "Cesarean Section" section) is sufficient for a tubal ligation in a patient with a BMI of less than 25. Once the peritoneum has been entered, the fundus should first be identified and then the insertion of the fallopian tube should be located, posterior to the insertion of the round ligament.

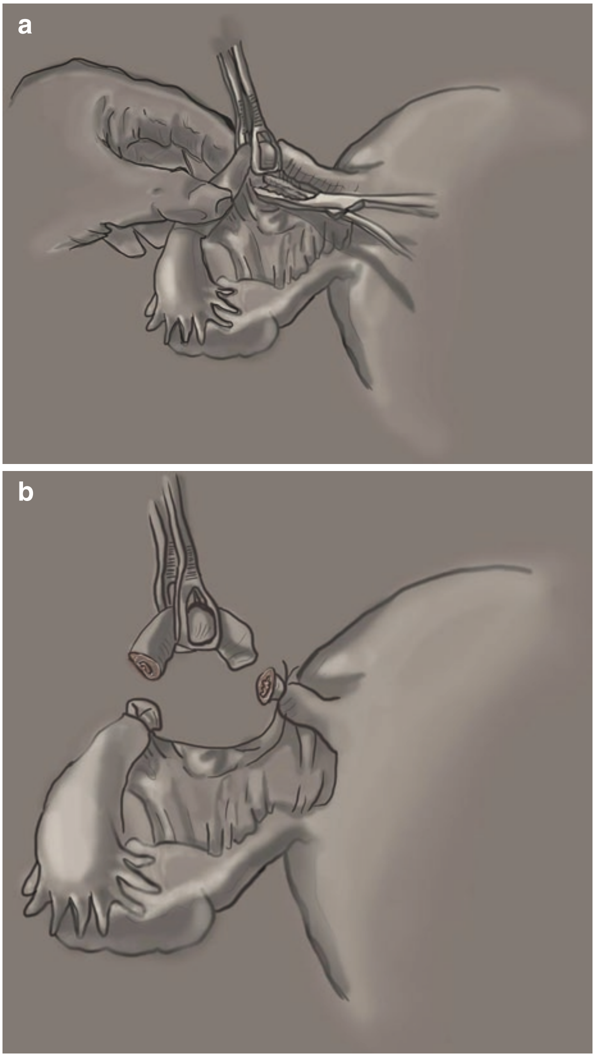

Fig. 17.4 Bilateral tubal ligation. (**a**) Isolate the tube and create a window in an avascular area of the mesosalpinx. (**b**) Ligate the tube and excise a segment in between the sutures

Two Babcocks can be placed around the tube to elevate it into view and serially reclamp it laterally in order to bring the fimbriae into view (Fig. 17.4). An avascular space of the mesosalpinx should be identified near the middle of the tube and dissected so as to create a 2 cm window underneath the segment to be excised. A Babcock is then replaced on the tube and 2–0 chromic or plain catgut suture is passed through the window to ligate the tube twice laterally, then twice medial to the Babcock. Use Metzenbaum scissors to cut the tube between the sutures, obtaining at least a 2 cm segment of excised tube (Fig. 17.4b). The pedicles should be at least 0.5 cm on each side, and they should be inspected to ensure hemostasis. This is repeated on the other side. Depending on the size of the incision, the fascia may require closure with 0 PDS or other delayed-absorbable suture. If the subcutaneous layer is greater than 2 cm, this layer should also be closed [2].

While not technically within the realm of gynecology and obstetrics, a discussion of contraception options would be incomplete without addressing vasectomy. The complication rate of female sterilization is 20-fold higher than that for vasectomies [2]. Additionally, the cost of performing a tubal ligation is five times higher than performing a vasectomy [2]. Therefore, for women in permanent relationships seeking permanent contraception, a discussion with their partners about a vasectomy is desirable.

Gynecological surgeons will also perform surgeries for urinary incontinence including pelvic organ prolapse, fistulas, and malignant diseases from the reproductive tract. These procedures should be performed by appropriately trained gynecological surgeons in order to avoid significant complications, or in case of fistulas, lost opportunities to solve the problem. Fistulas, particularly when identified early in the postpartum or postoperative period, are often best treated with prolonged catheter use and heal by secondary intention.

Pregnancy Determination and Dating

Pregnancy determination and dating is extremely important in order to diagnose pregnancy loss, ectopic pregnancy, preterm contractions, or if a woman is post-dates and at risk for a stillbirth. The possibility of pregnancy should always be considered in a woman of reproductive age. The first day of the last menstrual period (LMP) is used to calculate the current gestational age; however, exact dates might not be known. "It was five moons ago" might be a common answer. Determination that a patient is pregnant can be done with urine beta HCG testing if available. When the pregnancy is over 20 weeks, the woman feels quickening (fetal movement). A physical exam should confirm the intrauterine pregnancy – with a bimanual exam, the uterus will feel globular and enlarged beginning at 6 weeks. If greater than 12 weeks, the uterus can be palpated above the symphysis, and by 20 weeks, the uterus can be palpated at the umbilicus. Thereafter, the gestational age corresponds with the fundal height (±2 weeks), as measured from the symphysis to the fundus.

When ultrasound is available, dating is easier to confirm. Crown-rump length can be used for dating of pregnancies up to 14 weeks. Measure the maximum length from the cranium to the caudal end. If this measurement is greater than 8.4 cm, the gestational age is likely greater than 14 weeks [3]. Other measurements should be performed, including the biparietal diameter, head circumference, abdominal circumference, and femur length. The biparietal diameter is measured from the superior outer edge to the inner edge of the skull, across the thalami. The cerebellum and facial structures should not be visible. The head circumference can be measured in the same view. The abdominal circumference is measured when the spine, fetal stomach, and junction of the umbilical and portal veins are in view. Lastly, the femur length is measured from each end of the shaft, not including the distal femoral epiphysis [3].

First or Second Trimester Bleeding

Differential diagnosis of bleeding in the first or second trimester of pregnancy includes miscarriage, ectopic pregnancy, molar pregnancy, and bleeding due to implantation or subchorionic hemorrhage. Non-obstetrical reasons like cervicitis or cervical cancer are also seen.

Care for Miscarriages

Miscarriages are classified as (1) threatened, (2) missed, (3) incomplete, and (4) complete. Threatened, missed, and complete miscarriage all present with bleeding and the cervical os is closed. The differences are otherwise determined by ultrasound findings. Sonography of a threatened miscarriage will show a viable embryo with a heartbeat, a missed will show an empty sac or an embryo without a heartbeat, and a complete will not show any products of conception with an endometrial strip of less than ~1 cm. Observation for these situations is often warranted if the distinction cannot be made. An incomplete miscarriage, or miscarriage with ongoing bleeding, needs intervention to save the woman from severe anemia, sepsis, or death.

Medical management may be carried out for pregnancies up to 9 weeks if the women is stable, the bleeding is limited, and she is able to stay in the hospital or come back in a timely fashion. After 9 weeks, medical management is less effective. Misoprostol 400 mcg may be administered sublingually or 600 mcg may be given PO for an incomplete miscarriage. If the cervical os is closed, a higher dose might be required: 800 mcg vaginally or 600 mcg sublingually. These dosages may be repeated twice, 3 hours apart, if needed [4]. If medical management is not effective, surgical management should be performed.

It is important to treat pain associated with the miscarriage, as well as anemia and any underlying identifiable cause. Malaria, sickle cell disease and sexually transmitted infections may contribute to a miscarriage and should be treated appropriately. If the woman is suspected to have had an unsupervised abortion, tetanus immunoglobulins should be administered if available [1]. Rhesus (Rh)-negative women should receive Rhogam.

Dilation and manual vacuum aspiration (MVA) is the safest way to evacuate an incomplete or missed miscarriage. Dilation and curettage (D&C) may also be used if MVA is unavailable. Thirty minutes prior to the procedure, a dose of doxycycline or a second-generation cephalosporin will decrease the risk of infection [1]. The procedure can be performed under local anesthesia as described below if the patient is able to tolerate gynecological exams. If the patient is too anxious or the miscarriage is very traumatic for her, sedation is advised. The gestational age should be measured by ultrasound, if available. The size of the cannula chosen for the MVA should correspond to the number of weeks of gestation. If the cervix is closed, it can be dilated with dilators, increasing size cannulas, or misoprostol. Misoprostol should ideally be given 3 h prior to the procedure, but sufficient dilation may be achieved in 90 min. The misoprostol dosage is 400 mcg sublingual or 600 mcg PO for gestational ages up to 14 weeks [1]. The patient should be placed in dorsal lithotomy position. This procedure should be carried out using sterile technique. Anything that will be placed in the uterus should not touch the vaginal walls. A full vaginal prep could also be considered if the surgeon is less familiar with performing a MVA. A sterile speculum is inserted into the vagina and locked in place with the cervix in view. Gauze sponges should be soaked in betadine, or other available (non-alcoholic) antiseptics. The cervix should be cleansed by applying these sponges to the area using ring forceps. One percent lidocaine should be drawn into a syringe attached to a spinal needle. Two milliliters should be injected at the anterior lip of the cervix at the 12 o'clock position, where a tenaculum will be placed in order to apply countertraction. Cervical vessels penetrate the cervix at the 3 and 9 o'clock positions. Therefore, a paracervical block should avoid these areas, aiming instead for 4 and 8 o'clock, at the cervical-vaginal junction (Fig. 17.5). Insert the needle approximately 1.5 cm, aspirate, and then inject approximately 5 ml of

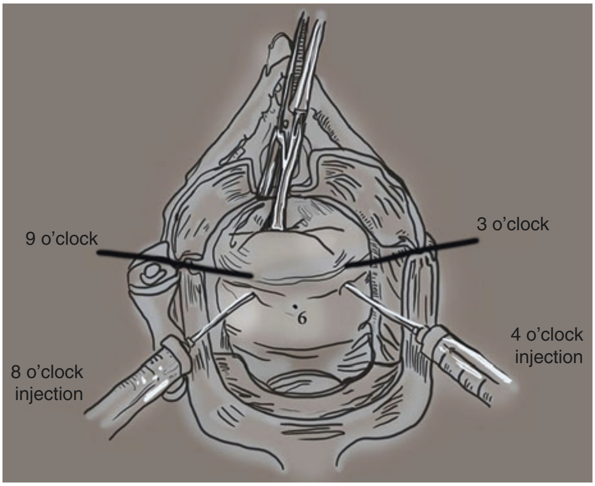

Fig. 17.5 Paracervical block. Inject local anesthetic at the cervicovaginal junction, at the 4:00 and 8:00 positions

lidocaine in each position as the needle is withdrawn. Once the paracervical block has been performed, the evacuation can begin. Dilate the cervix carefully, bracing your hands on the perineum. Excessive force may perforate the uterus so caution should be taken only to pass the dilator through the internal os. Pratt and Hank dilators are measured in French, with the number corresponding to three times the cannula size. Hegar dilators are measured in millimeters, so the size should correspond with the cannula size. If the correct sized cannula can be inserted into the uterus, you may proceed with the MVA. Ultrasound guidance, if available, can assist with the location of the products, but generally, the procedure is done under feel of the operator.

To operate the MVA, place the desired cannula at the end of the aspirator. Carefully insert the cannula while not on vacuum, into the external os and advance to the fundus with caution, so as not to create a false passage or perforate the uterus. Create the vacuum by drawing back the self-locking syringe (Fig. 17.6). Rotate the cannula while slowly withdrawing from the uterus, but do not rotate within the cervical canal. Once the cannula has been removed, undo the vacuum, disconnect the cannula from the syringe, and empty the contents. Reconnect and repeat until all the tissue is removed and only blood is retrieved. At this point, there should be a gritty texture to the uterus when the cannula is scraped against the uterine lining and the uterus should feel to be contracting around the cannula. If an ultrasound is available, it can be used to confirm the presence of an endometrial stripe less than 1 cm and empty uterine cavity. The tenaculum can be removed and the tenaculum sites inspected for signs of bleeding. Bleeding can be controlled by applying direct pressure with gauze or ring forceps, or silver nitrate sticks, if available. The speculum can then be removed once hemostasis is ensured.

If MVA is not available, a dilation and curettage may be performed (Fig. 17.7). Dilation should proceed as described above, generally up to size 25 Pratt dilator in order to accommodate the curette. The curette should be placed gently with the hand braced against the perineum to prevent perforation in the event that the patient moves. The curette is carefully advanced to the fundus and then pressure is applied to the endometrial surface as it is pulled back toward the cervix. It is then carefully advanced again and the process is repeated, rotating the curette to contact each surface of the uterine cavity. The curette is then removed from the uterus and the

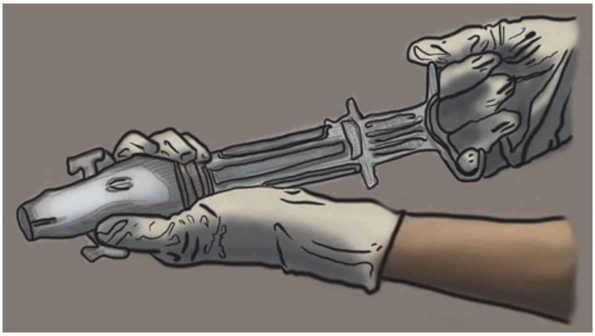

Fig. 17.6 Manual Vacuum Aspirator (MVA). Depress the buttons and pull back the syringe to its locked position to prepare the suction device, then press the buttons again to activate suction

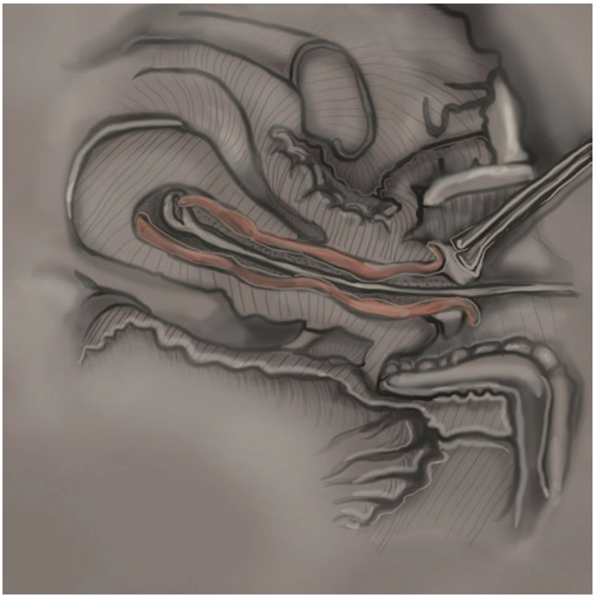

Fig. 17.7 Dilation and curettage. With a tenaculum on the anterior lip of the cervix for stabilization, gently insert the curette to the fundus and pull back to the cervix while applying pressure to the endometrial surface

extracted tissue is saved for examination. Once curetting is finished, the endometrium should have a gritty texture as described above. The tenaculum and speculum are removed, as described above, ensuring hemostasis.

The products of conception should then be evaluated to ensure that the aspiration was adequate. They should be washed gently with saline or water and strained with a strainer or piece of mesh. If placed in a glass container with water or saline, the fetal tissue will appear white and fluffy with an elastic-like film coating it. For visualization, place a light source underneath the glass container. For evacuations after 12 weeks, all fetal parts (e.g., four limbs, thorax, and calvarium) should be identified to ensure none were retained. A dose of doxycycline should also be given at the end of the procedure [1].

It is important to remain vigilant for signs of sepsis, either from long-standing retained fetal tissue (before or after treatment) or a previous unsafe abortion. Septic abortions are responsible for 20% of maternal mortality worldwide [1]. Patients may present with severe anemia, pain and fever, foul discharge or frank pus in the vagina, and signs of hemorrhagic or septic shock. Resuscitation should ensue with IV fluid, blood transfusion (if indicated and available), and broad-spectrum antibiotics. The antibiotic regimen should include a second-generation cephalosporin or carbapenem, metronidazole or clindamycin, and doxycycline, which should be continued for at least 10–14 days. Alternatively, Augmentin 1 g IV every 8 h and gentamycin 5 mg/kg IM daily may be used [1]. Uterine evacuation must be performed with caution, as the infection will soften the myometrium, resulting in a higher risk for perforation. Use ultrasound guidance and MVA, if possible. If the infection was a result of a prior D&C or MVA, the woman may require a laparotomy to evaluate for uterine perforation and associated bowel injury. Hysterectomy may also be necessary in this case (see "Hysterectomy" section).

Ectopic Pregnancy

Women who have an ectopic pregnancy classically present with abdominal pain (often with guarding and rebound tenderness) and vaginal bleeding. Some may have a palpable adnexal mass. History of a syncopal event is also common. In severe cases, women may present with hemodynamic instability or shock. This is unfortunately common in limited-resource settings as women often present after rupture, sometimes unaware of the pregnancy [1]. An acute abdomen with a positive pregnancy test is a ruptured ectopic until proven otherwise.

In hemodynamically stable women, diagnostic testing can be pursued. Transvaginal ultrasound is most sensitive to diagnose the location of the pregnancy and will reveal an empty uterus, possibly with an adnexal mass. Visualizing an adnexal mass or free fluid in the pelvis is strongly suggestive of an ectopic pregnancy. Transabdominal ultrasound on thin patients may give similar results; however, they are sometimes more difficult to interpret. If ultrasound is not available, culdocentesis can be performed by inserting a needle through the posterior fornix of the vagina, into the Pouch of Douglas. The aspiration of bloody fluid is highly suggestive of an ectopic pregnancy [1].

For women who are stable and have equivocal diagnostic results, and if reliable quantitative serum beta HCG and ultrasound are available and follow-up care is feasible, they repeat diagnostic testing in 2 days. Depending on the availability of transportation and proximity to the hospital, the patient can be sent home with strict instructions on when to return [1]. When, after 48 h, the beta HCG is neither doubled, nor rapidly declining fast (as would be the case in a complete miscarriage), ectopic pregnancy is the diagnosis. If methotrexate is available, this should be offered by a gynecologist experienced with the indications and follow-up.

Women who are hemodynamically unstable need emergent resuscitation with large-bore IVs and fluid boluses and possibly a blood transfusion. The surgeon should proceed with an exploratory laparotomy (or laparoscopy if available) and perform a salpingectomy if an ectopic pregnancy is found.

In order to perform a salpingectomy, the laparotomy may be performed via a Pfannenstiel incision (see "Cesarean Section" section); however, if the differential diagnosis includes surgical causes of the hematoperitoneum including a ruptured spleen or liver, a midline vertical incision is advised. Once peritoneal access has been achieved, the hematoperitoneum can be suctioned and the tube can be identified and secured with a Babcock. A Kelly clamp is placed at the border of the tube with the mesosalpinx, beginning with the fimbriated end of the tube. A second Kelly is clamped onto the mesosalpinx closer to the ovary and the mesosalpinx is then transected with scissors (Fig. 17.8). The pedicle is ligated with 2–0 or 3–0 delayed-absorbable suture and the clamp removed. The clamp closest to the tube may remain. This process is repeated until the uterus is reached. At this point, the Kelly clamp should be directed across the fallopian tube, and the tube will be cut between the two clamps where it inserts at the uterus. This pedicle is also ligated with 2–0 or 3–0 delayed-absorbable suture and the tube is removed. The pelvis should then be irrigated prior to closure [2].

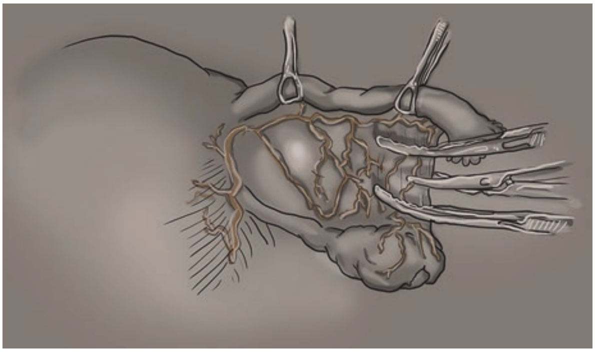

Fig. 17.8 Salpingectomy. Clamp, transect, and ligate the mesosalpinx

A salpingostomy will save the tube but increases the risk of another ectopic pregnancy and therefore should only be used in limited circumstances. When the tube is not ruptured, the patient has no other functional tube, and the woman will have access to emergency surgery in the future, salpingostomy may be considered. The patient should be counseled regarding her future risk of another ectopic pregnancy. A salpingostomy is made by a 1–2 cm incision into the section of distended tube containing the ectopic pregnancy. The pregnancy can then be dissected from the wall of the tube using high-pressure irrigation or blunt dissection and then removed with forceps. Bleeding can be cauterized and the tube can be left to heal by secondary intention. As above, the pelvis should be irrigated prior to closure to minimize the risk of retained trophoblastic tissue [2].

Rhogam should be administered to women who are Rhesus (Rh) negative, and beta HCG levels should be followed, if possible, to ensure a decrease to undetectable levels. Trophoblastic tissue may persist in the pelvis and may necessitate an additional surgery if identified. If beta HCG levels can be followed, women should be provided contraception so as to prevent a new pregnancy that would obfuscate the monitoring.

Molar Pregnancy

Molar pregnancy and gestational trophoblastic disease (GTD) are abnormally formed pregnancies which need to be treated by removing the products of conceptions and, in some cases, chemotherapy. The typical molar pregnancy is a fast-growing pregnancy, with a very soft uterus and a "snowstorm" appearance on ultrasound. Bleeding can be a presenting symptom, and sometimes the vesicles can be seen in the vaginal discharge. Since beta HCG levels are abnormally high in molar pregnancies, patients can present with hyperemesis. Patients may also be hemodynamically unstable. Treatment is suction of the products out of the uterus. Curettage is discouraged since there is a high chance of perforation (see above).

Intravenous oxytocin should be given at the time of suction to stimulate uterine contraction and minimize the risk of hemorrhage [5]. If the woman is Rh negative, Rhogam should be given. In the event of hemorrhage, a hysterectomy may be required (see “Hysterectomy” section). There are two types of molar pregnancies: (1) complete (no fetal parts are visible) or (2) incomplete (fetal parts or sometimes a fetus is visible). In both cases, the pregnancy needs to be evacuated. The diagnosis of complete vs incomplete molar pregnancy is made on pathological evaluation of the products of conception. Women with complete molar pregnancies are at risk for developing gestational trophoblastic neoplasia, which is a molar pregnancy with the potential to metastasize. Therefore, these women should be referred to gynecologists who can follow them closely after surgery to ensure that beta HCG levels fall to undetectable levels, otherwise chemotherapy is indicated. Contraception should be provided so a developing pregnancy will not affect the beta HCG surveillance.

Obstetric Emergencies

The Essentials

- *More than 75% of maternal deaths in low- and middle-income countries (LMICs) are caused by postpartum hemorrhage, infection, preeclampsia and eclampsia, delivery complications, and unsafe abortion.*

Third Trimester Bleeding

Bleeding in the third trimester is an obstetrical emergency until the status of the mother and fetus is stable and the quantity of the bleeding is determined negligible. Differential diagnosis for bleeding in the third trimester includes preterm labor. However, bleeding could also occur when the placenta is implanted on or near to the cervix (placenta previa), the placenta is separating before delivery of the fetus (placental abruption) or in the event of a ruptured uterus. A placenta that is abnormally attached in the endometrium (placenta accreta) or myometrium (placenta increta/percreta) can also cause third trimester bleeding, but this will be discussed in the “Postpartum Hemorrhage” section).

Placenta Previa

Placenta previa often presents as painless vaginal bleeding in the third trimester. Suspicion of placenta previa should arise when the fetus is palpated high in the uterus, the fetus is malpresenting (e.g., breech or transverse), the woman had a prior cesarean section, or there is a twin gestation. Before performing a digital vaginal exam on any patient, a placenta previa should always be excluded because catastrophic bleeding may occur. A placenta previa can be diagnosed with an ultrasound or with a speculum examination if there is cervical dilation. The delivery should be performed via a cesarean section, preferably around 36 weeks; however, if there is significant bleeding, an earlier delivery may be necessary. If possible, the patient should receive steroids for fetal lung maturation (see "Preterm Labor" section below).

Placental Abruption

Placental abruption is generally diagnosed clinically by the following common symptoms: sudden onset of severe, continuous abdominal pain, a hardened uterus with no apparent contractions, sudden appearance of vaginal bleeding, shock out of proportion to bleeding, and fetal bradycardia or demise [6]. Placental abruption is more frequently seen in women who have preterm rupture of membranes, hypertension, preeclampsia, cocaine abuse, or abdominal trauma.

After stabilization of the woman, the next step depends on the fetal heart tones. If there has been a fetal demise, one could proceed with an induction of labor and subsequent vaginal delivery as long as the maternal status remains stable. If there are fetal heart tones or the mother is unstable, an emergent cesarean section is indicated.

Uterine Rupture

Uterine rupture is also a clinical diagnosis. During labor, impending rupture presents with maternal agitation, severe persistent abdominal pain, and an hourglass-shaped uterus. Signs of rupture are pain, shock, cessation of contractions, fetal bradycardia or asystole, and palpable fetal parts just under the skin. Risk factors for uterine rupture include prolonged labor, grand multiparity, fetal malpresentation, excessive oxytocin or misoprostol use, and prior uterine surgery [6].

Treatment should include resuscitation with IV fluids and blood products (if available). Insert a Foley catheter into the bladder and proceed with an emergency midline laparotomy and cesarean section if the fetus is undelivered. Hysterectomy may be necessary if hemorrhage cannot be controlled. The tear is usually anterior and inferior, placing the bladder at risk of injury [6]. If hysterectomy is not performed, bilateral tubal ligation should be considered to prevent future pregnancies, as these women will be at high risk for subsequent rupture.

Preterm Labor

Preterm labor is defined as the onset of contractions and cervical change prior to 37 weeks gestation. Common causes are infections of the urinary and reproductive tracts and malaria [6]. If an infection is identified, it should be treated. Preterm labor may be difficult to assess in the setting of limited prenatal care and imaging, but can be approximated by measuring fundal height (see "Pregnancy Determination and Dating" section). If there are no comorbidities and the fundal height measures less than 34 weeks, it may be appropriate to prolong pregnancy for 48 h in order to administer betamethasone (two doses of 12 mg IM 24 h apart) or dexamethasone (four doses of 6 mg IM 12 h apart) to promote fetal lung maturity [6]. Tocolysis with salbutamol, nifedipine, or magnesium sulfate can be given to prolong pregnancy in order to administer steroids. Nitroglycerin can be used if these are not available, and indomethacin can be used prior to 32 weeks (Table 17.1). However, if the mother has any pregnancy-related or medical comorbidities, imminent delivery may be more appropriate if continued pregnancy will jeopardize her health (e.g., infection, preeclampsia, placental abruption).

Rupture of Membranes

Preterm rupture of membranes (PROM) is defined as rupture of membranes prior to contractions. If this occurs prior to 37 weeks of gestation, it is called premature preterm rupture of membranes (PPROM). Following rupture of membranes, the fetus and mother are at risk for infection, so cervical exams must be minimized to reduce this risk. The infection of membranes is termed chorioamnionitis, and this can result in both neonatal sepsis and maternal endometritis. Chorioamnionitis, which can also occur during labor, is defined as at least two of the following symptoms: maternal fever (>38.0 Celsius), maternal tachycardia, fetal tachycardia, and fundal tenderness. Treatment is broad-spectrum antibiotics (amoxicillin with gentamycin or clindamycin). Additionally, PPROM patients are at risk for preterm labor and placental abruption.

In the event of PROM, the woman should begin labor within 24 h to reduce the risk of infection. If contractions do not occur spontaneously, labor should be induced with oxytocin. Women with PPROM who have achieved at least 34 weeks gestation are generally recommended to deliver, as the risks of prematurity are outweighed by the risks of infection. However, if neonatal care is unavailable, the clinician should use his/her best judgment. In the event of PPROM before 34 weeks of gestational age, a 7-day course of amoxicillin and a single 1 gram dose of azithromycin has been found to help prolong pregnancy, but delivery should be pursued if there are signs of infection or placental abruption. Tocolytics should not be given if there is evidence of preterm labor [5].

Hypertensive Disorders

Pregnancy can be complicated by chronic hypertension or pregnancy-induced hypertension, which both are risk factors for preeclampsia, eclampsia, and HELLP (hemolysis, elevated liver enzymes, and low platelets) syndrome. Chronic hypertension in pregnancy and pregnancy-induced hypertension need close follow-up and treatment for blood pressures >160/110 or if proteinuria (>300 mg/24 h) develops. New-onset proteinuria can establish the diagnosis of preeclampsia. This disease is

Table 17.1 Tocolytic agents for preterm labor

Tocolytic agent	Dosing	Contraindication	Maternal side effects	Fetal side effects
Terbutaline (beta-mimetic)	0.25 mg SQ q20 min	Cardiac arrhythmias	Arrhythmias, pulmonary edema, myocardial ischemia, hypotension, tachycardia	Tachycardia, hyperinsulinemia, myocardial and septal hypertrophy, myocardial ischemia
Magnesium sulfate	4-6 g bolus in 20 min, then 2 g/h	Myasthenia gravis	Flushing, headache, muscle weakness, pulmonary edema	Lethargy, hypotonia, respiratory depression, demineralization with prolonged use
Indomethacin (Prostaglandin synthetase inhibitor)	50–100 mg PO followed by 25–50 mg every 6 h	Significant hepatic or renal disease, pregnancy >32 weeks gestation	Nausea, vomiting	Constriction of the ductus arteriosus, pulmonary hypertension, reversible decrease in renal function with oligohydramnios, intraventricular hemorrhage, hyperbilirubinemia, necrotizing enterocolitis
Nifedipine (calcium channel blocker)	20 mg loading dose, then 10 mg every 4–6 h	Cardiac disease, maternal hypotension, concomitant use of magnesium sulfate	Flushing, headache, dizziness, nausea, transient hypotension	None

characterized by generalized edema and damage to the liver, lungs, and cerebrum, resulting in the common symptoms of severe headache, scotomata, right upper quadrant or epigastric pain, and persistent edema. Preeclampsia is also associated with pulmonary edema, oliguria, and hyperreflexia.

The Essentials

- *Symptoms of preeclampsia: headache, scotomata, right upper quadrant pain, epigastric pain, nausea or vomiting*
- *Physical exam: elevated blood pressures; facial, bilateral leg, or hand edema; pulmonary edema; diminished urine output; hyperreflexia*
- *Laboratory findings: proteinuria (3+ on dipstick), elevated creatinine, transaminitis, hemolysis, thrombocytopenia*

When the patient is term (>37 weeks of gestation), labor should be induced since delivery will resolve preeclampsia. If the patient is less than 37 weeks, she should receive steroids (see "Preterm Labor" section) for fetal lung maturation prior to induction. However, if the symptoms described above are persistent, blood pressures are persistently >160/110, or she has significant laboratory evidence of kidney failure, liver failure, or hemolysis, then she should be delivered to avoid maternal complications regardless of the gestational age [7]. High blood pressures should be treated with PO or IV labetalol, nifedipine, or hydralazine [5]. An induction of labor could be attempted; however, if maternal status worsens, a delivery via cesarean section might be indicated. Magnesium sulfate should be administered to prevent seizures throughout labor and the first 24 h postpartum. Start with a bolus of 4–6 g given over 10–20 min followed by 2 g/h. If a drip is unavailable, you may use 5 g of IM magnesium in each buttock followed by 5 g IM every 4 h in alternating buttocks. One gram of calcium gluconate IV is the antidote to magnesium toxicity and should be readily available for each patient who is given magnesium therapy.

Seizures in the setting of pregnancy are diagnostic for eclampsia until proven otherwise. Treatment is prompt administration of magnesium as described above, to continue until 24 h postpartum. If this does not stop the seizure, the bolus can be repeated or administer lorazepam 0.1 mg/kg IV. If this also fails, phenytoin 1,000–1,500 mg should be given. Monitor vitals, reflexes, and urine output. Delivery within 24 h of the seizure is warranted, and if the patient can be induced in that timeframe, vaginal delivery is preferable [5]. Of note, the differential diagnosis for seizures in pregnancy also includes epilepsy or generalized seizure disorder, cerebral malaria, and meningitis [6].

Cord Prolapse

Cord prolapse is an obstetric emergency for the fetus. It is suspected when membranes are ruptured and suddenly no fetal heart tones are heard, or when a cord-like structure is felt on cervical exam. Immediately place the patient in Trendelenburg or knee-chest position with her chest low and sacrum high [6]. Push the presenting part cranially to keep pressure off the cord in order to maintain blood flow through the cord. If pulsations are felt in the cord after the presenting part is pushed up, a cesarean section is indicated. The person who is pushing the presenting part up should stay in that position until the fetus is delivered via cesarean section. If no pulsations can be felt in the cord and no fetal heart tones can be heard, a fetal demise has occurred, and you should proceed with vaginal delivery [6].

Intrauterine Fetal Death

When an intrauterine fetal death (IUFD) is diagnosed, the woman should be delivered. A vaginal delivery should be prioritized, and induction of labor is generally successful with misoprostol followed by oxytocin. In general, IUFDs can be delivered vaginally without the need for operative intervention; however, sometimes a vacuum-assisted delivery is indicated. Forceps should not be attempted on IUFDs since there is a high likelihood of true cephalopelvic disproportion (CPD), which would place the mother at more risk for extensive tears and associated bleeding. After delivery of an IUFD, the uterine cavity should be manually explored to make sure that there is no occult uterine rupture or retained products.

Situations of fetal death which require operative management include women who are fully dilated and the fetus is not coming with prolonged pushing (>3 h) or breech presentation and head entrapment [6]. The latter occurs specifically with hydrocephalus. These situations should not occur in the hospital, but are sometimes encountered by women who tried to deliver at home. Medically, a fetal craniotomy is preferred to avoid the maternal morbidity and mortality associated with the alternative of a cesarean section in the second stage of labor [6]. However, this should not be attempted without involvement of local hospital staff. Confirm fetal death with several key members of the hospital staff and discuss potential cultural or legal objections of a craniotomy with the staff and the woman.

A craniotomy should be performed in the operating room, as profound bleeding or septic shock may ensue. General anesthesia is preferred; however, light sedation with spinal anesthesia or pudendal block are reasonable alternatives (Fig. 17.9). The patient should be placed in dorsal lithotomy position, prepped and draped in a sterile fashion, and broad-spectrum antibiotics should be given. If the patient cannot be catheterized to drain the bladder, a suprapubic puncture is required [6].

A craniotomy is performed by perforating a fontanel and allowing brain matter and CSF to flow out. The cranial bones can then be grasped with Kocher clamps circumferentially and pulled. Caution should be taken to avoid injury to oneself, as well as to the vaginal walls. If the fetus is partially delivered in breech position (often seen with hydrocephalus), it should be rotated such that the spine is facing up. Identify and penetrate the foramen magnum and allow fluids and tissues to flow out. Transverse presentations have an increased risk of uterine rupture during craniotomy and should therefore be avoided. A manual inspection of the uterus is required to ensure no uterine rupture has occurred and all products have been removed.

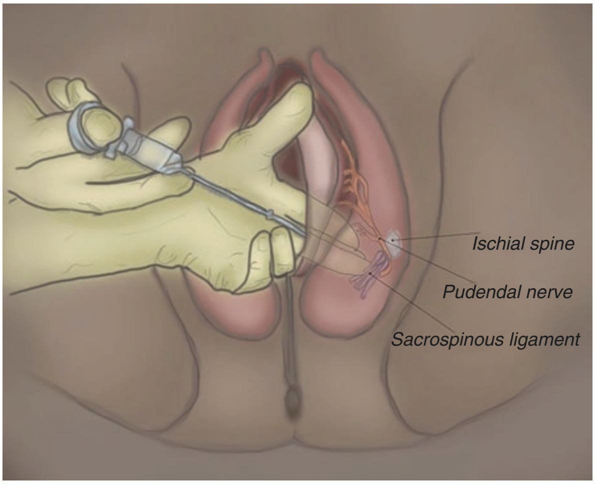

Fig. 17.9 Pudendal block. Locate the ischial spine and advance needle until the resistance of the sacrospinous ligament is felt. Inject local anesthetic at this location prior to advancing through the ligament, just until the point when resistance is no longer felt, and inject anesthetic at this location as well. Take caution to aspirate so as not to inject intravascularly

Lacerations should be repaired as described below (see "Laceration Repair" section). A Foley catheter should be placed for at least 3 days to prevent fistula formation in the case of prolonged obstructed labor, and a methylene blue test can be performed if damage to the urinary system is suspected [6].

Delivery of a Neonate

Normal Vaginal Delivery

If available, prepare for delivery by wearing eye protection, boots, and a gown. Clean hands with antiseptic or soap and water, and put on sterile gloves. If possible, place a sterile drape underneath the woman's buttocks and have a sterile towel available for delivering the fetus. Prepare the instruments, which should include four clamps, bandage scissors, suture scissors, needle driver, either 2–0 or 3–0 vicryl or polysorb suture, 4–0 vicryl or polysorb suture, ring forceps, and tissue forceps.

To deliver the fetus, place two fingers on the head to maintain flexion and control the speed of delivery. Use the other hand to place pressure on the perineum to help mitigate tears. As the head delivers, allow extension and restitution (external rotation of the head) to occur naturally before palpating around the neonate's neck for the presence of a cord. If there is cord around the neck (nuchal cord), first attempt to reduce it: gently pull it away from the neck, over the head, and in front of the baby. If the cord can only be loosened, this should enable you to deliver by pushing the cord over the shoulders as the fetus is delivered. In the case of a very tight nuchal cord, it should be clamped and divided.

Following external rotation of the head, hands should be placed laterally on each side of the head and gentle downward traction applied until the anterior shoulder delivers. Once this has occurred, the head and trunk can be pulled upward to facilitate delivery of the posterior shoulder. Support the head with one hand and use the other to contain the neonate's arms and legs so as to minimize trauma to the birth canal and perineum. If the neonate has good muscle tone, color, and is breathing, s/he can be given directly to the mother. The umbilical cord should be doubly clamped and divided.

Give the mother 10 IU oxytocin intramuscular or per IV-drip to allow the uterus to contract well after the delivery. Misoprostol can be given buccally or rectally (600 mcg) if oxytocin is unavailable [6]. The uterus can be stimulated to contract by rubbing the uterus abdominally. To deliver the placenta, clamp the cord close to the perineum and apply gentle downward traction while placing a hand just above the pubic symphysis to provide resistance against inversion of the uterus. Maintain constant pressure and reclamp close to the perineum as lengthening occurs. When the placenta is visible at the introitus, use both hands to twist the placenta to allow the membranes to deliver intact. Apply fundal massage to aid with contraction. If the fundus is not firm, bimanual massage can be performed by placing one hand in the vagina and massaging the uterus between the abdominal and vaginal hands (Fig. 17.10). Inspect the cervix, vagina, and perineum for lacerations and repair as necessary to provide tissue reapproximation and hemostasis (see "Laceration Repair" section). After the uterus has contracted, the placenta should be inspected to ensure that the maternal side of the placenta has no missing parts that may lead to a delayed postpartum hemorrhage.

Breech Delivery

Local midwifes are often experts at vaginal breech deliveries and extractions. The difference between a vaginal breech delivery and a breech extraction is that a breech delivery occurs with as little touching as possible, while an extraction requires that the feet of the fetus are grabbed and pulled down. Extractions are often used to

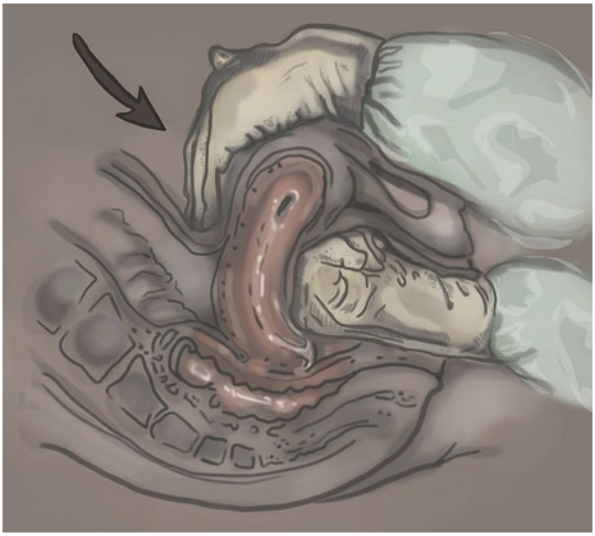

Fig. 17.10 Bimanual massage. Place an abdominal hand at the fundus and one hand vaginally. Aggressively massage the uterus between the two hands to improve uterine tone

quickly deliver a second twin in breech presentation. The surgeon might be involved in breech deliveries when done via cesarean section, which requires the same maneuvers through the hysterotomy. Indications for cesarean section versus vaginal breech delivery attempt depend on the patient's parity, pelvis shape, and fetal size, as well as the progress of labor – judgment that is not easily acquired by reading a textbook. In both situations, gentle traction can be applied at the hips or the shoulders, but never around the abdomen or chest. Three other essential keys to elegant delivery of the fetus are the following: (1) keep the sacrum anterior; (2) when the scapula are seen, swipe the arms anteriorly and downward by sliding your fingers along the scapula, shoulder, and humerus to pull only when the elbow is reached; and (3) to deliver the head, apply suprapubic pressure (or, for a cesarean section, pressure above the hysterotomy), rather than traction on the fetal body (Fig. 17.11) [5].

Shoulder Dystocia

During a vaginal delivery, if the body does not easily follow delivery of the head, impaction of the shoulder behind the symphysis or sacral promontorium has likely

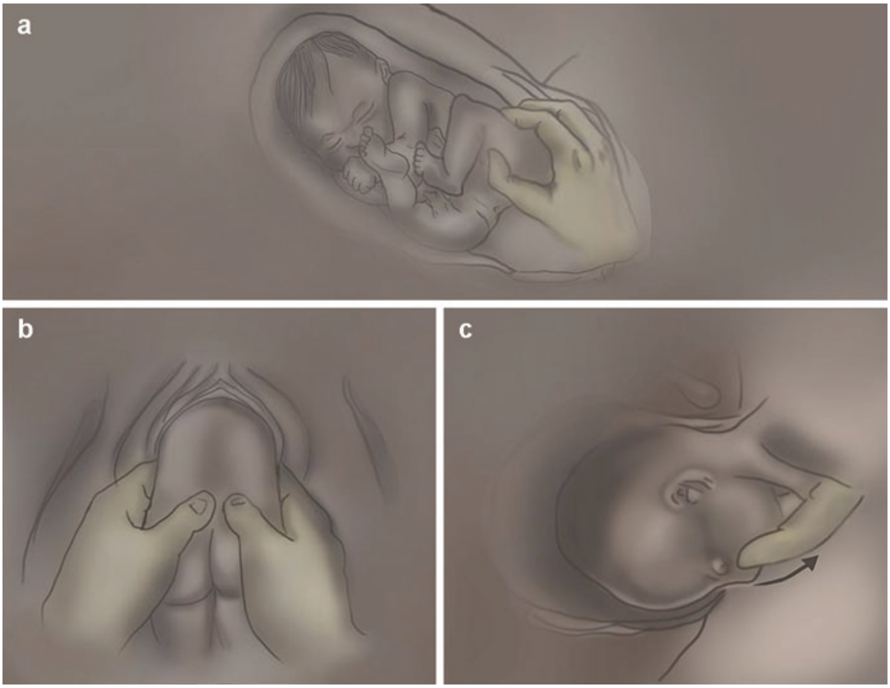

Fig. 17.11 Breech delivery. (**a**) Grasp fetal thigh and apply pressure to popliteal surface to flex knee and deliver leg. (**b**) Place thumbs on the sacrum and fingers along the iliac crest and apply gentle downward traction until scapulae can be seen. (**c**) Place index and middle finger on the maxilla to flex the head and avoid hyperextension injury

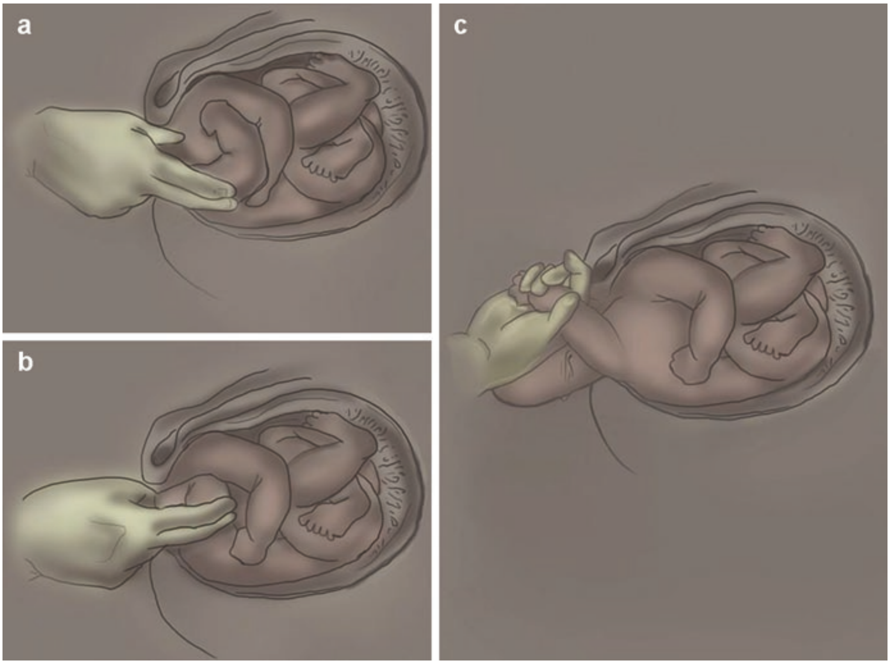

Fig. 17.12 Shoulder dystocia maneuvers: delivering the posterior arm. (**a**) Identify the posterior arm with two fingers. (**b**) Flex the elbow and apply pressure toward midline. (**c**) Deliver posterior arm through vagina

occurred. A dystocia should be anticipated if there is retraction of the head after crowning has occurred. Ensure that the mother's bladder is empty. Let her stop pushing and first, attempt the McRoberts position by flexing the mother's thighs in a cephalad direction. Apply suprapubic pressure directly above the pubic symphysis, onto the posterior aspect of the anterior shoulder to rotate it beneath the pubic bone. If this does not work, any of the following techniques may be used at the provider's discretion [5]: (1) Deliver the posterior arm: Insert two fingers along the posterior arm to locate the elbow. Flex the elbow and sweep the forearm across the chest to bring the arm through the vagina. (2) Rubin: Grasp either shoulder posteriorly and rotate it toward the chest. (3) Woods corkscrew: Grasp the posterior shoulder anteriorly and rotate it 180° so it becomes the anterior shoulder. (4) Gaskins: While the patient is on her hands and knees, apply gentle downward pressure to deliver the posterior shoulder. (5) If none of the above work, the same things can be done again, as they may be effective upon second attempt. (6) Clavicle fracture: Pull the clavicle of the anterior shoulder outward from the chest. Although this method sounds horrible, unintended clavicular fractures during birth are common and no further management is indicated, even when the fracture is displaced (Fig. 17.12). (7) A last resort is the Zavanelli: The fetal head is pushed back into the pelvis following the cardinal movements in reverse order so that the fetus can be delivered via cesarean section. The reversed cardinal movements include (1) external rotation back to occiput anterior (OA), (2) flexion (bring the chin of the baby to the sternum), and (3) internal rotation to replace the occiput in line with the fetal back.

Vaginal Delivery of Multiples

A multiple gestation should be suspected when the uterus is abnormally large, when multiple heads are felt on palpation, or when multiple fetal heartbeats are heard by doppler. The diagnosis can be confirmed with ultrasound.

Place an IV when the woman presents in labor. If the first twin is in breech presentation, deliver by cesarean delivery. After delivering the first twin, ensure that a clamp remains on the placental side of the umbilical cord and do not try to deliver the placenta as this will compromise the second twin. If the second twin descends with the head first, delivery can continue as previously described for a normal vaginal delivery. Oxytocin infusion can be titrated up if contractions have not resumed 15 min after the first delivery. If the second twin is transverse or breech, then a breech extraction can be performed by grasping both feet of the fetus and delivering the neonate with the maneuvers described above (see "Breech Delivery" section) [5].

Operative Delivery

The term "operative delivery" indicates assistance of the delivery with a vacuum or forceps. Indications for operative delivery include prolonged second stage of labor (pushing more than 2 h), fetal distress, and difficulty with extraction during cesarean section [8]. Contraindications to an operative delivery generally include malpresentation (transverse, face, chin posterior, or brow presentation), head not engaged (head station higher than −2 cm from the ischial spines), cervix not fully dilated, and prematurity. (Expert providers may use forceps to deliver a premature neonate [5].) The key to operative deliveries is the knowledge of the position of the fetal head (occiput anterior or posterior and not more than 45% angled to transverse) and an estimation of whether this fetus will be able to fit through the pelvis or not.

Before use of a vacuum, ensure the mother's bladder is empty. The technique is similar with a reusable metal vacuum or a disposable handheld Kiwi ® vacuum. Apply the suction cup to the fetal scalp, with the center of the cup placed 3 cm from the posterior fontanelle. Ensure that no vaginal or cervical tissue is under the cup. Pump to a pressure of 0.2 kg/cm^2 (the pressure will be indicated on the device), check again for entrapped maternal tissue, then resume pumping to reach a maximal pressure of 0.8 kg/cm^2. Traction should be applied during a contraction while the woman is pushing. The vector of traction is perpendicular to the plane of the cup, so initially there should be downward traction to allow the fetal head to come through the pelvic outlet, and as the fetal head extends, traction becomes more horizontal. Do not attempt more than three trials of traction (during three contractions), and do not apply suction for more than 30 min. If the vacuum fails, perform a cesarean section [8].

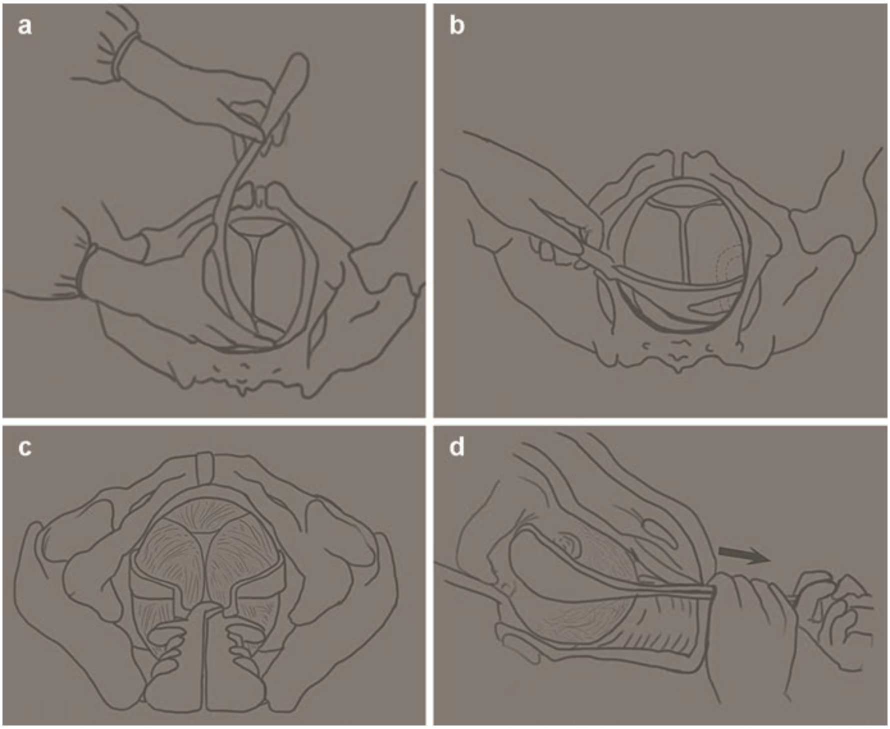

Fig. 17.13 Forceps delivery. (**a**) Place the blade posteriorly while protecting maternal tissue. (**b**) Rotate the blade along the fetal scalp such that the shank is in the same plane as the sagittal suture. (**c**) Once placement of both blades is correct, the shanks should interlock in the same plane as the sagittal suture, with the blades perpendicular to the sagittal suture. (**d**) Apply traction downward as the pelvic outlet is navigated, then horizontally as the head extends

Forceps delivery is associated with more maternal morbidity, including fourth-degree lacerations. There is more technique required to place the blades than there is to perform a vacuum delivery. Further, there are several kinds of forceps and specific instruments are preferable for certain clinical presentations. All forceps have three parts: (1) the blades, (2) the joint or lock, and (3) the shank. Practice the placement first to make sure you understand how the joint comes together (e.g., locking or sliding). Before use of forceps, ensure the mother's bladder is empty. Understand the position of the fetus, as the blades are placed parallel to the sagittal suture of the fetal head (occiput can be anterior or posterior). Place the forceps blades while protecting the maternal vaginal tissue by placing the entire hand on the maternal sidewall as the blade is placed. The blade should slide easily without resistance. The first blade is placed and then held by an assistant. The second blade is placed in a similar manner and the shanks should then be perpendicular to the sagittal suture with the posterior fontanelle centered between the blades [6] (Fig. 17.13). Thereafter, similar traction techniques apply to the forceps as to the vacuum. If the fetal head is not descending after three contractions with traction and pushing, a cesarean section should be performed.

Episiotomy

While generations of midwives and doctors have been trained to perform an episiotomy for every nulliparous woman, the current standard is to avoid this, since a tear is less painful and results in less pelvic organ prolapse in the long term. However, an episiotomy is useful if a tight perineum is impeding delivery and the fetal heart tones indicate fetal distress.

Anesthetize the area with 1% lidocaine. While the fetal head is visible during a contraction, place two fingers in the vagina between the head and perineum. Use scissors to make a single incision between your fingers. Incisions should be either 2–3 cm posteriorly at the 6 o'clock position (midline episiotomy), or 3–4 cm mediolaterally, toward the ischial tuberosity. The midline episiotomy allows for better healing, but has a greater risk of extension into the external anal sphincter or rectal mucosa, which causes more long-term maternal morbidity. The mediolateral incision will give more space and has less risk of extension toward the rectum, but is more difficult to repair and may be more painful. Pressure should be applied to the episiotomy between contractions to minimize bleeding. The repair is similar to that of a laceration repair (see "Laceration Repair" section below). Compared to repairing a natural tear, the episiotomy may have more clearly delineated tissue planes; however, it is associated with more bleeding [5].

Laceration Repair

Lacerations of the birth canal can be seen at the cervix, vaginal walls, labia, or the perineum. Repair is indicated for both hemostasis and cosmesis. Cervical lacerations often do not require repair unless bleeding is present. The most difficult aspect of the cervical tear repair is adequate visualization, and therefore this repair sometimes requires an operating room and sedation or spinal anesthesia. During transit to the operating room, a ring forceps can be placed on the laceration to maintain hemostasis. To accomplish the repair, use vaginal retractors to assist with visualization and provide traction with ring forceps on each side of the tear and Sew with an absorbable suture from above the apex of the tear toward the distal end of the cervix using locking sutures [5].

Vaginal tears need repair for hemostasis. Infiltrate the area in need of repair with 1% lidocaine. Start just above the apex for good hemostasis and use an absorbable suture with a running-locking suture technique. Ensure that the repair does not leave a potential space that can lead to a vaginal hematoma, which can easily accumulate 1 liter before being noticed. A vaginal hematoma should be suspected if the woman complains of rectal pressure. Perform a rectal exam to ensure no sutures have penetrated the rectum during the repair. If this has occurred, they will need to be removed to prevent fistula formation [5].

Labial lacerations need repair if they are causing bleeding or if the tissue does not naturally reapproximate. Infiltrate the area with 1% lidocaine. Use a smaller suture, preferably a 3–0 or 4–0 with a small needle. Interrupted sutures are often preferred as postpartum swelling may occur.

Perineal tears are vaginal tears that extend into the perineum. These three-dimensional tears can be difficult to repair if unfamiliar with the anatomy. First- and second-degree perineal tears do not involve the anus or rectum and can be closed with 2–0 absorbable sutures. Place the first stitch at the apex and suture the vagina to the hymenal ring in a running locked fashion, ensuring that the deep tissue is included to avoid vaginal hematomas (Fig. 17.14a). Place a stitch to reorient the plane of the repair such that the new plane is perpendicular to the previous plane. The perineum can then be closed in running fashion or with individual stitches thrown in the horizontal plane (Fig. 17.14b). Caution should be undertaken so as not

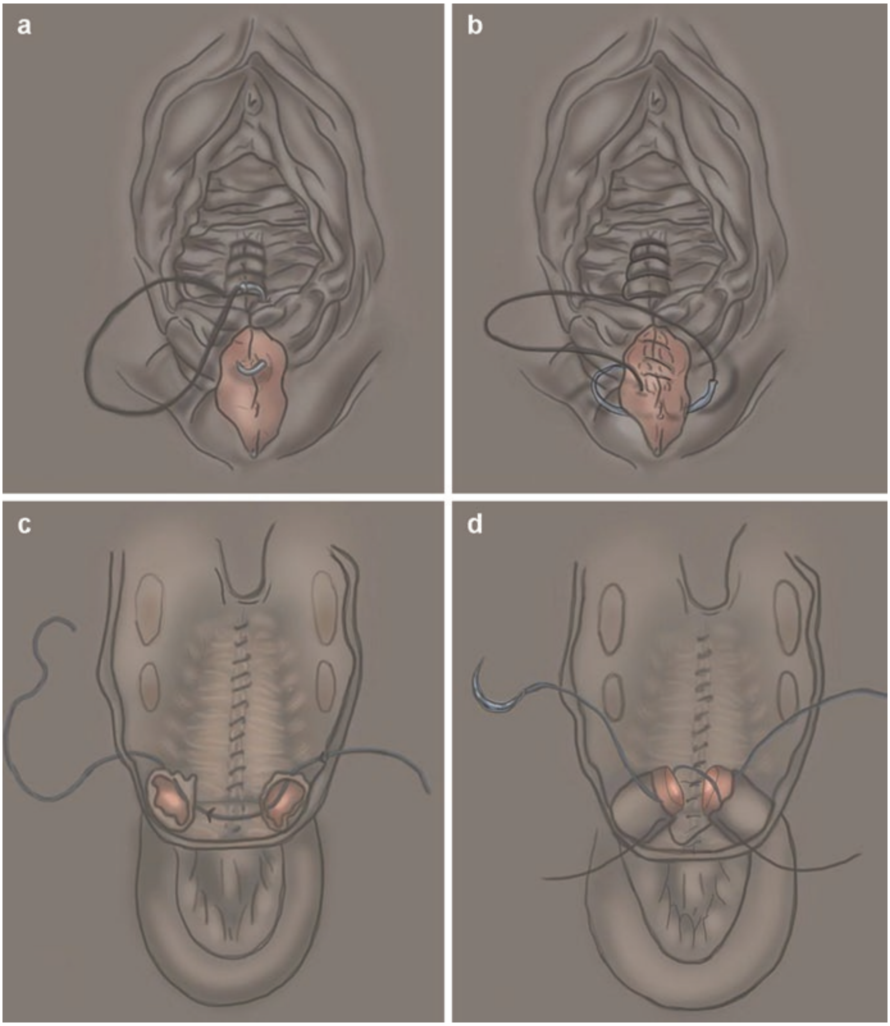

Fig. 17.14 Laceration repair. (**a**) Stitch in running, locked fashion along the vaginal plane to the hymen, then throw a stitch to switch to the perpendicular plane. (**b**) Stitch the perineum in running fashion. (**c**, **d**) For third-degree lacerations, identify the ends of the sphincter and ligate them together with interrupted sutures placed posteriorly, then inferiorly, superiorly, and, finally, anteriorly

to penetrate the rectum. Finally, the skin of the perineum can be closed using a running subcuticular stitch.

Third-degree perineal tears involve the anal sphincter (which is red and fleshy and results in deformation of the anus). The ends of the sphincter muscle can be grasped with Allis clamps and interrupted sutures should be placed at 3, 6, 9, and 12 o'clock positions through the capsule. The simplest repair is accomplished by reapproximating the sphincter muscle fibers together in the following order: posterior, inferior, superior, and finally, anterior (Fig. 17.14c, d). Fourth-degree perineal lacerations also involve the rectal mucosa (smooth and white), which should be repaired with a fine (4–0) suture in running or locking fashion. This is followed by repair of the anal sphincter. The technique for the remainder of the third and fourth degree tears is similar to that performed for a second-degree tear.

The Essentials

Absolute indications for a cesarean section include:

- *Fetal malpresentation (transverse lie, large infant in breech, first twin breech)*
- *Cephalopelvic disproportion*
- *Placenta previa*
- *Failed operative delivery*
- *Arrest of dilation*
- *Prior vertical uterine scar (from myomectomy or classical cesarean delivery), three or more low segment transverse cesarean sections*
- *Severe antepartum bleeding with signs of shock*
- *Uterine rupture*

Relative indications include:

- *Arrest of labor*
- *Abnormal fetal heart rate*
- *Multiple gestation*

Cesarean Section

The Essentials

- *In limited-resource settings where family planning and surgical resources are scarce, it is important to avoid incisions in the active segment of the uterus unless absolutely necessary.*

To perform a cesarean section, enter the abdomen with either an infraumbilical midline vertical or Pfannenstiel incision. A midline vertical incision is preferable if the case is emergent, more operating space is needed, or access to the upper abdomen might be indicated. A Pfannenstiel incision is a 10–12 cm incision 2–3 cm above the pubic symphysis, with the lateral edges of the incision curving slightly superiorly. Using a Bovie or blade, extend the incision deeply through the subcutaneous layer until the fascia is visible. Incise the fascia at the midline with the knife or Bovie and extend with scissors transversely on both sides. Clamp two Kocher clamps to the superior edge of the fascia on either side of midline and apply traction so the fascia can be bluntly dissected from the rectus muscle and the midline can be separated with mayo scissors; repeat this on the inferior side of the fascia. The muscle can then be bluntly separated at the midline and the peritoneum identified. Peritoneal entry can be achieved bluntly or by elevating it with hemostats and incising with a knife or Metzenbaum scissors. The peritoneum can then be stretched laterally to allow better access. When performing a Pfannenstiel for uterine or adnexal surgery, use a self-retaining retractor and pack the bowel cranially. When using a Pfannenstiel for a cesarean section, use a bladder blade to retract the bladder from the site where the hysterotomy needs to be made.

The uterus should be incised transversely in the lower uterine segment, if possible. The lower uterine segment is a layer of thinner muscle fibers, abundant elastic tissue, and fewer large blood vessels. Therefore, it carries a lower risk of intraoperative bleeding, is easy to repair, and is less likely to result in uterine rupture during a subsequent vaginal delivery. An incision in the active uterine segment is prone to bleeding and requires a multilayer closure of the thicker tissue. Further, the woman will have up to a 10% chance of uterine rupture during a subsequent delivery. Therefore, in limited-resource settings where family planning and surgical resources are scarce, it is important to avoid incisions in the active segment unless absolutely necessary. Extension to the active segment may be required if an incision in the lower segment cannot accommodate delivery of a neonate. A classical incision is a vertical incision that starts inferiorly and may reach the fundus or beyond. It may be indicated for a bladder adherent to the lower uterine segment, fibroids, abnormal placentation, or preterm cesarean sections for small fetuses [5].

Before making the hysterotomy, identify the lower segment by palpation, noting the difference in texture as described above. The peritoneum overlying the lower uterine segment can be easily lifted, whereas, at the active segment, the peritoneum is more adherent to the uterus. A "bladder flap" can be created by incising the loose peritoneum transversely with scissors and then bluntly releasing it from the lower uterine segment. A bladder blade can then be used to retract the bladder out of the operative field. (The bladder blade can also be inserted without first creating a bladder flap.) A transverse uterine incision should be made with a scalpel without too much pressure so as not to injure the neonate. Upon entering the uterine cavity, membranes or amniotic fluid will be apparent. Remove the scalpel from the field and extend the incision laterally with cephalocaudad traction. Bandage scissors may also be used to extend the incision superolaterally while carefully holding your fingers under the scissors to avoid cutting the fetus. Extending the incision too much superiorly will enter the active segment, while lateral extension risks lacerating the uterine vessels.

To deliver the infant, a hand should be placed between the head and the lower uterine segment under the pubic symphysis. Then push the head up and flex it toward the hysterotomy. While fundal pressure is applied, the head is guided through the incision. Twenty units of oxytocin should then be given at 10 ml/min to help the uterus contract. After clamping and cutting the umbilical cord, hand the baby to the nurse. Fundal massage is applied intra-abdominally, while gentle traction is applied to the cord to help detach the placenta and deliver it through the uterine incision. The uterine cavity should then be inspected and either wiped with sponges or suctioned to ensure all products of conception and membranes have been removed. Ring forceps can assist in identification of the edges of the hysterotomy and help tamponade bleeding.

The hysterotomy is closed with 0- or 1–0 absorbable or delayed-absorbable sutures in running-locking fashion, starting just lateral to the hysterotomy and ensuring the entire myometrium is included. Vertical uterine incisions can be closed with running stitches using 0- or 1–0 chromic catgut or vicryl in two or three myometrial layers and a serosal layer run with 2–0 chromic catgut [5]. If there was meconium or chorioamnionitis, copiously irrigate and suction the cul-de-sac and paracolic gutters. After inspecting carefully for hemostasis, the fascia can be closed in customary fashion with 0 PDS or 0 vicryl. The subcutaneous layer can be reapproximated with interrupted sutures using 3–0 vicryl; do this for subcutaneous layers >2 cm to prevent seroma formation or for cosmesis. The skin can then be closed with subcuticular stitches using 4–0 monocryl or staples.

Postpartum Hemorrhage

Postpartum hemorrhage is defined as blood loss greater than 500 cc for vaginal delivery and greater than 1 L for a cesarean section. It is one of the most common causes of maternal death in limited-resource settings. A large proportion of hemorrhages can be prevented by standard administration of postpartum IV or IM oxytocin. The differential diagnosis of postpartum hemorrhage includes (1) uterine atony, (2) retained placenta, membranes or clots, (3) cervical laceration, and (4) vaginal lacerations/episiotomy.

Uterine Atony

Uterine atony and subsequent bleeding should be expected if a uterus is largely distended prior to delivery (e.g., twin gestation, polyhydramnios, large fetus), there is either a prolonged or very quick delivery, or there are retained products of conception. Bladder distention can also cause uterine atony [5].

To manage atony, place a Foley to drain the bladder, apply fundal massage through the abdomen, or perform bimanual massage (see "Normal Vaginal Delivery" section). If the uterus still does not firm up, the following additional uterotonics can be given in addition to the standard 10 unites of oxytocin: (1) Methergine 0.2 mg IM (contraindicated if hypertension or prior to delivery of the placenta); (2) misoprostol, up to 1,000 mcg rectally or buccally; (3) Hemabate 250 mg IM or IV; and (4) oxytocin drip (30 U in 1 L to run for 2 h, followed by 30 U in 1 L to run for another 12–20 h, if needed) (Table 17.2). These medications can be given successively if needed. The uterus can also be tamponaded with packing, a Foley bulb, or Bakri

Table 17.2 Uterotonics to treat postpartum hemorrhage

Medication	Dosage	Administration	Dose frequency	Contraindications	Side effects
Oxytocin (Pitocin)	10–80 IU	IV drip in 1 L of LR; IM as bolus	Continuous drip	None	Hyponatremia
Methylergonovine (Methergine)	0.2 mg	IM; intrauterine; PO	Every 2 h	Hypertension, (pre)eclampsia	Hypertension
15-methyl prostaglandin F2α (Hemabate)	0.25 mg	IM; intrauterine	Every 15 min (maximum of 8 doses)	Active cardiac, pulmonary (asthma) or hepatic/renal disease	Diarrhea, nausea
Misoprostol (Cytotec)	600–1,000 mcg	PR; buccal	Single dose	None	Fever, nausea

balloon inflated in the uterine cavity [6]. The placenta should always be assessed for missing parts, and if retained products are suspected, a manual swipe through the uterus may reveal and remove them. A curettage (see "Care for Miscarriages" section) is indicated if attempts at manual extraction are unsuccessful.

In the event that the entire placenta cannot be delivered, manual removal might be required. The surgeon will need a long glove (preferably up to the elbow) and should then insert the whole hand up to the fundus, guided by the umbilical cord. When the placenta is reached, find an edge of it and then dislodge the placenta by sweeping behind it. Manual removal will increase the risk of infection, so prophylactic broad-spectrum antibiotics should be given. If the uterus has already clamped down around the placenta, nitroglycerine (sublingual or IV 50–100 μg) can be given. It has a profound relaxing effect on the uterus and its onset of action is very quick (30–90 s), while the half-life is short (approximately 3 min). If nitroglycerine is unavailable, tocolytics might be given (Table 17.1); however, these are associated with a greater risk of hemorrhage. While the uterus relaxes, the placenta can quickly be removed and uterotonics can then be given to prevent further postpartum hemorrhage (Table 17.2) [5, 6].

In rare instances, controlling postpartum hemorrhage requires surgical maneuvers. If the bleeding is profound, compression of the abdominal aorta should be attempted at the bedside while preparing for an exploratory laparotomy [6] (Fig. 17.15). If the bleeding is emanating from the uterine vessels, an O'Leary stitch can be placed. An O'Leary stitch goes through the broad ligament and the uterus to ligate the uterine artery (Fig. 17.16). This can be attempted at multiple locations along the artery with care not to sever the venous vessels, which are large and friable in pregnancy and the immediate postpartum period. If this is unsuccessful, hypogastric artery ligation may also be attempted [5].

If hemorrhage is due to severe atony and not responding to the above measures, a B-Lynch stitch can be performed with a large needle and #2 chromic or vicryl suture (Fig. 17.17) [5, 6]. Pierce the myometrium below the hysterotomy and enter the uterine cavity, exiting above the hysterotomy. Travel around the fundus and pierce the posterior myometrium in a transverse direction. Then, come back over the fundus and enter the uterine cavity from above the hysterotomy and exit below. Finally, bleeding that cannot be controlled with any of the above techniques

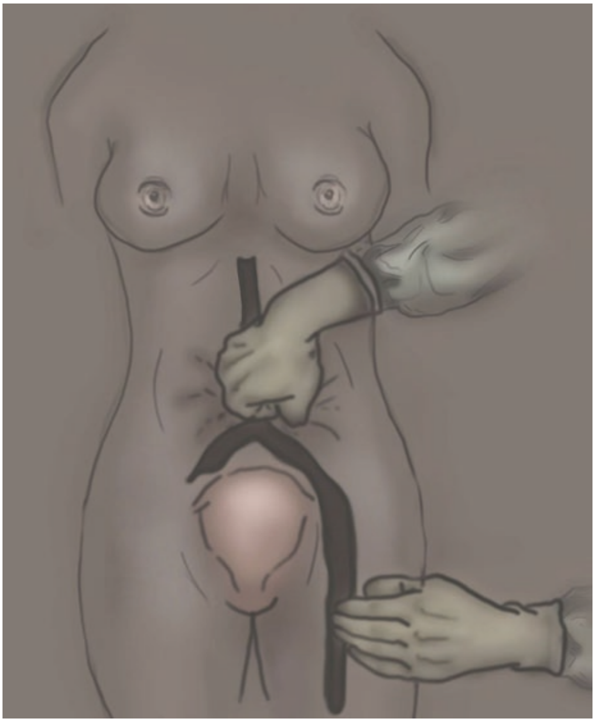

Fig. 17.15 Aortic compression. Apply firm, direct pressure to the aorta until exploratory laparotomy can be performed

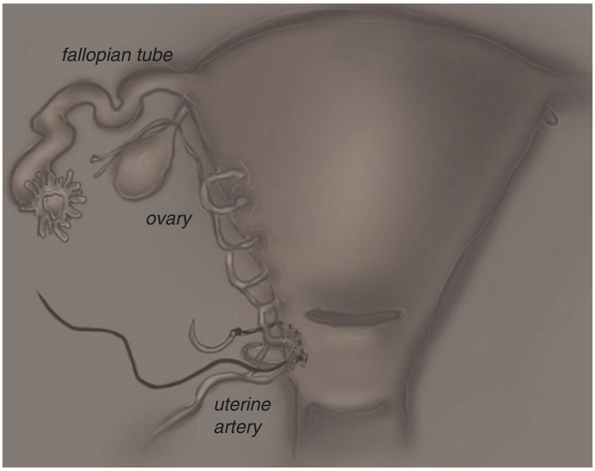

Fig. 17.16 O'Leary stitch. Place a stitch through the broad ligament and uterus to ligate the uterine artery

warrants a hysterectomy (see "Hysterectomy" section). A postpartum hysterectomy may be especially difficult secondary to the increased vascularity, and consideration should be given to a supracervical hysterectomy for speed of the procedure and less risk of injuring the ureters. The ureters are difficult to identify during an emergency hysterectomy with potential ongoing bleeding [5].

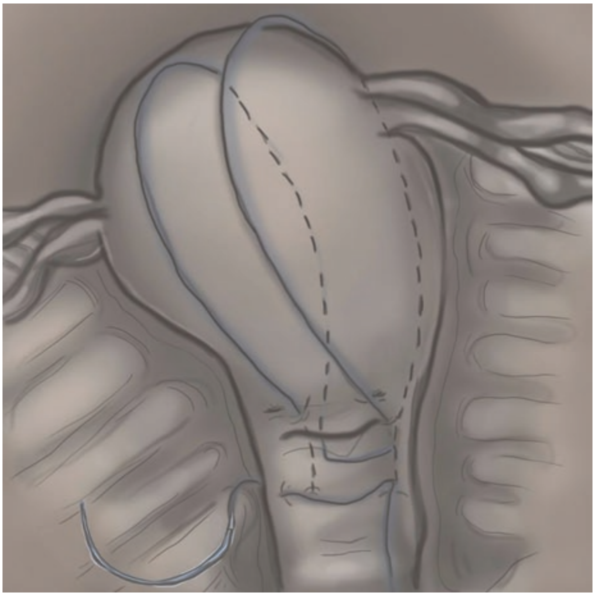

Fig. 17.17 B-Lynch stitch. Place a stitch through the myometrium from below the hysterotomy, exiting above it. Then travel around the fundus, traverse horizontally on the posterior surface, and bring the stitch around the fundus again, entering the cavity above the hysterotomy and exiting below it to complete the stitch

Uterine Inversion

Uterine inversion is an obstetric emergency that should be identified when the fundus is no longer palpable in the expected location. It may be palpable in the lower uterine segment or cervix, or it may be visible in the vagina or introitus. The woman may have profuse bleeding or become quickly unresponsive secondary to shock or pain.

To treat inversion, stop uterotonics (i.e., oxytocin) and attempt rapid replacement of the uterus by pushing the inverted uterus back into place. If contractions render this impossible, give terbutaline 0.25 mg IM and/or magnesium sulfate (6 g IV bolus). If the lower uterine segment is contracting, try nitroglycerin 50–100 μg IV. In the meantime, administer IV fluids and order blood, since the patient might experience profound uterine atony [6]. Uterine inversion is often encountered with a placenta accreta-percreta – in this case, don't try to remove the placenta as this will increase bleeding. Be ready to perform a laparotomy if the uterus is not able to be restored, if profound bleeding occurs, or if a placenta accreta-percreta is present. Once the uterus has been replaced, start uterotonics (Table 17.2).

Placenta Accreta-Percreta

Placenta accreta, increta, and percreta represent a spectrum of progressively severe invasion of the placenta into the endometrium, myometrium, or beyond the uterus into adjacent pelvic structures. You should suspect these disorders in the setting of a placenta previa, prior uterine surgery (e.g., cesarean sections, myomectomies), or a pregnancy presenting with a hemoperitoneum. Placenta accreta may also be suspected from ultrasound imaging when there is sonographic absence of a hypoechoic retroplacental space, when the placenta is contiguous with myometrium, or when placental lakes are prominent and hypervascularity is noted [9].

The placenta will not separate from the uterus in a normal fashion and may therefore require a (partial) hysterectomy. Ideally, delivery should therefore proceed via cesarean section and the placenta should be left in place after delivery of the fetus while a hysterectomy is pursued. However, if anatomical planes are severely distorted, it is wise to leave (part of) the placenta in place if bleeding is controlled and treat the woman postoperatively with methotrexate and oxytocin to allow the placenta to regress secondarily [6, 9].

Most likely, however, placenta accreta-percreta will be encountered during labor when the placenta will not deliver and postpartum hemorrhage is encountered. In this case, the patient should be taken to the operating room immediately for a hysterectomy. Life-threatening hemorrhage is not uncommon (even with advanced surgical planning), as well as disseminated intravascular coagulation and acute respiratory distress [6, 9].

Infections in Obstetrics

Although multiple infections can occur and impact pregnancy, this section will focus on common infections that are important to recognize and treat in a timely manner.

Human Immunodeficiency Virus

Local treatment options and guidelines should be followed when available. The chances of vertical transmission of HIV from mother to child can be reduced significantly by the interventions below. For patients living with HIV who are not on antiviral therapy, 2 mg/kg IV AZT should be administered over 1 h at the time of presentation, followed by 1 mg/kg/h dosing until delivery [10]. Avoid artificial rupture of membranes, operative delivery, and episiotomy if possible. When formula and safe water is available, breastfeeding is not recommended. Otherwise, exclusive breastfeeding for 6 months with abrupt weaning is advised. If antiretrovirals are available, the mother should be referred to a program to ensure compliance with therapy while breastfeeding and availability of prophylactic treatment for the neonate as indicated. A cesarean section could be offered in the setting of a known high viral load; however, this is not 100% protective and must be weighed carefully with the disadvantages of a uterine scar (see "Cesarean Section" section) [6, 8, 10].

Chorioamnionitis

Chorioamnionitis is characterized by fetal or maternal tachycardia during delivery, maternal fever, fundal tenderness, and foul-smelling vaginal discharge. It is treated with ampicillin 2 g IV every 6 h and an initial 2 mg/kg dose of gentamycin followed by 1.5 mg/kg every 8 h [5]. Vaginal delivery is preferred to reduce the risk of endometritis; however, a cesarean section may be considered for worsening maternal or fetal status remote from delivery. Maternal fever should be treated with Tylenol, and IV fluid should be given to account for insensible losses. After expulsion of the placenta and membranes, the infection resolves and there is no need to continue antibiotics unless there is a postpartum fever or the woman delivered via cesarean section. In these instances, antibiotics should be continued for 24–48 h after the last fever or after cesarean section, whichever came last [5].

Endometritis

Endometritis is a polymicrobial infection of the endometrium and is diagnosed postpartum by fever, fundal tenderness, and foul-smelling lochia. The treatment is ampicillin 2 g IV every 6 h, gentamycin 5–7 mg/kg every 24 h, and clindamycin 600–900 mg IV every 8 h (or flagyl 500 mg IV every 8 h) until the patient is afebrile for 24–48 h [5, 6].

Mastitis

Mastitis should be suspected when a hard, red, tender area develops in one breast. Nonsteroidal anti-inflammatory drugs, heat packs, and continued breastfeeding are beneficial. Treatment should cover staphylococcus and may consist of 7–10 days of dicloxacillin 500 mg four times daily, Keflex 500 mg four times daily, Augmentin 875 mg twice daily, or 10–14 days of clindamycin 600 mg four times daily [11]. If there is no clinical response to antibiotics, suspect an abscess, which requires drainage. Pain control is very important in order to continue breastfeeding.

Conclusion

Knowing when and how to perform basic procedures and surgeries in gynecology and obstetrics is critical for any surgical provider in limited-resource settings. The topics discussed in this chapter represent the bread and butter of emergency obstetric and gynecologic care and encompass the most prevalent causes of maternal morbidity and mortality worldwide. While many of the conditions described require the expertise of a trained surgeon, experienced midwives and obstetric nurses are also invaluable resources as you learn how to provide obstetric care in limited-resource settings. It is important to know where the referral center is and recognize the need for appropriate and timely referral. Nonetheless, with some training and practice, non-obstetric surgeons can become competent at many obstetric and gynecologic procedures, enabling them to provide women and fetuses/neonates with lifesaving care.

Acknowledgments Illustrated by Chrystie Tyler.

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Essential Urology

18

Louis L. Pisters

Introduction

Approximately 20% of operative cases performed in low- and middle-income countries (LMICs) are urological in nature. This chapter covers three of the most troublesome and one of the most common urological conditions seen in low-resource settings. The four topics discussed include urethral stricture, benign prostatic hyperplasia (BPH), vesicovaginal (VVF) fistula, and urinary stones. There has been a shift in urethral stricture repair toward buccal mucosal onlay flaps and away from penile skin flaps, although both techniques are still necessary. End-to-end urethral reconstructions are also utilized for select patients with bulbar urethral strictures and those with pelvic fracture-related urethral injuries. Open and endoscopic treatment of BPH is discussed. A simple modification to open BPH technique safely allows the surgery to be performed with the elimination of postoperative bladder irrigation. Repairs for both obstetrical and postsurgical VVF and ureterovaginal fistulas are presented with discussion of appropriate flaps to improve the likelihood of successful repair. Finally operative surgery for urinary stones is presented with detailed description of renal vascular and collecting system anatomy that facilitates removal of stones within the calyces of the kidneys. All of the techniques presented in the chapter could be performed in a low-resource setting, and our hope is that the chapter will improve the outcome for patients with the most challenging urologic conditions.

L.L. Pisters, MD
Department of Urology, The University of Texas MD Anderson Cancer Center,
1515 Holcombe Blvd, Unit 1373, Houston, TX 77030, USA
e-mail: lpisters@mdanderson.org

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The Essentials

- *A simple test for urethral stricture is to fill a catheter tip syringe with 30–60 ml of lubricant and inject the lubricant up the urethra. If the lubricant flows out the meatus and does not go up the urethra with steady pressure, then a stricture almost certainly exists.*
- *The success rate of open urethral reconstruction is reduced significantly by multiple prior urethral dilations and internal urethrotomy procedures. It is therefore wise to consider dilation or urethrotomy mainly in patients with short segment strictures and no significant spongiofibrosis.*
- *The long-term cure with internal urethrotomy is only 20–35% with the best results in short-segment bulb strictures less than 1.5 cm with no spongiofibrosis. Urethral dilation also has very low long-term cure rates.*
- *Buccal mucosal flaps and penile skin flaps have equal cure rates.*
- *There is no reason to close a buccal mucosal donor site.*
- *A urethra that is 14 French will still have a normal urinary flow rate of >15 ml/s. In a patient with multiple strictures or panurethral stricture, it is only necessary to fix the critical strictures less than 14 French.*

Any process that injures the urethral epithelium or the underlying corpus spongiosum resulting in inflammation and scarring can cause a urethral stricture. These processes include trauma such as instrumentation, gonorrhea or other sexually transmitted disease, lichen sclerosis, also known as balanitis xerotica obliterans or rarely a congenital cause of urethra stricture. Presenting symptoms of urethral stricture disease include obstructive voiding symptoms especially straining to urinate, poor urinary stream, or urinary tract infection. Urinary retention can occur, but patients developing acute retention have a long history of obstructive symptoms preceding the retention episode. Although a urethral stricture can become apparent at any age, many patients in developing countries with urethral strictures are between the ages of 20 and 40 years old. The past medical history should include an assessment of prior trauma, sexually transmitted disease, and any history of prior urethral stricture repair. On the physical examination, it is important to examine the penis and perineum for of evidence of urethrocutaneous fistulas and examine the penile and scrotal skin for regions of non-hair-bearing skin that might be used in a reconstruction (Fig. 18.1**).** Palpate the penis for areas of spongiofibrosis in the region of the stricture. It is also important to note whether the patient has a suprapubic tube present.

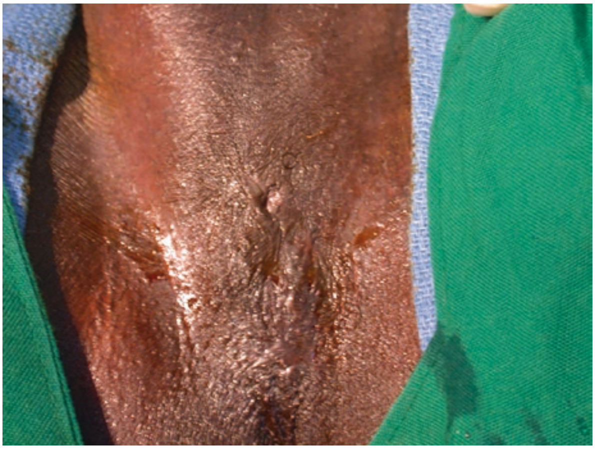

Fig. 18.1 Urethrocutaneous fistula arising from bulbous urethra

Evaluation

Radiographic evaluation includes a contrast study of the anterior urethra, prostatic urethra, and bladder (Fig. 18.2). It is important to stage the stricture with a combined retrograde urethrogram and, if a suprapubic tube is present, an antegrade dynamic voiding cystourethrogram study. The goal is to assess the length, location, and assess the density of the stricture (spongiofibrosis). The retrograde urethrogram is obtained by placing the patient in an oblique position and injecting 20–30 cc of radiographic contrast solution under pressure up the urethra with a nozzle tip (Toomey) syringe. If a narrow or obliterating stricture is present, not all of the contrast can be injected. It is important to distend the urethra all the way up to the stricture and keep a tight physical grip on the glans penis with the nozzle tip syringe so that contrast does not leak out around the glans penis. If the urethral meatus is narrow and will not accommodate a nozzle tip syringe, then a pediatric foley catheter can be used to intubate the narrow meatus and facilitate a retrograde injection. If the urethral meatus is totally scarred, then there is no way to perform a retrograde study. If a suprapubic tube is present, it is important to perform an antegrade study by filling the bladder with contrast, clamping the suprapubic tube, and asking the patient to void when the film is obtained. The purpose behind asking the patient to void during an antegrade study is so that the patient will hopefully open his bladder neck and prostatic urethra to reveal the upper extent of the stricture. Not all patients are able to open the bladder neck and prostatic urethra, and an alternative way to evaluate the upper extent of the stricture is to perform antegrade flexible cystoscopy via the suprapubic tube tract. The best performed studies include both the antegrade

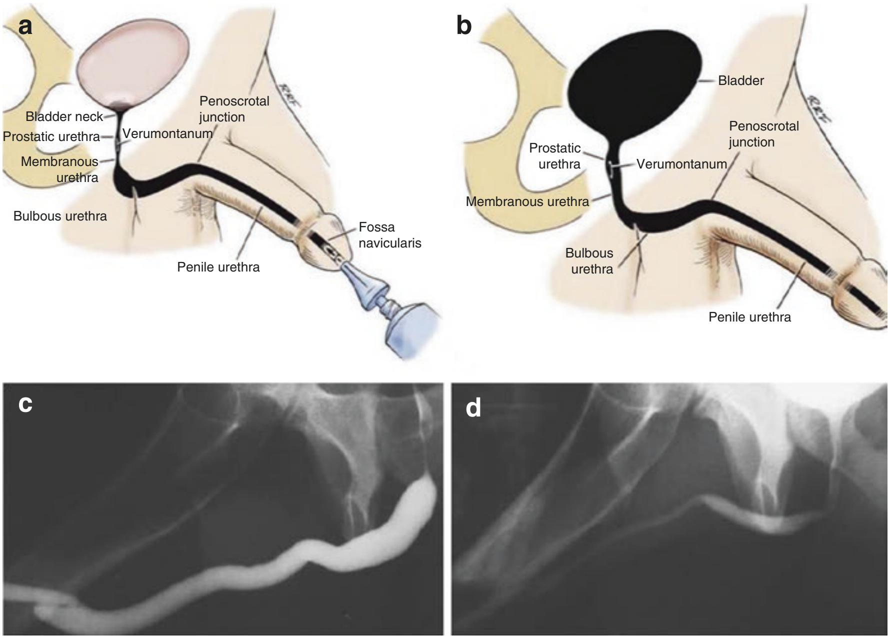

Fig. 18.2 (**a**) Representation of a dynamic retrograde urethrogram with the criteria of McCallum illustrated. (**b**) Representation of a dynamic voiding urethrogram with the criteria of McCallum illustrated. (**c**) A normal retrograde urethrogram. (**d**) A normal voiding urethrogram ((**a**, **b**) Modified from McCallum [31]) [1] (Image from Jordan and McCammon [1], © 2011, with permission from Elsevier)

and retrograde contrast on the same film. The combined radiographic study allows for the best definition of the location and length of stricture if a completely obliterated segment is present. When taken together, the radiographic and physical findings will help stage the stricture (assess its length, caliber, degree of spongiofibrosis, and presence of any fistula (Fig. 18.3)). The stage of the stricture will help to determine which treatment would be most appropriate for a successful outcome.

If a patient presents with severe straining to urinate and a poor urinary stream with impending urinary retention, it is reasonable to attempt a urethral catheter placement. One simple test for urethral stricture is to fill a catheter tip syringe with 30–60 ml of lubricant and inject the lubricant up the urethra. If the lubricant easily goes into the bladder, then there is no stricture, and a 16–20 French catheter should easily pass. Silicone catheters are stiffer than the typical yellow latex catheters and are therefore easier to pass. If however the lubricant flows out the meatus and does not go up the urethra with steady pressure, then a stricture almost certainly exists. It is important to minimize urethral trauma, and in the latter case if a stiff silicone 10–12 French urethral catheter does not go into the bladder, then there is no point in trying to persist in pas urethral catheter, and consideration should be given to putting in a suprapubic tube. When in doubt, place a suprapubic tube.

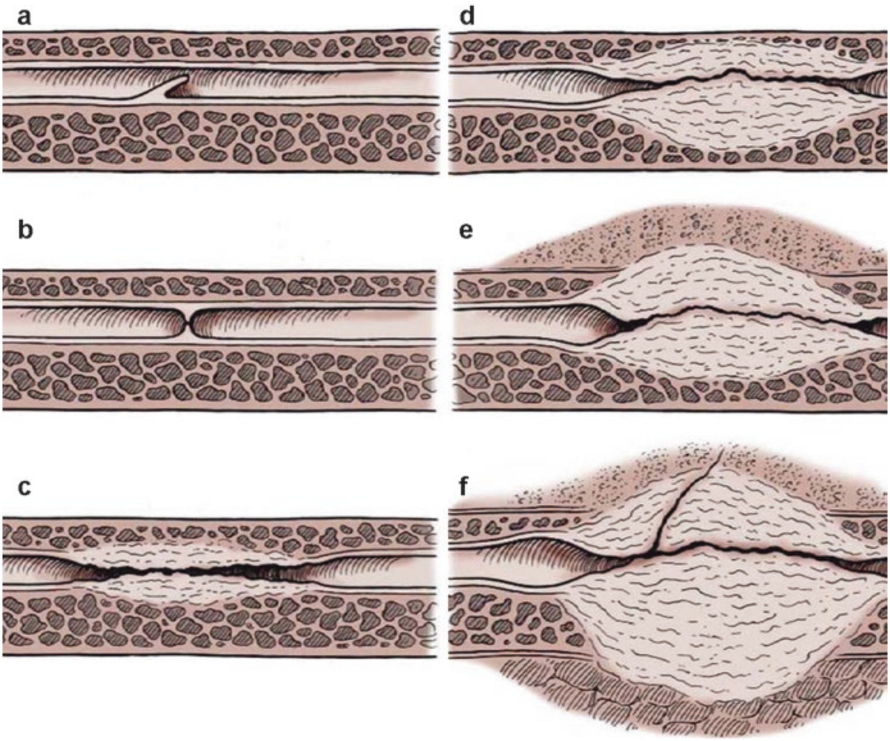

Fig. 18.3 The anatomy of anterior urethral strictures includes, in most cases, underlying spongiofibrosis. (**a**) Mucosal fold. (**b**), Iris constriction. (**c**) Full-thickness involvement with minimal fibrosis in the spongy tissue. (**d**) Full-thickness spongiofibrosis. (**e**) Inflammation and fibrosis involving tissues outside in the corpus spongiosum. (**f**) Complex stricture complicated by a fistula. This can proceed to the formation of an abscess or the fistula may open to the skin or the rectum. (**a**–**f**, From Jordan [32]) [1] (Image from Jordan and McCammon [1], © 2011, with permission from Elsevier)

Management of Urethral Stricture

Urethral Dilation

Urethral dilation as a single intervention for a urethral stricture has a very limited role in the developing world. Urethral dilation only works well for mild mucosal limited strictures without significant periurethral scarring. These strictures are usually mild and a result of prior instrumentation and are very rare in the developing world. The dilation procedure seeks to stretch the scar without producing more scarring. Although the use of filiform and followers or Amplatz dilator type of progressive urethral dilation has been well described, the long-term success of this type of dilation is exceedingly low if there is spongiofibrosis and it has significant risk of urethral perforation or rectal injury in inexperienced hands. In a low-resource setting, the risk to benefit ratio for progressive dilation is exceedingly low and favors alternative intervention. In the acute setting of someone with impending urinary retention due to urethral stricture, placing a suprapubic tube is a better option than aggressive attempting to dilate a stricture that already has significant periurethral scarring. Although a single dilation procedure is unlikely to provide long-term patency, there is a role for intermittent self-dilation with a catheter for a focal short segment stricture following open urethroplasty or an endoscopic procedure. In this case, the intermittent self-dilation is being used as an adjunct to other corrective procedures, not as a primary intervention.

Internal Urethrotomy

Internal urethrotomy is a cystoscopic procedure in which the stricture is incised endoscopically in the hope that it will reepithelialize. After the stricture is incised, it is a race between reepithelialization and wound contraction. In general, there must be at least some lumen still present for a guidewire to be advanced into the bladder to provide a guide as to where to incise. It helps to advance an open-ended ureteral stent over the guidewire to provide a firmer guide of the pathway into the bladder. The procedure is easiest to perform with a half-moon blade which allows the operator to incise the stricture at 12 o'clock by advancing the half-moon blade through the stricture and cutting the stricture when pulling the blade back toward the urethrotome. A straight urethrotome blade is also available. It is generally advisable to incise the stricture at 12 o'clock due to the presence of vascular supply laterally. In those patients who have significant spongiofibrosis, the visual internal urethrotomy will not provide long-term patency. The long-term cure with internal urethrotomy is 20–35% with the best results in short-segment bulb strictures less than 1.5 cm with no spongiofibrosis [2]. It is possible to combine internal urethrotomy with intermittent self-dilation to provide long-term patency.

A number of studies demonstrate that the success rate of open urethral reconstruction is reduced significantly by multiple prior urethral dilations and internal urethrotomy procedures [3, 4]. It is therefore wise to consider dilation or urethrotomy mainly in patients with short segment strictures and no significant spongiofibrosis.

Open Urethral Reconstruction

The best long-term patency for strictures with significant spongiofibrosis will be open urethroplasty. Since most patients with strictures in the developing world have significant spongiofibrosis, many will need an open urethroplasty to establish long-term patency. There are a variety of open repairs, and the selection of a repair depends on whether a lumen is still present and the length and location of the stricture. The mechanism of injury also has bearing on the type of repair necessary to provide patency. Patients who have traumatic pelvic fracture with shearing of the prostatic urethra off the pelvic floor or a straddle injury crushing the membranous urethra into the pubic bone will usually need open end-to-end repairs.

Patient Positioning and Prep for Open Urethroplasty

Patients are positioned in an exaggerated high lithotomy position with legs in stirrups. Make sure the operating table is positioned high enough to minimize strain of the surgeon's back. Before shaving the patient, it is important to note the distribution of non-hair-bearing skin in the event that a penile skin flap may be needed. Most cases can be done with spinal anesthesia, but if buccal mucosal flaps are needed, the patient will need to be intubated for buccal flap harvest. If a suprapubic tube is present, we usually remove it before performing the skin prep and place a new one through the old tract after the skin prep has been completed. The bladder is distended with 60 ml of povidone-iodine for a contact time of 15 min via the new suprapubic tube. Non-randomized studies suggest a lower rate of surgical site wound infection following povidone-iodine administration [5].

Short Segment Bulb Strictures

A "Mercedes symbol" perineal incision can be made with the vertical aspect of the incision made along the median raphe and then extending to the right and left above the anus. This allows wide exposure of the urethral bulb. Very good light and a fine tip grafting sucker will greatly assist the dissection. The goal is to completely excise the fibrosis and perform a spatulated end-to-end anastomosis. The best results are obtained if the fibrosis is completely excised, the urethral anastomosis is widely spatulated, and the anastomosis is completely tension-free (Figs. 18.4 and 18.5). Strictures with a length of 1–2 cm are easily treated with end-to-end anastomosis. In some cases a stricture of 3–4 cm can be excised and repaired with primary anastomosis, especially in young patients. The more proximal the location of the stricture (closer to the membranous urethra), the greater the likelihood of successful primary end-to-end repair.

The following tips may be helpful in facilitating the dissection. Put a traction suture in the glans penis which allows the penis to be put on slight traction and moved as needed for the surgery. Insert a catheter up the urethra to the distal aspect of the stricture. An 18 French urethral catheter is the ideal size, but if the patient has multiple post-gonococcal strictures, then a 16 French or rarely a 14 French catheter can be used. A urethra that is 14 French will still have a normal urinary flow rate of >15 ml/s [6]. Therefore in a patient with multiple strictures or panurethral stricture, it is only necessary to fix the critical strictures less than 14 French.

It helps to have the catheter distend the urethra making the urethra easy to palpate and locate. The catheter will have a natural tendency to fall out. After the urethra distal to the stricture is dissected, it is helpful to use a Babcock clamp to hold the distal urethra with the Foley in place. Make sure the Babcock clamp is non-crushing and atraumatic to the urethra itself. Sharp dissection is needed to get through the fibrotic tissues and sharp dissection around the urethra is the safest mode of dissection. If an end-to-end anastomosis is planned, then it is important to dissect the posterior attachments of the urethra so that the urethra above the stricture is free and mobilized for tension-free anastomosis. The urethra is very adherent posteriorly to the corporal bodies, and the best strategy is to hug the corporal bodies

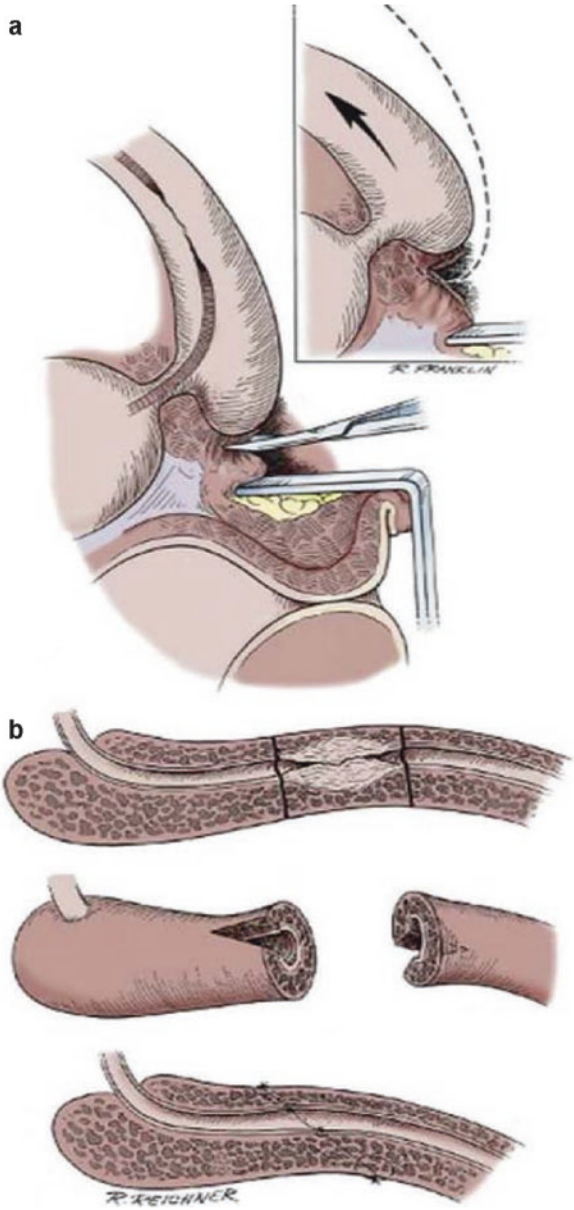

Fig. 18.4 Techniques for excision and primary reanastomosis of anterior urethral stricture. (**a**) The bulbospongiosus is released from its attachment to the perineal body. The arteries to the bulb are not divided. This technique allows the urethra to be mobilized distally. This technique combined with development of the intracrural space can shorten the path of the urethra by approximately 1–1.5 cm. (**b**) Technique of a primary spatulated anastomosis after excision of an anterior urethral stricture (**a**, **b** From Jordan [33]) [1] (Image from Jordan and McCammon [1], © 2011, with permission from Elsevier)

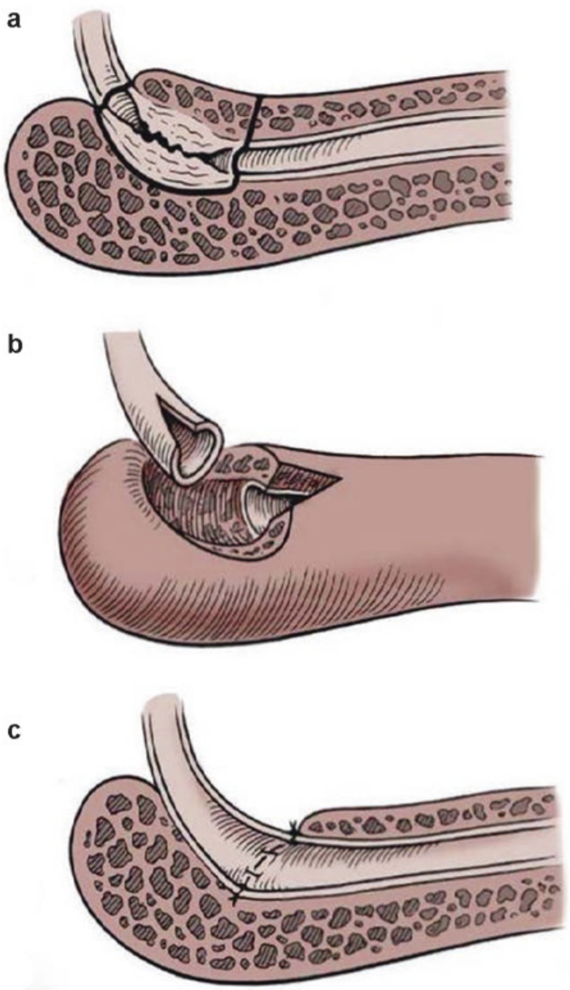

Fig. 18.5 Technique of excision of very proximal bulbous urethral stricture with reanastomosis. This technique is facilitated by dissection of the membranous urethra. (**a**) The area of the stricture is defined for excision. (**b**) The stricture is excised and both ends of the urethra are spatulated on the dorsal aspect. (**c**) The anastomosis is complete [1] (Image from Jordan and McCammon [1], © 2011, with permission from Elsevier)

behind the urethra. It is easy if one is not careful to perforate or tear the urethra directly posterior. It is better to put a tiny hole in the corporal body (that can easily be closed with a 2–0 absorbable suture) than to perforate the urethra posteriorly. The corporal bodies will bleed, but this is easily controlled with direct pressure until a suture can be placed.

There are several surgical approaches to dissecting the proximal aspect of the stricture depending on whether a suprapubic tube is present and whether there is a lumen still present at the site of the stricture. If the patient has a suprapubic tube in place, then it is best to advance either a metal sound or a foley catheter down through the suprapubic tube tract through the bladder and prostate and then up to the proximal aspect of the stricture. This can be done by gently probing the metal sound against the bladder neck until it falls through the prostatic urethra. After the metal probe enters the prostatic urethra, it can be gently advanced through the urogenital diaphragm and into the urethral bulb. This approach works well, especially for obliterating proximal bulb strictures. If a lumen still exists through the strictured area, then it is best to open the urethra on its ventral surface and split the stricture open ventrally to find the normal urethra below the stricture. A third approach to finding the proximal end of the stricture is to transect the urethra at the level of the obliterating scar and then, with good scissors, trim the proximal and distal ends until adequate lumen is identified. With the urethral catheter in the distal end of the urethra, simply transect the urethra just below the tip of the urethral catheter and then trim the obliterated proximal and distal ends until good lumen is identified. It is important to mobilize enough urethra proximally and distally for a tension-free anastomosis. Mobilizing the urethral bulb will provide at least 1 cm or more length (Fig. 18.4). Dissect the bulb extensively from both the right and left sides before freeing it in the midline. The urethra can easily be mobilized for 5–6 cm or more distally to provide a tension-free anastomosis. Spatulate both ends. Then put in 4–6 interrupted sutures posteriorly and laterally. Optimal suture is 4–0 polydioxanone (PDS) or poliglecaprone 25 (Monocryl), but any absorbable suture between 2–0 and 5–0 would work. Tag these stitches until all the posterior and half of the lateral sutures are placed. Then tie these sutures to bring the back wall of the anastomosis together. Then pass the final urethral catheter through the repair into the bladder. The catheter can be brought through the opening in the anterior aspect of the anastomosis and then advanced the rest of the way into the bladder, which helps to facilitate a 90° turn underneath the pubic bone. Finally close the anterior aspect of the anastomosis with interrupted absorbable sutures. It helps to tag the anterior sutures also and then tie them after all are placed. It is important to get mucosal to mucosal apposition. The mucosa can be hard to see if the sutures are tied as they are placed and therefore interrupted suture placement and delayed tying of sutures may be preferable. The final steps are to check for hemostasis, irrigate the wound, place a Penrose drain, and close the perineum. We usually leave the urethral catheter for 1 month, but 2 weeks of catheter drainage would be adequate for a simple urethroplasty.

Onlay Grafts Versus Penile Skin Flaps

A graft is tissue that does not have its own blood supply and relies on a bed of surrounding tissues for ingrowth of vascular supply. A flap is typically penile skin that is mobilized and maintains its original blood supply. Skin flaps from the penis were popular in the 1980’s and 1990’s and skin flaps have gradually been replaced by onlay grafts. A randomized trial of buccal mucosal onlay grafts compared to penile skin flaps shows no difference in long-term patency [7]. The grafts are technically easier to perform with little potential morbidity and have been used in all parts of the urethra.

Fig. 18.6 Buccal mucosal graft harvest. Note the significant width and length of a single buccal graft

Buccal mucosal flaps are easily obtained from the inside of the cheek (Fig. 18.6). The main structure to be aware of is Stensen duct, the parotid gland duct that is opposite the second upper molar. After the patient is intubated, a jaw retractor is utilized to open the jaw. Saline can be injected underneath the mucosa to elevate the mucosa off the buccinator muscle. Stensen duct can be visualized and the outline of the graft can be demarcated with the electrocautery. The graft can be taken from just inside the lip and thus a 2 cm wide by 7 or 8 cm long graft can easily be harvested. If additional graft is needed, a second graft can be obtained from the other cheek. There is no need to close the donor sites within the mouth. Two randomized trial shows less pain, an earlier return to regular diet, an earlier return to full mouth opening, and a decrease in bothersome perioral numbness at 6 months leaving the buccal mucosal graft harvest site open rather than closing the site [8, 9]. Patients can take a soft diet for 3 or 4 days before resuming regular diet. Amazingly, most patients do not have oral complaints. The buccal mucosal grafts have become the gold standard for onlay procedures.

Oral grafts can also be taken from the underside of the tongue (lingual graft) or from the inside of the lower lip. Wharton's duct, the sublingual salivary duct, must not be injured during lingual graft harvest. Although the mucosa from the bottom of the tongue or inside of lower lip are often more flimsy and not as wide as the buccal grafts, the patency rates are equal to buccal mucosal grafts [10]. There might be a higher complication rate with lingual grafts. In one series, 17% of patients had a numb tongue, 5% had paresthesias, and 8% of patients had slurred speech after 6 months [11].

The buccal grafts can be used for either ventral or dorsal onlay onto the urethral plate. A meta-analysis comparing ventral versus dorsal onlay of buccal mucosal grafts shows no difference in long-term success rates (87.6% and 89.2% respectively, $p = 0.472$) [12]. A separate systemic comparison of the two onlay techniques also shows no difference in long-term patency [13]. If a lumen is present, the urethra is opened on its ventral side starting about 1 cm above the stricture, then through the stricture and about 1 cm below the stricture for ventral onlay. If dorsal onlay is planned, then the urethra needs to be mobilized at least 2 cm above and below the stricture to allow greater mobility so that the urethra can be rotated 180° to facilitate a dorsal slit in the urethra starting 1 cm above the stricture, going through the stricture to a point about 1 cm below the stricture (Fig. 18.7). It is important to try to provide a nutritional bed to support the buccal graft. Ventral onlay works best in the urethral bulb region (Fig. 18.8). The urethral lumen is dorsally located at the urethral bulb with thick highly vascularized spongiosis that can be loosely closed over the buccal mucosa graft along with the bulbospongiosus muscle as a "spongioplasty." The dorsal onlay technique has been popularized by Barbagli, which involves fixing and quilting the buccal graft to the corpora cavernosa and then suturing it to both edges of the urethrotomy with the urethra rotated back to its original position to cover the grafted area [14]. With the dorsal onlay approach, the corpora cavernosa provide the nutritional and vascular bed for the buccal graft to survive.

Penile Skin Flaps

There is still a role for penile skin flaps, particularly for distal strictures involving the glans penis and the meatus. Another case for penile skin flaps is that of a long-segment obliteration of the urethra with no lumen, where a new tube needs to be created. In these cases it is important to try to limit the length of tubularized flap by aggressive mobilization and excision of scar. The penile skin flap is better suited to tubularization than a buccal flap. The blood supply to the penile skin comes from the superficial external pudendal artery, which gives off branches that cross the spermatic cord and enter the base of the penis anterolaterally and posterolaterally. These branches interconnect with each other and form an arterial network in the dartos fascia connected to the anterior lamella of Buck's fascia [15]. Figure 18.9 demonstrates the technique of a longitudinal skin island for a long-segment distal stricture. Note that the primary blood supply is oriented longitudinally arising from the proximal tissue at the base of the penis allowing the pedicle of the skin flap to be mobilized so that the entire pedicle can reach the urethral bulb by being tunneled underneath the scrotal skin. Note also that non-hair-bearing scrotal skin can also be used as a flap based on the tunica dartos of the scrotum.

Augmented Anastomosis

In some cases, after the spongiofibrosis has been excised, there is enough urethral tissue to be brought together for a partial end-to-end anastomosis. The remaining gap in the anastomosis can be filled with either a buccal graft or a skin flap.

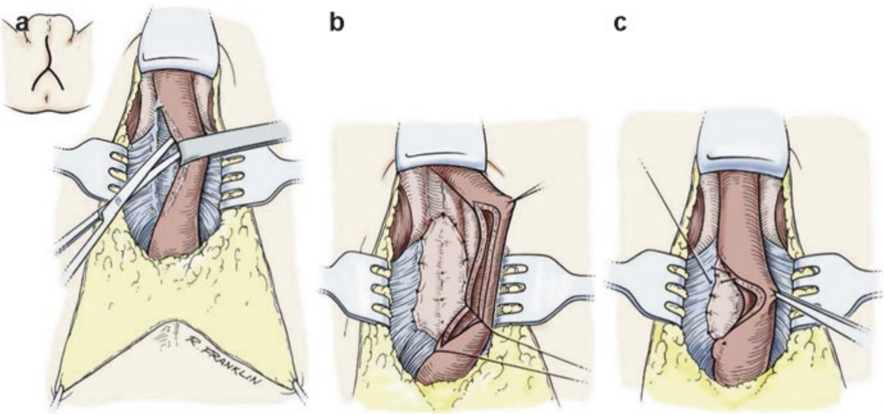

Fig. 18.7 Use figure legend from Fig. 36–24 from Campbells Urology and relabel figure as Fig. 7 Legend from PDF: technique of dorsal graft onlay popularized by Barbagli. (**a**) The corpus spongiosum is detached from the triangular ligament and corpora cavernosa. (**b**) A dorsal urethrostomy is performed. The graft is spread fixed to the corpora cavernosa. Note the pie-crusting incision. (**c**) The edges of the stricturotomy are then sutured to the graft as well as to the corpora cavernosa [1] (Image from Jordan and McCammon [1], © 2011, with permission from Elsevier)

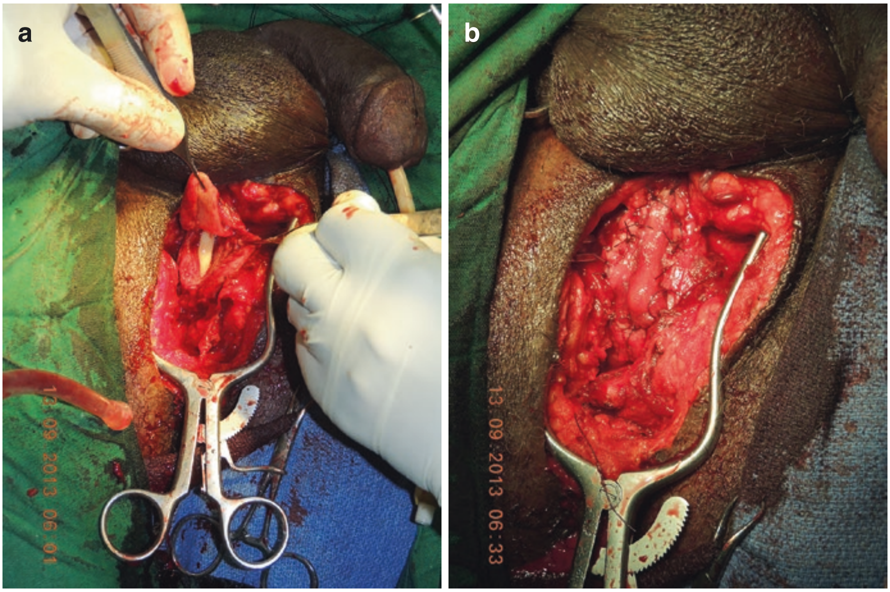

Fig. 18.8 (**a**) The buccal flap is sutured to the edge of the urethral muscosa. (**b**) The graft is completely sewn in place and ready for spongioplasty

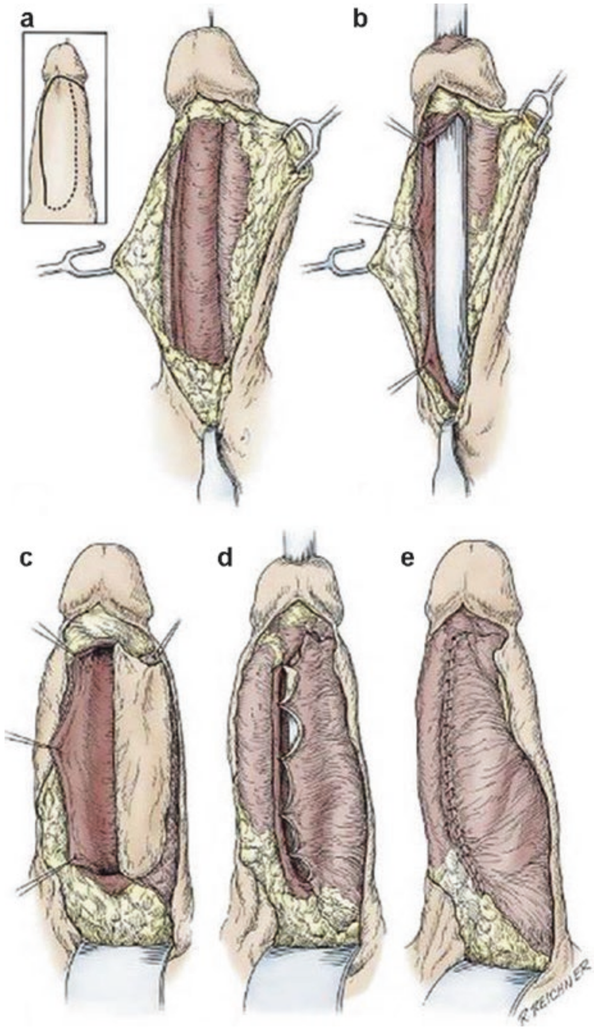

Fig. 18.9 Penile longitudinal skin island. The incisions to be made to mobilize the flap are demonstrated in the inset. The heavy line is the primary incision made full thickness through the dartos fascia and superficial Buck fascia lateral to the corpus spongiosum. (**a**) Dissection elevates the dartos fascial flap well past the corpus spongiosum in the midline. (**b**) A lateral urethrostomy placed to face the flap has opened the entire length of the stricture. (**c**) The skin paddle of the flap has been developed by making the incision outlined by the dotted line (inset) and undermining the skin lateral to it. The medial edge of the flap has been fixed to the edge of the stricturotomy. (**d**) The flap is inverted into the defect. (**e**) A watertight subepithelial suture line has been completed with a running absorbable monofilament suture. The skin will be closed with subcutaneous sutures and interrupted cutaneous sutures (**a**–**e**, From Jordan [34]) [1] (Image from Jordan and McCammon [1], © 2011, with permission from Elsevier)

Traumatic Pelvic Fracture and Crush Injuries

In a low-resource setting, road traffic accidents with pelvic fracture and associated membranous urethral disruption are common. There are also patients who experience a straddle injury to the urethra in which the urethra is crushed up against the pubic bone. In each of these types of cases, the best initial treatment is a suprapubic tube with delayed reconstruction, assuming that a gentle attempt to pass a urethral catheter was unsuccessful. With a delayed repair, an end-to-end anastomosis is typically required and patients should be positioned for surgery in an exaggerated lithotomy position. In the case of pelvic fracture, the pubic symphysis often needs partial or complete resection in order to shorten the distance between the distal urethral segment and the prostatic or membranous urethra. These operations can be performed entirely perineally, but some cases may require a combined abdominal and perineal approach (Fig. 18.10). It helps to put a metal urethral sound through the suprapubic tube tract to allow identification of the proximal segment. All of the

Fig. 18.10 Abdominal view of repair of pelvic fracture-related urethral injury. A pubectomy has been performed. The urethra has been mobilized and anastomosed to the prostate apex. The penrose drain is shown below urethral anastomosis

intervening fibrotic tissue should be resected. With some pelvic fractures in which the prostate is sheared right off of the pelvic diaphragm, there may be a sinus tract or fistula from the prostate apex. Do not mistake the fistula or sinus tract tissue for healthy urethra. It is important to dissect through this tissue all the way to the urothelium of the prostate for anastomosis. If the distal urethra needs to be anastomosed to the prostate apical urethra, then it helps to mobilize the prostate off of the rectum so that the distal gland is angled upward to connect with the distal urethral segment. Young patients have a relatively small prostate and the neurovascular bundles can be mobilized off of the prostate and rectum so that the gland is angled upward. Many of the patients with these injuries are young and successful repair is therefore quite rewarding.

Benign Prostatic Hyperplasia (BPH)

The Essentials

- *Long-standing outlet obstruction can cause irreversible bladder damage that will cause urinary symptoms that persist even after the obstruction is fixed.*
- *Surgical treatment is the gold standard even in high-income counties (HICs).*
- *Urinary tract infection (UTI) is present in 8–24% of patients with BPH*
- *Each hospital should develop a pathway or protocol to treat the BPH patients undergoing open surgery in an effort to improve surgical outcomes. The pathway should include the preoperative urinalysis and treatment of UTI if present, preoperative antibiotic prophylaxis and intraoperative instillation of povidone-iodine into the bladder.*
- *TURP is easier to perform in cases with a prostate size of less than 60 cc. Open prostatectomy is best for prostate gland sizes above 70 cc.*
- *The verumontanum of the prostate is the distal landmark and the bladder neck is the proximal landmark of resection during TURP.*
- *With a simple modification to surgical technique, suprapubic prostatectomy can be performed without the need for postoperative irrigation.*
- *High-quality catheter traction can be obtained by having an assistant hold the catheter on traction and then tie gauze tightly around the catheter right at the urethral meatus.*

BPH is common in low- and middle-income countries. As the prostate gland enlarges with aging, the enlargement can cause lower urinary tract obstructive symptoms (LUTS) and if not addressed, eventually urinary retention. In resource-poor settings, many patients have indwelling catheters for years due to retention caused by BPH. Large prostate glands are very common in Africa. Most but not all patients with a large prostate have lower urinary tract symptoms. Lower urinary tract symptoms sometimes develop in patients with a small prostate. Medical therapy for BPH can be very expensive due to need to take medication long-term. Surgical treatment is therefore the gold standard even in HICs.

The traditional determinant for the need to treat BPH is based on the degree of patient bother due to LUTS. LUTS symptoms when moderate to severe interfere with quality of life. One question to ask patients that will gauge the degree of bother is “If you had to spend the rest of your life with your urinary condition just the way it is now, how would you feel about it”? Nocturia can severely impair quality of life. Someone who has nocturia three to six times or more per night are often severely sleep deprived and may not perform as well on daytime tasks including work. Nocturia is therefore a symptom that should be addressed due to its significant impairment of quality of life. Although BPH is regarded as a benign condition, long-standing outlet obstruction may cause significant bladder wall thickening that results in an unstable bladder, prone to spasms and extreme urgency. Bladder spasms cause an urge to urinate. The patient with the unstable bladder and spasms will continue to have spasms with resulting urgency even after the obstruction is relieved. .Long-standing outlet obstruction can cause irreversible bladder damage that will cause urinary symptoms that persist even after the obstruction is fixed. The absolute indications for BPH surgery include acute urinary retention, recurrent infection, recurrent hematuria, and azotemia.

Preparing Patients for BPH Surgery

Urinary tract infection (UTI) is present in 8–24% of patients with BPH, and it is therefore important to treat preexisting UTI or administer antibiotics for prophylaxis prior to BPH surgery. A single dose of gentamycin 80–120 mg IV is usually adequate for prophylaxis, but patients with suspected UTI should be treated for several days to a week with appropriate antibiotics prior to surgery to reduce the risk of urosepsis. If the patient has an indwelling catheter due to retention, remove the catheter and place a new one after the patient has been prepped and draped for surgery in the operating room. Instill 60 ml of povidone-iodine intravesically for a contact time of 15 min via the new urethral catheter. Non-randomized studies suggest a lower rate of surgical site wound infection following povidone-iodine administration [5]. Each hospital should develop a pathway or protocol to treat the BPH patients undergoing open surgery in an effort to improve surgical outcomes. The pathway should include the preoperative urinalysis and treatment of UTI if present and should also include preoperative antibiotic prophylaxis and intraoperative instillation of povidone-iodine into the bladder to reduce the risk of surgical site infection.

Which BPH Surgery: TURP or Open Prostatectomy?

Prostate size impacts the optimal selection of BPH surgical approach. TURP is easier to perform in cases of mild to moderate BPH with a prostate size of less than 60 cc. Open prostatectomy for BPH is most appropriate and easiest to perform for prostate gland sizes above 70 cc. Those in the 60–70 cc range could be treated with either TURP or open prostatectomy. Open surgery can be performed on prostates with a size less than 70 cc, but as the size decreases, paradoxically the level of difficulty of the surgery increases. Very large prostates (>80–100 cc) are very difficult to treat with TURP but generally easy cases for open prostatectomy. Due to the high prevalence of BPH in patients who have very large prostates and often a history of acute urinary retention, open prostatectomy is one of the most common urology cases in a low-resource setting.

Advantages to open surgery over TURP include a lower retreatment rate and more complete removal of adenoma, and the open surgery avoids the risk of TUR syndrome. Disadvantages of open BPH surgery include the need for an incision, longer convalescence, and possibly more bleeding.

TURP (Trans Urethral Resection of the Prostate)

TURP was originally developed in 1920s, can be done under spinal anesthesia, and is the preferred approach for BPH with a prostate gland size less than 70 cc. Consider performing flexible or rigid cystoscopy prior to starting TURP to evaluate urethra and prostate. If a urethral stricture is present, consider a visual internal urethrotomy or perineal urethrostomy or consider open BPH surgery. In order to perform a TURP, any stricture needs management to allow a 24 Fr or greater resectoscope to be placed.

The following tips may help facilitate the TURP procedure. The verumontanum of the prostate is the distal landmark, and the bladder neck is the proximal landmark of resection. It is essential to know at all times where the resectoscope is in relation to landmarks of the bladder neck and verumontanum. The bladder neck is typically resected during the procedure, and it is essential to keep the ureteral orifices intact. Resect the tissue at the bladder neck and base first keeping the resectoscope in a stable position and then resect the prostate apex later. In the region of the bladder neck are often arterial bleeders. Be sure to control arterial bleeding as you go. If an arterial bleeder is missed, it may go into spasm and cause postoperative hemorrhage. Although there are no rules on where to start the resection and how it should progress, the surgeon should have an idea in his mind of how to progress in an orderly stepwise manner from one location to the next until the procedure is completed. One approach is to resect laterally first, then posteriorly, and finally anteriorly, starting at the base and working to the apex. Once the lateral tissue is taken down, the anterior tissue hangs in view for easier resection. Learn to recognize venous sinuses and if you encounter one, move to a different area to resect after getting control via coagulation. If there is bleeding from a venous sinus, then a higher index of suspicion for symptoms associated with TUR syndrome must be maintained. After the resection completed, hold the catheter on manual traction for 10 min and hand irrigate. If hemostasis is adequate, the catheter should irrigate clear to light pink at the end of the procedure. It is important to study the manual irrigation effluent: If bright red or streaks of bright red, suspect arterial bleeding; if effluent continually dark burgundy red, suspect venous bleeding. If the catheter effluent is bloody, reinsert the resectoscope and coagulate bleeding sites. Postoperative continuous bladder irrigation (CBI) is usually not needed.

TUR syndrome occurs in less than 2% of cases and is caused by a dilutional hyponatremia with a serum sodium less than 125 mmol/L. Risk factors for TUR syndrome include large prostate glands (>45 g), long resection time (>90 min), and the presence of multiple venous sinuses. Signs and symptoms of TUR syndrome include mental confusion, nausea, vomiting, hypertension, bradycardia, and visual disturbance. The management of TUR syndrome includes stopping the resection (it can always be completed in a delayed manner as a second stage operation), giving IV furosemide, and giving NS or 3% saline IV. It is important to correct the serum sodium slowly to avoid central pontine myelinolysis.

Open Prostatectomy for BPH

Open prostatectomy for BPH is one of the most common urologic operations in hospitals in low- and middle-income countries. Open surgery involves removing the adenomatous tissue via direct finger blunt dissection and some sharp dissection to divide fibrous tissue bands. The distal prostatic urethra at the prostate apex must be divided to allow complete removal of adenomatous tissue around it. In many low-resource hospitals, there are general surgeons who have extensive experience with open prostatectomy for BPH, and the surgical technique can be learned from one of these regional experts or a visiting urologist.

The two different approaches to open prostatectomy include the retropubic approach and the suprapubic approach. In the retropububic prostatectomy, the enucleation of the adenomatous tissue is performed through a transverse incision in the anterior prostate pseudocapsule. The advantages of the retropubic approach include excellent anatomic exposure of the prostate, direct visualization of adenoma to ensure complete removal, precise transection of urethra distally to preserve continence, clear visualization of prostate fossa after enucleation to control bleeding, and no trauma to the bladder. In the suprapubic prostatectomy, the bladder is opened twice (once through the anterior bladder wall and a second time with a circular incision of the bladder neck which then provides exposure to the adenoma below. The suprapubic approach is ideal for concomitant bladder stones and bladder diverticulum and is the best approach for patients with a large median lobe. If there is poor lighting, the suprapubic is easier because the incision in the bladder is higher in the pelvis and more accessible to the limited lighting available. The other advantage of the suprapubic approach is that the ureteral orifices are directly visible and surgeons can directly dissect median lobe tissue of the posterior bladder neck without worry about injury to the ureteral orifices.

Bleeding is often a concern with open prostatectomy. It is important to realize that the primary blood supply to the prostate is via the prostatic pedicles which are located laterally toward the base of the prostate. Therefore when enucleating adenoma, most arterial and venous bleeding will occur posterolaterally within the prostatic fossa (between the 4 and 5 o'clock region on one side and the 7–8 o'clock region on the other side). The other region where bleeding may be common is the bladder neck. Direct packing and digital pressure with focal suction will allow the open arterial and venous vessels to be seen within the prostatic fossa, and these should be directly oversewn with absorbable sutures as much as possible. Most of the larger vessels are in the base region and are easily seen. The apical region may be hard to visualize, but bleeding from this area can usually be easily controlled during the surgery with gauze packing. In general, venous bleeding can be managed with intraoperative packing and is easier to control with catheter traction postoperatively. However, arterial bleeding is best controlled intraoperatively, since it is a major cause of postoperative bleeding and harder to control with catheter traction.

Postoperative management involves a decision on whether or not to use bladder irrigation after surgery. The quality of catheters in the developing world is poor and bladder irrigation may result in bladder perforation if the inflow is open and the outflow is clotted. Continuous bladder irrigation also represents additive cost (for the irrigation fluid) and added nursing burden. With a simple modification to suprapubic prostatectomy technique, postoperative bladder irrigation is not needed. Okorie conducted a study at Banso Baptist Hospital in Cameroon of patients undergoing suprapubic prostatectomy in whom 43 had irrigation and 39 had suprapubic prostatectomy with surgical modification and no irrigation [16]. Clot retention occurred in 11 patients with irrigation compared to 2 without irrigation, ($p < 0.01$). Patients in the irrigation and no irrigation groups had similar prostate size and rates of retention. The authors concluded that postoperative irrigation was not needed. The modification to suprapubic prostatectomy technique included placement of a running suture from 1 o'clock position to 11 o'clock position on the bladder neck (to oversew any bladder neck vessels), suturing the bladder neck to the prostatic fossa with 3–0 polyglactin suture, and then narrowing of the bladder neck with additional interrupted sutures vertically starting from the 12 o'clock position to the diameter of the surgeon's index finger (Fig. 18.11a, b). It is important not to close the bladder neck too tight. It should be in the range of 28–32 French (narrow enough that the catheter balloon does not fall into the prostatic fossa, but not so narrow that the patient develops a postoperative bladder neck contracture). With the catheter on traction, the bladder and prostatic fossa are separated so there is less risk that that blood from the fossa will flow into the bladder and cause clot retention. With this technique, the bladder neck parachutes somewhat into the prostatic fossa, helping to put direct pressure on the pedicle vessels, and the technique may also cause some

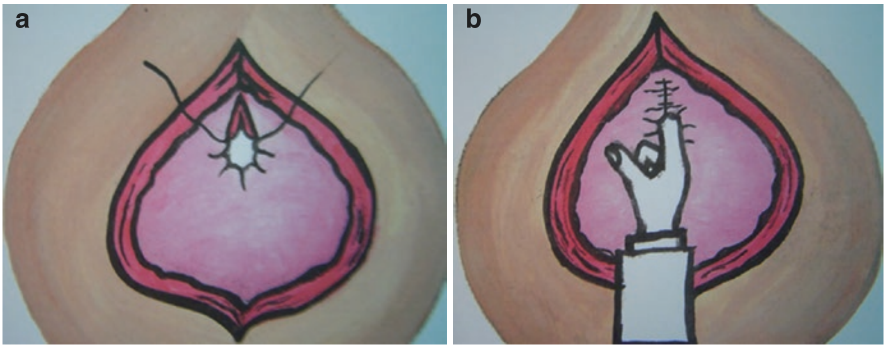

Fig. 18.11 (**a**) Running suture from the 1 o'clock to the 11 o'clock position, suturing the bladder neck edge to the prostatic capsule. (**b**) Bladder neck narrowed up to the diameter of the surgeon's index finger [16] (Reprinted from Okorie et al. [16], © 2010, with permission from Elsevier)

kinking of the prostate pedicle vessels to reduce risk of postoperative clot retention. In a separate report of 47 patients operated on with this technique, the mean drop in blood hemoglobin was 1.06 mg/dL. Only three patients had clot retention, and these clots were easily flushed out. None of the patients required a blood transfusion [17].

In spite of optimizing surgical technique, some patients will have postoperative bleeding or clot retention. If clot retention occurs, the clots need to be evacuated from the bladder with manual irrigation. It helps to put the catheter on traction during irrigation and securing the catheter on traction after all the clots have been removed. Another tip is to put 50 cc of water in the urethral catheter balloon and put the catheter on good traction. Most hospital tape in the developing world is poor quality so it is hard to get good catheter traction with tape. A simple method for getting better quality traction is to have an assistant hold the catheter on traction and then tie gauze tightly around the catheter right at the urethral meatus. When the assistant releases the traction, the patient's penis may distort somewhat, but good traction is achieved. Traction may be needed for 12–24 h to allow vessels in the prostatic fossa to seal. Continuous bladder irrigation is another recognized way of treating postoperative bleeding. Continuous bladder irrigation can be administered via a three-way catheter or two two-way catheters (inflow via urethral catheter, outflow via suprapubic tube). If bleeding persists, taking the patient back to the operating room for re-exploration under anesthesia to control bleeding may be necessary. If the patient is being re-explored and it is difficult to control bleeding due to coagulopathy or other factors, consider packing the patient tightly with gauze, place a suprapubic tube, close, and take the patient to an appropriate place in the hospital for resuscitation. The patient could then be taken back to the operating room 2 days later to remove the packing and close any defects in the urinary tract.

Vesicovaginal (VVF) and Ureterovaginal Fistula

The Essentials

- *Most fistulas in the developing world are obstetrical or postsurgical in etiology and require surgical correction.*
- *Excision of the fistula tract is advisable in most post-hysterectomy surgical fistulas.*
- *The fistula tract should be incorporated into the repair of most obstetrical fistulas.*
- *Flaps may improve the success rate of fistula repair. Martius flap is commonly used during obstetrical fistula repair. Omental pedicle flap can be used for post-hysterectomy fistula repair with abdominal approach.*
- *Ureteral fistulas can be repaired with simple ureteral reimplantation.*

Fistulas in the developing world are vastly different from those in modern countries and a major cause of patient suffering. The most common causes of urinary tract fistula in the developing world are obstructed labor and iatrogenic related to surgical complication following a pelvic operation, most commonly a hysterectomy. Patients with obstetrical fistulas are often shunned by their families and communities, leaving these patients destitute. Patients with postsurgical fistulas also suffer economically, having to pay for an operation to correct an injury that occurred during their initial surgery.

Vesicovaginal Fistula

Presentation

VVF presents as constant urine drainage per vagina. With a moderate to large VVF, there is no voiding due to the high volume constant leak. A tiny VVF will present with some voiding with low volume and constant urine leak. Patients do not report pain. Postsurgical VVF presents as constant urine leak 1–3 weeks after urethral catheter removal. Following hysterectomy the diagnosis of VVF can be delayed as the vaginal discharge may be attributed to recent surgery. If there is concern about fistula, some of the drainage can be collected and sent for a creatinine test. If the drainage creatinine is above the serum creatinine, then this is diagnostic for urine leak. Up to 12% of postsurgical VVFs have an associated ureteral injury or ureterovaginal fistula.

Obstetrical VVFs involve an ischemic injury to the bladder and vagina as a result of compression of these structures against the bony pelvis. It is important to recognize that obstetrical VVFs are part of an obstructed labor complex. Depending on the extent of ischemic injury to pelvic structures, patients may have urethral loss, stress incontinence, hydronephrosis, renal failure, rectovaginal fistula, rectal atresia, anal sphincter incontinence, cervical destruction, amenorrhea, pelvic inflammatory disease, secondary infertility, vaginal stenosis, osteitis pubis, and foot drop.

Physical Examination

Both bimanual and bivalved speculum examination should be performed to determine the size, location, and number of fistulae. VVFs due to obstructed labor are distal and easy to both palpate and visualize. Post-hysterectomy VVFs are high, located on the anterior vaginal wall at the level of the vaginal cuff.

Confirmatory Dye Testing

To evaluate for VVF, instill blue dye into the bladder via a catheter and either observe the vagina directly for blue-tinged leak or pack the vagina with gauze to look for blue stain on the gauze. If the packing remains dry and no leak is seen, consider the presence of a ureterovaginal fistula. A ureterovaginal fistula is confirmed if a repeat vaginal packing test is positive for blue stain after administration of intravenous indigo carmine.

Additional Testing

Serum creatinine should be obtained to assess renal function. An abdominal ultrasound should be obtained to assess the upper urinary tracts. The majority of patients with a ureterovaginal fistula have ipsilateral upper tract dilation or hydronephrosis on the side of the fistula. Some large VVFs due to obstructed labor have bilateral hydronephrosis. Cystoscopy, cystogram, intravenous pyelogram (IVP), CT scan, and MRI are optional tests that are not needed in the majority of patients. The fistula should be biopsied in anyone with a history of pelvic malignancy.

Management

For patients with a small postsurgical fistula, a trial of indwelling urethral catheter for 2–3 weeks can be conducted. If the patient is dry with the catheter in place, there is a better chance of the fistula spontaneously closing. Coagulating the fistula tract with an electrode or using fibrin sealant has also treated tiny postsurgical fistulas.

Most patients in the developing world are going to need surgery to correct the fistula. The best chance to repair the fistula is the first attempt. For patients with VVF due to obstructed labor, there may be benefit to waiting 3–6 months to allow ischemic demarcation and inflammation to subside. Postsurgical fistula can be managed early, and either an early or late repair can have an excellent outcome.

One issue at the time of surgery is whether or not to excise the fistula tract. In postsurgical VVFs, excision of the tract results in clean, well-vascularized viable edges which can be easily approximated. One disadvantage to excision of the fistula tract is that it results in larger soft tissue defects. In most obstetrical fistulas, especially moderate to large ones, the best approach is to incorporate the fibrous ring into the closure. It is important to recognize that obstetrical fistulas are ischemic in their etiology, and trying to resect the fistula to “healthy” tissue could leave a huge soft tissue defect. Another decision for the surgeon is whether to take an abdominal or vaginal approach to repair. An abdominal approach will offer excellent exposure to postsurgical fistulas that are high and near the vaginal cuff and is the approach of choice for a ureterovaginal fistula or a fistula requiring ureteral reimplantation. Tissue flaps to consider with an abdominal approach include an omental pedicle flap or rectus abdominus rotational flap. An abdominal incision has poor exposure for obstetrical fistulas that are distal and near the bladder neck/distal vagina. In contrast, the vaginal approach provides excellent exposure to distal fistulas near the bladder neck and can be used for many fistulas not requiring ureteral reimplantation. The labial fat pad (Martius flap) and gluteal skin or gracilis myocutaneous flap can be used with the vaginal approach. A combined abdominal and vaginal approach may

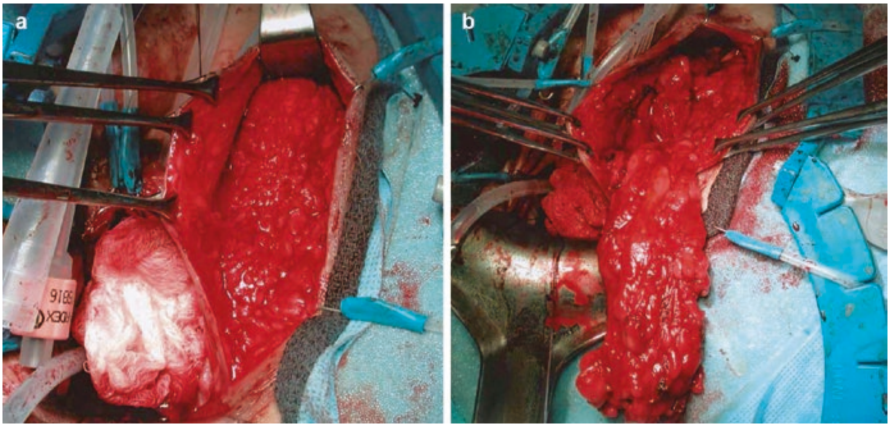

Fig. 18.12 Harvesting of a Martius flap. (**a**) The incision is made in the labia. (**b**) A large flap may be obtained [20] (Image from Rovner [20], © 2011, with permission from Elsevier)

be needed for huge fistulas in which there is loss of the urethra. Some highly experienced fistula surgeons can repair the majority of fistulas vaginally, which has a quicker recovery for patients. Most patients will not make their way to a dedicated fistula hospital, so the surgeon should pick the approach (abdominal or vaginal) that will yield the best results in their hands.

Flaps are exceedingly important and should be considered in all obstetrical VVFs and moderate to large postsurgical VVFs. In a non-randomized study, Evans reported a 100% success rate of VVF repair with a flap compared to a 63% rate without a flap [18]. Eilber reported a 96% success rate using peritoneal flaps and a 97% success rate using Martius flaps in 208 patients undergoing VVF repair [19]. Although there are no randomized studies to document the benefit of flaps, the overall risk of serious complications with flaps is exceedingly low, and any intervention to improve successful VVF repair on the first attempt should be considered.

The Martius flap (labial fat pad flap) should be considered in all obstetrical VVFs. This flap consists of fat and connective tissue, and its blood supply is both superior (from branches of the external pudendal artery) and inferior (by posterior labial vessels of the internal pudendal artery). The flap may be divided at either its most superior or inferior margin (leaving either superior or inferior blood supply intact). (Figure 18.12) demonstrates the harvest of a Martius flap based on the inferior blood supply. The flap is then tunneled underneath the vaginal wall to cover the site of bladder closure (Fig. 18.13).

Repair of Specific VVFs

For most surgeons who do not have considerable vaginal surgery experience, the simplest approach to repair a VVF is a transabdominal transvesical approach

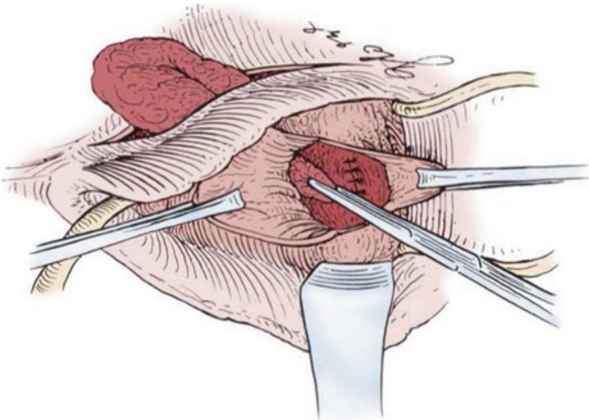

Fig. 18.13 Tunneling of the Martius flap (From Raz [35]) [20] (Image from Rovner [20], © 2011, with permission from Elsevier)

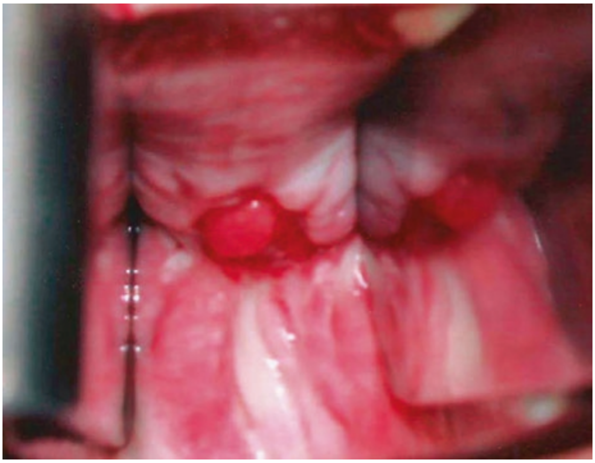

Fig. 18.14 Vesicovaginal fistula (VVF) on physical examination. A large VVF is seen at the apex of the vagina after hysterectomy. The VVF in this image is seen as reddish pink bladder mucosa prolapsing into the vagina. Handheld Heaney right-angled retractors provide lateral retraction in this image [20] (Image from Rovner [20], © 2011, with permission from Elsevier)

(Figs. 18.14 and 18.15). The bladder incision can be made much lower than is shown in the figure, and it is helpful to continue the posterior incision in the bladder right to the site of the fistula. It is also helpful to put a flap of omentum or peritoneum in-between the bladder closure and the vaginal closure.

Obstetrical VVFs

Although each VVF is unique, a common obstetrical VVF is shown in Fig. 18.16. The urethra is intact and the fistula is at the bladder neck. Since these fistulas are distal, they are best repaired transvaginally. Steps in the repair are very similar to Fig. 18.17 which depicts the steps in repairing a similar size post-hysterectomy fistula. A Foley catheter is placed in the fistula for traction. The vaginal wall is incised 1–2 mm from

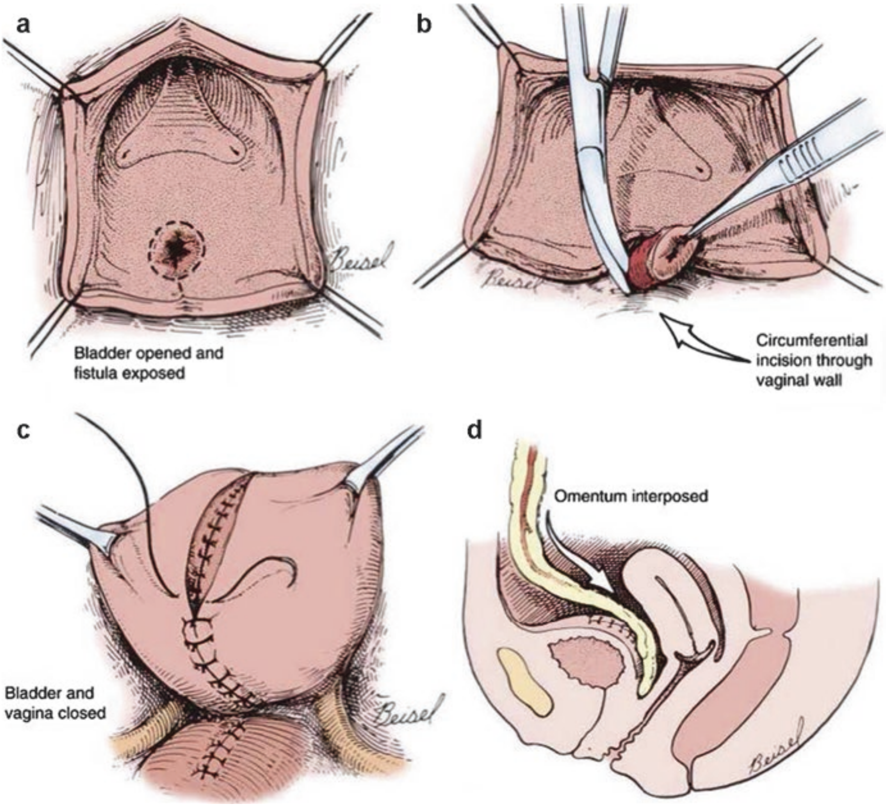

Fig. 18.15 Diagrams of suprapubic repair of vesicovaginal fistula (VVF). (**a**) The bladder opened and bivalve down to the level of the VVF. (**b**) The VVF tract is excised. (**c**) After closure of the vagina, the bladder is closed in multiple layers. (**d**) Omentum is interposed between the bladder and vaginal closures (From Ganabathi et al. [36]) [20] (Image from Rovner [20], © 2011, with permission from Elsevier)

the fistula leaving the fibrous ring. The vaginal walls are dissected circumferentially around the fistula. It is important to mobilize the vaginal wall extensively. I typically close the urinary tract in one layer and test the bladder by distending the bladder via a urethral catheter. A Martius flap is mobilized and tunneled under the vaginal wall to cover the bladder closure. The vagina is then closed in one layer on top.

In severe VVFs, there can be complete urethral loss (Fig. 18.18). A combined abdominal and vaginal approach is necessary to correct these complex fistulas. Since there is no way to reconstruct a functional urethra, I would favor primary bladder closure, placement of an omental pedicle flap to separate the bladder closure from the vaginal closure, and diversion of the bladder with a Yang-Monti catheterizable reconstruction (Figs. 18.19, 18.20) [21, 22]. Other options for these

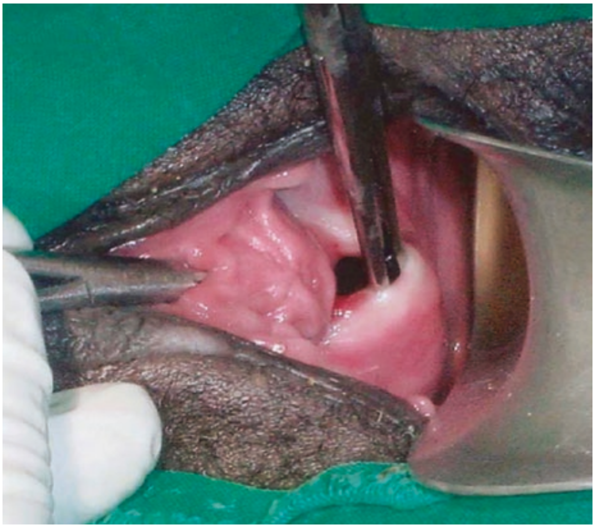

Fig. 18.16 Urethrovaginal fistula at the bladder neck from obstructed labor. A hemostat is seen entering the urethral meatus (Courtesy of Mark Morgan, M.D., Department of Obstetrics and Gynecology, Hospital of the University of Pennsylvania, Philadelphia, PA) [20] (Image from Rovner [20], © 2011, with permission from Elsevier)

complex fistula include ileal conduit or ureterosigmoidostomy. Before considering ureterosigmoidostomy, it would be very important to check the integrity of the rectal sphincter which can be compromised in a fistula patient. This can be done by filling the rectum with 180–240 cc of water to see if the patient can hold it. Ureterosigmoidostomy has a risk of adenocarcinoma at the ureteral anastomosis, but the latency period on the cancer is about 20 years. Patients should undergo annual colonoscopy starting about 5–6 years later.

Post-VVF Leakage

If a patient has urine leakage following a VVF repair, there are two main causes. In some patients, the VVF repair is intact, and the leakage can be due to sphincteric insufficiency. Such a patient may benefit from a urethral sling or suspension procedure. The other cause is recurrence of the VVF.

Repair of Ureterovaginal Fistulas

These fistulas most commonly occur after hysterectomy and may be difficult to see vaginally. If a dye test of the bladder is negative, a ureteral fistula should be

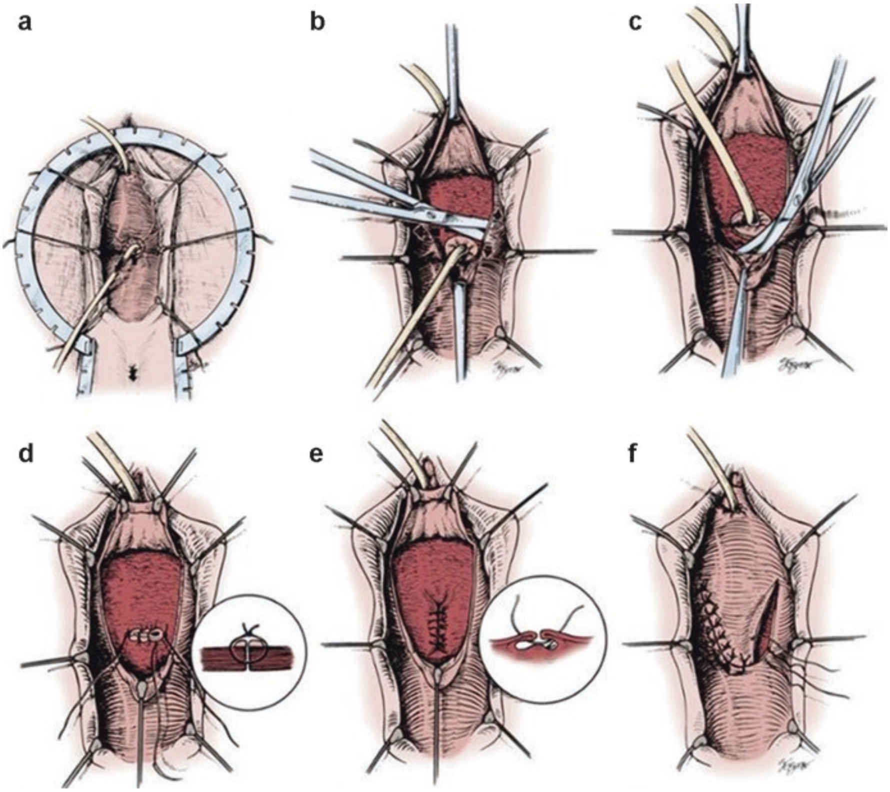

Fig. 18.17 Technique of vaginal repair of a post-hysterectomy vesicovaginal fistula (VVF). (**a**) Retraction including ring retractor, vaginal speculum, and Foley catheter in the VVF tract. (**a**) Foley catheter is seen in the VVF tract providing traction on the vaginal cuff. (**b**) Mobilization of anterior vaginal wall flap. Lateral flaps are developed as well, thereby isolating the VVF tract. (**c**) Mobilization of posterior-vaginal wall flap. (**d**) Initial layer of closure is performed without excising the edges of the fistula tract. (**e**) The perivesical fascia is closed with Lembert-type sutures. This line of closure is perpendicular to the initial suture line. (**f**) The vaginal wall flaps are advanced to avoid overlapping suture lines. (From Ganabathi et al. [36]) [20] (Image from Rovner [20], © 2011, with permission from Elsevier)

considered. Many of these patients have ipsilateral hydronephrosis on the side of the fistula, and this can be seen on ultrasound. These fistulas are very simple to repair by reimplanting the ureter to the bladder. The ureter is divided above the fistula and the distal stump of the ureter is tied. The ureter is then spatulated and sewn to the bladder. In a patient with an isolated ureterovaginal fistula, there is no need to dissect out the fistula itself.

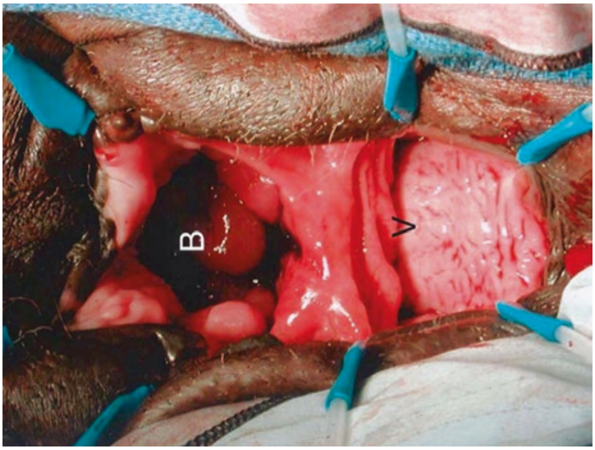

Fig. 18.18 Severe complete erosion of the urethra secondary to chronic indwelling urinary catheter. This patient with advanced multiple sclerosis underwent surgical bladder neck closure and ileovesicostomy (ileal chimney). *B* bladder, *V* vagina [20] (Image from Rovner [20], © 2011, with permission from Elsevier)

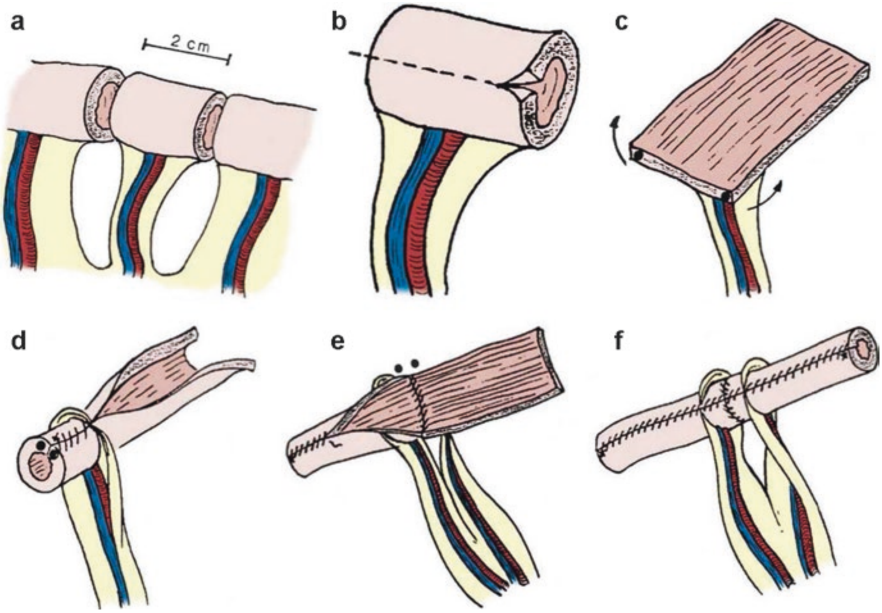

Fig. 18.19 (**a**) A 2- to 3- cm segment of terminal ileum is isolated on it blood supply. (**b, c**) The tubular segment is opened approximately one fourth of the way up one side. This results in a well-vascularized rectangular plate. (**d**) The rectangular tube is now closed over a catheter with a running absorbable suture. (**e, f**) Two Adjacent segments can be joined together to create one long tube (From Monti et al. [37]) [21] (Image from Benson et al. [21], © 2007, with permission from Elsevier)

Urinary Calculi

The Essentials

- *Most stones >6 mm will not pass.*
- *Stones can migrate both proximally and distally and some may pass spontaneously. It is therefore helpful to repeat imaging right before surgery to confirm the stone position.*
- *Get proximal and/or distal control of the urinary tract, so that the stone does not dislodge and migrate out of the operative field.*
- *For stones at the UVJ, a transvesical approach opening the bladder and then opening the ureteral orifice is the simplest approach.*
- *Ultrasound is the best modality for intraoperative stone localization.*
- *Briefly clamping the renal artery makes the kidney softer and may improve the ability to palpate a stone within the kidney.*
- *All renal parenchymal dividing procedures should be done with vascular control and renal hypothermia should strongly be considered.*
- *Renal cooling protects the kidney if an ischemic approach is needed. All methods of cooling are equally effective, and ice slurry may be the most readily available method of renal cooling in a low-resource setting. Sterile plastic bags, water, hammer, chisel, and a freezer are all that is needed.*
- *After renal artery clamping, pack the kidney packed in ice for 12 min – the time it takes for central cooling.*
- *Transient occlusion of the posterior renal artery branch (followed by optional administration of intravenous indigo carmine or methylene blue) provides clear delineation of the relatively avascular boundary between the anterior and posterior renal artery segments. This plane may also be demonstrated with intraoperative ultrasound.*

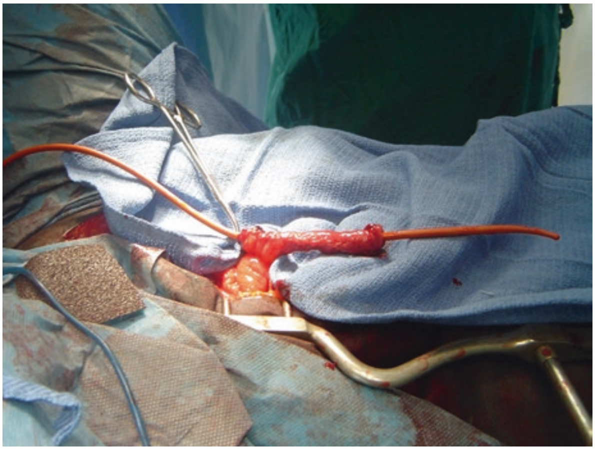

Fig. 18.20 A picture of a completed Yang-Monti bowel segment. The mesenteric side is then anastomosed end on to the bladder and the distal end is brought out as a catheterizable stoma [22] (Reprinted with permission from Okorie and Pisters [22])

Table 18.1 Common urinary calculi

Stone composition	Frequency (%)	Plain X-ray appearance	Predisposing factors
Calcium oxalate with/ without calcium phosphate	75%	Opaque	Hypercalciuria hyperuricosuria hyperoxaluria
			Hypocitraturia
Pure calcium phosphate	9%	Opaque	Renal tubular acidosis medications: acetazolamide
Magnesium ammonium phosphate (struvite)	8%	Opaque	Infection with urea-splitting bacteria
Uric acid	6%	Lucent	Hyperuricosuria
			Acid urine
Cysteine	2%	Opaque	Cystinuria
Indinavir	Rare	Lucent	HIV patient receiving Indinavir

In a developing world setting, urinary calculi can be a significant source of morbidity and mortality. Sepsis and loss of renal function can be life-threatening complications, especially if dialysis is not available or affordable. The most common types of urinary stones are shown in Table 18.1. Uric acid stones are not visible on plain x-ray, but are visible on CT imaging. The anti-retroviral drug Indinavir can cause urinary stones that are radiolucent and usually undetectable on CT. Magnesium ammonium phosphate stones (Struvite) are related to urea-splitting organisms including Proteus, Pseudomonas, Kebsiella, and Staphylococcus. Ultrasound is the most commonly used modality to demonstrate urinary stones in a low-resource hospital setting.

Preoperative Evaluation of the Stone Patient

The three main considerations when seeing a stone patient include: (1) defining the location, nature and configuration of the stone, (2) determining the ipsilateral and contralateral renal function, and (3) assessing the patient for potential causes of the stone. Patients should undergo a laboratory evaluation that depending on availability should include serum calcium, phosphorus, uric acid, creatinine, urea nitrogen, and electrolytes. These basic laboratory tests can identify patients with severe metabolic derangements such as hypercalcemia, hyperuricemia, and acidosis and may suggest underlying causes for stone formation such as hyperparathyroidism or renal tubular acidosis. Many patients will have a normal laboratory evaluation. A urinalysis should be obtained and if positive, a urine culture. A renal ultrasound should evaluate both kidneys, and if the serum creatinine is normal and the contralateral kidney appears normal on ultrasound, then the patient can be reassured they have good baseline renal function. An IVP is an alternative test to the ultrasound and gives better localization of mid to distal ureteral stones. The IVP is also an excellent assessment of contralateral renal function.

Open Stone Surgery

Since modern treatments of stone disease are not readily available in low-resource hospital settings, open stone surgery dating back centuries remains the mainstay in stone management. A stone less than 5 mm has a good chance of spontaneous passage. The larger the stone, the longer it will take to pass and the less likely spontaneous passage will occur. Most stones >6 mm will not pass. Stones can migrate both proximally and distally and since some may pass spontaneously, it is helpful to repeat imaging right before surgery to confirm the stone position prior to incision so that the incision is appropriate for the stone location.

Stones in the Ureter, Bladder, or Urethra

Since it is hard to tell whether a stone is fully impacted and immobile based on imaging, it is important to get proximal and sometimes distal control of the urinary tract, so that the stone does not dislodge and migrate out of the operative field. For instance if a stone is located at the ureterovesical junction (UVJ), it is helpful to identify the ureter at the pelvic brim and put an occlusive vessel loop on it. This prevents a non-impacted stone from migrating back up to the kidney. In the case of a stone located at the ureteropelvic junction (UPJ), an obstructing vessel loop could be put on the upper ureter. For stones at the UVJ, a transvesical approach opening the bladder and then opening the ureteral orifice to expose and remove the stone is the simplest approach. It is important to open up enough of the ureter to remove the stone as atraumatically as possible. For stones located in the ureter above the UVJ, get proximal and distal control of the ureter, then open the ureter anteriorly and longitudinally (length wise) to remove the stone. After the stone is removed, close the ureter with 5–0 absorbable sutures. Take small bites of ureter and sew urothelium to urothelium to prevent a stricture. Wear magnifying loupes and use a headlight if available. Bladder stones are easily removed. The bladder can be closed in one layer with absorbable 2–0 or 3–0 suture. Stones in the urethra can be removed cystoscopically with grasping forceps. If no cystoscope is available, then the stone can be pushed back into the bladder with a catheter or urethral sound and then removed transvesically. It would be rare for a stone to get impacted in the anterior urethra, but this could happen in a patient with an unrecognized urethral stricture. In such a case, it could be handled similar to the ureteral stone, by opening the urethra and then closing it directly with 5–0 absorbable sutures. If the urethral stricture is 14 French or larger, it does not need to be repaired at the same time.

Stones in the Kidney

Stones in the kidney, especially those in a minor calyx are challenging to remove with open surgery. Knowledge of both the collecting system anatomy and the arterial supply to the kidney are essential in deciding a surgical approach. The number of calyces in a kidney is usually 8 but can vary from 4 to 12. While a single calyx may drain one papilla, a composite calyx may drain multiple papillae. The polar calyces vary in size and shape and are often compound. There are usually two to three infundibula that drain the calyces and empty into the renal pelvis (Fig. 18.21). Renal arteries are end arteries so that ligating or injuring a renal artery branch will result in loss of some renal parenchyma. Renal vein branches are collateralized so that ligating a renal vein branch does not result in loss of functional renal parenchyma. There is significant variation of renal artery branch anatomy. There are four renal artery vascular segments: the upper and lower pole, and then the anterior and posterior kidney (Fig. 18.22). The arterial branch to the upper pole often arises outside of the renal parenchyma and can usually be easily isolated. The lower pole branch also typically arises outside of the renal parenchyma and often descends in front of the renal pelvis before dividing into anterior and posterior branches. The most clinically important relationship is the relatively avascular border between the anterior and posterior vascular renal artery segments. Importantly, this relatively avascular plane is not at the mid-axis (lateral renal border of the kidney), but is slightly posterior to the mid-axis. This relatively avascular plane is the plane of dissection for anatrophic nephrolithotomy (splitting the kidney open to access the

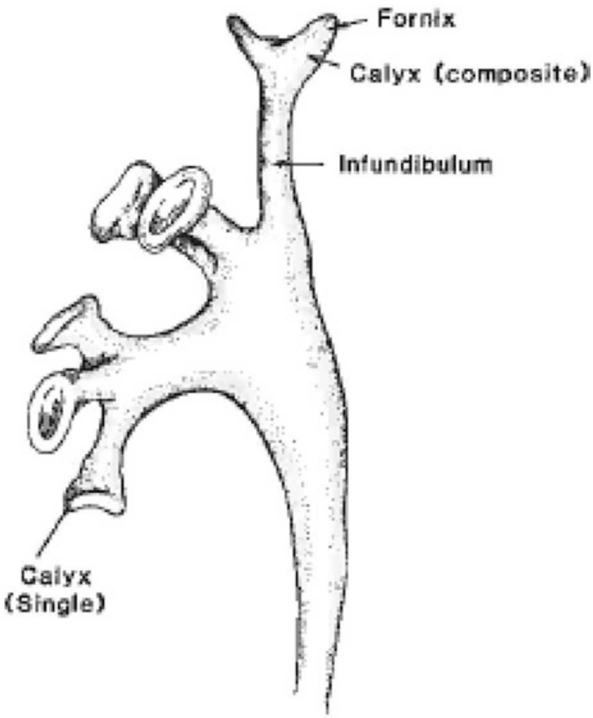

Fig. 18.21 Anatomy of the intrarenal collecting system [23] (Image from Spirnak and Resnick [23], © 1987, with permission from Jay Gillenwater)

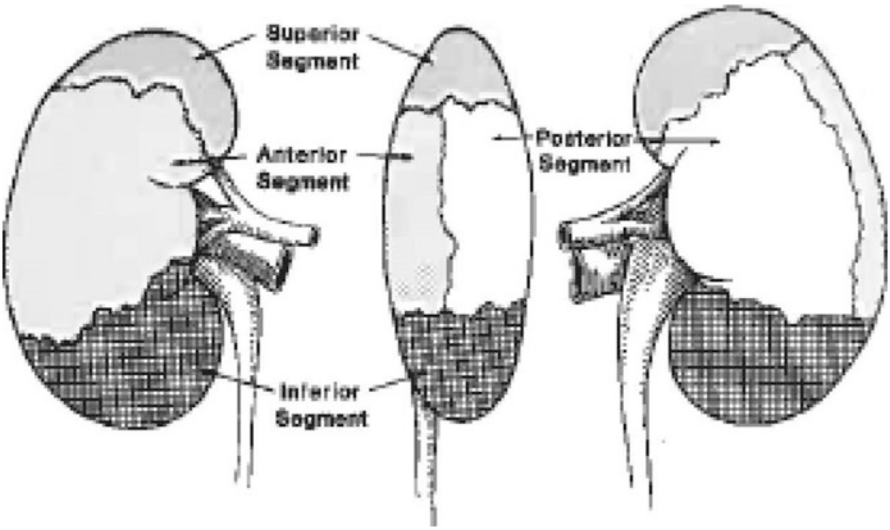

Fig. 18.22 Vascular renal segments [23] (Image from Spirnak and Resnick [23], © 1987, with permission from Jay Gillenwater)

calyces and pelvis in a transparenchymal approach. The posterior branch of the renal artery usually runs posterior to the renal pelvis in the upper aspect of the renal hilum. In more than half the kidneys, the posterior segment is the first branch of the main renal artery. Transient occlusion of this branch followed by administration of intravenous indigo carmine or methylene blue provides clear delineation of this segment and help to identify the relatively avascular boundary between the anterior and posterior renal artery segments. Another method of identifying this plane is to use color Doppler ultrasound to look for the avascular boundary. This boundary allows segmental division of the kidney between the anterior and posterior divisions, but also between the posterior division and the upper and lower polar segments.

Surgical Approach to the Kidney

Although there are many different surgical approaches to the kidney, the flank approach is the best approach to operate on the kidney for a calyceal stone or a complex stone involving multiple calyces (staghorn), when division of the renal parenchyma is anticipated. This retroperitoneal approach leaves the peritoneum intact, thereby facilitating cooling of the kidney with ice without cooling of the abdominal contents (Fig. 18.23). After intubation, the patient is flipped into a flank position with the kidney rest positioned just slightly above the iliac crest. The patient's back should parallel the edge of the operating table and the bottom leg is flexed at the hip and knee and the upper leg is extended. Pillows are placed between the legs and an axillary role is placed under the lower axilla to avoid brachial plexus

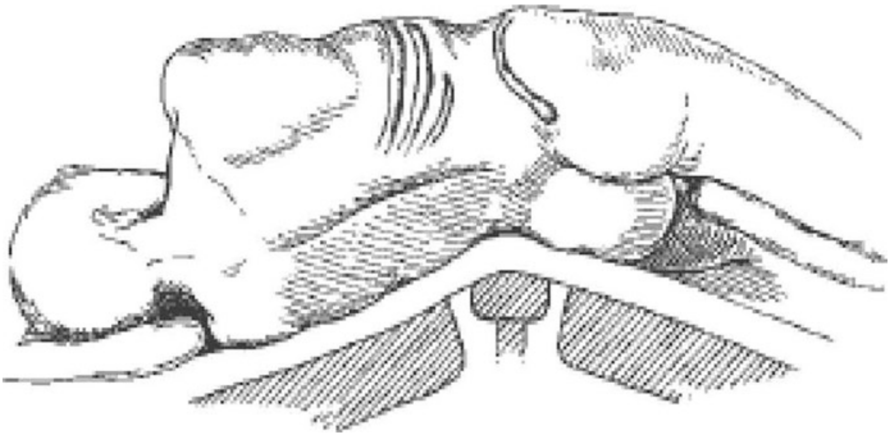

Fig. 18.23 Patient in standard flank position with the kidney rest elevated [23] (Image from Spirnak and Resnick [23], © 1987, with permission from Jay Gillenwater)

injury. The kidney rest is slowly elevated and the table flexed to put the upper flank on tension. The upper arm is supported on an armboard. The patient is secured to the operating room table with a seat belt and tape.

An 11th rib incision on the left or a 12th rib incision on the right usually facilitates excellent exposure of the renal hilum. The ribs are resected posteriorly and the retroperitoneum is entered through the bed of the rib. It helps to mark out the incision with a marking pen and to make 6 or 7 marks perpendicular to the planned incision to get the skin correctly lined up on the closure. It is also important to avoid suture entrapment of the intercostal nerve at the lower margin of the rib bed. The kidney rest is lowered and the table taken out of flexion prior to closing. A drain is used in all cases since the collecting system is opened.

Intraoperative Localization of Renal Stones

In a low-resource hospital setting, the best modality to localize the stone will be intraoperative ultrasound which can also give information on depth of the stone and AP orientation. Intraoperative ultrasound can localize fragments as small as 2–3 mm [24]. If available, intraoperative fluoroscopy may help, but unless someone had extensive experience with fluoroscopic localization, ultrasound may be more useful. Palpation of the kidney is useful as some stones can be felt. One maneuver to improve the ability to palpate a stone is to briefly clamp the renal artery. The kidney will become softer and that may make the stone easier to palpate. Additionally, a flexible cystoscope can be inserted into the renal pelvis through a small incision in the renal pelvis. The flexible cystoscope will allow visualization of infundibula, but is too large to pass into a calyx. If available a flexible ureteroscope can be advanced through the pyelotomy incision and will pass into the calyces.

The Importance of Renal Hypothermia

The kidney is highly metabolically active and will only tolerate 20–30 min of warm ischemia before progressive loss of nephron function occurs. It is well known that renal cooling during periods of ischemia inhibits the metabolic activity of the renal tubular cells, decreases oxygen consumption, and preserves renal function [25]. Lowering the core renal temperature to a temperature of 15 °C or lower provides maximal protective benefit. All methods of cooling are equally effective, and ice slurry may be the most readily available method of renal cooling in a low-resource hospital setting. In some countries, IV fluids come in a thick sterile inner bag that is covered by an outer bag. If this is available, then just freeze the IV bag (with the original outer bag in place). Open the outer bag and deliver the frozen inner IV bag onto the field. It will be necessary to have an orthopedic hammer and chisel (any sterile hammer and chisel will do) and a strong metal bowl on a strong table so that the ice block can be broken up into small pieces. It is best to hammer the ice while it is still contained in the frozen bag. After the bag is extensively hammered, open the bag and chisel ice into small pieces. An ice slurry (mixture of crushed ice with a little water) works the best. If sterile IV bags are not available, you could create your own by putting IV fluid into a sterile plastic bag and put the first sterile bag into a second sterile bag. It takes time to hammer and chisel the big ice block into smaller pieces, so have an assistant start preparing the ice before making the skin incision. Two liters of ice may be needed for the longest cases (such as anatrophic nephrolithotomy).

If a hypothermic parenchymal splitting stone extraction is planned, it is important to perform all the dissection of the kidney and renal hilum before clamping the main renal artery. Bulldogs work best because they are small and don't obstruct the field of view. The renal vein should be skeletonized, but clamping of the renal vein is optional. If significant venous bleeding is encountered after dividing renal parenchyma, then a bulldog could be put on the vein also. It is also important to demarcate on the renal capsule the planned incision for the surgery. Use a series of electrocautery marks since a marking pen will wash off in the ice. Give 12 g of mannitol and 20 mg of furosemide 5 min before renal artery cross clamping and readminister these drugs after the cross clamp is removed. Put an intestinal bag (or any other sterile plastic bag) around the kidney and synch it around the hilum to help contain ice and reduce risk of the patient becoming hypothermic. After the renal artery is cross clamped, fill the entire intestinal bag with ice packing the ice around the kidney and putting ice all the way up to skin level. Leave the ice undisturbed for 12 min – the time it takes for central cooling of the kidney. If you do not wait the full 12 min, then the central part of the kidney may still be warm. Remove only enough ice to do the surgery. Keep ice slurry on as much kidney tissue as possible during the surgery. After removing the stones, close the collecting system with 4–0 or 5–0 absorbable suture. Oversew any open arteries or veins with 5–0 absorbable suture. Magnifying loupes, a good headlight, and a small grafting type sucker will greatly help this part of the procedure. The renal parenchyma itself does not hold sutures well, but the vessel walls themselves will hold the suture. After all open vessels are secured, remove the ice and renal artery cross clamp. As much as possible, try to avoid cross clamping the renal artery a second time, since this can result in greater reperfusion injury to the kidney. Hold direct pressure on any new bleeding points and systematically sew them up. Finally close the renal capsule and place a drain before closing the flank. All parenchymal dividing procedures should be done with vascular control and hypothermia should strongly be considered in these cases.

Specific Renal Stone Operations

Pyelolithomy

This operation is shown in Fig. 18.24. It is important to put an occlusive vessel loop on the upper ureter to prevent downward stone migration before approaching the pelvis itself. The incision in the renal pelvis should be large enough to remove the

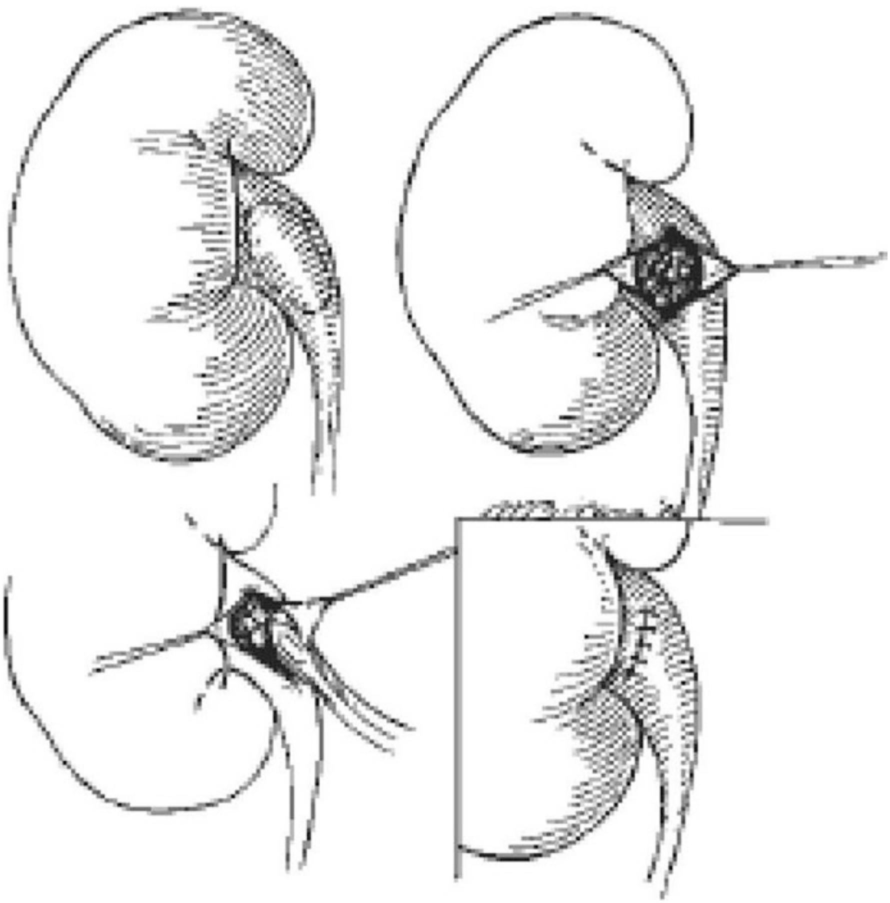

Fig. 18.24 Technique of simple pyelolithotomy [23] (Image from Spirnak and Resnick [23], © 1987, with permission from Jay Gillenwater)

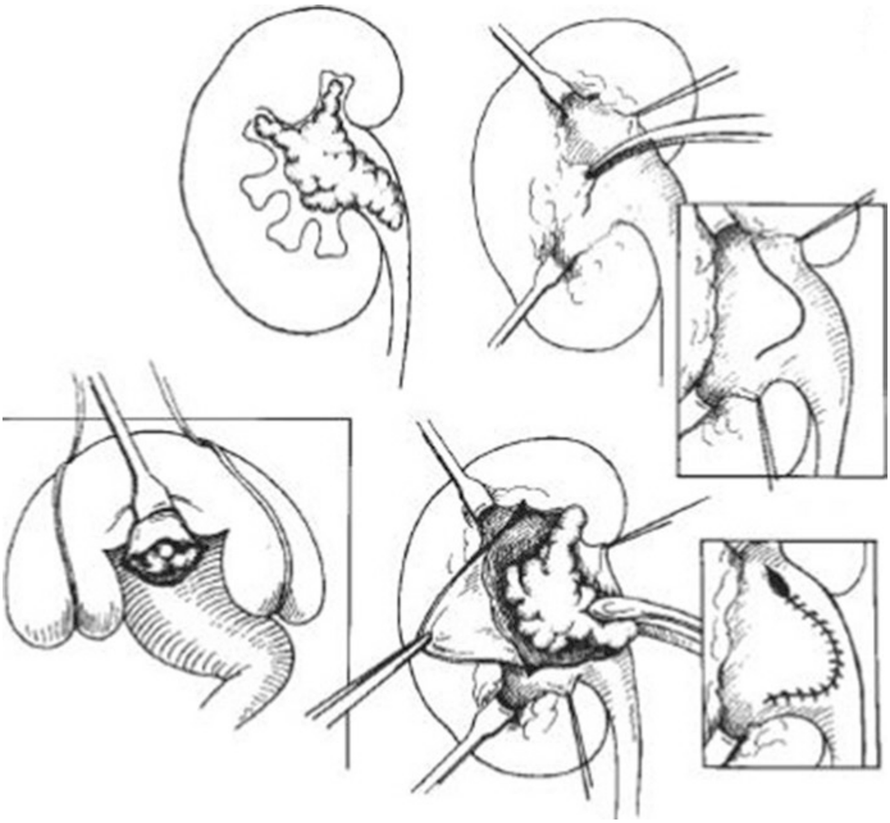

Fig. 18.25 Technique of extended pyelolithotomy [23] (Image from Spirnak and Resnick [23], © 1987, with permission from Jay Gillenwater)

stone without tearing the urothelium. The incision can be carried part way around the renal pelvis if the stone is large. After the stone is removed, irrigate the renal pelvis thoroughly to remove any tiny debris.

Extended Pyelolithotomy

This operation is indicated for renal pelvic stones extending into an infundibulum (Fig. 18.25). Control of the main renal vessels is obtained in case of vascular injury. The renal pelvis is exposed and the adventitia between the renal parenchyma and the collecting system is incised to expose the renal sinus. A small vein retractor or peanut is used to bluntly dissect the parenchyma off the collecting system. Note that the posterior branch of the renal artery will run along the posterior renal pelvis and will need to be retracted in order to avoid injury. A curved pyelotomy incision is made, and it helps to remove the pelvic vertex of the stone followed by the most easily mobilized infundibular extension [26]. After stone removal, use a nasal

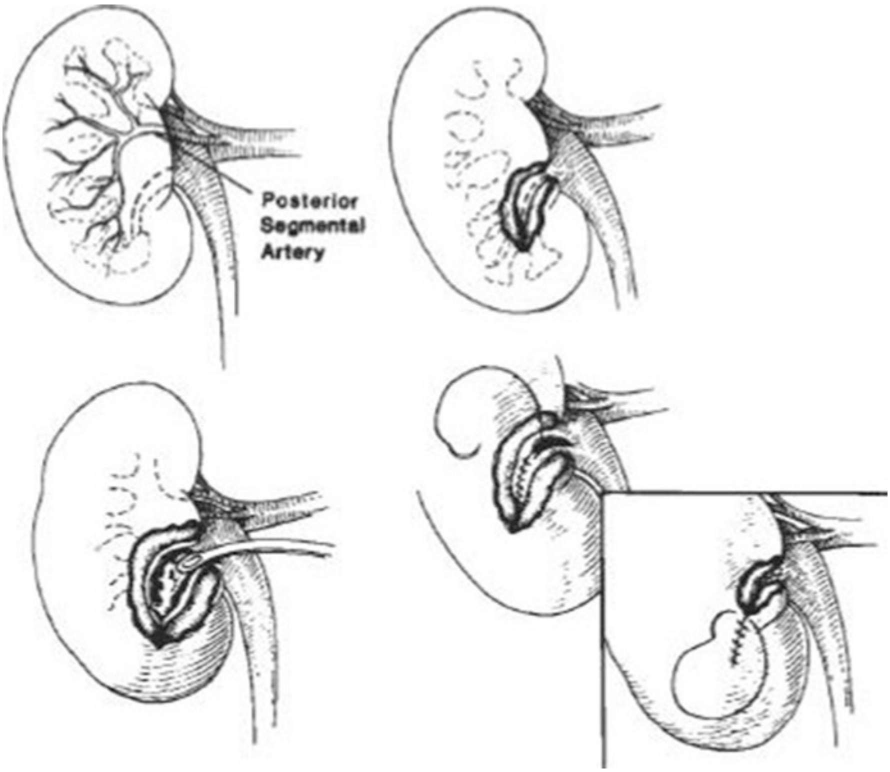

Fig. 18.26 Technique of extended pyelonephrolithotomy. Note the position of the posterior segmental artery paralleling but not crossing the lower pole infundibulum [23] (Image Spirnak and Resnick [23], © 1987, with permission from Jay Gillenwater)

speculum to examine as many calyces as possible. Irrigate the pelvis and calyces prior to closing the collecting system.

Pyelonephrolithotomy

This operation is used for large intrapelvic renal stones with extension into the lower pole collecting system (Fig. 18.26). The operation is based on the relatively avascular plane between the posterior and inferior segmental arteries. The incision in the parenchyma is made posteriorly. In order to identify the plane of dissection, the posterior branch of the renal artery can be clamped followed by administration of intravenous indigo carmine or methylene blue. The pyelotomy incision is extended along the lower pole infundibulum, but not through the minor calyx. After stone removal and irrigation of the collecting system, the renal pelvis and infundibulum are closed with 4–0 or 5–0 absorbable suture. The renal capsule is then closed with 2–0 or 3–0 absorbable suture.

Radial Nephrotomy

Single or multiple radial nephrotomy incisions can be used to remove peripherally located stones and used as a complementary procedure to one of the operations described above. This can be a great technique to remove stones that are palpable and peripheral. With hypothermia and renal artery cross-clamping, the operation can be performed in a bloodless field (Fig. 18.27). The radial orientation of the incisions in the posterior renal parenchyma are made parallel to the orientation of the renal vasculature in an effort to minimize nephron loss (Fig. 18.28). Since the incisions are made posteriorly, they avoid large venous branches crossing over the anterior surface of the calyx [27]. Stone surgery is different from cancer surgery in that after the capsular incision is made, blunt dissection can be used to divide the renal parenchyma which is soft. Blunt dissection is less likely to disturb the interlobular arteries which can be identified and retracted. Once the pericalyceal fat is identified, sharp dissection can be used to open the calyx and retrieve the stone. The calyx is then irrigated and closed. The renal capsule is then closed with 1–2 mm of renal parenchyma.

Anatrophic Nephrolithotomy

Staghorn calculi are associated with significant morbidity and mortality. Patient survival is reduced if a Staghorn calculus is left in place with mortality rates over 10 years ranging from 10% to 50% [28]. Repeat infection, sepsis, and progressive loss of renal function are the primary causes of morbidity and mortality in patients with untreated Staghorn calculi. Renal function will deteriorate in the absence of progressive radiologic changes in the size of the stone in about 50% of patients. Anatrophic nephrolithotomy is indicated when the patient has a branched renal calculus or Staghorn calculus associated with infundibular stenosis or when prior stone surgery has been performed making dissection of the renal sinus treacherous. The procedure is also indicated in the patient with a small intrarenal pelvis. When performed properly, this procedure provides maximal exposure to the intrarenal collecting system and allows for complete removal of all stones. The procedure also facilitates reconstruction of stenotic areas of the collecting system.

Anatrophic nephrolithotomy is a renal parenchymal splitting operation that provides maximal exposure to the collecting system. Patients undergoing anatrophic nephrolithotomy should be positioned in a flank position due to the need to cool the kidney with ice. The operation takes advantage of the relatively avascular plane between the anterior and posterior segmental arterial blood supply. After the perinephric fat is removed off of the renal capsule, the main renal artery and its branches are skeletonized. An obstructing vessel loop is placed on the upper ureter to prevent stone fragments from migrating inferiorly. The plane between the anterior and posterior renal segments can be identified by clamping the posterior segmental artery and injecting 20 mL of methylene blue or indigo carmine through a peripheral vein. All of the kidney was stained blue except for the posterior segment. This avascular plane may also be identified using color

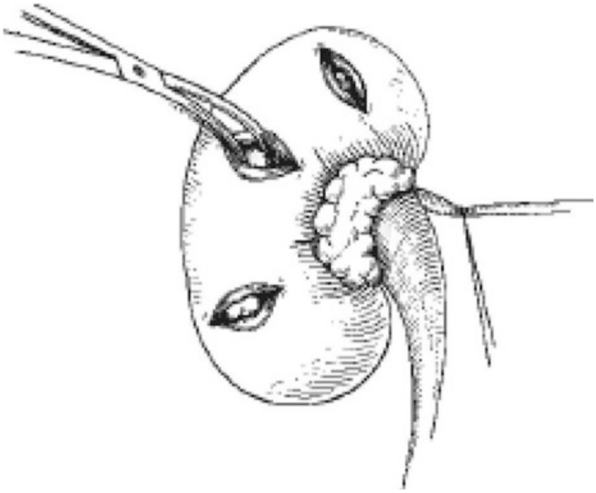

Fig. 18.27 Radial distribution of the multiple nephrotomies and the vessel loop placed around the renal artery [23] (Image from Spirnak and Resnick [23], © 1987, with permission from Jay Gillenwater)

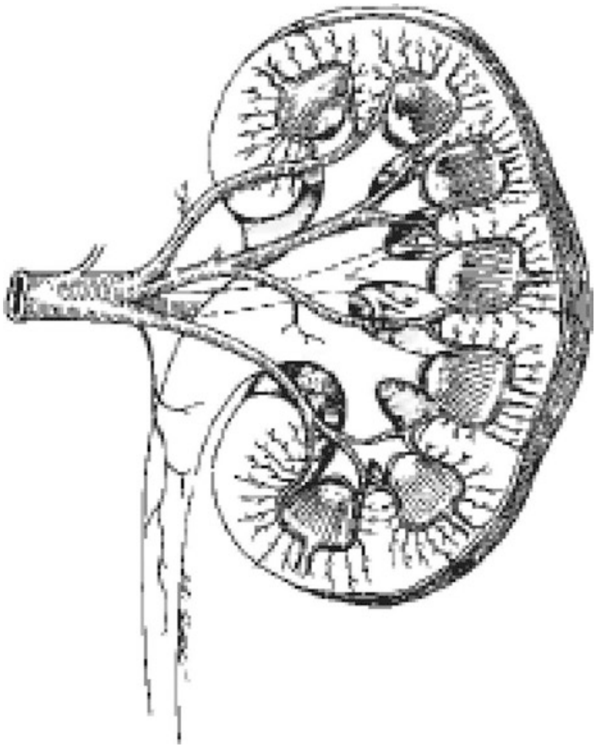

Fig. 18.28 Radial distribution of the renal vasculature [23] (Image from Spirnak and Resnick [23], © 1987, with permission from Jay Gillenwater)

Doppler ultrasound. The plane should be marked using a series of focal electrocautery burn marks on the renal capsule. The kidney is supported by an umbilical tape placed both above and below the renal hilum. After the kidney is cooled as

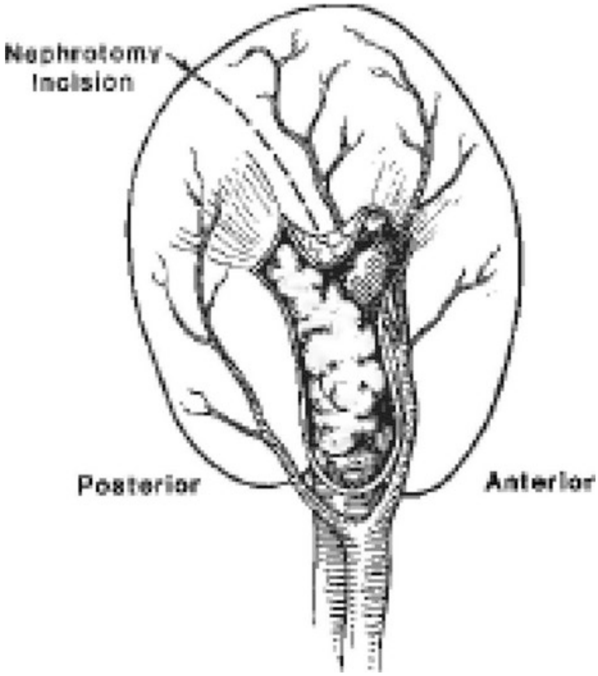

Fig. 18.29 Renal cross-section showing the proper placement of the nephrotomy incision in the avascular plane and the desired site of entry into the collecting system [23] (Image from Spirnak and Resnick [23], © 1987, with permission from Jay Gillenwater)

described above, an incision is made in the avascular plane and the incision is angled slightly as the parenchyma is being divided toward the posterior infundibula (Fig. 18.29). Blunt dissection using the back of a scalpel is used to divide the renal parenchyma. Small bleeding vessels can be controlled as the parenchyma is divided using 5–0 or 6–0 absorbable sutures. If large posterior calyceal stones are present, a dilated calyx may initially be entered. Using a probe, the remaining collecting system can then be identified and opened. Renal papilla have dual blood supply and is less traumatic to bisect a papilla than to circumvent one. Attempts to remove the stone should not be made until all of the calyceal and infundibular extensions of the stone identified and the stone mobilized from those structures. Posterior calyces are opened along their anterior margins, anterior calyces are opened posteriorly and polar calyces are opened along their appropriate lateral margins. After removal of all stone fragments, the collecting system was thoroughly irrigated. Reconstruction of stenotic infundibula or calyces is carried out as needed. Care must be taken in closing the collecting system to include only the epithelium and underlying muscularis since the interlobular arteries are close and could be inadvertently damaged. Hemostasis is then assessed and the renal capsule was closed with running 2–0 or 3–0 absorbable suture. The ice slush is then removed and then the renal artery bulldog clamp is released. The kidney and upper ureter then covered with the perirenal fat and a drain is placed prior to wound closure. Nephrostomy tubes are not needed and should not be used as they may be a nidus for continued infection and further stone formation.

Correction of Calyceal or Infundibular Stenoses

Stenotic areas within the upper collecting system may promote stone formation and should be corrected at the time of open stone surgery. There are different surgical approaches to repair stenoses depending on their location. If scarring involves a single calyx, this calyx may be sutured directly to the renal pelvis. If two adjoining calyces are scarred, this may be corrected by opening the stenotic mouth of each calyx and then suturing the wall of the adjoining calyces together to create one larger opening. Stenotic infundibula can be corrected using Y-V plasty advancement techniques to advance renal pelvic wall tissue into the incised stenotic infundibulum.

Managing Complications of Open Stone Surgery

Bleeding may occur in the immediate postoperative period, or in a delayed manner even up to 14 days postoperatively. Patients with an AV fistula may present with severe hematuria 5–14 days after the surgery. If bleeding fails to respond to conservative measures and blood transfusion, then arteriography with selective embolization would be considered in a modern hospital setting. In the developing world, open re-exploration with repair of the damaged vessel is indicated.

Ureteral obstruction from tiny retained stone fragments can occur and is best treated with a ureteral stent. Retained stone fragments are a distressing complication of open stone surgery and are reported in 5–30% of cases [29, 30]. Immediate on the table, reimaging of the kidney after stone removal with either fluoroscopy, plain x-ray, or ultrasound may help to reduce the rate of retained stone fragments.

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Head and Neck Essentials in Global Surgery

19

Wayne Koch, Eleni M. Rettig, and Daniel Q. Sun

Part I: General Considerations in Head and Neck Tumor Surgery in Resource-Limited Settings

Introduction

Caring for patients with head and neck tumors (HNTs) in resource-limited settings such as sub-Saharan Africa combines the universal challenges intrinsic to these patients with those encountered by care providers of all specialties working outside the developed world. Head and neck tumors run the spectrum from benign to aggressive malignant phenotypes, and their management affects critical human form and function. Patients from all cultures are concerned about appearance, particularly of the face, which is the focal point of all social interaction. Tumors that distort appearance are not merely a cosmetic concern, but can affect economic, psychological, and social aspects critical to healthy, fulfilled living (Fig. 19.1a, b). Equally important are the critical functions of breathing, eating/drinking, and verbal communication, all of which may be adversely affected by HNTs and their management. It is insufficient, then, to merely render a patient free of tumor, recognizing this is the top priority for most affected individuals. One must also preserve or restore acceptable form and function to ensure that patients can return to daily life and even survival. Different cultures may have slightly different challenges and expectations in these matters, but they are critical in every human society.

W. Koch, MD, FACS (✉) • E.M. Rettig, MD • D.Q. Sun, MD
Department of Otolaryngology-Head and Neck Surgery, Johns Hopkins Medical Institutions, 601 N. Caroline Street, 6th Floor, Baltimore, MD 21287, USA
e-mail: wkoch@jhmi.edu; erettig@jhmi.edu; dsun8@jhmi.edu

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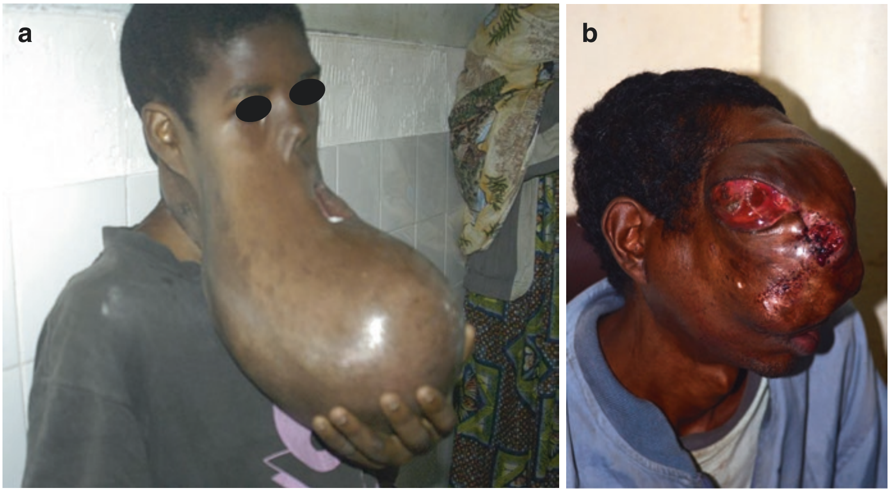

Fig. 19.1 (**a**) Patient with large neurofibroma arising from the chin. (**b**) Patient with large maxillary ameloblastoma. These figures illustrate complex needs of patients with large HNTs

Resource limitation impacts the delivery of health care in many ways. Access to modern, high-quality care is quite limited throughout much of the developing world. Patients may travel for many days to reach a clinic or hospital capable of making even rudimentary steps to diagnose and manage their condition. When they arrive, they compete with many others for very limited resources. Financial constraints combine with political and cultural favoritism to exclude many of the most needy individuals from access to those with the skill and equipment to help. After treatment, necessary postoperative management and tumor surveillance are not available within a day's travel for many.

The quality of care available even in the most sophisticated centers in much of the resource limited (RL) world is rudimentary. Hospitals with expert practitioners in one area often lack the full array of management professionals needed for multidisciplinary care. Equipment for diagnosis and treatment is often lacking and even more often inadequately maintained. Those experts who are available may be stretched to the boundaries of human capability by the enormous need. They and their staff are poorly compensated so that inefficiencies in systems are not addressed. Rehabilitative care and survivor support are also of low priority and thus a luxury in the RL world.

In order to begin to meet these challenges, care providers seeking to help HNT patients in the RL world must make adjustments that would be not considered or even acceptable in the developed world. Utilization of low-tech options and solutions can often replace expensive and high-maintenance equipment with only minimal decrement in quality. When technology is employed, it can be immensely helpful but must be protected from undue wear and tear. Adjustments of methods of use and expectation allow for maximizing what resources are available. Labor is relatively inexpensive in much of the RL world, and employment to do simple tasks is welcomed, so some of the workload may be shifted accordingly.

Patient expectations and views on disease processes are highly variable across the world based on differing social norms, even with the universal nature of many issues as mentioned earlier. Each cultural setting must be studied and accommodated in so far as feasible. In many RL settings, death is more familiar and more readily accepted than in the developed world. Referral to palliative care may even be expected by some who come knowing that they or their loved one is quite ill. Pain tolerance and attitude toward return to work are also more readily embraced in some areas. Gratitude for what can be done and acceptance of what cannot, while not ubiquitous, are encountered by many who serve people in RL health-care facilities.

Otolaryngology/Head and Neck Emergencies

Airway compromise is one of the most acute emergencies faced by otolaryngologists/head and neck surgeons, and its management in resource-limited settings presents unique challenges. Success requires prompt recognition and development of a treatment plan using a team approach, close coordination and cooperation with anesthesiologists, and close monitoring following resolution of the acute emergency. Physical exam findings such as stridor, drooling, tripoding, accessory muscle use, voice changes, and severity of dyspnea are much more important than oxygen saturation in airway assessment.

Acute airway obstruction has many etiologies. In children, foreign body aspiration is a frequent cause, and clinicians should carry a high index of suspicion even when it is not a presenting complaint. Many foreign body aspirations are unwitnessed and present with asthma-like symptoms such as wheezing or productive cough diagnosed as pneumonia. Obstruction at the level of glottis or supraglottis may cause stridor, dysphagia, drooling, and/or voice changes, while bronchial foreign bodies often present with wheezing, productive cough, and/or asymmetric breath sounds. Studies have shown that, due to its less acute angle at the carina, the right mainstem bronchus is the most common site of tracheal or bronchial foreign bodies. In children who are stable, plain film chest x-rays can be obtained. Although radiolucent objects cannot be directly identified on plain film, they will yield characteristic findings such as hyper-expansion of the obstructed lung due to air trapping. In neonates and babies, plain films in the lateral decubitus position of each side are a valuable technique. Normally, there is mediastinal shift to the dependent side, which is absent when the dependent bronchus is obstructed, as a result of air trapping.

Children with suspected upper airway foreign body should proceed to the operating room immediately for direct laryngoscopy, bronchoscopy, and removal of foreign body. In contrast, those with lower airway foreign bodies who present with stable respiratory status usually have a several-hour window for operative management. The surgeon should be prepared to perform rigid bronchoscopy with removal of foreign body with optical forceps. It is especially helpful if parents/caregivers can produce an example of the suspected foreign body so that the surgeon can choose the most appropriate grasping tools ahead of time (Fig. 19.2).

Fig. 19.2 Object shown is a plastic part of a shoe that was removed from the trachea of a Cameroonian child using a rigid bronchoscope and the optical grasping forceps shown in the image

Anesthesia considerations are crucial in the successful management of airway emergencies and especially so in children due to their lower functional reserve. We advocate for maintaining spontaneous respiration for as long as possible and avoidance of paralytic agents and medications that can cause apnea, such as midazolam. Ketamine is a good agent of choice in children and widely available in many regions of the world. In our practice, a typical sequence in pediatric airway foreign body removal involves:

- Establishment of bag mask airway. IV sedation is provided at this time, but spontaneous respiration is maintained.
- Direct laryngoscopy with removal of glottic or supraglottic foreign bodies if present. Topical lidocaine is also sprayed on the vocal folds at this time to prevent laryngospasm.
- Ventilating rigid bronchoscopy with removal of tracheal or bronchial foreign bodies if present.
- Placement of endotracheal tube (may also be placed initially if suspicion for upper airway foreign body is low).

It is essential to develop an airway plan with the entire team, including anesthesiologists and operating room staff, and ensure all necessary equipment is ready and in working order, prior to commencement of the case.

In certain resource-limited settings where childhood vaccinations are incomplete, epiglottitis due to *Haemophilus influenzae* and diphtheria are possible etiologies of airway distress. These children present with typical signs of upper airway obstruction such as tripoding, drooling, and inability to speak. The radiographic hallmark of epiglottitis is a thickened epiglottis on lateral neck plain film (“thumb” sign). It is important for clinicians to recognize this condition and promptly proceed to the operating room for tracheostomy without further agitating the child with an extensive examination that may precipitate acute airway obstruction. Due to the severity of upper airway edema, these patients are frequently not intubatable transorally.

In adults, common etiologies of acute airway obstruction include angioedema and laryngeal mass. While they usually have typical signs of upper airway obstruction such as stridor, drooling, and voice changes, flexible fiber-optic nasopharyngoscopy is crucial in delineating the nature, site, and extent of obstruction. A laryngeal mirror exam can also be used; however, it may be difficult or impossible in patients with oropharyngeal edema or in acute distress. Angioedema typically progresses linearly from the lips to tongue to base of tongue and finally to the larynx, although isolated laryngeal edema is also possible. In patients not in acute distress, prompt medical management alone with high-dose intravenous corticosteroids and antihistamines can often be sufficient. However, close monitoring is crucial as angioedema peaks 6–8 h after initial onset and delayed airway compromise is possible. In patients who are in acute distress, nasal trumpet and humidified oxygen are important temporizing measures.

While some patients with limited laryngeal mass or edema may still be intubatable transorally, typically for patients who need establishment of a definitive airway, the surgeon must choose between an awake fiber-optic transnasal intubation and proceeding directly to awake tracheostomy. This choice depends on surgeon experience and availability of equipment such as a fiber-optic bronchoscope with good image quality, which may not be readily available in many resource-limited settings. In proceeding to an awake tracheostomy, it is crucial to keep the patient spontaneously breathing, laying them flat only after local anesthetic has been infiltrated and the surgeon is ready to make the incision. In emergent situations, a cricothyrotomy is an appropriate option although it should be converted to a tracheostomy as soon as possible. If available, a laryngeal mask airway can be an invaluable tool to provide critical time for establishment of the surgical airway.

Surgical Adjustments When Radiation Oncology Is Unavailable

The Essentials

- *Radiation may be used as curative or adjuvant therapy in many HNTs.*
- *Lack of radiation services necessitate special considerations in surgical management of HNTs.*
- *Conservation laryngectomies may be used for T1 or T2 laryngeal tumors.*
- *Margins must be cleared surgically when adjuvant radiation is not available.*

Radiation is a mainstay of care of HN malignancy wherever it is available, provided either as primary therapy or adjuvant postoperative treatment with or without chemotherapy. In the RL world, radiation treatment centers are very few, equipment is often antiquated, and well-trained specialists are equally rare [1, 2].

High cost and long waiting lists preclude most individuals from receiving radiation care even when diagnosis and referral are appropriate. Surgeons caring for individuals with HNTs must adjust their practices accordingly. Such adjustment takes the form of extending the use of surgery in some situations while not recommending or proceeding with surgery in others.

The goals for managing HNTs are principally curative, but also may be maintenance of function and quality of life (palliation). If the likelihood of achieving the desired goal is altered by the unavailability of radiation, surgical decisions must be altered accordingly. In some cases, this may mean more radical or comprehensive surgery. For example, total laryngectomy is a good option for complete removal and cure of tumors limited to the laryngeal framework, many of which would be treated instead with radiation if available. Similarly, vertical hemilaryngectomy effectively replaces radiation for T1 and small T2 lesions of the glottis with preservation of voice and swallowing and high rates of cure.

On the other hand, in the absence of postoperative radiation, margins of resection must be generous, and nodal metastasis thoroughly removed if surgery is to be contemplated with a reasonable hope of long-term cure. While extensive neck dissection may be technically possible, cases with multiple nodal metastases, particularly those with gross extracapsular spread, must be realistically assessed for reduced likelihood of cure. If function cannot be maintained when adequate margins are included in the resection of primary disease, patients must be counseled accordingly and directed toward palliative options.

HNT Surgery in the Absence of High-Tech Imaging

The Essentials

- *Surgeons must adapt to decision making in the absence of high-quality imaging.*
- *Specific views of the skull may be used with plain film to provide certain diagnostic information when CT is not available.*
- *Ultrasound is a widely available, affordable, and high-yield technique.*
- *Chest x-ray and serum alkaline phosphatase may be used to screen for metastatic disease in the absence of PET/CT.*

Computerized imaging is gradually penetrating the RL world market. In Northwest Cameroon, several centers offering computerized tomography (CT) imaging of acceptable quality including the availability of IV contrast have recently been established. Magnetic resonance imaging (MRI) and positron emission tomography (PET) are more scarce. In the absence of computerized imaging, a surgeon is more dependent on physical examination findings, experience, lower technology imaging (plain films and ultrasound), and surgical exploration for clinical decision making.

Even CT imaging is expensive so that indigent patients may be forced to choose between imaging and definitive (surgical) management of a disease condition. Therefore, surgeons working in RL settings must be very judicious in the use of scanning which is quite commonplace in the developed world.

Plain films of the paranasal sinuses (Waters, Towne, Caldwell, and lateral views), mandible, and temporal bone can be quite helpful if done with appropriate indication and technique. For instance, Waters and Caldwell views can be used to evaluate for acute sinusitis, while Towne view may be used to evaluate for skull fractures. Sinus imaging can demonstrate opacification of ethmoid, frontal, maxillary, and sphenoid air cells, air fluid levels, and the presence or absence of sharp, normal bony walls of these structures. The temporal mandibular joint (TMJ), facial and maxillary bone fractures, and cystic lesions of the maxillofacial bones can all be demonstrated, and information on size and destruction of bone contour can be estimated by an appropriate series of films with several angles of view.

Ultrasound is available in many places in the RL world and can be useful in the workup of HNTs. Differentiation between cystic and solid structure may help direct initial approach, particularly in lateral and central neck masses and in the thyroid. Ultrasound can not only determine the size of lymph nodes but also critical architecture including the presence of normal fatty hilum, presence of increased vascularity, internal calcifications, and spherical versus oval structure.

Chest x-ray coupled with serum alkaline phosphatase levels can replace chest CT scan or PET scan in workup screen for distant metastasis with acceptable decrement in sensitivity.

Detailed findings such as orbital floor invasion by a maxillary mass, anterior cranial fossa invasion of a nasal roof or frontal mass, palatal bone erosion by a nasal mass, etc. may not be readily discernable without computerized imaging. In some cases, then, only surgical exploration can determine the extent of disease. Planning a surgical approach to allow early stopping without endangerment or loss of critical function should a tumor be found to be unresectable is an important part of performing HNT surgery in the absence of advanced modern imaging capability.

HNT Surgery in the Absence of Readily Available Histopathology Services

The Essentials

- *Surgeons must adapt to decision making without specific tissue diagnosis.*
- *Frozen section analysis is frequently not available in RL settings.*

Accurate decisions regarding management of HNT typically requires timely, expert evaluation of tumor specimens by a qualified, experienced pathologist. Frozen section analysis of intraoperative specimens is standard in the developed world hospital.

Histopathology services, like most others, are rare in most RL settings. At RL hospitals, a variety of arrangements have been piloted to fill the gap, including telemedicine solutions, periodic visiting pathology services, and centralized laboratories in country or abroad. Each of these has strengths and limitations [3, 4]. Patients often travel to hospitals in the RL world from great distance, so delays while waiting for pathologic analysis are costly and sometimes limit completion of care.

In some clinical decision making, exact histopathologic diagnosis is less critical than surgeons who regularly enjoy this service may appreciate. Take for example salivary gland masses. If a discrete solid mass is present, greater than 1 cm in size, without surrounding inflammation, the indication for removal is not dependent on distinguishing benign from low-grade malignant histologic type preoperatively. The one exception is in the case of lymphoma, which may be relatively easily distinguished by fine-needle aspiration (FNA) biopsy if available [5].

High-grade malignancy indicative of need for radical removal or futility with resection may be suspected in the setting of rapid growth, fixed physical nature of a large mass, preoperative facial nerve paralysis, extensive metastatic disease in the neck, or chest x-ray with nodules suspicious for metastases. Similar consideration for resection without exact histologic diagnosis might pertain to cystic masses of the mandible and enlarging >1 cm, friable exophytic or ulcerative red lesions of oral mucosa. Laryngeal cancer is also fairly distinctive in its clinical appearance, although tuberculosis can mimic early diffuse epithelial neoplasia, a distinction that may be made by staining for acid-fast bacilli. Clinical judgment based on length of course of disease, symptoms associated, risk profile, appearance on imaging, and features on clinical exam can narrow many differential diagnosis lists to help move toward decision to resect without final histologic confirmation. Informed consent of the possibility of limitation of certainty should be obtained.

Frozen section margin analysis is rarely available in RL settings. Generous margin allowance on initial resection is the first consideration. Margin analysis of specimens done with fixed tissue processing can prompt further surgery or other response later [6]. In this scenario, the location of separate margins must be carefully mapped and documented. At times, reconstruction is best postponed until completeness of resection is confirmed. These considerations pertain to bone resection in developed world settings, so the concepts and options will not be totally unique to the RL world.

HNT Resection in the Absence of Advanced Reconstruction Options

The Essentials

- *Lack of advanced reconstructive options such as free tissue transfer presents special challenges to the surgical management of HNTs.*
- *The pectoralis major flap is an important tool in the armamentarium of head and neck surgeons.*
- *Familiarity with common regional flaps will aid in surgical planning and improve patient outcomes.*

Free tissue transfer has become the mainstay and standard of care for most HNT resection cases. Although pioneering steps to take this technology into RL settings have been underway for over a decade, the option is beyond the practical capability of most centers. Even if it could be done with extensive donation and volunteer support, the strain on an RL hospital may outweigh the benefit to individual patients. The opportunity cost of tying up an operating room and staff for 4–8 h beyond the time taken for resection precludes service to two to four other patients in need, and the real cost of non-volunteer and non-donated resources cannot be easily recouped by charges payable by most patients in the RL world.

Of course standard practices in the developed world may be modified to the RL setting. Loupes may replace microscope magnification in extraordinarily skilled hands. Twenty-four-hour Doppler monitoring may be relaxed to fit the capability of the postoperative care unit available. Selection of cases to avoid extreme peripheral vascular disease or other patient-related contraindications is wise. Flap selection limited to ideal tissue and maximum surgeon experience is also indicated.

Options when free tissue transfer is not available include not offering surgical resection, resecting without reconstruction, or reconstructing with less technically demanding flap choices. Patient and surgeon expectations for form and function must be adapted to the clinical setting and facility capability.

Before the advent of free flaps, regional and local flaps were the workhorses of HNT reconstruction. Chief among these was the pectoralis major myocutaneous flap (pec flap) (Fig. 19.3). In experienced and creative hands, a pec flap can reach to the temporal skin externally and palate internally. By recruiting both thoracoacromial and lateral thoracic pedicles, its blood supply is robust and reliable. With adequate thinning of the muscle attachments, its reach and resistance to pressure effects in the tunneled tissue is optimized. Problems with pectoralis flaps include the thickness of the tissue, particularly in women with more than very small breasts, and limitation in maximal size of flap paddle while still permitting donor site closure. Alternate regional pedicled flaps

Fig. 19.3 Pectoralis major myocutaneous flap used to reconstruct anterior cervical skin defect after total laryngectomy

including latissimus dorsi and trapezius are viable options but have added considerations of patient positioning and donor site healing which make them backup choices for most situations. These flaps may affect the ability of a patient to return to physical labor, adversely affecting their economic and therefore their social standing.

Regional flaps including supraclavicular, submental, forehead, nasolabial, and cheek-neck advancement are ideal in appropriate settings. Full discussion of these options is beyond the scope of this chapter. Scarring may be more readily accepted in some cultural settings than others, so the sensitivities and priorities of a particular patient must be sought and accommodated as much as possible. In Cameroon where traditional healers often create scar as an effect of their ministration, scars that occur during surgery are generally of much less concern than they would be in the USA. However, deformity may affect one's social standing, and desirability as a marriage partner based on healthy appearance is a highly valued commodity.

HNT Surgery in the Absence of Supportive Services

The Essentials

- *Surgeons must be familiar with the rehabilitation needs of HNT patients.*
- *Familiarity with social factors and cultural norms that may aid or inhibit postoperative rehabilitation is important in optimizing treatment decisions.*

Management of HNTs is a multidisciplinary endeavor in the developed world. Speech language pathologists, physical and occupational therapists, dentists and prosthodontists, home nursing, nutritionists, and other health-care providers who are a regular part of the multidisciplinary team at major cancer centers throughout North America are often not available in RL settings. More of the burden of explaining and assisting with rehabilitation after HNT surgery will fall to the surgeon under these circumstances. Nurses assigned to a HNT service may be sent for special training and can perform at least some of the functions if properly instructed and enabled. Working relationships with ancillary specialists such as dentists, prosthodontists, ophthalmologists, endocrinologists, etc. may require patients to travel great distances at personal expense. Expectations and decisions to do surgery that will result in disability must be adjusted accordingly. The socioeconomic condition of cancer survivors in RL settings may be more adverse than in wealthy societies with a government-mandated "safety net." Family ties are often quite strong in African society, so patients will have some support, but may also be hidden or shunned. Social and spiritual counseling may be of help.

Part II: Consideration for Specific Head and Neck Surgery Procedures

Care of Laryngeal Cancer

The Essentials

- *Patients in RL settings are more likely to present with advanced stage disease.*
- *Conservation laryngectomies may be used to treat T1 or T2 tumors.*
- *Total laryngectomy may be used to treat locally advanced disease.*
- *The surgeon must be familiar with the postoperative care and rehabilitation needs of TL patients.*

Most laryngeal cancer arises in patients who have smoked cigarettes, a practice which varies widely in different RL societies. Education about laryngeal cancer is quite sparse, so patients and health-care providers may not be aware of early warning signs such as persistent hoarseness. For this reason, the majority of patients present with advanced disease causing airway obstruction, pain, and hemoptysis. When early diagnosis is made, laryngofissure for excision of small true cord lesions is an excellent substitute for laser microsurgery or radiation therapy. Vertical hemilaryngectomy resecting the true and, if necessary, false cord on one side is also easy to perform and relatively easy to manage in the postoperative setting, although a tracheotomy is required. Patients generally recover quickly to an acceptable quality of life. Similarly, total laryngectomy (TL) for nonmetastatic transglottic disease offers a high likelihood of cure even without postoperative radiation (Fig. 19.4). Surgery must be thorough, including removal of the skin and trachea involved in preoperative tracheotomy, hemithyroid and level VI nodes if subglottic extension or gross thyroid cartilage invasion is present, and therapeutic/prophylactic neck dissection for all but the most minimal glottic tumors.

After TL, support through rehabilitation, resumption of eating, monitoring for fistula, provision of electrolarynx device, and coaching for esophageal speech are needed in a well-organized HNT center in the RL setting. Stoma care, suctioning, and humidification are needed. Meticulous removal of sutures in a timely fashion and emphasis on teaching removal of stomal crusts are critical to reduce the likelihood of stomal stenosis. Suction machines which are provided to every TL patient in most developed world settings are often returned after a month or two due to lack of need/use. Most patients have sufficient pulmonary power to generate a good cough and clear mucus. This is also true in RL settings where the availability of home electrical supply and funds adequate for purchase of a suction machine preclude their precautionary provision. Good humidity and instillation of sterile saline are helpful to reduce tracheal crusting. A study from the University of Cape Town has shown that humidity retained by a simple moistened gauze overlying the tracheostoma is equivalent to expensive heat and exchange moisturizer (HME) devices [7].

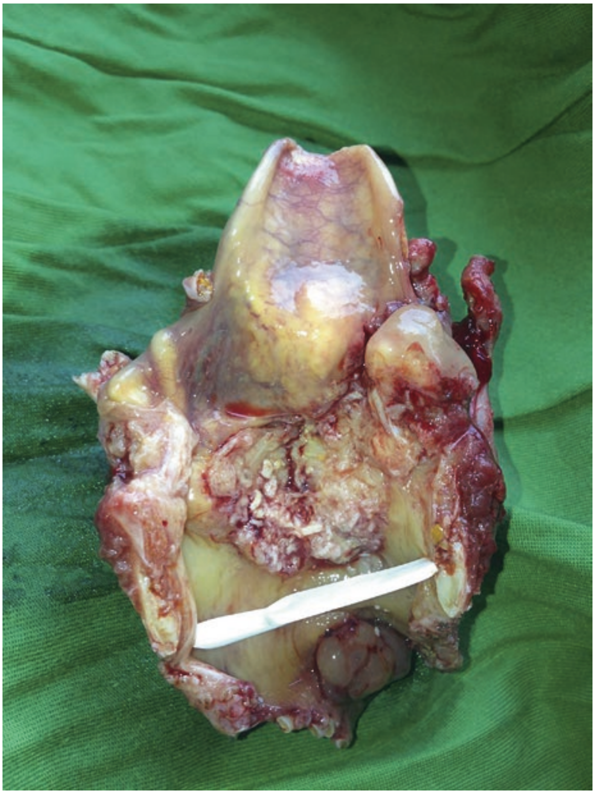

Fig. 19.4 Transglottic extension of exophytic laryngeal cancer as viewed from posterior cricoid split performed on back table

At Mbingo Baptist Hospital (MBH) in Northwest Cameroon, some 25 TLs and 5 vertical hemilaryngectomies have been performed by the senior author in the course of 10+ short-term visits. All of these cases were glottic in site origin, and most of the TLs had transglottic lesions. Over one half of these had required tracheotomy at the time of presentation (Fig. 19.5). The paucity of supraglottic disease may account for the low rate of regional node metastasis adding to the feasibility of TL alone for curative intent. There have been one local and two regional recurrences that have come to attention in admittedly limited follow-up (given a large distance from home to hospital for some of these patients). Similar experience has been reported in Nigeria [8, 9].

An informal network of laryngectomy survivors has formed who counsel and support each other. Despite simple home conditions, none of these individuals have suffered from difficulties with managing a laryngectomy lifestyle. Electrolarynx devices have been made available to TL patients free of charge with visiting speech language pathology volunteers providing initial instruction and coaching (Fig. 19.6). Elsewhere in Africa, the University of Cape Town has published experience providing tracheoesophageal puncture (TEP) devices for voice restoration even for patients traveling from rural villages [10, 11]. However, the expense of the TEP prosthesis is an impediment to widespread adoption of this technology in most RL settings. This experience illustrates the feasibility and value of offering laryngectomy to a selected group of patients in the setting of an established hospital center despite remarkable resource limitation.

Fig. 19.5 Tracheotomy performed for airway obstruction by late-stage laryngeal cancer

Fig. 19.6 Laryngectomy patient learning to use electrolarynx for voice restoration

Management of Palatal and Maxillary Tumors

The Essentials

- *Palatal and maxillary tumors may be benign or malignant, but carry a relatively low risk of cervical metastasis.*
- *Weber-Ferguson approach offers excellent exposure and access for surgical resection.*
- *Dental obturator is a good reconstructive option to minimize nasal regurgitation.*

At MBH in Cameroon, the most common site of presentation for HNT after the glottic larynx is the hard palate/maxilla. These lesions run the gamut from benign conditions such as pleomorphic adenoma (Fig. 19.7) and ameloblastoma to malignancies including squamous cell, adenoid cystic, mucoepidermoid, and adenocarcinoma. The reason for the frequency of these tumors is not readily apparent. Nodal metastases are

Fig. 19.7 Pleomorphic adenoma arising from hard palate

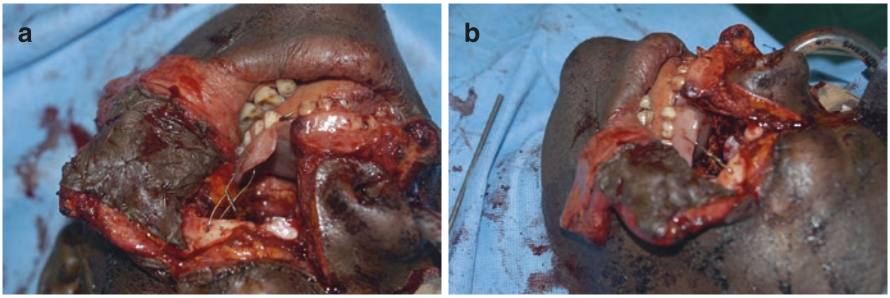

Fig. 19.8 (**a**, **b**) Maxillectomy via lateral rhinotomy approach with dental prosthesis wired to zygoma. Lateral and anterior views

uncommon, and surgery is the mainstay of therapy since radiation therapy is hard to obtain and not of high efficacy for minor salivary gland malignancies. Resection must be sufficient to obtain clear margins, both in soft tissue and in bone, and surgeons must be familiar with the anatomy of the paranasal sinuses and infratemporal fossa in order to thoroughly remove tumor extending superiorly. In our experience, transoral resection is possible for smaller lesions, while Weber-Ferguson lateral rhinotomy approach is best to permit wide exposure for resecting larger lesions particularly in settings where lighting and skilled assistance are limited (Fig. 19.8a, b). When the orbital floor is taken, the globe may be suspended using temporalis muscle in an effort to reduce diplopia and disfigurement. Similar experience has been reported by surgeons in Nigeria [12].

Loss of hard palate and alveolar tissue is typically replaced with dental obturator or free tissue transfer in resource-rich settings. Dental prosthetics may be obtained even in RL settings, although refinements such as dental implants for stabilization when teeth for clasps are not available, and instruments to produce hollow and finely sculpted prostheses may be lacking. Patients with no obturator and no reconstruction may still be able to take an oral diet, finding ways to modify foods, positioning, and rinsing the mouth that permit sustenance. The hypernasal voice of the open maxillectomy defect is also a problem for patients who seek to return to employment requiring clear speech.

Management of Parotid Gland Tumors

The Essentials

- *Facial nerve weakness on preoperative exam suggests malignant etiology.*
- *Surgeons must be familiar with identification of facial nerve using anatomic landmarks without reliance on electrophysiologic nerve monitoring, which is not available in RL settings.*
- *Pleomorphic adenoma is the most common benign tumor of the parotid gland and requires excision with a cuff of normal gland.*

A broad spectrum of pathologies, both malignant and benign, may be encountered in the treatment of tumors of the parotid gland [13, 14]. In RL settings, FNA and imaging are frequently unavailable in the preoperative workup of these lesions. Physical exam characteristics that favor a benign mass include mobility of mass from both overlying skin and underlying soft tissue or bone on palpation, the absence of facial nerve weakness, lack of tenderness, slow growth rate, and the absence of cervical lymphadenopathy. Even benign lesions often require surgical excision due to continued growth and the development of a noticeable facial mass (Fig. 19.9). Multiple cystic lesions of the parotid gland should arouse suspicion for HIV and should not be treated with surgical excision. While needle aspiration may be effective for decompression, these cysts invariably recollect and definitive management involves treatment of the underlying HIV disease.

Surgical excision of the parotid gland has been well described and involves definitive identification of the facial nerve using well-established anatomical landmarks as it emerges from the stylomastoid foramen and dissecting relevant branches for a given tumor location. This is particularly important in RL settings as facial nerve monitoring systems are not available. Monopolar electrocautery should be avoided in proximity to the nerve. If bipolar cautery is not available, monopolar cautery applied to a fine-toothed pickups may be used to more accurately delivery energy while minimizing collateral electrothermal nerve injury. Where available, we use suction drains postoperatively to prevent fluid accumulation under the skin flap that delays wound healing. Passive drains (e.g., Penrose) can also be used together with wrap dressings in RL settings.

Pleomorphic adenoma is the most common solitary parotid gland tumor. At MBH in Cameroon, patients sometimes present with keloid of the skin overlying the tumor characteristic of "burning" by traditional healers (Fig. 19.10). This should be differentiated from cutaneous infiltration of the tumor. Malignant masses may require sacrifice of one or more facial nerve branches, as well as concurrent neck dissection. Eye lubrication and moisturization should be a focus of postoperative care when facial nerve sacrifice is performed to minimize the risk of exposure keratitis.

Fig. 19.9 Benign but enlarging parotid mass

Fig. 19.10 Parotid mass with keloid caused by traditional medicine therapy

Management of Thyroid Gland Masses

The Essentials

- *Benign multinodular goiter is the most common etiology of thyroid masses in RL settings.*
- *Ultrasound is a high-yield imaging tool of the thyroid gland and in screening for suspicious lymph nodes.*
- *Subtotal thyroidectomy ought to be considered for benign disease to avoid lifetime dependence on hormone replacement for patients.*
- *Recurrent laryngeal nerve monitoring is not available in RL settings, and surgeons ought to be familiar with both intraoperative identification and preservation of the nerve, and recognition and management of nerve injury postoperatively.*

Benign multinodular goiter (MNG) of the thyroid gland is the most common diagnosis for presenting thyroid mass in RL settings as in the developed world. Goiter is common in regions lacking iodine supplementation and in which dietary patterns include known goitrogens such as cassava and cabbage [15].

While ultrasound-guided FNA biopsy targeting suspicious components within the MNG is the standard of care in developed countries, it is frequently not available or logistically impractical in RL settings. Other conditions that may lead to consideration of thyroidectomy include Graves' disease and uninodular goiter. Consideration must be given to the availability of adequate medical preoperative preparation for patients with hyperthyroidism. Beta-blockers, Lugol's solution, and methimazole are available in most surgical centers even if propylthiouracil is not. It is important that patients receive adequate treatment to prevent thyroid storm during anesthesia and to reduce thyroidal blood flow so far as possible [16, 17].

Small goiters are of concern for younger persons for cosmetic reasons. If a thyroid nodule results in a midline bulge in a young woman, she may be ostracized because her neck looks like a man's (laryngeal thyroid notch). In some societies, older women with very large goiters may be forced to live separated from the village because their goiter is taken to be a sign of witchcraft or curse. Rarely, large goiters may cause compressive symptoms with difficulty with breathing and swallowing making thyroidectomy a physiological necessity (Figs. 19.11 and 19.12).

In RL settings, the decision to undertake total thyroidectomy for benign disease must take into consideration the availability of lifetime thyroid hormone replacement therapy, which may not be available or affordable for many patients. Subtotal resection therefore may offer many advantages, including avoiding the need of levothyroxine, minimizing the risk of postoperative hypocalcemia in settings where serum calcium monitoring may also be challenging, and mitigating the risk of recurrent laryngeal nerve (RLN) injury. Partial thyroidectomy is contraindicated for Graves' disease management as the residual gland may undergo hypertrophy with return of hyperthyroidal symptoms. Similarly, patients with MNG who undergo removal of the dominant lobe may experience enlargement of the remaining lobe over many years' time. In such cases, removal of the remaining lobe can be easily undertaken later. Avoidance of dissection of the lobe that is to be left behind at the time of lobectomy prevents scar that could make completion thyroidectomy hazardous.

In RL settings, neuromonitoring of the RLN is often not available [18]. However, the safest approach continues to be positive identification of the RLN prior to final gland resection near the cricothyroid insertion rather than a subtotal dissection. Especially in the case of large goiters, the RLN on each side may be significantly displaced out of its normal anatomical positions by expanding nodules. These nerves may be swept up with blunt dissection of the goiter (Kocher maneuver) adherent to the fascia. Sometimes, they may even course in a splayed fashion on the anterior surface of the gland. Surgeons should be aware that in the absence of quantitative EMG monitoring, anatomic integrity of the nerve does not necessarily indicate electrophysiologic integrity. Traction injury may occur while medializing the gland, usually at the insertion point, to cause neuropraxia and vocal fold paralysis/paresis. Therefore, staging the lobe removals may be indicated if the nerve first

Figs. 19.11 and 19.12 Large goiters may mark patients for social shunning

approached has been vigorously manipulated or has not been identified. Patients who undergo total thyroidectomies should be monitored closely after extubation for stridor/dyspnea. While patients with unilateral vocal fold paralysis may have breathy dysphonia, those with bilateral vocal fold paralysis usually exhibit a normal voice (since both vocal folds are in an adducted position) but present with stridor.

Substernal extension of goiters is another point of special consideration. Those in the anterior mediastinum can usually be delivered using finger dissection with appropriate extension of the neck. Removal of a smaller lobe lacking substernal extension before addressing the side with mediastinal disease may provide room for delivery of the larger substernal mass. Posterior mediastinal compartment nodules may necessitate sternotomy.

Signs of thyroid malignancy include very firm consistency, decreased elevation with swallowing and overall mobility, rapid expansion in size, dysphagia, dysphonia (indicative of recurrent nerve involvement), and stridor. Intraoperatively, invasion of the strap musculature, trachea, esophagus, and RLNs and cervical metastases are signs of malignancy. Papillary thyroid carcinoma (PTC) is the most common thyroid malignancy encountered. Its management in RL settings is complicated by the lack of available radioactive iodine as adjuvant therapy. Recent guidelines indicate that hemithyroidectomy is sufficient for unifocal well-differentiated disease of less than 2 cm and does not violate the gland capsule [19]. This is especially helpful in RL settings as it obviates the need for lifelong levothyroxine therapy. Moreover, prophylactic central and lateral neck dissections are not necessary in the absence of clinically manifest nodal disease [19]. Preoperative ultrasound may augment the physical examination of the neck when malignancy is suspected. Nodes greater than 1 cm in levels III, IV, or VI, those with round rather than oblong shape, lacking fatty hilum, and having increased vascularity (on US), are suspicious for malignancy.

Management of Masses of the Mandible

The Essentials

- *Ameloblastoma is a common etiology of mandibular masses.*
- *Resection necessitates segmental mandibulectomy while avoiding tumor spillage.*
- *Reconstructive challenges must be considered preoperatively.*

While mandibular masses invoke a broad list of differential diagnoses, this section will focus on ameloblastoma, as it is a frequent entity encountered in some RL settings such as West Africa. Ameloblastoma presents as a firm, nontender, immobile mass in the mandible or maxilla that does not involve the overlying skin or mucosa (although skin and mucosa may be thinned or macerated by trauma of the opposing dental surfaces) (Fig. 19.13). The typical demographic is a young patient in their teens to 30s. Preoperative diagnosis may be difficult to achieve without FNA and imaging, which typically shows a well-encapsulated cystic mass that expands but does not invade bone (Fig. 19.14). In RL settings, patients usually present at an advanced stage with a sizeable mass that distinguishes ameloblastoma from less aggressive (e.g., radicular) cysts of the mandible, although odontogenic keratocysts (OKC) may also be encountered [20].

Fig. 19.13 Large mandibular ameloblastoma

For both ameloblastoma and OKC, surgical resection with clear margins is indicated and usually involves segmental mandibulectomy. Care must be taken not to violate the cyst wall, which increases the risk of recurrence. Care must be taken to resect all disease. In the absence of modern imaging, multicystic disease may invade the ascending ramus and coronoid without easy detection. Failure to recognize and resect these extended tumors results in "recurrence" at a later date, often with enlargement necessitating completion hemimandibulectomy up to the joint itself with little option for reconstruction [21, 22].

Reconstruction can be a major challenge in RL settings. Vascularized fibula or other bone free flaps with dental implants are unavailable to most of the population of the world. An intraosseous metal plate may be placed to span the defect created by tumor resection and maintain facial contour and remaining dental alignment. Since soft-tissue resection is not needed for ameloblastoma management, the alveolar tissue can be elevated and closed primarily if it has not been too attenuated by tumor expansion. Muscle flaps such as pedicled pectoralis flaps may be used to cover the plate. However, over time, the metal plate will fatigue and screws loosen, particularly in younger patients who continue to consume a normal diet. The plate may then extrude through the skin or cause infection and fistula. In order to prevent these late complications, free bone grafts (fibula or iliac crest) may be applied at a second stage after oral closure has matured using a cervical approach to avoid oral contamination. The bone graft should be sized precisely to span the gap and affixed to the previously placed plate with additional screws [23]. Patients can function

Fig. 19.14 CT image of multicystic ameloblastoma of mandible

remarkably well with no reconstruction when the ameloblastoma defect is lateral, particularly when remaining dentition is limited. The jaw may shift toward the defect upon opening, but facial appearance can be acceptable, and diet reasonably varied. However, the challenge for resumption of normal life for these individuals should not be underestimated [24].

Neck Dissection

The Essentials

- *Indication for and extent of neck dissection is determined by primary site of disease.*
- *Dissection and preservation of the spinal accessory nerve is crucial in performing neck dissections to minimize long-term morbidity.*

Neck dissection is critical in the treatment and staging of head and neck squamous cell carcinoma and other malignant HNTs in order to assess the extent of disease, determine appropriate treatment, and achieve regional disease control. The need for therapeutic neck dissection is based on clinical examination and, when available, imaging and histology, while indications for elective neck dissection are determined by the site and extent of primary disease.

The lack of radiation therapy in many RL areas lends added import to neck dissection. A thorough removal of cervical lymph nodes may be the only means by which to achieve locoregional disease control when there is no adjuvant therapy available. Alternatively, it may not be wise to attempt removal of extensive disease if surgery would be highly debilitating and recurrence is almost certain in the absence of radiation. If nodes are noted to be "sticky" to surrounding structures indicating extranodal extension, wide excision sacrificing expendable tissues including sternocleidomastoid muscle, jugular vein, etc. can be performed.

In the RL setting, clinical and intraoperative evaluation of pathologic lymphadenopathy may be confounded by a high prevalence of other diseases associated with cervical lymphadenopathy, e.g., HIV and tuberculosis, particularly when resources for histologic evaluation of fine-needle biopsies or intraoperative frozen sections are scarce [25]. The head and neck surgeon should be cognizant of this possibility.

Neck dissection does carry risk of significant morbidity depending on which structures are affected. Injury or sacrifice of the spinal accessory nerve can result in shoulder pain and reduced range of motion. Shoulder function may be critical for the livelihood of persons engaged in physically intensive occupations. One's value and status in society may be directly related to the ability to perform physical tasks. Even in the absence of formal physical therapy services, shoulder range of motion exercises should be provided to patients with postoperative weakness to reduce this morbidity.

Tracheostomy

The Essentials

- *Tracheostomy care poses a significant challenge in RL settings.*
- *Specific training in tracheostomy care for nursing and support staff is critical for patient safety.*

Tracheostomy is a mainstay of definitive airway protection and is necessary in the RL setting for a variety of reasons including enlarging masses, trauma, and vocal cord paresis. Tracheostomy may be palliative in certain instances, such as unresectable laryngeal cancer. In contrast to developed countries, tracheostomy is performed infrequently for respiratory failure and ventilator dependence given the paucity of artificial ventilation capabilities in RL countries.

Postoperative tracheostomy care is resource-intensive and presents several challenges. Vigilant nursing care is required for cleaning and suctioning as frequently as every hour in the several days following surgery in order to prevent life-threatening mucous plugging; humidification is also important to prevent the formation of thick, dangerous mucous plugs. In the RL setting, suction machines may be limited in number, may be in poor repair, or may even compete for electricity with other important bedside devices such as oxygen compressors, and humidification devices may also be in short supply.

Some of these challenges can be abrogated through meticulous tracheostomy care and teaching. Nursing, patient and caregiver education on the importance of tracheostomy hygiene, troubleshooting in the event of a blockage, and replacing a dislodged tube is crucial to maintaining a safe airway. Humidification can be achieved with a moist gauze rather than commercial devices, as described previously for laryngostomas. Foot-pump suction machines are an alternative to electrical devices. Reusable metal tracheostomy tubes (Jackson tubes) that can be cleaned and replaced obviate the need for a supply of disposable plastic tubes that may be scarce in an RL setting.

Many patients undergoing tracheostomy for reversible airway compromise can be decannulated prior to discharge from the hospital; however, some patients will continue to require tracheostomy after they return home. Successful home tracheostomy care in the RL setting is possible and has been described in the pediatric context as dependent on caregiver training, appropriate equipment, and adequate support from social and medical services [26].

Cutaneous Malignancies of the Face

The Essentials

- *Most cutaneous malignancies of the face may be treated with wide local excision.*
- *Surgeons ought to be familiar with local and regional flap techniques for reconstruction.*

Direct sun exposure is common for individuals living in RL settings, many of which are near the equator. In addition, many workers in these societies endure day-long sun exposure in their regular routines. The effect can be particularly devastating for individuals with albinism or other congenital conditions such as xeroderma pigmentosum [27–29] (Fig. 19.15).

Protection from excessive sun exposure, even if possible, may be unknown or frowned upon. As a result, squamous and basal cell carcinomas are common, often involving critical structures such as nose, ears, lips, eyelids, and cheek-facial tissue.

Wide local excision of cutaneous cancers is the mainstay of management. Adequacy of margins may be difficult to ascertain where frozen section histology and Mohs technique are unavailable. Nodal disease in SCC cases is also challenging to detect in the absence of sentinel node biopsy functionality. Finally, careful follow-up for recurrence is impractical, and many individuals cannot adjust work conditions. Recurrent disease following resection and reconstruction using local flaps is particularly devastating.

Skin grafting, local flaps utilizing medial forehead skin (Fig. 19.16), cheek-neck advancement, and nasolabial and melolabial tissue are possible in RL settings. However, since these local tissues have endured the same degree of sun exposure as

Fig. 19.15 Skin cancer arising in setting of xeroderma pigmentosum

the neighboring resected tumor tissue, flap selection is challenging. Regional pedicled flaps, particularly pectoralis and deltopectoral, may be useful for larger defects, and these donor sites may have been spared some sun damage (Fig. 19.17a, b)

Sinonasal Conditions

The Essentials

- *In RL settings, surgeons must carefully consider endoscopic* versus *open approaches based on disease process and available imaging and equipment.*
- *Antrochoanal polyps may be excised at their pedicle on the maxillary ostium.*
- *Mucoceles are treated with marsupialization.*
- *Inverted papilloma often necessitates medial maxillectomy.*

Fig. 19.16 Median forehead flap reconstructing nasal dorsum defect due to cutaneous squamous cell carcinoma in patient with xeroderma pigmentosum

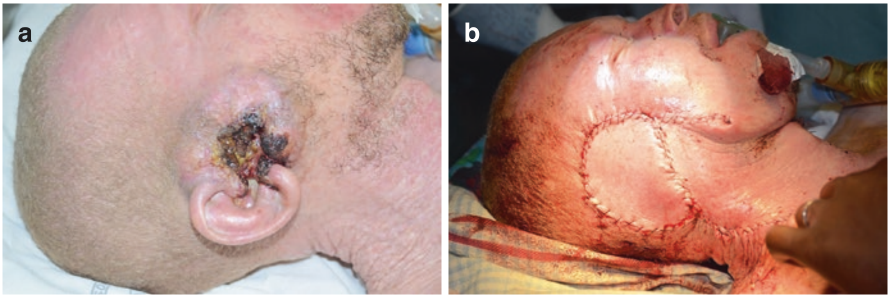

Fig. 19.17 (**a**, **b**) Pectoralis major myocutaneous flap reconstruction of auriculectomy defect in albino patient

Endonasal sinus surgery has become highly dependent on increasingly sophisticated instruments in the developed world. Given the limitations of technology in most RL settings, the conditions amenable to surgical intervention must be carefully selected. Certain conditions are straightforward in surgical approach and highly likely to achieve meaningful, long-term benefit. Among these are sinus mucoceles, antrochoanal polyps, and inverting papilloma. If glass rod sinus telescopes and light sources are available, these conditions may be managed endoscopically. Alternatively, lateral rhinotomy, sublabial maxillary antrostomy (Caldwell-Luc approach), or periorbital approach to the anterior ethmoid and frontal sinuses are cosmetically acceptable and provide excellent access for surgery performed with headlight and open instrumentation.

Antrochoanal polyps are large, obstructing fibro-inflammatory masses arising from the soft tissue of the maxillary medial wall. Often these polyps grow to totally obstruct the nasal passage and may be visible with simple headlight or flashlight both at the anterior nasal aperture and emanating from the nasopharynx behind the soft palate. Treatment involves total removal, avulsing the mass at the maxillary ostium. If endoscopic instruments are available, the complete removal of diseased mucosa from around the ostia and a wide antrostomy will help prevent recurrence. Relief of nasal obstruction is immediate and total, and blood loss is acceptable. [Note: nasal blood loss during endonasal surgery is controlled with a combination of topical vasoconstrictive agent applied on cottonoid pledgets (oxymetazoline), injection of xylocaine with 1:100,000 epinephrine into the regions of the anterior ethmoidal artery coursing across the anterior nasal roof and of the sphenopalatine foramen near the posterior attachment of the middle turbinate, and working with the anesthesiologist to maintain diastolic blood pressure below 60 cm H20.]

Sinus mucoceles may have a dramatic presentation, gradually distorting the adjacent orbital structures (Fig. 19.18). These aberrations arise when a sinus ostium becomes mechanically blocked resulting in a gradual accumulation of sterile mucous. Treatment entails wide marsupialization of the offending sinus air cell with release of the contents into the nose. If the orbital wall bone has been displaced by the mucocele, manual reduction of the thinned bony walls may be necessary to allow the globe to return to near normal position. Postoperative cleaning and debridement are vital to ensure that the air cell does not scar closed allowing the mucocele to recur.

Inverted papilloma arises from Schneiderian mucosa in the region of the middle turbinate. This condition is almost always benign, although squamous dysplasia and progression to carcinoma in situ and even invasive carcinoma do occur. Treatment is complete removal, often requiring medial maxillectomy. The removal of the entire medial wall of the maxillary sinus can be accomplished by an experienced surgeon using endoscopic technique; however, the procedure is also easily accomplished using a sublabial and transnasal approach.

Fig. 19.18 Orbital and forehead deformity due to ethmoid mucocele

Management of Epistaxis

The Essentials

- *Most epistaxis arises from the anterior septum and is easily controlled with pressure.*
- *It is important to identify the exact point of bleeding, stop all active bleeding, and remove clot before attempting to apply cautery.*
- *Nasal packs should be placed gently, removed as soon as reasonable, and accompanied by antibiotic treatment to prevent sinusitis.*
- *Consider and treat underlying causes including anticoagulation, hypertension, foreign body, and tumor.*

Nasal bleeding is a common emergency condition, which, fortunately, is usually self-limited and not indicative of major medical illness. The underlying causes should be carefully considered and addressed whenever the frequency or severity of bleeding indicates more substantial difficulty. Emergency management follows a simple, stepwise paradigm.

Most epistaxis arises from Kiesselbach's plexus, the rich network of mucosal capillaries of the nasal septum. Drying of mucosa due to arid air flow and digital trauma are the underlying causes of the vast majority of cases of epistaxis. Once these capillaries are injured, the healing process takes several days during which repeat injury and bleeding are common. Once adequate healing has occurred, bleeding episodes should cease. Hypertension is associated with more posterior nasal bleeding. Markedly elevated blood pressure must be controlled in conjunction with local nasal measures for successful treatment. The insertion of foreign bodies must be suspected in cases of toddlers with new onset of persistent unilateral nasal bleeding. Anticoagulation due to medication or intercurrent illness is another important consideration. Finally, nasal tumors often present as intractable epistaxis.

Simple anterior epistaxis may be controlled with digital pressure applied to the soft alar tissue firmly moving it over to touch the cartilaginous septum for 5–10 min. In children, this pressure should be applied firmly but gently by a trusted and calming adult. The use of vasoconstrictive spray or drops (oxymetazoline or Afrin) can be helpful. We do not advocate the insertion of bits of tissue into the nose by non-experts as these can dislodge clot, add to excoriative trauma, and result in retained foreign material if not fully removed. Application of moisturizing ointment for several days after bleeding is controlled can help prevent bleeding while the mucosal healing is ongoing.

When bleeding has been recurrent, the source should be identified and cauterized. If the nasal septal mucosa can be examined within 24 h of a bleeding episode, the site is usually apparent to an experienced eye. A headlight and nasal speculum are essential. The presence of a punctate red peak, 1–2 mm in size emanating from normal surrounding mucosa, is the key finding. Gentle manipulation of this incompletely covered capillary will result in brisk punctate bleeding, confirming the source. In order to cauterize, the bleeding must be temporarily stopped or reduced. Standing blood and clots should be removed with suctioning. A 7 French Frazier tip suction is ideal for this. The presence of clot outside the vessel tear can inhibit effective formation of clot needed to stop flow and permit healing of endothelium. Immediately after removing clot or identifying a potential bleeding source, a vasoconstrictive agent on cotton pledget should be gently inserted. Oxymetazoline and topical anesthetic such as 4 % tetracaine may be mixed for this purpose. When available 4 % cocaine hydrochloride solution is ideal as this medication provides excellent vasoconstriction and numbing effect. Xylocaine with adrenaline is another option. In all cases, the total dosage used must be monitored and limited with attention to avoid overdose, particularly in children. Focused and limited cautery can then be accomplished with silver nitrate pencil or hand-held electrical or battery units. Avoidance of extensive cautery and especially damage to mucosa on both sides of the same region of septum are important to avoid septal deterioration and perforation.

Only if these measures are ineffective is it necessary to pack the nose. If nasal telescopes are available, a full examination of the nasal cavity can be quite helpful in order to identify which vessel watershed is involved in bleeding. Ideally this is done before packing, as the act of placing packs introduces new nasal trauma and swelling making later identification difficult.

Numerous commercial products are available for nasal packing. Anterior bleeding can be controlled with tampons or products designed for epistaxis (merocel sponges). Once engorged with blood, these products expand to apply gentle pressure to the source of bleeding. It is important to have a means to remove any item inserted in the nose in one piece so that complete elimination of foreign materials is ensured when bleeding has stopped. The string of a tampon or nasal sponge can be taped to the cheek. Another approach is placement of a balloon which can be inflated with saline. The balloon can be placed in the anterior nasal vault or the nasopharynx. Epistat balloons have two channels and two balloons so that the anterior and posterior portion can be inflated and adjusted independently. Strip gauze packing and traditional posterior nasal packing (inserted with a bridle around the septum through the oropharynx) may be done by trained professionals in situations of extreme urgency. Nasal packing should be removed within several days of insertion, during which time underlying conditions such as hypertension and anticoagulation are corrected. Antibiotic prophylaxis is indicated as the presence of nasal packing will predispose the individual to sinus obstruction and infection. Retained foreign bodies can lead to "toxic shock" syndrome. Pain management is indicated particularly in the setting of posterior packing.

Ligation of feeding vessels is indicated in situations of intractable and life-threatening epistaxis. The lower nasal passage is fed by branches of the internal maxillary artery. This vessel can be reached at the upper extent of the divisions of the external carotid system, just above the digastric posterior belly and behind the submandibular gland with its facial artery branch. Care to avoid injury to the hypoglossal nerve ascending along the external carotid in this region is important. Alternatively, the internal maxillary artery can be approached through a Caldwell-Luc maxillary antrostomy followed by removal of posterior maxillary wall mucosa and bone. The vessel travels horizontally through infratemporal fat.

The upper nasal cavity is serviced by the anterior and posterior ethmoidal arteries which are branches of the internal carotid. When endoscopic evaluation indicates the blood is coming from high in the nasal vault, or external carotid branch ligation does not stop bleeding, the ethmoidal arteries can be safely reached via a periorbital "Lynch" incision, midway between the medial canthus of the eye and the dorsum of the nose. The incision is taken down to bone, and periosteal elevator used to lift the medial canthus attachments away from bone laterally as the orbit cone is entered. The arteries can be identified encased in periosteum as the pass from lateral to medial into the nasal roof at the suture line between the ethmoidal bone below and the frontal bone above. The anterior ethmoidal artery will be seen 2–2.5 cm posterior from the orbital rim. The second posterior ethmoidal artery is 10–12 mm behind the anterior entering the same suture line. These arteries can be ligated with clip or suture or controlled with bipolar cautery.

Deep Space Infection of the Head and Neck

The Essentials

- *Identify and treat underlying causes including decayed teeth.*
- *Anticipate and plan for airway management when impending.*
- *Reevaluate frequently and respond to disease progression with changes in antibiotic, surgical (re-)exploration, or treatment of overlooked causal factors.*
- *Consider extension to adjacent spaces in advanced or persistent cases.*

Deep space infection (DSI) of the face, skull base, and neck can be life-threatening and may develop rapidly, leading to sepsis, mediastinitis, meningitis, cavernous sinus and jugular vein septic thrombophlebitis, necrotizing fasciitis, and airway obstruction. Prompt recognition of deep space infection, accurate identification and correction of underlying causes, and appropriate selection of medical or surgical treatment are key steps in averting disastrous outcome. The most common source of DSI is dental pulp decay. The pattern of abscess extension is related to the offending tooth, its position in the alveolar skeleton, and the relative position of the buccinator (cheek) and mylohyoid (floor of mouth) muscles. The offending tooth must be identified and treated, most often by extraction in order to prevent reseeding of the abscess space even after incision and drainage. Other causes include sinusitis, sialoadenitis, tonsillitis, and venous injection (IV drug users). Conditions predisposing to DSI should also be considered and addressed including diabetes mellitus, immune compromise from HIV, chemotherapy, or underlying hematologic malignancy.

Abscess formation may be preceded by cellulitis and induration. During these early phases, pain and fever may be present, but physical exam will not demonstrate a collection of liquid infection (by palpable fluctuance or "pointing"), and radiographic imaging (CT or ultrasound) will not show fluid collection. Medical management with IV antibiotics and careful serial observation are indicated during the early stages of DSI. The presence of pus may be demonstrated by needle aspiration when suspected. A 22-gauge needle attached to a syringe can be inserted with retraction of the plunger as the needle is advanced. The location of pus can then be approximated by the angle and depth of the successful tap in order to direct subsequent definitive incision and drainage. Repeat aspiration of DSI of the head and neck is not recommended as the reaccumulation and progression of disease is more common when this so-called conservative management is attempted.

The spaces involved with abscess collection may progress following well-documented paths. Extension from the masseteric space into the temporal space and from the peritonsillar to the parapharyngeal space is typical. In the absence of CT scanning, extension beyond the first space found to contain pus should be considered. During the incision and drainage procedure, penetration beyond a drained cavity through muscle walls into adjacent spaces may be indicated. Again, a needle aspirate probe can be employed to confirm this and avoid inadvertent iatrogenic spread of infection. After drainage is judged to be complete, irrigation with saline and placement of drains to encourage dependent release of additional pus should be performed.

Airway compromise is particularly relevant to Ludwig's angina (infection of the submandibular and sublingual spaces with elevation of the tongue) and retropharyngeal abscess. Involvement of an airway management team with careful planning including availability of personnel and instruments for urgent surgical airway access is warranted.

Careful monitoring in an acute care setting is crucial for successful management of DSI. Whether initial medical management is chosen or subsequent to initial I+D, the DSI patient should be examined frequently by the surgical team and watched closely for signs of deterioration (sepsis or airway) by appropriate level of skilled nurses. Change in antibiotic coverage, return to OR, or investigation of overlooked underlying cause should be considered when prompt resolution is not forthcoming.

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Essential Pediatric Surgery

20

Dan Poenaru, Emmanuel A. Ameh, Arlene Muzira, and Doruk Ozgediz

Principles of Children's Surgery in Low-Resource Settings

The Essentials

- Burden of pediatric surgical disease in LMICs is large, the spectrum is wide, and presentation is often late.
- Appropriate size instruments and equipment and support services, including intensive and critical care, are limited.
- Prior planning in conjunction with the host surgeon is critical to success.

Burden of Pediatric Surgical Disease

Pediatric surgical conditions account for a significant portion of the burden of surgical disease in low- and middle-income countries (LMICs). This is partially due to regional demographics as more than half of the population is < 18 years

D. Poenaru, MD, MHPE, PhD (✉)
Department of Surgery, Montreal Children's Hospital, 1001 Decarie Boulevard, Room B04.2022, Montreal, QC h4A3J1, Canada
e-mail: dpoenaru@gmail.com

E.A. Ameh, MBBS, FWACS
Division of Paediatric Surgery, Department of Surgery, National Hospital, Central District, Federal Capital Territory, Abuja 900001, Nigeria
e-mail: eaameh@yahoo.co.uk

A. Muzira, MBChB, MMed (Surg)
Department of Surgery, Mulago Hospital, Mulago Hospital Complex, Kampala, Uganda
e-mail: arlenemzr@gmail.com

D. Ozgediz, MD, MSc
Department of Surgery, Yale New Haven Hospital, 333 Cedar Street, New Haven, CT 06520, USA
e-mail: doruk.ozgediz@yale.edu

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old in many countries, and fertility rates remain as high as seven per family, even in countries with limited life expectancies [1]. Prospective studies suggest that up to 85% of children in these settings will require surgical intervention by age 15 and that 40% of surgical unmet need at the population level is in children [2, 3].

Features of Pediatric Surgery in LMICs

The surgeon who comes to assist in a LMIC quickly notices that the pediatric surgical practice in this setting is radically different from what he/she had been exposed to in high-income settings. Pediatric surgery in LMICs is first characterized by a very wide spectrum of illness comprising all the pediatric subspecialties. The children frequently present late for care, sometimes in the teenage years or even adulthood, and the disease processes, especially in the case of tumors or colorectal disease, are very advanced. Many "classical" index conditions in Western pediatric surgery, such as congenital diaphragmatic hernia or necrotizing enterocolitis, are rarely encountered or grossly underreported. On the other side, nonfatal congenital anomalies such as imperforate anus, hypospadias, cleft lip and palate, or club foot are quite prevalent, reflecting a large backlog of chronic surgical disability. The pediatric surgeon in LMICs rarely inserts central lines (due to the absence of total parenteral nutrition, chemotherapy, and/or central venous catheters), and gastrostomy buttons are also rarely available. He/she deals instead with significant trauma, surgical infections, and surgical emergencies in older children (who, unlike the neonates, have a better chance to survive).

In the North American environment, a significant portion (40% or more) of pediatric operations will be for emergency conditions, and studies suggest this is comparable in resource-constrained settings [4]. A snapshot of selected inpatients on day 1 of the pediatric general surgery unit at Mulago Hospital (a national referral center) in Kampala, Uganda, reflects the broad spectrum of conditions treated there, ranging from trauma to congenital anomalies, oncology, and infectious diseases, and their attendant complications (Table 20.1).

Ancillary Services: NICU, PICU, Radiology, and Pathology

Ancillary services are often limited and less functional than one would be accustomed to in high-income settings. Neonatal ICUs often have no functioning neonatal ventilators, hemodynamic monitoring, or parenteral nutrition, consisting of oxygen by nasal prongs and peripheral hydration [5].

Radiology uniformly includes plain films and ultrasound. Contrast studies and computer tomography are inconsistent and often unaffordable. Fluoroscopy is rarely available. Pediatric radiologists are extremely rare.

Histopathological services are usually available only in large referral hospitals and in private settings. Pediatric radiologists are rarely found, and frozen section pathology is not available, to our knowledge, anywhere in East Africa [5, 6].

Table 20.1 Selected conditions present on pediatric surgery unit 1 day at Mulago Hospital 2010

Anorectal malformations	Trauma
2-year-old with repaired vestibular fistula with re-fistula	8-year-old with splenectomy post blunt trauma
Neonate with cloaca	10-year-old with bilateral chest tubes s/p motorcycle crash
Neonate with imperforate anus	
3-year-old with fecal incontinence post-PSARP	
Hirschsprung's disease	Infection
6 months old s/p Swenson with colostomy	9-year-old boy with abdominal sepsis without source at laparotomy
3-year-old with enterocutaneous fistula post-stoma takedown	5-year-old with post-op enterocutaneous fistula after typhoid perforation
2-year-old post-Swenson operation with incontinence	10-year-old s/p appendectomy
Infant with constipation and non-definitive pathology for Hirschsprung's disease	2-year-old with extremity gangrene after febrile illness
	5-year-old with snakebite
	1-year-old with wound tetanus
Oncology	Miscellaneous
2-year-old with testicular rhabdomyosarcoma	2-month-old with jaundice and? biliary atresia
4-month-old with sacrococcygeal teratoma	
2-year-old with Wilms' tumor	

Equipment and Supplies

General adult surgical instruments are generally available, but small and specialized instruments are often missing, making sometimes for a frustrating operative experience. Visiting surgeons are encouraged to bring their own small set of specialized instruments.

Catheters and tubes, such as thoracostomy tubes, Foley catheters, Replogle tubes, feeding tubes, and drainage tubes, are inconsistently available and typically not in small sizes. Again, the surgeon is encouraged to bring a small sampling of these from home.

Sutures are another major area of concern, with typical hospitals having only silk, nylon and one braided absorbable material, and nothing smaller than 3–0.

In all these areas, we recommend the visiting surgeon to contact his/her host in advance and request a list of needed equipment and supplies worth bringing over for the specific types of procedures likely to be performed. There are also several charitable organizations distributing selected donated supplies and equipment at low cost.

Support and Referral Contacts

Work in a foreign setting, often in a foreign language and using different drug names and test units, can be very challenging. Recruiting the help of a local surgeon is essential for safe and effective care, as well as professional comfort and satisfaction.

There are several helpful resources addressing pediatric surgery in LMICs including textbooks (geared to the district and tertiary hospitals in Africa), and papers highlighting pediatric surgical challenges in Africa, including tips for short-term pediatric general surgical missions [7–10].

Pediatric Acute Care, Anesthesia, and Resuscitation

The Essentials

- Understanding of the basic physiology and fluid and electrolyte management in children is essential.
- Local anesthesia resources and expertise may be limited.
- Knowledge of fundamentals of pediatric anesthesia and airway management are important to minimize morbidity and mortality.

Frequently, the greatest perioperative morbidity and mortality in the care of pediatric surgical conditions is related to safe anesthesia and perioperative care. Knowledge of the fundamentals of pediatric anesthesia and airway management and common pitfalls are essential before practicing in a resource-constrained environment.

An affiliated visiting anesthetic team may accompany the surgeon but, more importantly, should review availability of local anesthetic resources (human resources, equipment, drugs) and expertise. For example, ketamine is likely to be frequently used for shorter cases, compared to the high-income setting, and the visiting surgeon should be familiar with its basic properties and risks. In many settings, nonphysician clinicians may be the primary local anesthesia providers, and knowledge of the local practice is useful. There may be limited local practice to formally recover patients postoperatively. Particularly for elective cases, it may be useful to know the general volume of pediatric surgical cases (especially in neonates and infants). In some regions, especially outside of larger national referral hospitals, there may be no pediatric surgery performed other than by visiting teams [11].

The general surgeon with primarily adult training must have a sense of his/her comfort level with a particular case if outside the scope of practice in their home environment. In uncertain cases, the surgeon may wish to consult with colleagues or local experts to determine the safety of specific elective cases. If there is a low volume of pediatric operations performed under general anesthesia, especially for neonates and infants, deferring the operation to an older age, perhaps greater than 6 months old, may be considered, as the morbidity of general anesthesia is reduced. Sometimes, in the absence of anesthetic expertise, in neonates with an abdominal emergency, it may be safer to perform the operation using abdominal field block with local anesthetic, if referral to a larger center is not feasible.

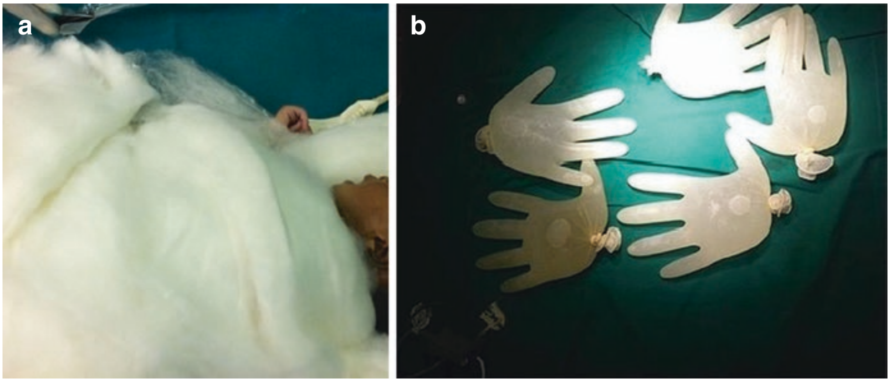


Fig. 20.1 Keeping babies warm in the absence of warming devices. (**a**) Using cotton wool and (**b**) using gloves with warm water

Vascular Access

Sometimes the greatest challenge may be intravenous access. The surgeon should be ready to establish alternate IV access if routine peripheral sites fail for infants and small children. IV access is often exacerbated by delay in presentation, failure to thrive for chronic conditions, and acute dehydration with need for resuscitation. Vascular access may be performed by intraosseous route, cutdown (saphenous, femoral, external jugular, umbilical in neonates), or percutaneous (external jugular vein or suitable scalp vein). Tunneled lines and fluoroscopy will likely be unavailable.

Heat Loss

Neonates are at risk of rapid heat loss even in tropical environments, and in the absence of formal warming devices, neonates and infants should be warmed intraoperatively with cotton wool rolls, gloves with warm water, or by other means (Fig. 20.1a, b). Warming intravenous fluids and blood before transfusion is helpful. Prolonged anesthetic time may compromise outcome in such children, and this may affect the surgical approach. Many hospitals may not have a neonatal intensive care unit or capacity to ventilate pediatric patients. This should of course be considered for any elective case that may require postoperative respiratory support.

Fluid and Electrolytes

Knowledge of the basic maintenance fluid requirements for infants and children is essential. For neonates, due to fluid overload in the first several days of life,

Table 20.2 Maintenance fluid requirements for children

Weight	Fluid requirement
<10 kg (first 10 kg)	4 cc/kg/h
10–20 kg (second 10 kg)	+2 cc/kg/h
>20 kg	+1 cc/kg/h

Table 20.3 Estimated total blood volumes in children

Age	Volume
Preterm	90–100 cc/kg
Term	80–90 cc/kg
Infant	70–80 cc/kg
>1 year	70 cc/kg

maintenance fluids are limited to 60–80 cc/kg/day, and D10 water is provided, with a gradual transition to 1/4 normal saline solution if possible over the first week. During this time, healthy neonates gradually lose this excess sodium through a physiologic diuresis. Neonatal resuscitation skills and resources may not be available in the austere setting; however, a major program (Helping Babies Breathe) is currently attempting to reduce neonatal deaths by teaching neonatal resuscitation skills in resource-limited settings [12]. Generally, the "4/2/1" rule for maintenance IV fluids can be used for children (Table 20.2). In other words, a 22 kg patient would require (4 × 10 = 40) + (2 × 10 = 20) + (1 × 2 = 2) = 62 cc/kg/h of IV fluid. Normal saline and Ringer's lactate are the most available fluids, and solutions will require mixing to meet the appropriate requirement. Pumps will not be available, and providers must work closely with nursing staff to give four to six hourly fluid infusions to compose the 24 h requirement.

Potassium depletion is common, particularly in those with abdominal emergencies presenting late (e.g., intestinal obstruction, typhoid perforation). This should be carefully corrected before surgery. Potassium replacement should also be considered postoperatively in patients who have had abdominal surgery and are NPO for more than 48 h.

Local blood bank capacity should be evaluated, especially for elective cases where blood may be necessary. Blood volume is highest in the neonatal period and decreases gradually over time (Table 20.3).

Nutrition

Caloric requirements are highest in the neonatal period and first year of life (100–150 kcal/kg/day) and gradually decrease to 60–80 kcal/kg in adulthood. Patients in many limited resource settings may not have access to parenteral nutrition or the diversity of enteral formulas available in a more resource-rich environment. Even if available, enteral formulas or specific components of parenteral nutrition may be available only in private pharmacies at an exorbitant cost to families. These factors should all be considered in operative planning and in any operation that may render a patient NPO for a prolonged period. Generally, parenteral feeding is indicated in children expected to be NPO for over 5 days. Enteral nutrition is always preferred if at all possible given the above factors. A higher proportion of children (20–30%) in limited resource settings will be undernourished at presentation, contributing to higher rates of postoperative complications such as superficial and deep wound infections [13]. Though NPO guidelines vary by setting, in general, a clear liquid diet can be taken up to 3 h before surgery, breast milk for 4 h.

Pain Management

The Essentials

- Unrelieved pain in children can lead to increased morbidity and mortality.
- Adequate and appropriate pain control should always be provided.
- Pain control should be multimodal, and two or more analgesics should be used to ensure effectiveness and minimize side effects.

Children, including neonates and preterm, do feel pain and require adequate and appropriate pain control when needed. Pain treatment is a recognized fundamental human right, and every effort should be made to alleviate it [14]. Despite this fundamental right, the management of pain in children in LMICs is often inadequate and suboptimal, due to several barriers: limited availability of appropriate drugs, lack of skills and training in pain management, and poor attitude toward pain care. Untreated or poorly treated pain in children has important consequences, including [15]:

- Apnea and syncope in neonates and infants
- Decreased mobilization with attendant risks of atelectasis and deep venous thrombosis
- Long-term consequences such as psychological and behavioral changes, late pain-related behavior and perception, and decreased cooperation due to fear of pain

Most pain in surgical practice is related to surgical and bedside procedures, trauma, infective conditions, and cancer. In any of these situations, the pain may be severe, moderate, or mild, and the management would depend significantly on the severity.

Management Approach

The perception and expression of pain by children is influenced by age, cultural background, and previous pain experience in addition to the cause of the pain.

Access to pain care should be an integral part of perioperative care; adequate planning should be made for every child undergoing any surgical and painful procedure [16].

Treatment of pain requires the consideration of the following issues:

1. Careful assessment of the cause and severity of pain. Pain assessment in children could be problematic as response depends on several factors. Assessment should be as objective as possible, using available pain assessment tools for children [17].
2. Frequent reevaluation and reassessment of the adequacy and effectiveness of treatment.
3. Availability and experience with commonly used drugs in the local setting. Knowing what drugs are available for pain treatment in the local setting is helpful. The safety profile and cost of available drugs should be taken into consideration, as the spectrum of available drugs may be limited and high cost may make preferred drugs unaffordable. Availability of nursing and anesthetic personnel with experience in pain management is crucial in the planning of appropriate multidisciplinary care.
4. Appropriate health personnel attitudes to modern pediatric pain treatment guided by appropriate education and advocacy.

The perception of pain is multidimensional, with several important components, all of which need to be addressed for optimal pain relief [18]. The components include:

1. Emotional (affective) component.
2. Behavioral component: behavioral response to pain.
3. Cognitive components: beliefs and cultural attitude to pain and pain control.
4. Sensory (neurological) component: the experience and response to pain. This component is the focus of most pharmacological (drug) treatment.

Treatment of pain should preferably be multimodal by combining appropriate pharmacological and non-pharmacological methods, whenever possible, to enhance the effectiveness of treatment. In choosing the drugs to use, combining two or more drugs helps to reduce dosage requirements and minimize the side effects of individual drugs. A practical approach, following the World Health Organization's step ladder treatment, is detailed in Fig. 20.2. The WHO recently proposed a two-step strategy for persistent pain from medical illness [18–20]. This is adaptable for treatment of surgically related pain, considering that differentiating between moderate and severe pain in children may be difficult, especially in younger children. Moreover, less potent opioids than morphine are of limited use in children. An exhaustive discussion of the treatment modalities is beyond the scope of this chapter.

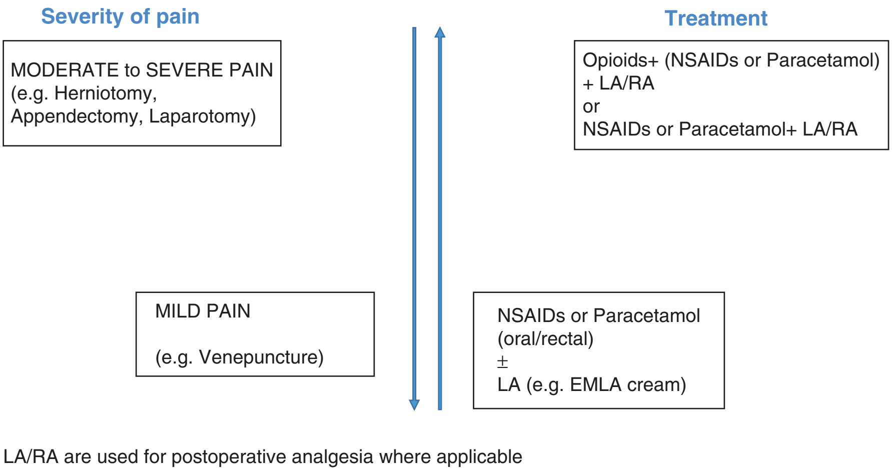


Fig. 20.2 Practical treatment of pain adapted for children. *LA* Local anesthesia by infiltration with bupivacaine, ropivacaine, or lignocaine, *RA* regional anesthesia (e.g., caudal block, nerve blocks, epidural block), *NSAIDs* nonsteroidal anti-inflammatory drugs (ibuprofen, ketorolac is a potent injectable form), *EMLA* eutectic mixture of local anesthetics. Notes: (1) Combine each modality with appropriate non-pharmacological treatment such as making the child comfortable, having parent/caregiver present to comfort the child, relaxation, and the use of appropriate images; (2) combining non-opioids (NSAIDs or paracetamol) with an opioid analgesic for moderate to severe pain is noted to produce opioid-sparing effect and reduces opioid requirements as well as the side effects [19]; (3) treatment should be tailored to the individual child, with dosing at regular intervals; (4) de-escalate or to lower levels as postoperative days progress and pain reduces or escalates to higher levels if severity of pain increases as identified on frequent reassessment; (5) avoid sedation in acute pain as it may mask response and severity [20, 21]; (6) morphine should be used in small doses and with caution, especially in neonates and infants and children with respiratory disease. Less potent opioids such as tramadol and pentazocine are of limited use in children as their safety remains inconclusive. However, the latter is often used in LMICs due to nonavailability of morphine; (7) below the age of 3 months, paracetamol should be used rather than NSAIDs; (8) the analgesics should be given intravenously for moderate and severe pain; (9) other modalities such as surgical options may be required in chronic pain

Pediatric Trauma

The Essentials

- Significant internal organ injury may occur without skull or rib fracture due to pliable skeleton.
- Traumatic brain injury is common and produces most mortalities.
- Therapeutic decision is often based on clinical findings as advanced imaging may not be available.

Abdominal Trauma

Introduction

Worldwide, but more so in LMICs, mortality due to trauma in children is largely attributable to head injuries. Abdominal and retroperitoneal injuries can lead to significant morbidity and mortality, especially following diagnostic delays due to shortage of affordable and readily available, up to date investigative modalities. This is unfortunately frequent in low-income countries.

Compared to adults, children are more susceptible to injuries from a low-velocity mechanism (such as falls) because their protective skeleton isn't yet fully developed; they have less fat to absorb and distribute mechanical forces, and their organs are in close proximity with each other. Motor vehicle crashes (MVCs) constitute the majority of pediatric injuries, and are more likely to have injury patterns in keeping with absent or poorly fitted restraints, or pedestrians hit by motor vehicles. However physiologically, children are more adept at compensation to shock, with minimal changes in vitals. One needs to be aware of the variability of vital signs based on age, with tachycardia an indicator of compensating hemodynamics.

Presentation

Abdominal organ injury is suspected on history and physical examination, and presentation may be delayed. Tachycardia in children is a sign of possible shock. Abdominal exam may reveal contusions, abrasions, tenderness, or distension, and these should prompt further evaluation. "Seat belt sign" and "handle bar" sign, or focal bruising in keeping with history of blunt force being exerted to the abdomen, should make one suspect abdominal injuries.

Investigation

Blood workup Baseline blood cell counts, blood group, and cross matching should be obtained during the initial trauma assessment.

Sonography Focused abdominal sonography for trauma (FAST)—done by the provider, where available—can be used during primary assessment as a screening tool for free fluid in the abdomen. An ultrasound is more likely to be available than CT scan. A formal abdominal ultrasound (performed by a technician) may also have similar benefits [22].

X-ray Though not usually helpful in the diagnosis of solid organ injuries, it may be useful in diagnosis of hollow viscus injury and pelvic injuries as well as skeletal trauma patterns that may prompt further evaluation for solid organ injury. Pneumoperitoneum is associated with intestinal perforations; pelvic fractures with bladder, urethral, and rectal injuries; and posterior rib fractures; thoracic and lumbar vertebral fractures may be associated with renal and pancreatic-duodenal injuries, respectively.

CT CT is highly accurate in diagnosis and staging of liver, spleen, and renal injuries. With contrast, duodenal, pancreatic, and vascular injuries can be diagnosed.

CT availability and affordability in LMICs are variable, and one should be in a position to make decisions on the available information, without awaiting a CT scan in an unstable child.

Explorative laparotomy Given that laparoscopy is not readily available in most LMICs, laparotomy is the next logical option in cases of diagnostic dilemmas such as free fluid with no solid organ injury, pancreatic injury, biliary tree injury, mesenteric hematomas, and diaphragmatic tears that may be missed in the initial evaluation and investigations.

Management

Liver and Spleen

Ninety to 95% of liver and splenic injuries in the pediatric population can be managed nonoperatively. This decision depends on accurate diagnosis and grading of the injury, hemodynamic stability, and the availability of close monitoring of the child, for any signs of deterioration. Signs of hemodynamic instability, peritonitis, or persistent fluid accumulation should prompt operative management. Nonoperative management involves hospital admission, observation, and possible repeat ultrasound scan. Higher grades of injury may require intensive care where possible or monitoring in a higher dependence unit. Children require restriction in activity up to 6 weeks after injury for higher-grade injuries that heal with nonoperative management.

Some children will present with tachycardia and evidence of intra-abdominal fluid, and initial resuscitation may fail to stabilize them. These children require emergency operative management because options such as massive transfusion protocols may not apply due to scarcity of blood and blood products in most LMICs, and the use of blood prior to achieving hemostasis is not advisable. However if available, 20 ml/kg of whole blood should be given to maintain hemodynamic stability till operative management ensues. Otherwise crystalloids should be used to sustain intravascular volume.

In the case of operative management for liver and splenic injuries, the patient is prepared and draped to provide surgical access to the chest, abdomen, pelvis, and femoral vessels. IV access should be initiated above the diaphragm. Packing of all four quadrants upon gaining access to the abdomen is done to achieve tamponade. Splenectomy is indicated in an unstable child with a high-grade injury. Postsplenectomy sepsis from encapsulated organisms is rare (0.2%), and pentavalent vaccine can be given especially to children <2 years who have splenectomy done to achieve hemostasis. Immunization against meningococcal infection and prophylaxis for malaria will also be required. The benefit of a splenic implantation into the omentum is uncertain, and partial splenectomy and splenorrhaphy, if appropriate, can be considered depending on the patient's stability and the surgeon's experience.

Operative hepatic injuries are more difficult to manage in resource-poor settings due to complexity of injuries and scarcity of general surgeons exposed to hepatobiliary surgery. In deep lacerations of the liver, in an unstable child, "damage control surgery" is a primary strategy. A Pringle maneuver, with intermittent occlusion of the porta, can help differentiate hepatic arterial and venous bleeding and can help to achieve hemostasis as resuscitation ensues. Adequate exposure requiring mobilization of hepatic ligaments is required, and this is followed by temporary maneuvers like packing and temporary abdominal closure to prevent abdominal compartment syndrome. Multiple reexplorations, change of packings, and repair of lacerations with deep figure-of-eight "liver sutures" may suffice for some injuries. Large hepatic fractures are best treated with anatomical liver resections. Packing and temporary abdominal closures can be employed until transfer to a facility with liver resection competence, but mortality in such cases remains high due to lack of critical care and other support measures.

Abdominal Compartment Syndrome
Intra-abdominal hypertension, associated with organ dysfunction, can occur in abdominal injuries resulting in decreased intra-abdominal organ perfusion and cardiopulmonary compromise. Manometry is scarce in LMICs, and one has to have a high index of suspicion, proper documentation of physical findings, and staged abdominal closure after damage control surgery. Signs of abdominal compartment syndrome include abdominal distension and firmness, hypotension, low urine output, and poor ventilation. Alternatively, this may develop in a patient managed nonoperatively and require laparotomy.

Biliary Injuries
These can be difficult to diagnose at initial presentation and may present at a delay with features of peritonitis or a biloma that are characterized by fevers, abdominal pain, altered bowel habits, and elevated liver enzymes. In LMICs, as interventional radiology is unavailable, management may involve placement of drains in the liver bed to drain the bile and transfer to a facility with ERCP with stenting. If this expertise is unavailable, operative exploration may be needed.

Pancreatic Injuries
These are difficult to diagnose without cross-sectional imaging or MRCP-ERCP. In the absence of peritonitis, allowing for formation of a pancreatic pseudocyst and managing the cyst later may be the safest solution in LMICs. If distal pancreas is involved, then distal pancreatectomy can be done.

Diaphragmatic Injury
When present, this is indicative of severe trauma. This can be diagnosed on two-view X-ray but may present at a delay, as well reported even in high-income settings. This may occur with pneumothorax or bowel herniation may cause hemodynamic instability. Primary repair with long-term absorbable suture is often possible.

Hollow Viscus Injury
Focal or localized blunt trauma can result in injury to hollow viscus. Seat belt injuries and acceleration-deceleration injuries also cause viscus injuries at points of

mesenteric fixation. Traumatic hollow viscus injury usually manifests as peritoneal irritation secondary to peritoneal contamination. Emergency laparotomy is indicated. Resuscitation, debridement, and primary closure may be attempted in the stable patient and depending on the location of the injury; diversion of stool may be needed in the unstable patient with multiple injuries, rectal injuries, or questionable bowel perfusion in mesenteric hematomas or bowel wall hematomas. For injuries to the stomach, primary repair is sufficient, and the gastroesophageal junction as well the posterior wall of the stomach must be inspected. Duodenal hematomas generally resolve with nonoperative management but may require a period of nutritional support that may not be possible in the resource-poor setting, and hematoma evacuation may thus be required. Isolated rectal injuries and perineal injuries also require a workup for possible sexual abuse.

Renal Injuries

Blunt trauma accounts for 80–90% of renal injuries, most commonly due to MVCs, and patients present with hematuria and flank pain. Organ preservation is the goal, and similar to other abdominal solid organs, nonoperative management is successful in the vast majority of cases. For the hemodynamically stable child, bed rest, serial exams, and interval ultrasounds (as needed) to monitor injury progress, as well as urinalysis until hematuria, have resolved. High-grade renal injuries with associated hemodynamic instability warrant nephrectomy, as do large urinomas.

Urinary Bladder Injuries

These may occur together with pelvic injuries. High-grade injuries with laceration and intra- or extraperitoneal extravasation of urine require operative management. Two-layered closure with absorbable suture (2/0) and bladder decompression through a suprapubic or urethral catheter are required to facilitate healing. Peritoneal lavage and suctioning of all intra-abdominal urine is important in preventing postoperative fevers and peritonitis.

Thoracic Trauma

The majority of thoracic trauma in children, again, is due to blunt force as a result of MVCs and may be part of a more complex picture in a multiply injured patient. A cardinal feature of pediatric trauma that also applies in the abdomen applies in the chest: the great pliability of the pediatric skeleton means that high-force injuries would cause broken bones/ribs in an adult, in a child may not lead to fractures but rather to underlying solid organ injury or contusion. In the chest this generally means that even with a significant degree of force, a child's ribs may not be broken, but the underlying lung may be contused.

Chest X-ray will be the primary investigation available as a CT scan is not likely to be routinely available. Lung contusion may be most apparent on a chest X-ray showing opacification of the affected area but no visible bone fracture. Pulmonary contusions generally will resolve with nonoperative intervention though X-ray resolution may lag. Lower rib fractures can be associated with abdominal visceral injuries, and these should be evaluated during the initial assessment.

Pneumothoraces, unless very small, require tube thoracostomy done in a similar technique to placement in an adult, but with a much smaller tube. Tension pneumothorax would ideally be identified in the primary survey and may mandate needle thoracostomy prior to placement of a larger chest tube. A large air leak suggestive of a major airway disruption may require thoracotomy and repair. Injuries to the great vessels (i.e., aortic tears) are not as common as they are in adults. Hemothoraces draining more than approximately 15–20 cc/kg or 2–3 cc/kg/h for 3 h or more may require thoracotomy for hemorrhage control. Penetrating thoracic trauma will require operative intervention in the majority of cases.

Head Injury

Traumatic brain injury (TBI) is different in children than adults. The relatively large head compared to the rest of the body makes the center of gravity higher and the head more likely to be injured. Unfused sutures allow some expansion and limited protection for the brain. Intracranial injuries frequently occur without skull fractures as the skull bones are thin and pliable and do not provide much protection.

TBI is common in children and accounts for up to 32% of all injuries in children in some studies. In LMIC reports of TBI combining children and adults, children account for about 4–13% [23, 24]. The majority of TBI in children occur from motor vehicle accidents (MVA) (often as pedestrians), falls from height, and assaults in the older child. In conflict areas, injury from missiles may become more prevalent [25, 26].

The patient may present with TBI in isolation or as part of multiple injuries. Due to lack of prehospital care in many LMIC settings, most of the patients are brought into the emergency room unresuscitated and without any prior first aid and may arrive hypoxic and hypotensive. Thorough examination of all systems is necessary (after resuscitation) to identify other injuries, which may take priority over TBI. Careful neurological examination should ascertain the severity of head injury using the Glasgow Coma Scale appropriate for children (Table 20.4) [27]. A tense anterior fontanelle (when the fontanelle is patent) suggests rising intracranial pressure. Lateralizing signs, including pupillary changes and limb weakness/paralysis, should be ascertained but are late signs especially in younger children with unfused sutures. Bleeding from any open head wounds should be controlled by gentle firm pressure and covered by warm, moist, and sterile gauze.

While evaluating the patient, those with moderate to severe head injury should have their C-spine protected using appropriate-sized cervical collar or collar improvised from available material such as cardboard. Alternatively, small sand bags and tightly rolled clothes can be placed on either side of the neck. Adequate resuscitation should be achieved as much as possible before moving the child out of the emergency room for any imaging studies.

Table 20.4 Glasgow Coma Scale for children

Assessed function	Infants	Children	Score
Eye opening	Open spontaneously	Open spontaneously	E4
	Open in response to verbal stimuli	Open in response to verbal stimuli	E3
	Open in response to pain only	Open in response to pain only	E2
	No response	No response	E1
Verbal response	Alert, coos, and babbles	Oriented, appropriate	V5
	Spontaneous irritable cry	Confused	V4
	Cries in response to pain	Inappropriate words	V3
	Moans in response to pain	Incomprehensible words/ sounds	V2
	No response to pain	No response	V1
Motor responses	Moves spontaneously and purposefully	Obeys commands	M6
	Withdraws to touch	Localizes painful stimulus	M5
	Withdraws in response to pain	Withdraws in response to pain	M4
	Response to pain with decorticate posturing (abnormal flexion)	Abnormal flexion to pain	M3
	Response to pain with decerebrate posturing (abnormal extension)	Abnormal extension to pain	M2
	No response to pain	No response to pain	M1
Grimace component	Spontaneous normal facial/or motor activity (e.g., sucks tube, coughs)		G5
	Less than usual spontaneous ability or only responds to touch		G4
	Vigorous grimace to pain		G3
	Mild grimace or some change in facial expression to pain		G2
	No response to pain		G1

Adapted from Abantanga et al. [27]
Severity in head injury using EVM components: GCS 14–15 = minor head injury, GCS 9–13 = moderate head injury, and GCS ≤8 = severe head injury

Plain radiographs (anteroposterior and lateral films) may be useful in the initial assessment as the presence of fractures may suggest possibility of intracranial injury (depressed fractures may be identified and the extent of depression of the inner plate could be helpful), and pneumocephalus may be seen [28]. However, intracranial injuries often occur without skull fractures, and radiographs are of limited value in therapeutic decision-making but may be the only imaging modality available. Anteroposterior and lateral C-spine radiographs should be obtained in moderate to severe injuries; however, children may have spinal cord injury without showing obvious radiological abnormalities (SCIWORA). CT scan is the desired imaging modality to identify and characterize brain injuries. If available, CT scan should always be obtained in moderate to severe TBI. MRI is rarely available except in a few large tertiary hospitals. In the absence of CT scan, transfontanelle ultrasonography (if the fontanelle is patent) may be helpful in identifying intracranial hematoma.

Resuscitation is crucial to the outcome of TBI. Respiratory and cardiovascular stability should be achieved. In moderate to severe injury, oxygen should be administered by available methods (face mask, nasal catheter, nasal prongs). This may mean endotracheal intubation and mechanical ventilation in severe head injury. Hypotension should be corrected.

Restraining for restlessness should be avoided and sedation may mask neurological signs and making it difficult to identify deterioration. Rather, the cause of restlessness (hypoxia, hypotension, increasing intracranial pressure, electrolyte derangements, full bladder) should be identified and addressed. Seizures can be controlled with phenobarbitone or phenytoin, which are less likely to interfere with neurological assessment.

Due to limited resources, the approach to treatment of TBI in children in LMICs may need to be modified (Fig. 20.3). The majority of TBI in children can be managed nonoperatively; only about 3–21% require surgical intervention for evacuation of intracranial hematoma or elevation of significantly depressed skull fracture [23, 24, 29]. The decision to operate is guided by clinical assessment due to lack of CT scan in many settings. Rehabilitation may be necessary for those with residual neurological deficits.

The outcome of TBI in children is good, as the majority has mild injury. One recent systematic review of children with mild TBI concluded that most achieve functional physical and psychological recovery [30]. Post-traumatic seizures have been reported in about 18% of children with moderate to severe injury, more so in those <10 years old [31]. Mortalities of 3–15% have been reported from TBI in LMICs, mostly from severe TBI [23, 24, 29].

Burns and Burn Care

Please see Chap. 21 Plastic Surgery for the Non-Plastic Surgeon in the Low Resource Setting.

Fractures

See Chap. 16 Essential Orthopedics for Global Surgery as well. Musculoskeletal injuries are common in children. The management of these injuries in children differs from the adult due to the fact that [32]:

- The periosteum is thicker and provides greater fracture stability.
- The periosteum is more active and has greater potential for fracture healing by traditional bone formation.
- Fracture healing is faster.

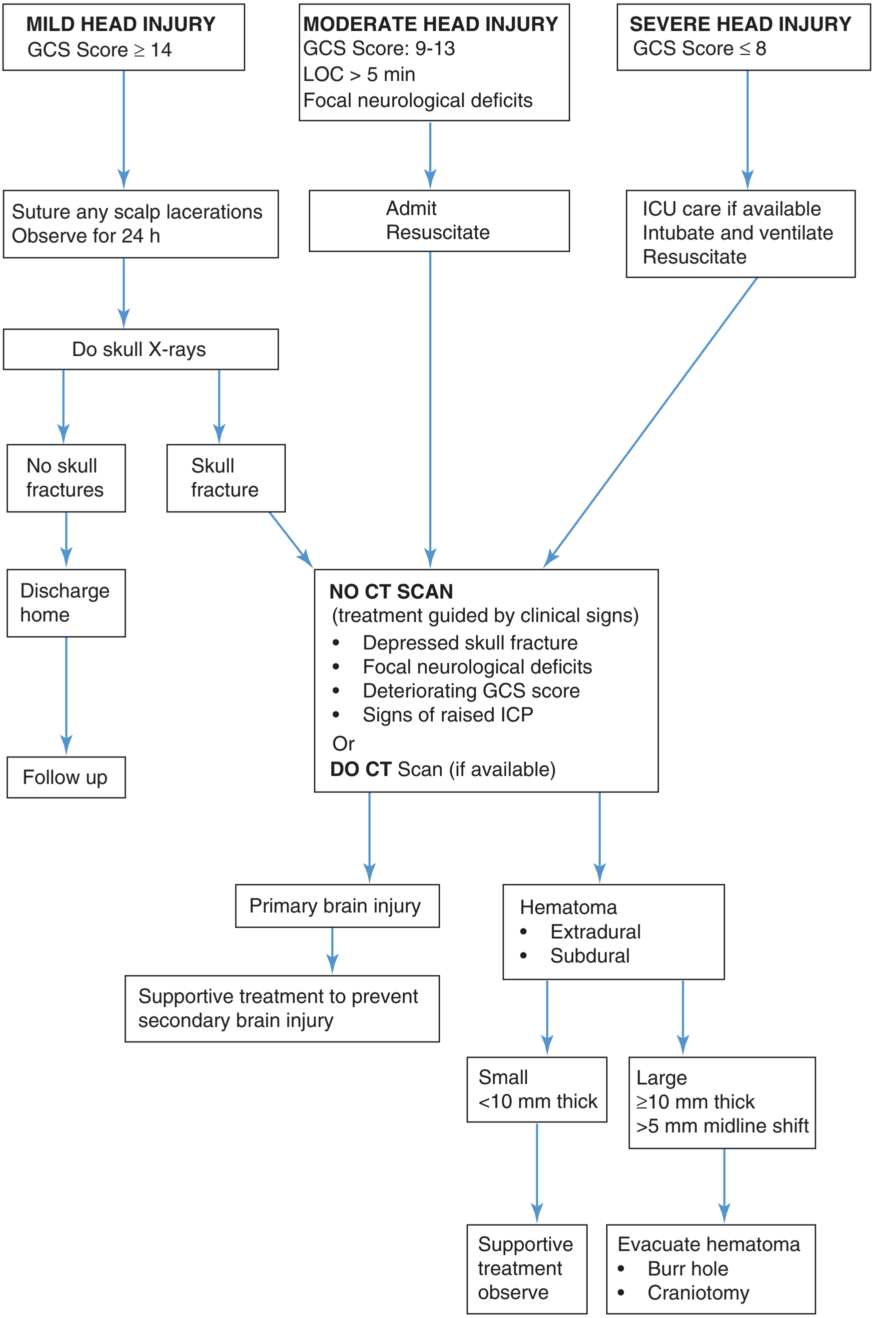


Fig. 20.3 Suggested algorithm for management of head injury in children in LMICs. *GCS* Glasgow Coma Scale, *LOC* loss of consciousness, *ICU* intensive care unit, *CT* computed tomography (Modified and adapted from algorithm provided by Dr. MR Mahmud, Consultant Neurosurgeon, Division of Neurosurgery, National Hospital, Abuja, Nigeria)

Table 20.5 Gustilo-Anderson's classification of open fractures

Type I	Clean wound <1 cm diameter with simple fracture pattern, no skin crushing
Type II	Laceration >1 cm – <10 cm without significant soft tissue crushing. The wound bed may appear moderately contaminated
Type III	Open segmental fracture or a single fracture, >10 cm laceration with extensive soft tissue injury
A	Adequate soft tissue cover, despite extensive laceration and skin flaps
B	Moderate soft tissue cover, periosteal stripping
C	Vascular injury

Although the management of these injuries can be straightforward, lifelong deformity and disability may occur with inappropriate management. The most common sites for fractures are:

- The upper limbs
- The femur
- The tibia
- The fibula

The injury may be isolated but in about 14%, the fracture occurs as part of multiple injuries [33]. Most children will present with pain, swelling, or deformity of the limb and inability to bear weight on the affected limb. An inconsistent history and fractures at different stages of healing should raise the suspicion of child abuse, especially below the age of 5 years [34]. Tenderness and deformity at the fracture site is often present. If the fracture involves only one cortex of the bone (greenstick fracture), deformity may be absent, and inability to use the limb may be the only finding. Any break in the skin close to the facture site should raise the suspicion of open fracture, which if present should be categorized according to the Gustilo-Anderson's classification. Although attempts have been made to modify this classification for pediatric size, the original classification detailed above remains useful (Table 20.5) [35]:

Neurovascular injury should always be excluded by careful evaluation. Neurovascular injuries may be due to entrapment between the fracture ends, contusion, or transection and are particularly at risk in supracondylar fracture of the humerus, distal femoral fracture, and posterior dislocation of the knee. Paresthesia and pallor distal to the site of fracture are features of vascular injury and compartment syndrome. They are often late signs, and in children, differentiating between the pain of compartment syndrome and fracture pain may be difficult. It's important to always consider the possibility of these complications.

The affected limb should be splinted using available appropriate material (cardboard, plastic, purpose-made splints, strapping to opposite limb in femoral fracture) to reduce pain and minimize further soft tissue injury. Plain radiographs are often all that is needed for decision-making. At least two views (anteroposterior and lateral) should be obtained to identify the site of fracture, the presence and extent of displacement and angulation, and joint involvement. A greenstick fracture is common in younger children and should be carefully looked for. The presence of gas within the soft tissues should raise the suspicion of clostridial (and other anaerobic) infection, which can occur in those presenting late and following traditional bonesetter intervention. In the child with multiple injuries, if available, the Lodox® (low-dose whole-body X-ray) can be helpful in quick identification of skeletal injuries.

Resuscitation and management of life-threatening injuries (cardiothoracic, abdominal injuries, and intracranial hematomas) take priority over definitive treatment of fractures. Compartment hypertension requires fasciotomy. During resuscitation and care of life-threatening injuries, fractures should be splinted. Appropriate analgesia (preferably intravenous) is provided to control pain and make the child comfortable.

Closed Fractures

Most closed fractures in children are amenable to nonoperative treatment (closed manipulation and reduction). This is best done under image intensifier or fluoroscopy (if available) and under general anesthetic. In the absence of general anesthesia, the fracture site can be anesthetized by nerve blocks or infiltration of local anesthetic (bupivacaine or lignocaine/lidocaine) into the fracture site hematoma, but care is taken to avoid intravascular injection of the local anesthetic. Fracture reduction is then achieved by gentle manipulation, including correction of displacements and rotational deformities. After reduction, adequacy of distal pulses should be confirmed to avoid vascular compromise. If reduction was not image guided, adequacy of fracture reduction should be confirmed by post-reduction radiographs. Slight overlap of the fracture ends is considered acceptable as it would usually correct over time by modeling. In HICs, operative reduction and internal fixation is done for these fractures in adolescents, but this option may be limited in many LMIC hospitals due to lack of appropriate resources and cost. However, operative treatment has the advantage of precision, earlier mobilization, and quicker return to activities. Type I open fractures can be safely treated in the same manner after cleaning of the wound [36].

Open Fractures

Type II and III fractures require careful and meticulous attention to the wound and accompanying soft tissue injuries. Cross-matched compatible blood should be available for transfusion. Wound debridement should be done preferably under general anesthetic and with tourniquet in place (tourniquet time should not exceed 30 min at a time). Debridement consists of adequate exposure (this requires extending the wound by incision), generous irrigation with large volumes of warm saline for removal of all foreign material, and excision of devitalized and necrotic tissue. (A large syringe, e.g., 50 ml or free-flowing saline from an infusion giving set can be used) [32, 34]. Bleeding or contracting muscle after tourniquet removal indicates the tissue is viable. If the viability of soft tissue is doubtful, it may be safer to defer excising such tissue until a second look. Both fracture ends should be visualized and cleansed as foreign material or soft tissue may be lodged between them. Unlike in adults, devitalized bone should not be removed but left in place as the periosteum will incorporate it during healing. Any exposed bone should be covered by local tissue. Before wound closure, the compartments should be palpated to exclude compartment tension. Following adequate debridement, the extended incisions can be closed primarily and the main trauma wound left open for delayed primary closure. Alternatively, the main trauma wound can be closed over a drain. Debridement may need to be repeated after 48 h in type III fractures. The timing of wound irrigation and debridement has been controversial, with the previous belief that infection rates are high if the wound is treated after 6 h from time of injury. In one report including adults and children, [37] and another report of 536 children with 554 open fractures, [38] there was no significant difference in infection rates across all types of open fractures, if treatment is done within 6 h compared to treatment after 6 h. Although there are no randomized controlled trials in children, it's now considered safe to treat open fractures within 24 h without increasing infection rates if appropriate antibiotics are given at admission [32].

In addition to these measures, parenteral broad-spectrum antibiotics (commenced on admission) should be given to prevent infection. A 3–23% overall infection rate have been reported in open fractures in HICs, but this rate may be higher in LMICs [37, 38]. The choice of antibiotics should be guided by prevailing local sensitivity profile, but where this is not available, a cephalosporin and metronidazole (or Co-Amoxiclav + aminoglycoside + metronidazole) should be given. Tetanus prophylaxis using tetanus toxoid should be given in unimmunized patients and patients with unknown immunization status to prevent tetanus. Fractures occurring in a particularly dirty environment (e.g., farm) require, in addition, passive tetanus immunization using human immune globulin or anti-tetanus serum as available.

Following nonoperative reduction, closed fractures can be immobilized by any available appropriate method including plaster of Paris cast (or Scotch cast) and traction (skin traction for younger children). When casts are used, the proximal and distal joints should be included in the immobilization. Immobilization of femoral fractures is particularly problematic as immobilizing the hip joint with a hip spica may be ineffective (the plaster cast may become wet and soften). Before application of a full cast, half plaster cast ("back slab") should be used first to allow edema to subside, to avoid creating a compartment syndrome. In clavicular fractures, the figure-of-eight splint may be all that is required. If operative reduction was done, appropriate internal fixation using available implants is done. It's recommended that implants be removed as soon as consolidation occurs, to avoid difficulties at removal.

Following operative care for open fractures, immobilization should be provided in such a way that allows access to the wound to facilitate wound care and identify any infection early. This can be provided by external fixators (if available) or plaster cast. If a cast is used, a "window" can be cut over the wound site after the cast has set.

Early mobilization, once there's consolidation to allow some weight bearing, should be encouraged to aid healing and minimize joint stiffness. Appropriate rehabilitation is important to ensure quick and full recovery to activities and function.

When appropriately and adequately treated, the outcome for closed fractures and type I open fractures are good. Nonunion is not common and acceptable overlaps would usually correct by remodeling. Osteomyelitis can be a problem following open fractures and occurs in up to 6% of patients in HICs [37] but in LMICs, the risk if osteomyelitis can be significantly higher. This should be minimized by early administration of appropriate antibiotics. Complications arising from traditional bonesetting are common in LMICs. Limb gangrene from these complications results in need for amputation to control progressing and avoid overwhelming infection.

Surgical Infection in Children

Typhoid Fever

The Essentials

- Severe surgical complications can occur if typhoid fever is not adequately treated.
- Intestinal perforation is the commonest severe surgical complication.
- Adequate preoperative resuscitation and appropriate antibiotics are crucial to survival.
- Simple closure and segmental resection are effective treatments for intestinal perforation.

Typhoid fever is a multisystem infection caused by *Salmonella.* The disease is transmitted by feco-oral route and is endemic in many LMICs, largely due to improper sewage disposal systems, inadequate supply of clean water, and unhygienic environment. Twenty-one million cases occur annually, with children aged 5–15 primarily affected, though it does also occur in younger children [39]. Untreated, several surgical complications can occur (Table 20.6).

Complications of typhoid fever frequently present late, commonly after attempting treatment with over-the-counter antibiotics or local medications. Nearly 10% of children with typhoid fever develop intestinal perforation while on medical treatment, which tends to mask the features [40]. Symptoms can include fever and headache; abdominal pain sets in frequently after 1 week of onset of fever, and sudden increase in abdominal pain suggests intestinal perforation or other intra-abdominal complication. Abdominal distension follows in patients with intestinal perforation but may also be present in those without perforation. Diarrhea or constipation may

Table 20.6 Surgical complications of typhoid fever

Common	Less common
Intestinal perforation	Abscesses (hepatic, splenic, other)
Intestinal hemorrhage	Pancreatitis
Cholecystitis	Orchitis
Osteomyelitis	Pleural effusion

be present and may be bloody in those with intestinal hemorrhage. Jaundice suggests the development of cholecystitis or overwhelming infection. Chest pain and pain in the limbs are suggestive of complication in those areas.

The typical child with typhoid is critically ill, particularly in cases of perforation. The diagnosis of intestinal perforation is mainly clinical, but laboratory tests and imaging may be necessary to guide treatment and also to exclude other conditions [41]. Serum electrolytes and creatinine should be drawn: in some patients, the electrolytes may be normal at presentation, but a repeat analysis after resuscitation commonly reveals depletion. For this reason, the decision to operate should not be made until the electrolytes are analyzed after resuscitation. However, lack of electrolytes and creatinine result should not unduly delay surgical intervention once adequate resuscitation has been achieved. Hypokalemia and metabolic acidosis are common. Complete blood count may identify anemia. Leukocytosis and neutrophilia are common in those with intestinal perforation. Blood should be grouped and cross-matched for pre-, intra-, and postoperative transfusion. Radiograph of the chest and upper abdomen may show pneumoperitoneum, which when large may need to be vented to improve respiration and reduce hypoxia. Abdominal ultrasonography can help to identify cholecystitis and also intraperitoneal abscesses.

Adequate preoperative resuscitations, including correction of fluid and electrolyte depletion and, if necessary, blood transfusion and nutritional support, are crucial to outcome of treatment. Intravenous broad-spectrum antibiotic combinations (to include an anti-salmonella antibiotic) should commence before surgery (e.g., amoxicillin or ampicillin + gentamicin + metronidazole, third-generation cephalosporin + metronidazole or ciprofloxacin + metronidazole).

The definitive treatment for intestinal perforation is surgical, to evacuate fecal contamination and prevent further contamination. In patients who are very ill and considered poor anesthetic risks, the use of ketamine is a safe and effective alternative. In addition to thorough peritoneal lavage, effective surgical options include simple closure of perforations, segmental resection, or damage control enterostomy, and decision should be determined by intraoperative findings.

Given the severity of infection and often delayed presentation in patients with typhoid intestinal perforation, complications following surgical treatment occur in 53–79% of patients, and mortality is variable with reported rates of 4.8–41% [42].

HIV and Tuberculosis

The Essentials

- HIV disease may present in children with surgical conditions such as soft tissue infections, cancers, and acquired rectovaginal fistula.
- Coinfection with tuberculosis may be manifested in thoracic or abdominal complications that may be difficult to differentiate from other pathologies.
- Antitubercular therapy should be attempted for the patient with chronic abdominal tuberculosis, but surgical exploration may be required.

In some regions, the prevalence of HIV in the pediatric population remains very high. Most children with HIV are infected through vertical transmission. As HIV+ patients may initially present to the medical system with a surgical condition, surgeons should be familiar with the general criteria for diagnosis of HIV infection. An infant or child may present with adenopathy suggestive of HIV disease, of HIV-associated tuberculosis, or with a soft tissue infection secondary to immune compromise. HIV-infected children also have a higher incidence of lymphoma. Several HIV-defining surgical pathologies bear mention such as spontaneous rectovaginal fistula or neonatal CMV enteritis. The symptomatic patient with HIV with an elective surgical condition should have surgery deferred until the medical status is optimized.

Tuberculosis is more prevalent in high HIV prevalence countries, with an overall reported incidence of 0.7–2 per 1,000 children, and accounts for about 15% of bowel obstruction in children [43]. General workup may include skin test and sputum for AFB. For chronic abdominal symptoms, contrast studies (from above and below) may show thickened bowel wall or strictures, and in case of ascites, a paracentesis may be performed. A more chronic presentation may have other causes of bowel obstruction in the differential, such as a delayed presentation of Hirschsprung's disease. Rectal examination may detect fissures, fistula, or stenosis. Ultrasound may show bowel thickening or peritoneal nodules. Nodular disease may also suggest malignancy; ascites may also occur from other medical problems such as liver failure or undernutrition.

Tuberculosis of the abdomen may present as acute or chronic peritonitis or bowel obstruction. For chronic symptoms, antitubercular therapy may be attempted for several weeks prior to surgery. Laparotomy may reveal thickened omentum, mesentery, or bowel wall. Copious ascites or adhesions may be present. Large or small bowel obstruction may occur due to thickening or strictures; presentation with frank bowel perforation is less common. High-grade strictures may require stricturoplasty in Heineke-Mikulicz fashion, and in cases of perforation, ostomy may be required due to peritoneal contamination. As tuberculosis cannot be "cleared" with surgery alone, the goals of operation are to treat the acute problem and to continue antitubercular chemotherapy postoperatively. Perforation is generally preferentially treated with resection and anastomosis rather than oversewing of the perforation alone, due to concern about tissue integrity around the site of perforation. Partial intestinal obstruction may be relieved with medical therapy over a period of months and may be attempted in selected circumstances.

Omphalitis: Surgical Complications

The Essentials

- Omphalitis is more common in LMICs and often responds to medical therapy.
- More aggressive infections can occur and require debridement and abdominal exploration.

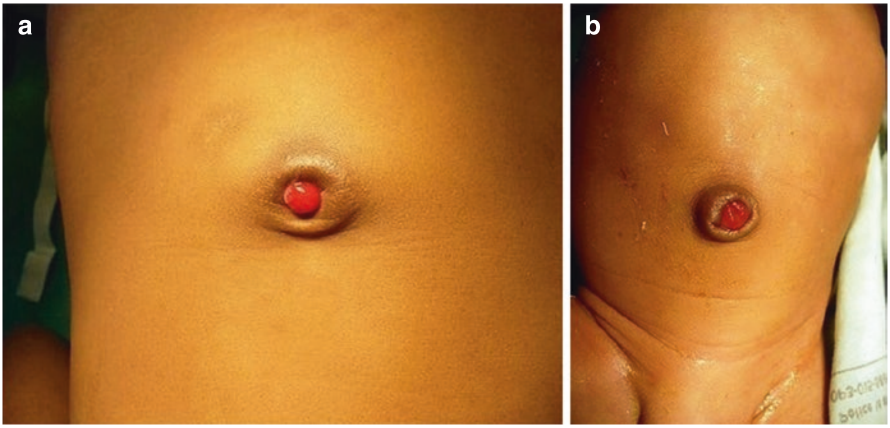


Fig. 20.4 Other umbilical pathologies to be differentiated from omphalitis. (**a**) Umbilical granuloma. (**b**) Patent vitelline duct (omphalomesenteric fistula)

Omphalitis is an infection of the umbilicus and umbilical stump. It is predominantly a disease of newborns but can also affect infants. Although omphalitis is mainly a medical disease, surgical complications may develop. The incidence of this condition in LMICs has been reported as 2–7 per 100 live births [44, 45]. In addition, the umbilicus is generally the portal of entry for cases of neonatal tetanus [46].

It is commonly caused by aerobic bacteria, including *Staphylococcus aureus* (most common pathogen), Group A streptococcus, *Escherichia coli, Klebsiella*, and *Proteus* species. In one-third of patients, anaerobic bacteria (*Bacteroides fragilis, Peptostreptococcus, Clostridium perfringens, Clostridium tetani)* are involved.

The disease is usually noticed at age of 3–5 days in preterm infants and 5–9 days in term infants. The local signs of omphalitis include purulent or foul-smelling discharge from the umbilicus or umbilical stump, periumbilical erythema, edema, and tenderness. Pyrexia, hypothermia, and jaundice may be present. Other features will depend largely on the nature of presenting surgical complication. Omphalitis should be clinically differentiated from other conditions such as umbilical granuloma, vitelline duct anomalies, and urachal anomalies (Fig. 20.4a, b)—which typically present without an infectious picture.

A microbiological swab of the umbilicus and blood should be sent for aerobic and anaerobic culture, and antibiotic sensitivity profile should be obtained to guide treatment. A blood count with differential for white cell counts may show a neutrophilia (or occasionally a neutropenia). Other investigations including plain abdominal radiography and ultrasonography may become necessary depending on complications suspected and to exclude other diagnoses.

Prompt antibiotic administration along with appropriate cord care normally controls uncomplicated omphalitis. In the absence of culture results, empiric antibiotic treatment should be started with Ampiclox + gentamicin (or a cephalosporin) + metronidazole. Tetanus prophylaxis is necessary in in most infants. The treatment of surgical complications is detailed in Table 20.7.

Table 20.7 Treatment of surgical complications of omphalitis

Time scale	Complication	Clinical notes	Treatment
Early	Necrotizing fasciitis	Most common surgical complication	Antibiotics
		Starts initially as periumbilical cellulitis	Excision of all devitalized tissue
		The scrotum and abdominal wall commonly affected	Local wound dressing until infection controlled
			Cover defect by direct suturing, skin grafting, or flaps as appropriate
	Intestinal evisceration	Usually the small intestine, occasionally the large intestine	Cover the intestine with moist gauze and place in transparent plastic bag (intestinal bag)
		Eviscerated intestine may be strangulated	Umbilical defect may need extension
			Cleanse the intestine and return to peritoneal cavity
			Nonviable intestine should be resected
			If peritonitis present, do formal laparotomy and cleanse peritoneal cavity
	Peritonitis	Could occur without abscess	If no abscess, antibiotics alone may suffice
		Ultrasonography needed to exclude abscess	If abscess present, do laparotomy and drain
	Distant abscesses	May be retroperitoneal, hepatic, or elsewhere on the body	Abscess should be drained by:
		Abscess needs to be localized by appropriate imaging	(a) Percutaneous aspiration using wide-bore needle under imaging. May need to be repeated
			(b) Open drainage
Late	Portal vein thrombosis	Portal hypertension is the major consequence	
		Although early complication, the major consequence is late	Portosystemic shunt required if portal hypertension develops[10]
		A cavernoma ma produce biliary obstruction	Biliary obstruction should be treated appropriately
	Umbilical hernia	A common problem	Most would close spontaneously or significantly reduce in size by age of 2–4 years
		Usually asymptomatic but complications may develop	If not closed by 4 years, or complication develops, surgical repair required
	Peritoneal adhesions	A result of subclinical or treated peritonitis	Laparotomy and excision of adhesions required
		Adhesions cause intestinal obstruction, which is usually not responsive to nonoperative measures	Any gangrenous intestine to be resected

Uncomplicated omphalitis usually resolves if treated promptly. Most patients with surgical complications should recover but delayed presentation may result in a high mortality rate.

Pyomyositis

This is a bacterial soft tissue infection often distinguishable from the common simple soft tissue abscess by its presence within muscle tissue. This can be distinguished from infection in these areas due to adjacent osteomyelitis but may initially be treated in a similar fashion. It is most common in the extremities (lower limb > upper limb) and may present with a warm, swollen, fluctuant extremity. In other cases it may just present as pain with difficulty in walking. Ultrasound may be helpful but unnecessary given typical clinical presentation. Treatment consists of incision and drainage, with packing as necessary. An alternative depending on size and location may be incision and drainage through a modest incision and then a counter-incision with the use of a Penrose drain across the wound to obviate the need for packing.

While the etiology of pyomyositis is unclear, workup for immunodeficiency may need to be considered. In addition, distinguishing the swollen possibly infected extremity from soft tissue sarcoma with surrounding inflammation can be difficult, and this should always be considered. If in doubt, biopsy of the surrounding tissue is critical. This can be especially challenging in the buttock in patients with a history of medicine injections into the soft tissue with swelling and scarring of the tissue. Familiarity with availability and effectiveness of local pathology services is also critical.

Empyema

The Essentials

- Pleural effusions can initially be treated by thoracentesis but may require tube thoracostomy if persistent.
- Mini-thoracotomy may be required for empyema, but thoracotomy and full decortication should be avoided if possible.

Pleural effusions occurring in the presence of underlying pneumonia (parapneumonic effusion, PPE) and empyema thoracis (ET) are common in LMICs and are estimated to complicate community-acquired pneumonia in about 20–53% of cases in children [47, 48]. It has been estimated that there are 151 million new episodes of community-acquired pneumonia in children below 5 years in developing countries (about 0.29 episodes/child-year) compared to 4 million new episodes (or 0.05

episodes/child-year) in high-income countries and remains a leading cause of death in under-five worldwide in 2015 [48–51]. Although the incidence of pneumonia is thought to have reduced over the decades, ET remains an important complication, and the incidence appears to be rising. The introduction of pneumonia conjugate vaccine has been effective in reducing the incidence of postpneumonic ET in some settings, with a 50% reduction in the incidence reported from South Africa [52].

A large majority of ET occur as a complication of pneumonia. However, in a small number of patients, it may complicate pulmonary tuberculosis and trauma, following thoracic surgery or needle aspiration of pleural effusion from other causes. The complication may also be part of the manifestation of systemic disease such as typhoid fever.

The clinical presentation of ET is frequently that of cough, fever, and respiratory distress, in a child being treated for pneumonia, but in a few patients, ET may be the first presentation. In large collections, there would be trachea deviation and lung collapse. Small collections may present simply as lack of improvement in a child being treated for pneumonia. Anemia and varying degrees of malnutrition are present in some patients, both of which could have impact on recovery and outcome.

The diagnostic evaluation should include an initial chest radiograph which is helpful in establishing the presence of collection (Fig. 20.5) and presence of lung parenchyma disease. In large collections, fluid levels may be present and loculations may be identified. However, it may be difficult to differentiate

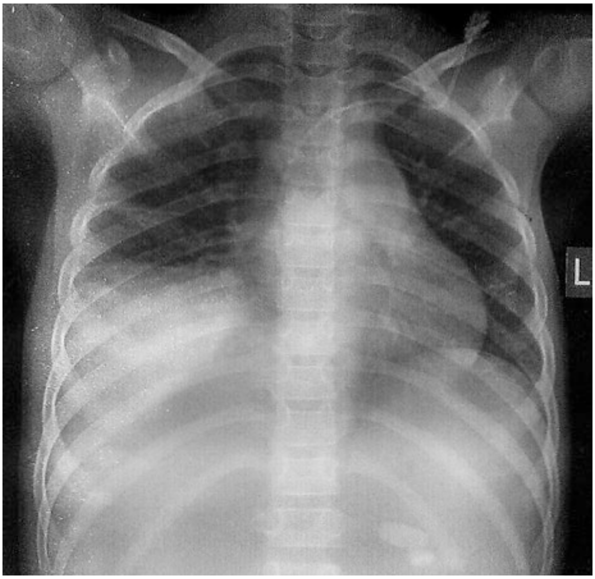


Fig. 20.5 Right-sided empyema thoracis in a 10-year-old girl

between collections and consolidation, and small collections may be missed. Thoracic ultrasound is good at quantifying the volume of collection and determining the presence of pleural peel (thickness) and loculations, as well as therapeutic decision-making, and should always be done if the facility is available.

Thoracentesis using a wide-bore needle (18–21G) helps to confirm the presence and nature of collection and should preferably be done under ultrasound guidance. In the absence of ultrasound, the site of thoracentesis should be guided by clinical and radiographic findings or done in the most dependent area of the chest. Repeated thoracentesis should be avoided. The aspirate should be cultured: *Staphylococcus aureus* is the isolate in >75%, mostly methicillin-sensitive *Staphylococcus aureus*, but methicillin-resistant *Staphylococcus aureus* (MRSA) is beginning to appear with increasing frequency in some LMIC settings and is important in HIV-associated ET [50, 53]. *Streptococcus pneumoniae* is cultured to a lesser extent, especially in older children. However, one recent report from South Africa, in which both the pleural fluid and blood were cultured, indicated that *S. pneumoniae* was the commonest cause of ET complicating community-acquired pneumonia: *S. pneumoniae* was cultured in 48% compared to *S. aureus* in 17%, with the former being more frequently cultured from blood [52]. In some reports, cultures are sterile in >50% of patients, possibly a result of prior treatment with over-the-counter antibiotics before arrival in hospital [50, 51]. Where possible, the aspirate should be analyzed for white cell count, lactate dehydrogenase (LDH), pH, and glucose, to help in categorization, but analysis for these parameters should not be routine. Lymphocytosis in the aspirate should prompt evaluation for pulmonary tuberculosis and malignancy [54].

Although computed tomography (CT) scan is effective at defining and characterizing ET, and assessing the state of the lung parenchyma, it should not be done routinely. Moreover, CT scan is not available in many LMIC hospitals (except large tertiary hospitals) and is costly. CT scan is best reserved for the planning of definitive surgical intervention when that becomes necessary. Sputum should be cultured and Ziehl-Neelsen stain done to exclude pulmonary tuberculosis, as appropriate. Complete blood count may show leukocytosis.

An understanding of the pathophysiology of PPE and ET has allowed the classification of the condition into various stages and grades. However, pleural infection is a continuum as detailed in the three stages detailed below [54]:

- Stage I (exudative): the pleural fluid/collection is clear.
- Stage II (fibrinopurulent): there's deposition of fibrin, increase in white cells, and eventual pus formation. Loculations may form.
- Stage III (organizational): there's infiltration of the cavity with fibroblasts and formation of thick inelastic pleural membrane (or peel). This stage may result in spontaneous healing or become chronic with lung entrapment and restriction.

It has been suggested that PPE is complicated if pH of the aspirate is <7.2, glucose <40 mg/dl, lactate dehydrogenase (LDH) ≥1,000 IU/L, size of the collection is

>1 cm, loculations are present, and bacteria culture is positive [55]. However, these biochemical parameters are not routinely necessary in clinical practice [54].

Clinical parameters and appropriate imaging should guide treatment. Early non-purulent collections may be treated by thoracentesis, but repeated thoracentesis should be avoided; all but very small collections require more definite drainage. Tube thoracostomy drainage is effective in 75–85% of cases [48]. As purpose-made chest tubes and drainage receptacles may not be available, other available materials can be used (e.g., Malecot's catheter, Nelaton's catheter, suction tubes, large nasogastric tubes). An algorithm for the treatment of ET, adapted to the LMIC setting, is detailed in Fig. 20.6. Most patients will require tube thoracostomy drainage using an appropriate-sized tube, and the presence of thick pus requires larger tube to ensure adequate drainage. The chest drain should be removed when drainage reduces to <10–15 ml/day, there's clinical improvement, and lung re-expansion is adequate as determined by repeat chest radiograph.

In HICs, placement of small catheters <14 F (e.g., pigtail catheter) along with fibrinolysis (using tissue thromboplastin activator or urokinase), even if there are loculations, and video-assisted thoracoscopic surgery (VATS) are considered first-line treatments and are associated with quicker recovery rates [47]. Although thoracostomy and fibrinolysis are used in some LMICs, these options are of limited use in the typical LMIC setting due to limited resources and cost. In the few patients, in whom tube thoracostomy tube drainage fails or is not appropriate, a mini-thoracotomy (using a small incision of about 3 cm in length) or rib resection should be done to break down loculations and a tube drain placed. This is effective in most patients, and decortication should be reserved for patients with lung restriction from peel, as this surgery may be associated with significant morbidity and long hospital stay. In some patients with chronic ET, an open chest drain could be used in some patients, but this is associated with prolonged morbidity. Lung parenchyma involvement such as lung abscess, lung necrosis, or bronchiectasis usually does not require surgical treatment.

Before availability of culture results, empirical broad-spectrum antibiotics should be started, including those effective against *Staphylococcus aureus* and *Streptococcus pneumoniae*. Once culture results are available, the antibiotic regimen should be guided by sensitivity profile, especially if the patient is not improving. Initially, antibiotics should be given parenterally for 5–7 days and then changed to oral route once pyrexia has subsided and continued for 1–4 weeks depending on the spectrum and sensitivity of bacteria involved and the response of the patient. Patients with underlying tuberculosis require administration of appropriate antituberculous drugs for 6–9 months. Other primary pulmonary pathologies should be treated as indicated [54].

Blood transfusion and nutritional rehabilitation should be done as necessary. Physiotherapy is considered unhelpful and should not be routinely done. However, in older children, early mobilization and exercise is helpful in aiding recovery [54].

With the administration of potent and appropriate antibiotics, and appropriate drainage and treatment, most patients with ET should recover. However, in LMICs,

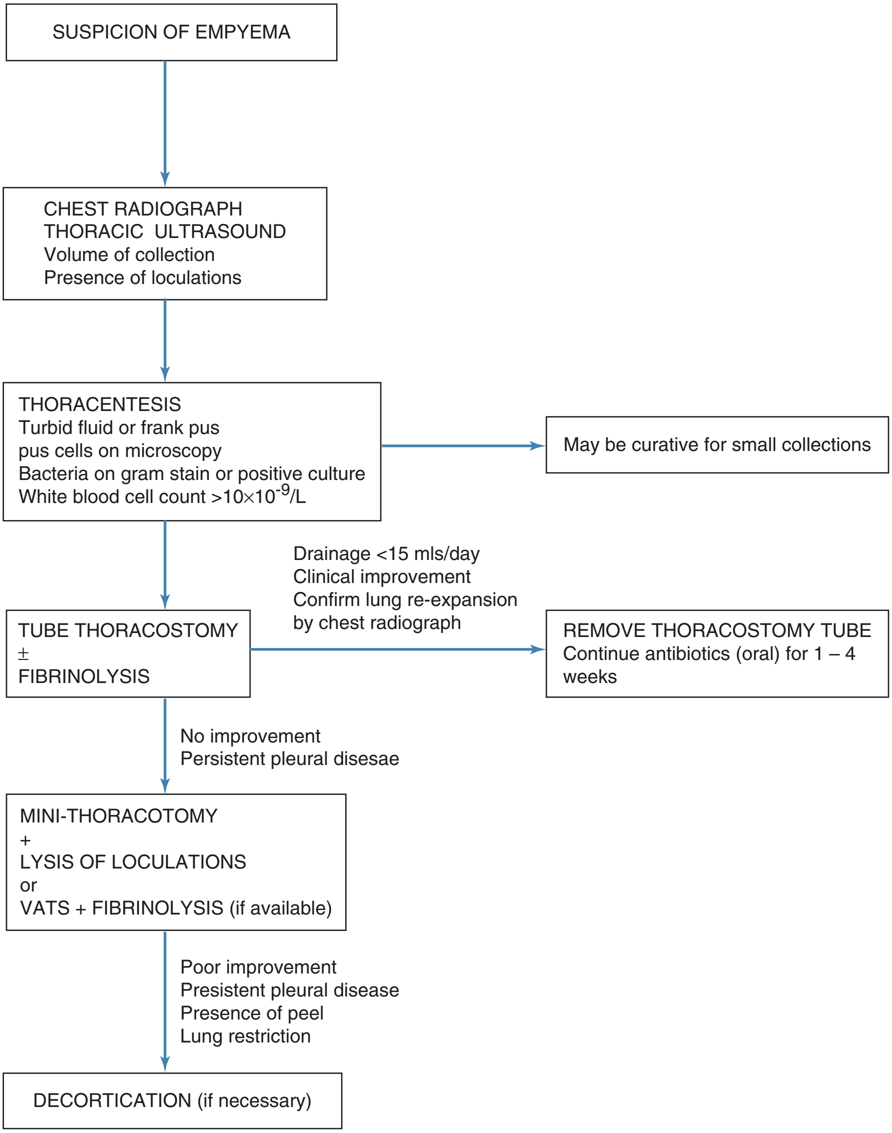


Fig. 20.6 Algorithm for treatment of empyema thoracis in LMICs. *VATS* Video-assisted thoracoscopic surgery. Fibrinolysis: use tissue thromboplastic activator or urokinase

mortalities of 4–16% have been reported, often from delayed presentation and underlying systemic disease [50, 52]. In tuberculous ET, bronchopleural fistula and malnutrition are common, pleural drainage is longer, and residual pleural fibrosis may persist [56].

Parasitic Infestations

The Essentials

- Ascaris intestinal infections can first be treated medically in stable patients.
- Exploration is required for failed medical management or peritonitis and may require resection, ostomy, or decompression of worms through enterotomy.
- Amoeboma and liver abscess should be first be treated medically with metronidazole, but failure may require percutaneous drainage or operative exploration.
- Hepatic hydatid disease should first be treated medically, but larger cysts may require operative exploration and excision with obliteration of the cyst cavity.

Parasitic infestations are endemic in many LMIC communities, and children often tend to bear the brunt of the disease. The World Health Organization (WHO) estimates that 882.5 million children required preventive chemotherapy for soil-transmitted helminths in 2009, with 74.3% of them located in Africa and Southeast Asia [57].

The common infestations are from helminths, protozoa, and ectoparasites and usually occur as a result of contact with or ingestion of contaminated food, water, or the primary host. Although parasitic infestations produce mostly medical illness, complications may arise that require surgical intervention [58, 59]. Some of the more common complications requiring surgical intervention are detailed in Table 20.8.

Gastrointestinal Complications

The gastrointestinal tract (GIT) is by far the leading site for surgical complications of parasites, ranging from acute to chronic manifestations and diagnostic confusion.

Intestinal Obstruction

Presentation with acute abdominal pain, arising from intestinal obstruction, intestinal volvulus, and intestinal perforation, is common manifestation with *Ascaris lumbricoides*, affecting about 41% of children with ascariasis [59–61]. In some settings, ascariasis is so endemic that it ranks as the leading cause of intestinal obstruction in children, reaching 60% in one report [58]. Intestinal obstruction is usually the result of heavy load of adult worms in the intestinal lumen, with the worms entangling and forming a "ball." Intestinal volvulus occurs as a result of the loaded loop of the intestine becoming redundant and twisting, intestinal gangrene may occur from the volvulus or from pressure necrosis caused by the ball of worms, and perforation occurs from ischemia of overlying intestinal wall. Occasionally, a worm may migrate through an anastomotic suture line leading to anastomotic leakage. Other

Table 20.8 Surgical complications of parasitic infestation in children

Site	Surgical complication	Parasites
Gastrointestinal tract	Intestinal obstruction	*B. Ascaris lumbricoides*
		Taenia saginata (solium)
	Intussusception	*C. Ascaris lumbricoides*
		Entamoeba histolytica
	Rectal prolapse	*Enterobius vermicularis*
		D. Trichuris trichiuria
		E. Entamoeba histolytica
	Recurrent abdominal pain	*F. Ascaris lumbricoides*
		Taenia saginata (solium)
		G. Enterobius vermicularis
		Trichuris trichuria
		H. Entamoeba histolytica
	Amoeboma (right iliac fossa mass)	*I. Entamoeba histolytica*
	Intestinal hemorrhage	*J. Entamoeba histolytica*
	Toxic megacolon	*K. Entamoeba histolytica*
Biliary tract	Biliary obstruction	*L. Ascaris lumbricoides*
	Cholangitis	*Clonorchis sinensis*
Urinary bladder	Granuloma	Schistosoma hematobium
	Carcinoma (squamous cell)	
Liver and lungs	Abscess	*M. Entamoeba histolytica*
	Cysts	*Echinococcus granulosus* (multilocularis)
Soft tissue	Dracontiasis (dracunculiasis)	*N. Dracunculus medinensis*
	Myiasis	Larvae of fly

worms such as *Taenia saginata* have been known to produce intestinal complications.

There are no clear distinguishing features from other causes of intestinal obstruction, but there may be a history of passage of worms in stool or vomitus. Plain abdominal radiographs may show the "whirlpool" pattern in addition to features of intestinal obstruction (intestinal dilatation and multiple fluid levels). Abdominal ultrasonography is helpful and may show outlines of floating worms within free fluid in the intestine [60]. Stool microscopy may show the ova of the causative parasite.

The initial treatment approach is medical, in addition to resuscitation, nasogastric drainage, and monitoring. Medical treatment is effective 50–78% of children with intestinal obstruction from ascariasis and consists of administration (through the nasogastric tube or oral if feasible) of albendazole, mebendazole, or levamisole [60, 61]. Gastrografin given by nasogastric tube may hasten the expulsion of the parasites. The progress of medical treatment can be monitored by ultrasonography.

In about 22–50% of children with ascaris obstruction, surgical intervention is necessary, due to worm impaction, peritonitis from intestinal gangrene, volvulus, or intestinal perforation. Impacted worms can be milked into the colon (to be passed out in the stool) [60, 61]. If this fails, the impacted worms can be evacuated through an enterotomy in a healthy looking adjacent segment of the intestine (not directly over the impacted worms as that segment may be compromised). Intestinal perforation and gangrene/necrosis require resection of the affected segment. Those treated surgically initially should receive appropriate anthelminthic once it's safe to administer enteral medications. Mortality of 1–19% from ascaris intestinal obstruction have been reported, but this should be unusual if presentation is early and treatment prompt.

Recurrent Abdominal Pain

A wide spectrum of GIT parasites (Table 20.8) produce abdominal pains and sometimes vomiting, the character of which is nonspecific and may be present for several weeks to months. Therefore, any child presenting with recurrent abdominal pain should have parasitic infestation excluded, usually by stool microscopy and abdominal ultrasonography. Even when evaluation reveals a surgical pathology, any identified parasitic infestation should be treated with anthelminthic before treating the surgical condition, to avoid postoperative morbidity from the parasitic infestation.

Other GIT Complications

Gastrointestinal parasites may also cause other GIT complications. Intussusception should be treated on its merit along with administration of appropriate anthelmintic drugs. Rectal prolapse may occur as a result of tenesmus and rectal irritation caused by the parasites. Stool microscopy (using fresh stool sample for amoebiasis) should show ova of the parasites or trophozoites of *Entamoeba histolytica*. Uncomplicated rectal prolapse is best treated nonoperatively by manual reduction and appropriate anthelmintic, including metronidazole for amoebiasis.

Entamoeba histolytica may produce a granulomatous reaction in the ileocecal region, resulting in the formation of a mass (amoeboma). This mass may be clinically indistinguishable from other causes of a mass in that region. Diagnosis may be confirmed from stool microscopy showing trophozoites of *E. histolytica*. Serologic tests using enzyme-linked immunosorbent assay (ELISA) or other immunological methods may be helpful. Sometimes, the diagnosis is only suspected when a mass is encountered in the ileocecal region at laparotomy. If a preoperative diagnosis is made, treatment should be medical by administration of metronidazole or tinidazole for 7–10 days. If the mass persists or intraoperative diagnosis is suspected, surgical excision should be performed and histopathological examination of the specimen done.

Biliary Complications

Jaundice from biliary obstruction and cholangitis may complicate infestation by parasites such as *Ascaris lumbricoides* and *Clonorchis sinensis* (liver fluke). Ultrasonography may show the outline of a worm within the biliary tree. Sometimes, *Ascaris* can migrate into the biliary tree following administration of anthelmintic for intestinal infestation. Medical treatment with appropriate anthelmintic is usually effective, and the response to treatment can be monitored by ultrasound if the parasite was identifiable at initial ultrasonography.

Liver and Lungs

Amoebic Liver Abscess

Hepatic abscess may occur as a complication/progression of intestinal amoebiasis. The patients usually present with right hypochondrial pain, fever, and tender mass in the liver with or without intercostal tenderness over the hepatic area. Sometimes, the abscess, which is usually in the right lobe, ruptures into the pleura or lung with the latter producing coughing of chocolate-colored material. Rupture into the peritoneal cavity produces amoebic peritonitis. Chest radiograph including the upper abdomen showing "tenting" or elevation of the right hemidiaphragm is suggestive of the diagnosis. Ultrasonography that would show the diagnosis of collection in the liver and needle aspiration (ultrasound guided if possible) of chocolate-colored fluid (anchovy sauce) confirms the diagnosis. Identification of amoebic trophozoites in the aspirate is unlikely, as it contains mostly necrotic liver tissue. The aspirate should be cultured to identify superimposed bacterial infection. The serological tests could be helpful if available and are positive in >90% of patients. Microscopic examination of fresh stool sample may identify the trophozoites of *Entamoeba histolytica* in patients with invasive disease.

The treatment of amoebic liver abscess is medical. Metronidazole or tinidazole should be given, initially intravenous, but should be changed to oral route once fever and tenderness have subsided. The medication should be continued for 10–14 days. Other anti-amoebic drugs including chloroquine and dehydroemetine are available but rarely used due to the fact that metronidazole is effective and associated with less side effects. Other appropriate antibiotics should be given if superimposed bacterial infection was identified at culture. Response to treatment should be monitored clinically and by serial ultrasonography. Surgical drainage is rarely required. Nonresponding abscesses (after 72 h of amoebicide) and abscess in the left lobe can be aspirated under ultrasound guide. In peritonitis, the amoebic pus should be evacuated percutaneously under ultrasound guide. However, if percutaneous drainage is not possible, the pus should be evacuated at laparotomy and the peritoneal cavity thoroughly lavaged with warm saline while protecting the wound edges to prevent cutaneous involvement.

Hydatid Disease

Hydatid disease is caused by *Echinococcus granulosus* and *multilocularis* (less commonly *Echinococcus vogeli*) and is endemic in North Africa and the Mediterranean region. The liver and lungs are most commonly affected and children aged 10 years and above predominate [62, 63]. The disease presents as single or multiple cysts in the liver and/or lungs. Diagnosis is established with the use of ultrasonography which is capable of identifying daughter cysts and hydatid sand and is able to differentiate it from amoebic liver abscess and pyogenic liver abscess. CT scan has a high sensitivity.

Medical treatment is recommended for cysts <5 cm in diameter and multiple cysts [63]. For cysts ≥10 cm and failure of medical treatment, surgical treatment (along with medical treatment) offers the best hope for cure. Surgery usually consists of removal of the parasites, sterilization of the cyst cavity with a scolicidal agent (e.g., formalin, chlorhexidine, cetrimide, povidone-iodine, ethanol, hypertonic saline), and protection of surrounding structures. The most effective surgical options include cystectomy or pericystectomy and capitonage (obliteration of the resulting cavity by multiple sutures). The effective anthelmintic for this infection includes albendazole and mebendazole, given over several weeks.

Surgical Emergencies in Neonates

Abdominal Wall Defects

The Essentials

- Distinguishing features of gastroschisis and omphalocele should be clear to a visiting clinician.
- While the bowel can be serially reduced and the defect closed in gastroschisis, the absence of TPN adversely impacts outcomes.
- Though associated anomalies are more common in omphalocele, outcomes are improved as nonoperative management is often sufficient in the neonatal period for larger defects, with subsequent repair of abdominal wall hernia at an older age.

Surgeons are frequently involved in the management of abdominal wall defects in the neonatal period. Gastroschisis involves a full-thickness defect in the abdominal wall to the right of midline, with bowel outside the abdominal cavity. In omphalocele, which is slightly more common, the bowel is outside the abdominal cavity, but the peritoneal lining is preserved (except when the coverings are ruptured).

In gastroschisis, immediate priority is resuscitation of the baby from third spacing and prevention of heat loss. Over the last decade, there has been a trend to placement of a temporary silo, serial reductions, and delayed closure of the abdominal wall under general anesthesia. If primary reduction is not possible at initial evaluation in a resource-limited setting, a temporary abdominal wall covering should be devised; in the absence of a spring-loaded silo, a basic dressing using a plastic bag may able to be used that covers the abdomen and the lower extremities to retain heat and minimize fluid losses. Alternatively, a silo can be constructed by using or sewing together several pieces of urine bags (generally softer than IV fluid bags) or female condoms and then performing gradual reductions once or twice a day [64] (Fig. 20.7). A Replogle tube should be placed for bowel decompression. In resource-rich settings, most babies have a 4–6-week hospital stay and a prolonged dependence on TPN due to inflammation of the bowel (from amniotic fluid exposure prenatally) and associated ileus that persists even after abdominal wall closure. This presents great difficulty in the absence of TPN. Even in the presence of a NICU and TPN, a recent South African series reported mortality of 43%, primarily due to

Fig. 20.7 Improvised silo (surgical silo) for omphalocele using urine bag

sepsis [65]. Volvulus and bowel ischemia may complicate gastroschisis, especially with late presentation (Fig. 20.8).

If general anesthesia is unavailable for closure and if the bowel can be gently reduced into the abdominal cavity without excessive increase in intra-abdominal pressure, the defect can be temporarily closed with either the umbilicus or "Wharton's jelly" folded over, a temporary piece of mesh, or suitable low-cost local alternative. This may result in a delayed formation of a hernia at this site, but this may be acceptable in this setting.

With omphalocele, associated defects are more common, and these are more often the cause of mortality than the omphalocele itself. Blood glucose should be obtained, and echocardiogram should be performed if available in the setting of an audible murmur and an abdominal ultrasound obtained. For smaller defects (<5 cm), primary closure is indicated; for larger defects, an escharizing agent such as 1% silver sulfadiazine (or native honey if the sac is infected) may be used to thicken the peritoneum and the defect and associated hernia repaired when the child is older (Figs. 20.9 and 20.10). If the fascia cannot be closed, then skin only can be closed, leaving a hernia that can be repaired at a later date. With an intact peritoneal covering, there is usually no delay in gastrointestinal function, and the baby can be started on feeds. Repairing the hernia at a later date may require the use of a mesh. If the sac is intact, serial gradual compression bandaging over a few weeks may help to facilitate earlier repair of the defect. In the case of ruptured omphalocele that cannot be primarily repaired, a temporary silo can be devised in a similar manner described above, with serial reductions subsequently performed. In the infant with omphalocele, tetanus prophylaxis should be given if the mother did not receive this during antenatal period or if the status is unknown.

Neonatal Bowel Obstruction

In the neonatal period, anorectal malformations (discussed below) are the most common source of bowel obstruction, followed by intestinal atresia-stenosis,

Fig. 20.8 Late presenting gastroschisis with bowel ischemia

Fig. 20.9 Omphalocele treated nonoperatively—newborn and after nonoperative treatment

Hirschsprung's disease, and malrotation. Perhaps the greatest difference between acute abdomen in the neonatal period in higher- and lower-income countries is that necrotizing enterocolitis, primarily a disease of prematurity, is rare in settings without a neonatal intensive care service and the capacity to care for the medical problems of prematurity. It will therefore not be discussed.

Fig. 20.10 Resulting ventral hernia from nonoperative treatment of a large omphalocele

Malrotation and Midgut Volvulus

The Essentials

- Bilious vomiting mandates evaluation for malrotation, best assessed by upper GI imaging.
- Peak incidence is in the first several months of life.
- Abdominal exploration may be required based on history and physical exam alone in some cases, and correction requires a Ladd's procedure.

Malrotation generally presents (80%) with bilious vomiting in the term infant 1 month of age or younger. The infant with bilious vomiting should be presumed to have malrotation until proven otherwise. The disease is due to abnormal fixation of

Fig. 20.11 Intestinal malrotation on upper GI study

the bowel prenatally, leading to a shortened distance between the ligament of Treitz and the ileocecal junction and a narrow mesentery, resulting in heightened risk of volvulus (Fig. 20.11). In the presence of abdominal distension and peritoneal signs, the patient may proceed to laparotomy without imaging, after establishing IV access and resuscitation. A nasogastric tube should be placed to decompress the bowel.

Plain abdominal films may show a range of findings, from near normal-appearing bowel gas pattern to “white out” due to bowel edema and ascites or pneumoperitoneum with perforated volvulus. A Doppler ultrasound may show swirling of the mesenteric vessels at the base of the mesentery with complete volvulus, though this may require an experienced pediatric radiologist. Though there is some controversy, the gold standard is an upper gastrointestinal study, to identify the duodenojejunal junction (DJ) and rule out other causes of proximal obstruction. The DJ should be located to the left of midline and at the level of the duodenal bulb, at approximately the L1 pedicle. This study, however, may not be available in the limited resource setting, and laparotomy may be indicated based on clinical suspicion alone [66].

A transverse laparotomy incision should be performed. Chylous ascites may be encountered in the presence of partial or intermittent obstruction. The bowel should

Fig. 20.12 Chronic midgut volvulus from intestinal malrotation

be fully eviscerated. In the setting of midgut volvulus (Fig. 20.12), the bowel is derotated in the counterclockwise direction and examined for improvement in perfusion. A pulse should be sought at the root of the superior mesenteric artery and can be evaluated by Doppler if available. The bowel can be covered with warm sponges, and a period of waiting 10–15 min may be appropriate. In cases of questionable viability and demarcation, a second-look laparotomy may be planned for 12–24 h if intensive care is available, and a temporary abdominal dressing may be devised. If the bowel is well perfused, a Ladd's procedure should be performed: (1) the mesentery should be broadened at the base, which involves carefully freeing peritoneal adhesions in this area; (2) the ligament of Treitz should be taken down to straighten the duodenum and upper jejunum; (3) the small bowel should be placed on the right and the cecum in the left hypochondrium; (4) an appendectomy should be performed. At the end of a Ladd's procedure, the bowel is left in a position of "nonrotation." After closure, feeds are commenced after evidence of return of bowel function.

Intestinal Atresia

The Essentials

- Intestinal atresias present in the neonatal period with bowel obstruction and diagnosis can be established with basic imaging.
- Repair requires establishment of intestinal continuity, often requiring tapering procedures.
- Outcomes are adversely impacted by availability of anesthesia and perioperative care.

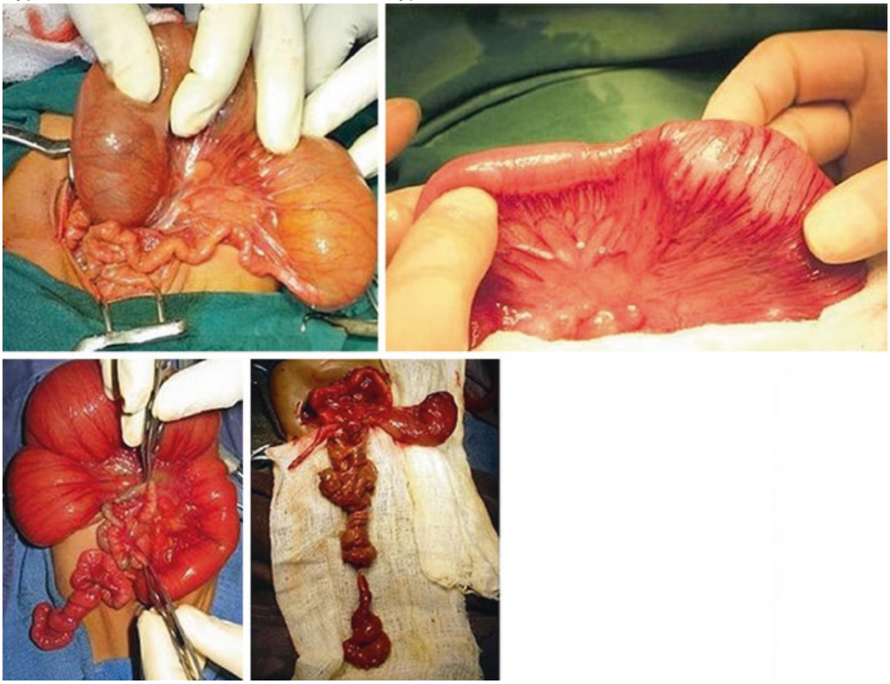
Fig. 20.13 Presentation of intestinal atresia on abdominal radiograph

Jejunoileal atresia and stenosis may have varied epidemiology, with an incidence ranging from 1 in 1,000 births in the African setting to 1 in 3,000 births in the United States. Duodenal atresia may also be encountered but is thought to be less common [67].

Neonates with atresia present in the early postnatal period with abdominal distension, vomiting, intolerance of feeds, and failure to pass meconium, while intestinal stenosis may not present until older age. Plain abdominal X-rays may show dilated intestinal loops (Fig. 20.13). Enema may show a microcolon or may confirm meconium plugs or ileus, and for these conditions, the enema may be therapeutic, and the patient may not require surgical intervention. Demonstration of colon continuity preoperatively also obviates the need to do this at laparotomy. Nasogastric decompression and IV resuscitation are necessary prior to laparotomy. Generally, nasogastric aspirate of > 20–30 cc in the newborn suggests obstruction.

Treatment at laparotomy depends on the type of atresia encountered (Fig. 20.14). Generally, the ends of the atresia must be resected before restoration of bowel continuity. At this time, the rest of the bowel can be flushed with

Type I Type II



Type III Type IV

Fig. 20.14 Four types of intestinal atresia

normal saline to evaluate for the presence of multiple atresias (20%). There may be a significant size discrepancy between dilated proximal bowel and decompressed bowel distal to the atresia. The approach may be dictated by the anatomy present. Sometimes resection of the bulbous end of dilated proximal bowel may facilitate anastomosis; an antimesenteric "slit" may also enlarge the distal bowel diameter. Tapering enteroplasty or imbrication may also be performed on dilated proximal bowel to address the size discrepancy. A continuous suture may need to be used to minimize anesthetic time for a neonate. Feeding is commenced after return of bowel function, and if possible, total parenteral nutrition is maintained during this time. For more proximal atresias, a transanastomotic feeding tube and a gastrostomy tube may be particularly helpful in an environment without parenteral nutrition. While survival in high-income countries is >90%, it may be as low as 40–50% in sub-Saharan Africa due to late presentation and the lack of parenteral nutrition [68].

Hirschsprung's Disease

The Essentials

- Hirschsprung's disease involved congenital aganglionosis of the intestinal tract, most commonly involving the rectosigmoid colon.
- Delayed presentation is the rule in resource-poor areas, with abdominal distension, chronic constipation, and malnutrition.
- While pathologic confirmation is the gold standard in HICs, exploratory laparotomy may be required in LMICs based on history, physical, and basic investigations.
- Full correction requires resection of the aganglionic segment and a low rectal anastomosis.
- A staged approach may be necessary in advanced presentation, with a temporary stoma, followed by a pull-through procedure, and then stoma takedown.

Hirschsprung's disease is less common overall than anorectal malformations, at approximately 1 in 5,000 births. It is marked by congenital aganglionosis of the intestinal tract and generally limited to rectosigmoid region (75–80%). In limited resource settings, a delayed presentation of constipation, abdominal distension, and failure to thrive is the general rule for rectosigmoid disease [69–71] (Fig 20.15a, b). Patients with longer segment disease generally present in the neonatal period. Older patients have generally been treated for medical causes of distension such as parasitic infestations or tuberculosis. Historically, the disease was treated in three stages, with initial decompressing colostomy, a subsequent rectosigmoid resection and pull-through, and, finally, colostomy takedown. In most well-resourced centers, a one-stage procedure is now performed, but frequently this is not possible when a patient presents with long-standing constipation and neglected disease as is the general rule in the resource-limited environment.

At initial evaluation, the patient should be examined for signs of peritonitis and enterocolitis. Enterocolitis is the primary cause of death in Hirschsprung's disease. Any patient presumed to have enterocolitis should be treated with broad-spectrum antibiotics, rectal decompression, and irrigations, as well as bowel rest. A nasogastric tube may be necessary for temporary decompression; laparotomy and fecal diversion may be necessary for inadequate decompression. At laparotomy, there may be a gross transition zone from proximal dilated ganglionic to distal aganglionic bowel (Fig. 20.16), and the colostomy should ideally be created just proximal to this gross transition zone. An ostomy created with aganglionated bowel is unlikely to function. Often the decision will need to be made without intraoperative pathology availability.

In the newborn period, the patient may present with signs of bowel obstruction and failure to pass meconium within 24 h of birth or may present with cecal

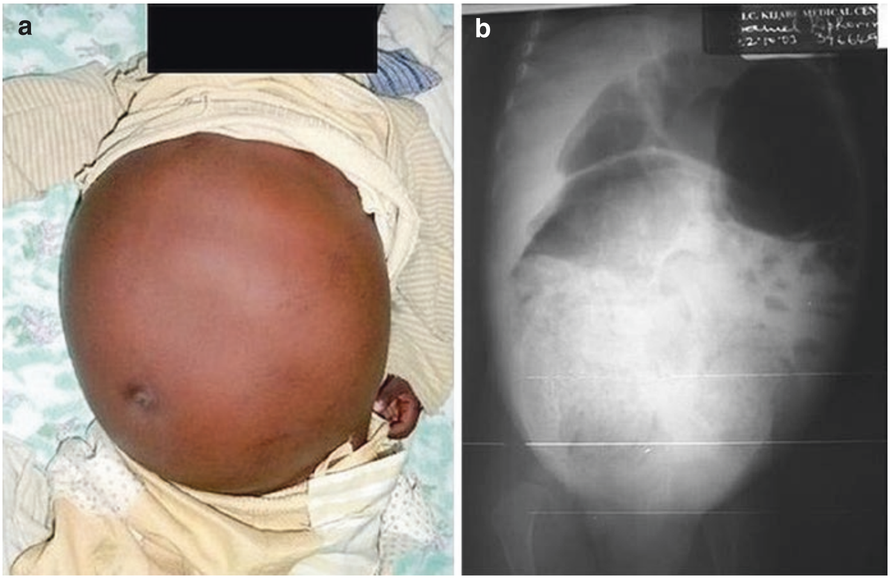
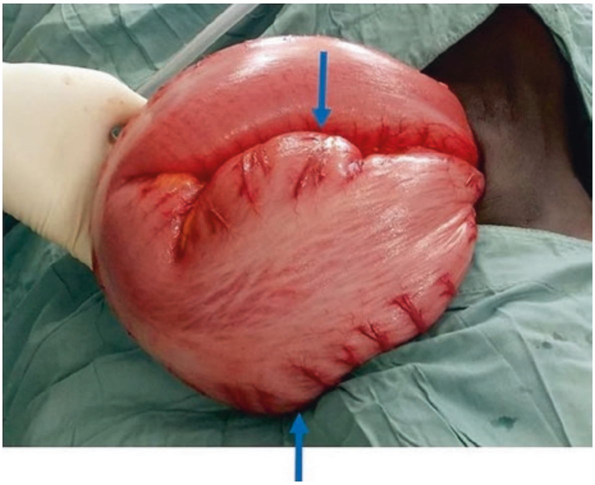


Fig. 20.15 Delayed presentation of Hirschsprung's disease: (**a**) marked abdominal distension and (**b**) radiograph showing colonic dilation and heavy fecal loading

Fig. 20.16 Transition zone in Hirschsprung's disease



perforation in the absence of atresia. A rectal examination may stimulate the passage of meconium. Plain X-rays are generally consistent with distal bowel obstruction, and a contrast enema may show a transition zone with dilated bowel proximal to a decompressed distal aganglionic segment. Definitive diagnosis is provided by full-thickness rectal biopsy, usually done under general anesthesia or caudal block. While suction rectal biopsy is favored in many better-resourced centers, this is generally unavailable in a limited resource setting. The biopsy should be taken approximately 2–2.5 cm proximal to the dentate line and in the posterior midline. Biopsies taken too high risk intraperitoneal perforation and too low risk the biopsy of the normal zone of hypoganglionated bowel just proximal to the dentate line. An anterior biopsy risks urethral (male) or vaginal (female) injury and should not be performed. Hallmarks of Hirschsprung's disease are the absence of ganglion cells and hypertrophied nerve fibers in the submucosal and myenteric plexuses. One of the greatest challenges in the limited resource environment might be the absence of reliable pathology services to interpret biopsy results. In these cases the surgeon will have to use best clinical judgment. Ideally, definitive pull-through should not be embarked upon without histologic diagnosis but can be safely performed in areas remote from pathology support services if surgical support is adequate. Intraoperatively, a gross transition zone can be a guide. For the neonate with cecal perforation, the site may be oversewn and a transverse colostomy created.

The goal of definitive surgery is the removal of aganglionic bowel and the restoration of bowel continuity. The three common operations described are the Soave, the Swenson, and the Duhamel. A detailed description of each of these is beyond the scope of this chapter. No one procedure has proven superior to others; thus, the surgeon should perform the procedure with which he or she is most comfortable or safest given the local environment. In the absence of safe neonatal anesthesia, the creation of a colostomy allowing the child to grow to an older age before definitive repair may be an acceptable alternative. For the patient presenting with massive fecal loading (Fig. 20.15b), on-table fecal washout will be necessary at the time of exploration and colostomy creation, and a mucous fistula should ideally be created at this operation to facilitate continued postoperative washouts. If the proximal colon is markedly dilated and loaded with much feces, it may be safer to resect most of this segment to reach the colon with manageable caliber. This will facilitate postoperative care and subsequent pull-through.

Patients will likely be encountered who have had a stoma created for "suspected Hirschsprung's" due to a clinical history of constipation, failure of meconium passage as a neonate, and functional bowel obstruction. In the interim many patients may develop complications such as colostomy stenosis (Fig. 20.17). This occurs as many colostomies may be created simply with a small antimesenteric incision (sewn to the skin) that are not fully defunctioning, leading to distension and bowel obstruction due to spillover. Massive prolapse (Fig. 20.18) may also be encountered and need to be addressed prior to or during a definitive procedure.

Even after a definitive pull-through procedure, patients with Hirschsprung's disease are at risk of enterocolitis, and this should be stressed to caregivers. A regimen of dilations should be prescribed as described above for anorectal malformations. Most patients are followed at least to age 5, but many will go on to require bowel management even after this period.

Fig. 20.17 Stoma stenosis in Hirschsprung's disease

Anorectal Malformations

The Essentials

- Anorectal malformations can present in a broad spectrum and often require a divided colostomy as an initial procedure.
- A three-stage procedure is often required, with anoplasty, followed by stoma takedown.
- Previous experience and familiarity with anoplasty if to be undertaken by the visiting surgeon.
- Associated VACTERL anomalies should be evaluated.

Fig. 20.18 Massive stoma prolapse in Hirschsprung's disease

Anorectal malformations are one of the most common congenital anomalies encountered in neonates and children in limited resource settings, with an estimated incidence of 1 in 3,500 births. There is a wide spectrum of disease, ranging from limited perineal anomalies to complex cloacal anomalies requiring more complex reconstruction. Familiarity with the variations in presentation is essential [72] (Fig. 20.19). Most anomalies other than perineal fistula can be approached through operative repair in stages, with colostomy, followed by definitive repair (posterior sagittal anorectoplasty) and then colostomy takedown after several months.

Anomalies are generally classified as high or low. In male patients, the most common anomaly is imperforate anus with rectourethral fistula, while in female patients, it is a vestibular fistula. Only approximately 5% of male infants will have imperforate anus without fistula. Most babies with no anal opening at all will be referred for surgical evaluation within 24–48 h of birth. Even if not diagnosed by trained birth personnel in a rural area, abdominal distension and failure to pass meconium will generally prompt parents to seek medical care. However, in LMICs,

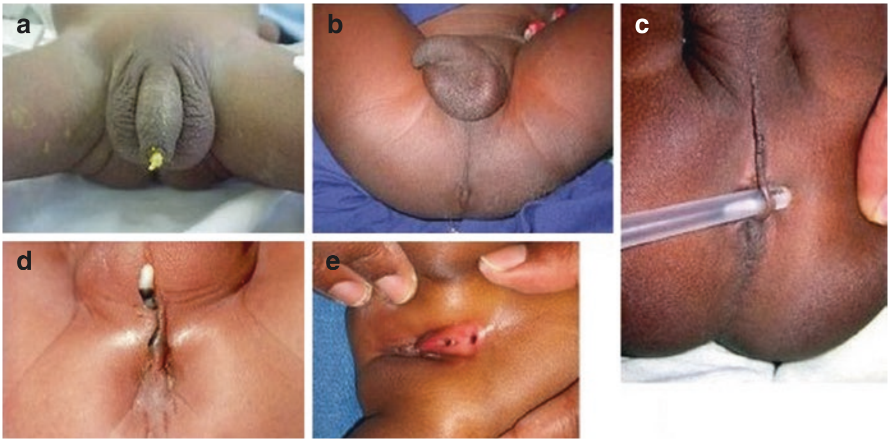


Fig. 20.19 Spectrum of presentation of anorectal malformations

delay in presentation is common. The construction of a colostomy beyond this time period can be very challenging due to progressive abdominal distension, and perforation can occur in cases of further surgical delay. Other patients with an abnormally positioned anal opening who are able to stool with some difficulty may have a delayed presentation to later infancy or childhood. Sometimes these patients are treated unsuccessfully for chronic constipation due to presumed medical causes and suffer great morbidity. Girls with an uncorrected anteriorly displaced anal opening or rectovestibular fistula may live their whole lives with this anomaly. Some practitioners have raised concerns about future vaginal delivery in these patients; however, studies with sufficient long-term follow-up are lacking.

Delay in presentation and complications of anorectal malformations are the rule, either pre- or postoperatively [70]. A common scenario might be one in which the surgeon is asked to "close a colostomy" that was created in the neonatal period, before the anoplasty has actually been done. In the acute neonatal setting, in the absence of an anal opening, a full physical examination should be performed. Anorectal malformations are part of the VACTERL syndrome, which includes vertebral anomalies, cardiac defects, renal anomalies, and limb anomalies. Cardiac auscultation may reveal a murmur; if available, an abdominal ultrasound should evaluate for renal structural anomalies. In the absence of hemodynamic instability, a formal echocardiogram may not be indicated. A careful perineal exam should be performed, noting the nature of the perineum, the integrity of muscle formation, and palpable sacral defects. Generally, a "flat" bottom with poor muscle formation and sacral defects is associated with a high malformation, while a well-formed perineum is more suggestive of a low malformation. For an abnormally located anal opening in the perineum (i.e., perineal fistula), the size should be noted with the knowledge that most normal neonatal anal orifices accommodate a size 10–12 Hegar dilator. In girls, all orifices should be examined to ensure there is not a single orifice (cloacal anomaly, the rarest malformation).

An abdominal X-ray is likely to show distally dilated intestinal loops; a cross-table lateral X-ray (an invertogram should not be done as vomiting and respiratory complications may occur) may be used at 8–24 h postnatally to estimate the distance from the rectum (should be visible with a column of air) to the perineal skin (marked with a radiopaque marker). If this distance is less than 1 cm, an experienced surgeon may choose to perform an anoplasty rather than a colostomy. If referred in the first day of life, one should wait 24 h before the construction of a colostomy in case meconium passes in this time period to reveal a low malformation that can be primarily treated with a perineal procedure. The presence of a "bucket-handle" anomaly on physical examination (Fig. 20.19c) suggests a low malformation that would be amenable to anoplasty, and sometimes a small previously undetected opening is revealed by gently using a small probe.

In cases of a large rectourethral fistula (as sometimes apparent by meconium staining of the urine), the baby may pass meconium in the urine, and the bowel may rarely be decompressed with a Foley catheter passed through the urethral opening.

The creation of a colostomy for the newborn with acute abdominal distension with no anal opening may be a lifesaving procedure. As recommended by Pena et al., this is done with a left lower quadrant incision [72]. The sigmoid colon is generally extremely distended on entry to the peritoneal cavity, and it may need to be decompressed prior to exteriorization. This can be done by placing a purse-string suture and decompressing with a 25 gauge needle. The proximal and distal ends of the sigmoid colon should be clearly identified, and the bowel should be divided. A divided colostomy is favored over a loop due to concern about partial diversion and spillover of stool. In addition, the colostomy should be constructed in the first mobile portion of the sigmoid colon (just after the descending colon) to allow maximum bowel length for the later pull-through procedure. The distal colon-rectum should be washed out at the time of colostomy creation. The baby can then start feeding when the colostomy is functional and the abdomen decompressed. Most families in austere settings will not have access to stoma supplies, and providers and patients usually improvise to care for the stoma with reusable materials such as napkins.

Prior to the definitive surgery, a distal colostogram should be done to identify the level of the malformation as well as the location of any fistula. Typically, no fistula may be identified as it might be plugged. In the absence of fluoroscopy, a series of X-ray images can be obtained using water-soluble contrast flushed through the distal colon. If barium is used, it should be flushed out to prevent impaction in the distal colon.

Approach to the definitive pull-through procedure depends on the type of malformation. In males, high malformations (bladder neck fistula) will need an abdominal approach to ligate the fistula (if present) and mobilize the rectum, while low malformations can be approached through the perineum only through the standard approach of Pena (Posterior Sagital AnoRectoPlasty or PSARP) [72] (Fig. 20.20). The goal of the operation is to fully mobilize the rectum, divide the fistula (if present) without urethral injury, and replace the rectum within the borders of the sphincter complex. Muscle stimulators to define the borders of the sphincter complex are

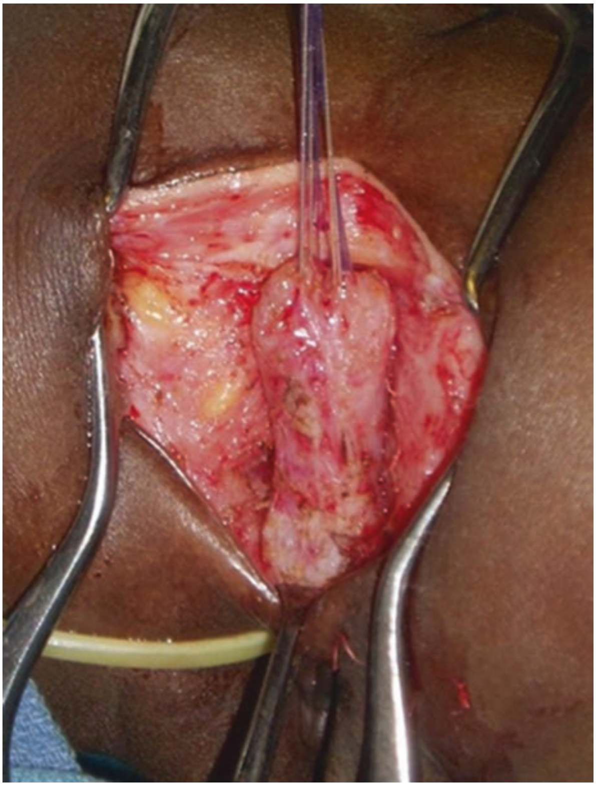


Fig. 20.20 Posterior sagittal anorectoplasty

expensive and may not be available locally; therefore, the visiting surgeon should either bring one or assemble a low-cost but effective alternative [10, 70]. The use of diathermy set at low voltage may also be helpful in identifying the borders of the sphincter complex. Anesthesiologists in some settings may also have a nerve stimulator that can be used.

In girls, for the most common malformation, a vestibular fistula (Fig. 20.19e), the surgeon must decide whether to perform a colostomy initially, with the repair (to "protect the repair"), or primary repair without diversion. There is also lack of consensus on the appropriate timing for surgery, whether in the neonatal period or delayed until the patient is several months old. This is dependent on the comfort of the surgeon in performing this procedure in the neonatal period and the condition of the patient. However, if there are any anesthetic limitations, it may be safer to do the PSARP after several months, when anesthesia is safer. A newborn who breaks down her repair may need diversion and possible redo surgery. Deep infection at the level of the repair also may result in incontinence—the best opportunity to achieve good results is at the first operation.

Postoperatively, rectal dilations should commence 10–14 days after surgery and can be continued at home by the child's caregivers. As Hegar dilators are generally

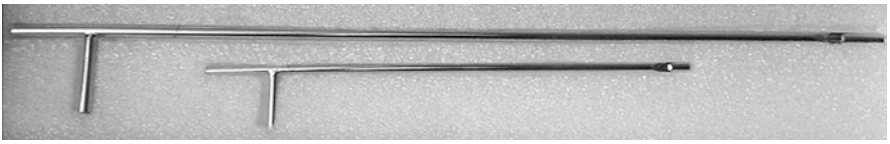


Fig. 20.21 Mohan's valvotome for treatment of posterior urethral valves

unavailable, a smooth appropriately sized candle covered by a glove with lube is a cheap suitable alternative for parents to continue dilations at home, as are other soft locally available supplies such as rounded pen end and the caregiver's gloved little finger. For children beyond several months of age, dilations are poorly tolerated, and most will put up quite a fight. As the anastomosis can scar down, follow-up is critical and this must be stressed to families. Caregivers can also be taught digital dilation. These patients need to be followed through infancy and childhood as solid food is commenced and also through the period of toilet training. Children with low malformations have a tendency to constipation, and those with higher malformations tend more toward incontinence. Continued follow-up over these periods is critical as dietary modification and the introduction of laxatives or constipating agents may be necessary. Anal stenosis may also produce these symptoms, so stenosis should always be excluded before taking a decision about treatment that has significant social and psychological consequences. In excluding stenosis, it should be noted that it may not always be at the anal verge and may be located slightly above this level.

Genitourinary Anomalies

The Essentials

- In settings where treatment equipment is not available, posterior urethral valves may need to be treated with vesicostomy.

These include posterior urethral valves (PUV) and bladder exstrophy. PUV present with obstructed bladder outlet and manifested by poor stream, repeated urinary infections, and even renal failure. The diagnosis is suspected by ultrasound which typically shows a thick, dilated, trabeculated urinary bladder, sometimes with associated upper tract dilatation. Confirmation is obtained by voiding cystourethrogram (VCUG) showing the posterior (proximal) urethral obstruction with dilated proximal urethra and bladder neck. Definitive treatment relies on endoscopic valvulotomy, but treatment of the newborn often lacks the appropriate instrument sizes and thus needs to be temporized until the baby grows or can be referred to a facility able to treat him/her. Temporization is best done with a formal vesicostomy approximating the bladder mucosa to the skin, thus alleviating the need for an indwelling catheter. The Mohan's valvotome (Fig. 20.21) is cheap and safe and can be used in the neonates. The oft-quoted practice of blind valve ablation using a Foley catheter balloon is dangerous and cannot be recommended.

Bladder exstrophy is a rare condition in which the anterior wall of the bladder and the abdominal wall overlying it are absent. The defect is obvious at birth and is surprisingly tolerated quite well by the children, with minimal risk of infections but tremendous social disability and stigma. The repair of the condition is not urgent but requires complex procedures. In the neonatal period, primary closure is indicated, often accompanied by iliac osteotomies with external fixation. After a couple of years of age, restoring continence becomes extremely unlikely even after multiple procedures, and the choice in limited resource settings is of a urinary diversion procedure, typically in the form of a continent ureterosigmoidostomy such as the Mainz pouch II procedure [73]. A visiting surgeon without appropriate expertise is best advised to direct these patients to a regional institution able to handle them (often in another country).

Thoracic Neonatal Conditions

The Essentials

- Esophageal atresia most commonly presents with excessive salivation and inability to pass an NG tube, with a distal tracheoesophageal fistula the most common type.
- Thoracotomy with fistula ligation and repair is the standard of care, but outcomes in the absence of critical care support are generally poor in LMICs.

The most common thoracic condition requiring intervention in the neonatal period is esophageal atresia, with the most common form being proximal atresia (EA) with distal tracheoesophageal fistula (TEF). While this anomaly is identified in the first day of life in most high-income countries, often diagnosis is delayed in LMICs and presents with no visible anomaly, but the baby has excessive salivation and inability to feed. Attempts to pass a nasogastric tube often reveal obstruction, with a chest X-ray showing the tube in the upper thorax. The presence of distal air in the gastrointestinal tract confirms the presence of a TEF. While multiple other types may be found, this is the most common type.

Unfortunately, mortality for this condition remains very high in low- and middle-income countries, often due to delayed presentation, anesthetic limitations, poor nutrition, and limited capacity for intensive and perioperative care. The most acute problem is typically the tracheoesophageal fistula that can cause abdominal compartment syndrome and also the accumulation of saliva in the proximal esophageal pouch that can lead to aspiration. Repair of these anomalies is best performed at a tertiary care center with intensive care capacity. Stabilization includes a small bore (8 French) orogastric tube on continuous suction in the proximal pouch and IV fluid resuscitation.

In high-income countries, the most common congenital neonatal condition encountered is a prenatally diagnosed cystic lung lesion, i.e., cystic pulmonary airway malformation (CPAM). Postnatal management in asymptomatic patients remains controversial though excision is generally performed in the first year of life due to risk of infection and (rare) risk of malignancy. These conditions are much more uncommon in resource-poor areas due to lack of antenatal imaging and due to the asymptomatic nature of the lesion.

Surgical Emergencies in Older Children

Appendicitis

The Essentials

- History and exam may mandate exploration in the absence of diagnostic tests.
- Perforation may be more common in resource-poor areas and requires exploration through right lower abdominal incision or laparotomy.
- A stable patient with a possible phlegmon may be treated with antibiotics with plans for interval appendectomy.

Presentation of appendicitis in the child is quite similar to adults. In North America and Europe, the lifetime incidence of appendicitis is estimated to be 7–8%; in Africa, it is estimated to be lower, closer to 1–2%, perhaps due to variation in diet and the immune system. Peak incidence is in the 12–18 age group and rare in neonates and infants [74].

In most austere settings, the decision to operate for appendicitis will be based on history and physical examination alone, without the aid of any ancillary tests. However, imaging can be helpful. Plain films may show a fecalith in the right lower quadrant or an obstructive pattern. Ultrasound may be highly sensitive and specific, though this is mostly observer dependent. In resource-rich environments, perforated appendicitis with abscess is generally diagnosed on CT scan, and imaging-assisted drainage may be performed with a plan for interval appendectomy several months later. This approach for perforated appendicitis is not possible in most resource-constrained settings without interventional radiology capacity, and nearly all such patients will require surgical intervention. Moreover, most patients with perforated appendicitis in these settings will have general peritonitis at presentation, making initial nonsurgical approach inappropriate.

In the child <4 years old, presentation with perforation is the rule, due to both the difficulty for young children to describe mild symptoms and the fact that the omentum in young children is thinner and less able to contain infection. The patient with symptom duration >3 days who presents with a palpable right lower quadrant mass, but is pain-free and tolerating a diet, may be treated with antibiotics for 7–10 days and presumed to have appendicitis with contained perforation. This may be then followed up with interval examination and then appendectomy as indicated. A rectal examination should be performed in patients presumed to have perforation and abscess, and if initial nonoperative therapy is considered, transrectal drainage of a pelvic abscess can be performed under sedation.

An additional challenge is that fever, abdominal pain, and other symptoms similar to those of appendicitis are common in malaria-endemic regions due to improper use of antimalarials. These medicines are readily available at pharmacies without a prescription, and parents may not seek medical attention until their child has not responded to a full course of therapy. Alternatively, they may first see a traditional healer. These factors contribute to the frequent advanced presentation of diseases for acute abdominal conditions. In addition, the broader differential diagnosis for acute abdominal pain in children in the tropics must be considered, including, for example, intestinal perforation from infectious causes such as typhoid fever, infectious complications of undernutrition or immune suppression, as well as spontaneous bacterial peritonitis.

In the patient with diffuse peritonitis, a midline approach may be chosen to allow for adequate exploration and washout. In children the appendix may be ligated with a simple or purse-string suture and dissected either antegrade or retrograde depending on the ease of dissection. Drains may be useful in localized abscess cavities. In the absence of formal Jackson-Pratt drains, other available tubing or a corrugated rubber sheet may be used.

In extreme cases where the appendiceal stump is liquefied and the surgeon is concerned about the development of a cecal leak and subsequent colocutaneous fistula, a diverting loop ileostomy may be constructed, though this can have significant morbidity in an austere setting. A tube cecostomy, perhaps with a Foley catheter, may be more helpful and easier to manage in such a case.

Intussusception

The Essentials

- Intussusception is most common in the 3-month to 3-year age group and is frequently mistaken for a medical gastroenteritis.
- Crampy intermittent abdominal pain is typical and ultrasound the gold standard for diagnosis, though a suspicious history and physical requires exploration.
- Prior to laparotomy adequate resuscitation is needed including IV fluids, nasogastric tube decompression, and antibiotics.
- While enema fluoroscopic reduction is common in HICs, laparotomy with reduction and resection is often required in LMICs, with a temporizing stoma often required due to patient status.

Intussusception occurs most frequently in the 3-month- to 3-year-old age group and is most commonly idiopathic in origin, frequently due to a preexisting viral

Fig. 20.22 Intussusception protruding from the anus

illness that may have produced intra-abdominal lymphadenopathy. These mesenteric lymph nodes, usually in the terminal ileum, are the most common lead point of the intussusception. In infants with gastroenteritis, vigorous peristalsis may also precipitate an intussusception. The intussusception is generally ileocolic (approximately 80–90%) but can extend as far as the rectum or colon. In a minority of cases, the intussusception may be colocolic or limited to the small bowel. It is one of the most common causes of acute abdomen and bowel obstruction in children in poor countries [75, 76].

Classically, children present with fits of intermittent crampy abdominal pain, (where the child draws their knees up to the chest), with intervening periods of normal behavior. It may or may not be possible to elicit a prior history of viral illness. There may be bilious or non-bilious vomiting, or "currant-jelly stools," (bloody mucoid stools) an indicator of possible mucosal compromise. On physical examination, the abdomen is generally distended. The presence of peritoneal signs should raise concern for possible bowel compromise and mandates operative exploration. The child may have visible signs of dehydration and sepsis. Other causes of bowel obstruction should be excluded on physical examination. With early presentation, an abdominal mass may be present. A rectal examination should be performed as well to evaluate for blood in the stool, and in the most extreme cases, the intussusception may protrude through the anus (Fig. 20.22), initially perhaps raising the question whether this may be rectal prolapse. Vital signs may reflect dehydration or septic response.

Plain abdominal films may show distended bowel loops consistent with intestinal obstruction or, in early cases, may be more normal appearing. Ultrasound may be confirmatory if the characteristic features of target and pseudo-kidney signs are present. With late presentation, pneumoperitoneum may be present. A contrast enema, in the hands of an experienced radiologist, may be therapeutic in up to 80% of the time; however, this modality is frequently unavailable in a resource-limited setting. Moreover, contrast enema is contraindicated if there are features of intestinal strangulation, which is common in these settings. The medium of the enema may be pneumatic or hydrostatic and is generally performed with the aid of fluoroscopy or ultrasound. If an enema is available in the local environment and the first attempt does not fully reduce the intussusception, it may be attempted again if some progress was made on the first attempt, in the absence of peritoneal signs or hemodynamic instability. In resource-limited settings, surgeon-performed pneumatic reduction enema may also be performed safely in the operating room under general anesthesia [77]. Rarely, reduction by enema can result in perforation and in extreme cases with abdominal compartment syndrome requiring emergency decompression with an 18 gauge needle at the bedside, prior to transport for laparotomy. It should be stressed that the presence of peritoneal signs and clinical signs of sepsis mandates laparotomy. Aggressive resuscitation and close monitoring of urine output are important.

In this age group, a primarily right-sided transverse or midline laparotomy may be performed. The bowel is delivered and the intussusception identified. The intussusception should be reduced by milking the intussuscepted bowel from the distal end proximally rather than trying to "pull it out" at the site of intussusception, as this may result in tearing of the bowel. Once reduced, the bowel should be evaluated for viability. Nonviable bowel should be resected and an anastomosis performed between ends of well-perfused bowel. In cases of systemic sepsis or poor perfusion, creation of a temporary ostomy may be the safest option after bowel resection rather than risking anastomotic breakdown. In addition, patients must be closely observed postoperatively in cases of manual reduction without resection, as reduced bowel that appears viable intraoperatively still has risk of necrosis postoperatively, especially in the poorly resuscitated patient. In such cases, postoperative decompensation mandates exploration to rule out bowel necrosis and perforation. Intestinal malrotation may coexist and should be excluded intraoperatively.

In cases where the intussusception is reduced nonoperatively, there is an approximately 10% risk of recurrence, and this should be stressed to the parents. In some cases, also, the intussusception may reduce on its own, without any intervention. Intussusception in the older child raises the question of a pathologic lead point, and this generally requires laparotomy for definitive diagnosis. The most common pathologic lead points are Meckel's diverticulum or polyps of the small and large bowel but may also be malignant conditions such as small bowel lymphoma. As with other surgical conditions in the resource-limited setting, patients often present with high-grade bowel obstruction and severe dehydration, and this compromises outcomes, with mortality rates of 8–50% reported in these settings, compared to negligible mortality rate in high-income countries [78].

Typhoid Perforation

See Chap. 15 Tropical Infectious Disease Medicine for Surgeons – A Primer section on Typhoid fever.

Acute Scrotum

The Essentials

- Testicular torsion requires prompt recognition and surgical treatment to avoid testicular loss.
- Exploration may either be through a midline raphe incision or an ipsilateral scrotal incision.
- Detorsion and orchiopexy should be performed or orchiectomy in cases where the testicle is necrotic.
- Contralateral orchiopexy should be performed.

"Acute scrotum" is a term used to define sudden onset of scrotal pain, which may or may not be associated with scrotal swelling and or erythema. The most crucial step in management of any acute scrotum is the timely recognition of testicular torsion. Any degree of ischemia is associated with impaired testicular function and morphology. There is a 4–8 h window before significant damage to the testis occurs, but this depends on the degree of twist. Testicular torsion is primarily a disease of neonates and adolescents though it may occur at any age.

Intravaginal torsion (IVT) describes the torsion that occurs in the "bell clapper" anomaly, whereby the tunica vaginalis has a high attachment onto the spermatic cord resulting in a long mesorchium and highly pendulous and mobile testis that is susceptible to torsion. This is present in 12% of males. In extravaginal torsion (EVT), the entire testis complex, which hasn't yet fused to the scrotal bed, twists en bloc. In addition, vestigial appendices may occur anywhere along the testis, and these may undergo torsion, independent of the testis (including appendix testes or appendix epididymis). Most neonatal cases are an extravaginal torsion.

A cremasteric spasm associated with trauma, vigorous exercise, cold weather, or nocturnal erections is the most common trigger. Direction and extent of torsion affect degree of ischemia.

At birth, a hard swollen, non-tender edematous, and dusky hemiscrotum that doesn't transilluminate may be noted, indicative of prenatal torsion. Meanwhile, a child with a painful, edematous, and erythematous hemiscrotum with history of a normal scrotum at birth suggests postnatal torsion. A child who initially had a palpable testis but with time the testis is non-palpable (“vanishing” testis), is usually due to atrophy of a testis that underwent torsion in late gestation. Fifty percent of patients with acute torsion have experienced previous episodes of testicular pain that resolved spontaneously, after a short time, suggesting that “intermittent” torsion is also possible.

In cases of “acute scrotum” in which testicular torsion is highly suspected, time is of the essence! History taking and physical examination are sufficient to make an accurate diagnosis in 60–90% of cases. The following features are most suggestive:

1. Pain, rapid and severe, can be associated with nausea and or vomiting with inability to stand straight. This pain however may begin to dissipate after 6 h.
2. Pain can radiate to the medial thigh and lower abdomen.
3. Previous episodes of self-limiting scrotal pain (“prophetic pain”) are suggestive of intermittent torsion.
4. Loss of the cremasteric reflex on the affected side (negative predictive value of 96% for testicular torsion).
5. A high-riding testis, close to the external inguinal ring due to shortening of the cord, is present in 26–80% of patients.
6. Angell’s sign is present in 25–90% of patients—this refers to the “horizontal lie” or positioning of the contralateral testis when patient is examined in the upright position.
7. Prehn’s sign refers to elevation of affected testis in comparison to the contralateral testis.
8. Fever is an ominous sign indicative of infarction.

Investigations should not delay intervention, as time is of the essence and may delay testicular salvage surgery. Investigations can be used if diagnosis is equivocal, and symptoms are of a longer duration than hours. Ultrasound is suggestive but is operator dependent, and detection of blood flow doesn’t necessarily rule out torsion.

Key principles of management are as follows:

1. Manual derotation (if early presentation); two-thirds of patients have internal rotation, and manual derotation in the external rotation direction (opening a book) can be attempted. If this fails, derotation in the opposite side can then be attempted. Sedation and spermatic cord blocks are discouraged as one cannot determine the success of the maneuver if the patient cannot report “relief” of the symptoms.
2. Surgical exploration of the scrotum; a single incision through the median raphe allows exploration of both scrotal compartments. Alternatively, mid- to upper scrotal incisions can be used.
3. If the testis is obviously necrotic, orchiectomy/orchidectomy should be done, and lavage of scrotal pouch is recommended. A future silastic prosthesis can be considered if available.

4. If the testes fail to regain pink/red color after derotation/detorsion, and only dark/black blood oozes from a nip on the tunica albuginea, then orchiectomy/orchidectomy is indicated.
5. After untwisting, if the testis regains some mottled color after wrapping in warm saline for 5–10 min, with red bleeding from the tunica albuginea, the testis should be preserved.
6. Once found salvageable, the affected and the contralateral testes should be fixed in a sub-dartos pouch using absorbable sutures at three points. Avoid silk, as it may lead to abscess formation. Eversion of the tunica vaginalis combined with a dartos pouch fixation is associated with excellent fixation results.

For torsion of appendices, if the diagnosis is certain, management includes bed rest, scrotal elevation, and analgesia (especially NSAIDS), and inflammation will resolve in 2–7 days. A minority of these patients may require surgery if pain and inflammation persist beyond 2 days. If found, on scrotal exploration, the twisted appendix is simply excised. Failure to fix the contralateral testes may result in torsion in the other testes.

Pediatric Solid Tumors

Wilms' Tumor

The Essentials

- Wilms' tumor more commonly presents with advanced disease in LMICs than HICs.
- Initial diagnosis and staging requires biopsy and ultrasound.
- Advanced stage of presentation often requires neoadjuvant chemotherapy although resectable tumors can be excised initially after staging.
- After neoadjuvant chemotherapy, resection through a transverse incision can be performed.

This is one of the most common solid childhood tumors. In LMICs, it represents about 3–20% of all malignant tumors in children [79, 80]. Patients may present with an incidental abdominal mass or with microscopic hematuria, hypertension, malaise, weight loss, or anemia. Pain with fever and a rapidly enlarging mass may indicate acute tumor rupture. In developing countries, due to late presentation, a large abdominal mass is obvious at presentation (Fig. 20.23). Anemia and malnutrition are present in more than 50% of the patients at presentation [81]. A minority of patients with Wilms' tumors have an associated named syndrome, and those associated features may be present.

Abdominal ultrasound can identify the renal origin of the tumor and can assess the contralateral kidney, and ipsilateral renal vein and inferior vena cava for tumor extension. Intravenous urography may show a distortion of the pelvicaliceal system of the affected kidney, and sometimes there may be non-excretion of contrast. CT scan is most accurate in characterizing the extent of disease, but this is often unavailable or too expensive in LMICs. As a result, IV urography may be used more frequently. A TruCut® needle biopsy of the tumor to confirm histological diagnosis can be done under ultrasound guidance (preferably using a Doppler ultrasound). Biopsy may be required also to exclude Burkitt's lymphoma. Open biopsy risks severe hemorrhage and tumor dissemination and should be avoided. A plain chest film should evaluate for pulmonary metastasis. The tumor should be staged, and the National Wilms Tumor Study (NWTS) or Société Internationale d'Oncologie Pédiatrique (SIOP) staging system can be used. In sub-Saharan Africa, >50% of patients present with stage III and IV disease.

The treatment of Wilms' tumor involves surgery, chemotherapy, and radiotherapy. The NWTS and SIOP protocols can be used. The NWTS protocol advocates that resectable tumors are excised primarily. However, the SIOP protocol may be better suited for the LMIC setting [82]. This protocol consists of administration of preoperative chemotherapy for all patients, using vincristine and actinomycin D (given for 4 weeks and surgery in the fifth week) without histological diagnosis: this is aimed at reducing the tumor size to minimize the risk of intraoperative tumor rupture/spillage and increase the chance of complete resection. Following surgery, chemotherapy is continued based on risk stratification according to tumor histology (favorable or unfavorable) for a total of 18–24 weeks. Goals of surgery are abdominal exploration, complete tumor resection without spillage (in low-stage tumors), nephroureterectomy, lymph node biopsy at the renal hilum, and removal of tumor from the renal vein or inferior vena cava in cases of tumor extension to these locations.

Wilms' tumor is presently considered a curable disease, and long-term survival can be expected for >80% of patients in developed countries. In LMICs, however, the 5-year survival is below 50%, largely due to the late stage at diagnosis, comorbidities, and problems with completion of chemotherapy.

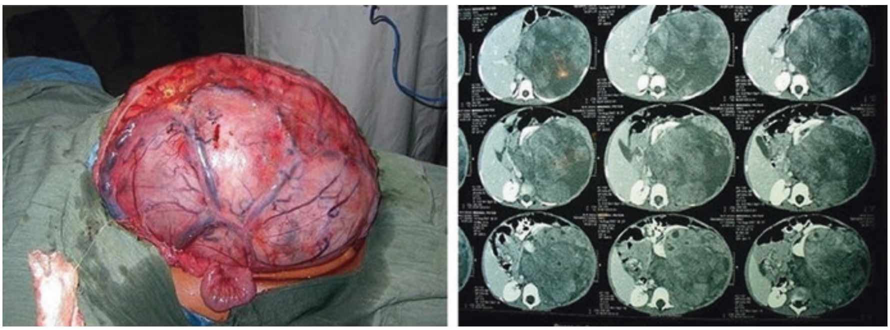


Fig. 20.23 Late presentation of Wilms' tumor

Lymphadenopathy and Lymphoma

The Essentials

- Lymphadenopathy is common and may require incisional or excision biopsy.
- The differential diagnosis is broad and medical workup is needed.
- Larger nodes than 2 cm that are persistent may require biopsy.

The general surgeon is frequently called to evaluate “lumps and bumps” in children, often to establish the malignant potential of these lesions and to decide whether a biopsy is indicated. Most of the time, if there is a reasonable level of suspicion, a biopsy should be performed as these are low-risk procedures that can give high-yield diagnostic information.

Lymphomas are generally classified as Hodgkin’s (85% globally) and non-Hodgkin’s (15%) type [83]. In sub-Saharan Africa, Burkitt’s-type lymphoma is endemic and the most common type of lymphoma in children, often presenting with a mass about the jaw (Fig. 20.24). The endemicity may be partly due to an

Fig. 20.24 Burkitt’s lymphoma

association and interaction between EBV and malaria which may also be affected by influence of HIV. In older children, the other forms are more common [84]. Burkitt's lymphoma is one of the "small round blue cell" tumors of childhood, and one of the most rapidly dividing human tumors, with a doubling time of 24–48 h. It is therefore also very chemosensitive, and this lends urgency to diagnosis and initiation of therapy. Generally, the incidence of B-cell lymphomas has increased in high HIV incidence areas, and HIV-related Burkitt's lymphoma has been shown to be less chemosensitive.

Initially, a careful history should be performed asking specifically about size of mass, other possible lymph nodes, and constitutional symptoms such as fever, weight loss, and lethargy. Risk factors for immune compromise should be evaluated, and an HIV test should be obtained. Up to 18% of patients with HIV disease may present with adenopathy [85].

Careful lymph node examination should be performed of all regions assessing whether nodes are fixed or mobile, matted, single, or multiple and whether there is associated abdominal visceromegaly. Nodes greater than 2 cm or those with rapid growth may be considered more suspicious for malignancy. Any node in the supraclavicular region is considered abnormal and suspicious and should be biopsied. In the cervical region, nodes in the posterior triangle are more suspicious for malignancy than those in the anterior neck. Cervical or axillary (the most common locations) adenopathy should ideally be investigated by chest X-ray (to rule out tuberculosis or a mediastinal mass).

With suspicion for infected nodes, a short course of empiric antibiotics may be administered. Without response or if nodes have persisted beyond 4–6 weeks, a biopsy should be obtained. Blood tests are unlikely to alter the need for a biopsy. A single fluctuant tender node is more suggestive of acute suppurative lymphadenitis and can be treated with incision and drainage or aspiration with culture.

Tuberculous lymphadenitis is particularly common in high HIV prevalence areas; even in the absence of TB, lymphadenopathy may be the presenting symptom of HIV disease. This is in distinct contrast to the microbiology in North America, where infection with atypical mycobacteria is more common. BCG vaccination itself can also cause lymphadenitis in 36/1,000 vaccinations.

FNA usually cannot be done in children without adequate sedation, and the aspirate may not provide adequate tissue for flow cytometry required to diagnose lymphoma. An open incisional or excisional biopsy technique is preferred in most instances. In some cases, diagnosis may be obtained by bone marrow biopsy or by aspiration of pleural fluid.

A wide spectrum of infectious and non-infectious diseases can also cause lymphadenopathy and the reader is referred to other sources for a more complete discussion.

Though lymphadenopathy may be the most common presentation of lymphoma in children, and the characteristic jaw mass of Burkitt's lymphoma may be well recognized, other presentations include intussusception and or bowel obstruction, abdominal mass, mediastinal mass, pleural effusion, or splenomegaly [86]. In the rare cases of isolated bowel tumors with Burkitt's lymphoma, a complete resection, if possible, will be essentially curative, though postoperative chemotherapy will still be needed as the disease is multifocal. Most abdominal masses, however, will be unresectable (only a biopsy needs to be taken in most cases), and chemotherapy will be the mainstay of therapy. Staging laparotomy, once part of the management of lymphoma, is no longer indicated. Prognosis will depend on the local availability of chemotherapy programs as well as compliance with therapy [87].

Sacrococcygeal Teratoma (SCT)

The Essentials

- Sacrococcygeal teratomas most commonly present with an exophytic tailbone mass, but some subtypes also have a large pelvic component.
- Full excision including coccygeal resection is required as recurrence and malignant degeneration is possible.

These congenital germ cell tumors are the most common tumor of the newborn period (Fig. 20.25). The classic form consists of a growth over the tailbone that can be very large. The basic classification includes four types: Type I that is predominantly external; Type II that is mixed external and pelvic, but predominantly external; Type III that is visible externally but has a predominant pelvic component; and Type IV that is purely pelvic. As with other teratomas, they are comprised of tissue from all three germ cell layers. Commonly they have a large cystic component. A pelvic ultrasound is recommended to identify a pelvic component if one exists, as

Fig. 20.25 Giant sacrococcygeal teratoma

this may change the operative approach. Most tumors can be excised in a prone position, and must include a coccygectomy, otherwise these tumors can recur. Control of the middle sacral artery is a critical step of the procedure, and bleeding from this vessel can be life-threatening. Excision in the newborn period is recommended as these tumors are benign but have a propensity for malignant degeneration if untreated or if they are incompletely excised. Unfortunately, in resource-poor areas, in addition to delayed presentation, poor identification of the disease, treatment such as incision and drainage of a presumed sacral abscess, or incomplete excision due to lack of a coccygectomy can lead to significant complications.

Elective Conditions in Children

Hernias and Hydroceles: Pediatric Aspects

The Essentials

- Pediatric hernias do not self-resolve and should be repaired by high ligation through a groin incision.
- Incarcerated hernias require reduction and subsequent repair.
- Non-communicating hydroceles require repair after age 1 and can be approached in a similar fashion to inguinal hernias.

Hernias and hydroceles are very common surgical conditions in children, regardless of context, affecting up to 1–5% of term children and a higher percentage of premature babies. Hernias are more common on the right side, more commonly affect males, and 99% are indirect hernias due to a patent processus vaginalis. Hernias in children are more commonly associated with some conditions such as abdominal wall defects and in children with ascites. Incarceration is more common in the neonatal period and posesses risk not only to the bowel but to the ipsilateral testicle (atrophy due to ischemia or frank necrosis).

Generally, parents will report that the baby has had an intermittent bulge on either side. A careful physical exam should be performed. Both testicles should be examined to ensure they are descended, the genitalia should be examined, and the placement and size of the anal opening should be evaluated. If no hernia is initially palpated or seen, the examiner can induce increased abdominal pressure by gently holding the baby's arms and/or legs down or putting gentle, downward pressure in the suprapubic region. Transillumination may help to detect a hydrocele; if this is felt to be a noncommucating hydrocele (no history of change in size), then operation can be deferred to age one, as some of these may self-resolve (Fig. 20.26). In addition, a "silk glove sign" may be present with a thickened hernia sac; this is detected by rolling the cord structures over the ipsilateral pubic tubercle.

Timing of repair is important: ideally, pediatric hernias are repaired close to the time of diagnosis to minimize chance of incarceration; however, in a resource-poor setting, the availability and safety of neonatal general anesthesia should be considered

Fig. 20.26 Congenital hydrocele

as general anesthesia is preferred. Ketamine may also be used. Controversy remains over routine contralateral exploration, but most large retrospective series suggest that only a minority (7%) of children will develop a contralateral hernia.

A standard high ligation at the internal ring should be performed; this is the most important part of the procedure. Given the high preponderance of indirect hernias, a floor repair (i.e., Bassini or other) is generally unnecessary. In infant girls in particular, approximately 20% may contain the fallopian tube or ovary as part of a sliding hernia, and the surgeon should be prepared to invert the sac around a purse-string suture at the internal ring if necessary. In infants, the external ring and internal ring are nearly superimposed, and it may be unnecessary to open the aponeurosis of the external oblique muscle upon entry. For large hernia sacs that extend into the scrotum, scrotal extent of the sac does not need to be excised. This may cause excessive bleeding and traumatize the cord structures. At the conclusion of the operation, if the testicle has been lifted out of the scrotum, it should be returned to its normal location to minimize the chance of iatrogenic cryptorchidism, a rare complication. In the case of transection of the vas deferens, it should be repaired with fine absorbable sutures. These operations are more challenging in infants and young children due to the small size of the vas and vessels and, often, a delicate hernia sac. The bladder in an infant is an intra-abdominal organ and at risk for injury, especially with an incision that strays medially.

If an incarcerated hernia is detected clinically, attempts should be made at reduction, ideally with sedation and analgesia. Gentle pressure is usually able to reduce the hernia, and the patient should be observed at least for 4–8 h to ensure that feeds are tolerated and that peritonitis does not develop. Ideally, the hernia repair should be performed in the next 2–3 days, allowing for some of the tissue edema in the cord to abate. Even several days later, the tissues and sac are likely to be extremely friable. In cases of suspected strangulation, and possible bowel compromise, reduction should not be attempted, and as in adults, a groin exploration should be performed to evaluate the bowel. If this cannot be adequately performed through the groin, a laparotomy may be necessary.

Undescended Testes

The Essentials

- Intervention for undescended testicles is delayed until at least a year old to allow for possible descent.
- Role of ultrasound is controversial for non-palpable testicles.
- For inguinal testicles, a two-incision groin approach is used, with mobilization through the upper incision and orchiopexy through the lower incision.
- Abdominal testicles require exploration and orchiopexy or orchiectomy if nonviable.

Cryptochidism (undescended (UDT) or maldescended testis) is one of the commonest urogenital malformations in the male pediatric population worldwide. Its etiology is multifactorial and still quite obscure. If "undescended" the testis may be regarded as palpable or not palpable, retractile or "peeping," ascending, and ectopic or acquired UDT which may be iatrogenic (e.g., postinguinal hernia repair). Occasionally, the child may have anorchia. This variability in nomenclature poses a diagnostic dilemma, which may require maneuvers like squatting, increasing abdominal pressure, and sitting cross-legged as the physicians run their fingers from the iliac crest to the scrotum in order to classify the condition. If both testes are not palpable, hormonal testing to stimulate evidence of the presence of adequate testosterone levels may be required, prior to attempting exploration; however, this test may not be available in most resource-poor areas.

The incidence of UDT is higher in premature or low birth weight infants, but these testes are usually expected to descend by 1 year of age, beyond which, spontaneous descent is deemed unlikely, and orchiopexy is warranted. The coexistence of UDT with other congenital anomalies is fairly common as is an associated inguinal hernia, and these must be addressed in the same sitting [88].

Cryptorchidism is one of the most common visible urogenital malformation among African newborn males and school boys and sometimes in resource-poor areas, even in adolescents. While many patients present at age >5, occasionally the patient may even present in their early twenties. If there is a coexisting hernia or if the testis is trapped in the inguinal canal, the mother may report an incidental, nontender, inguinal swelling. Rarely, cryptorchidism is an incidental finding by the pediatrician or general practitioner [89].

The use of ultrasound in localizing testis in children with UDT in LMIC is controversial. Ultrasound is not necessary in cases where the testis is palpable. It may be requested in cases of a non-palpable testicle, but its sensitivity has been questioned in some studies [90].

Once a diagnosis of UDT is made, orchiopexy is the logical next step in children >1 to ensure fixation of the testes in the scrotum for optimum function. Other indications (besides possible fertility benefits) for orchiopexy include (1) prevention of future torsion, (2) detection for cancer screening, and (3) less likelihood of traumatic injury.

The inguinal approach is most common for the palpable UDT, with takedown of the gubernaculum and a herniotomy to obtain sufficient cord length to plant the testis in the scrotum and its fixation in a sub-dartos pouch. A hernia-type incision is made to identify and mobilize the testicle, and subsequently, an upper or lower scrotal incision is made to create the pouch. Usually absorbable sutures are used. A Bassini-type approach to reinforce the floor of the inguinal canal in cases where there is a large associated direct hernia may be done.

If there is difficulty obtaining adequate length, the proximal cord may be further mobilized, and potential ligation of the epigastric vessel may be helpful. If the testes cannot reach the base of the scrotum, it should be left as low in the inguinal canal as possible to facilitate future physical examination to monitor for malignancy. If there is a very small testicle, or a "nubbin," this should be removed. In cases of non-palpable testicle, an exam under anesthesia should be performed. A minilaparotomy may be needed in the absence of laparoscopy, and the testicular vessel may need to be ligated for adequate length to bring it to an extra-abdominal location (in the presence of a normal contralateral descended testicle). The family should be counseled that this testicle may or may not be viable, and the blood supply will depend on adequate collateral supply from the vas deferens.

Immediate post-operative complications may include scrotal hematoma, and early recurrent inguinal hernia. Ideally, children after orchiopexy should be followed for at least a year to be sure that the testicle remains descended.

Head and Neck Conditions

The Essentials

- Lymphatic malformations are common and require intervention due to risk of infection and hemorrhage, though intervention is nonemergent and may wait to 6 months to 1-year-old.
- Distinguishing between macrocystic lesions and microcystic lesions can be helpful, as sclerotherapy may be an effective first-line treatment for macrocystic lesions.
- Resection should not compromise critical neurovascular structures.
- Branchial cleft remnants are present at birth and may or may not be symptomatic.
- Resection is nonurgent and can be deferred to 6 months to 1-year-old.
- Resection often involves following the tract to the oropharynx to minimize chances of recurrence.

The most common pediatric neck masses are enlarged lymph nodes, and lymphoma would be the most concerning entity in the differential diagnosis. In the neonatal period, lymphatic malformations (formerly known as "cystic hygromas") may be encountered. The type and timing of intervention depends mostly on the severity of clinical symptoms. Lymphatic malformations may range from small cystic masses

Fig. 20.27 Large cervical lymphatic malformation treated by sclerotherapy with bleomycin. At presentation at age 7 days, after 10 months, and after 20 months

to large disfiguring lesions that can compress and even involve the airway. They are generally classified as being either “macrocystic” or “microcystic” depending on the type of cysts involved—with large unilocular cysts considered “macrocystic.” This affects management in that macrocystic lesions may be temporized by aspiration (with nearly 100% chance of recurrence), while microcystic lesions often behave as solid tumors and do not respond to aspiration due to many septations between small cysts. Ultrasound is a reasonable first imaging study and can often confirm the cystic nature of the lesion and identify septations and size of spaces to determine whether the cyst is microcystic or macrocystic. This can also confirm (using Doppler) that there is no significant vascular component of the lesion, as sometimes lymphatic malformations can have a mixed arterial or venous component. In resource-poor areas, optional further definition of the lesion with CT or MR imaging may not be available.

As with other neonatal conditions, in settings with limited resources, deferring invasive surgery to an older age when anesthesia is safer is preferred. Urgency of intervention would be determined primarily by the severity of symptoms, especially of airway compression, and feeding. The general indications for intervention for these lesions are (1) infection, (2) bleeding, (3) risk of growth and impact on adjacent structures, and (4) cosmesis. Lymphatic malformations are not believed to be a risk factor for malignant degeneration, although lymphangiosarcoma is considered a different clinical entity.

Surgery is the preferred treatment option for microcystic lesions. Goals of surgical excision in the most aggressive cases are to grossly excise the lesion without sacrificing any critical neurovascular structures. Closure may be a challenge; often there is extra skin (with the lesion acting almost as a “tissue expander”), and the lesion may come up to and sometimes even involve the skin—microcystic malformations in particular have a propensity to “weep” through the skin. Often a large space is left behind and a drain should be considered.

Sclerotherapy should be the first line of treatment for macrocystic lesions, using bleomycin or doxycycline-based solution [91] (Fig. 20.27). OK-432, which is the preferred sclerosant, is rarely available in LMICs. Even if the lesion does not completely disappear, the residual mass would be smaller and easier to remove at surgery.

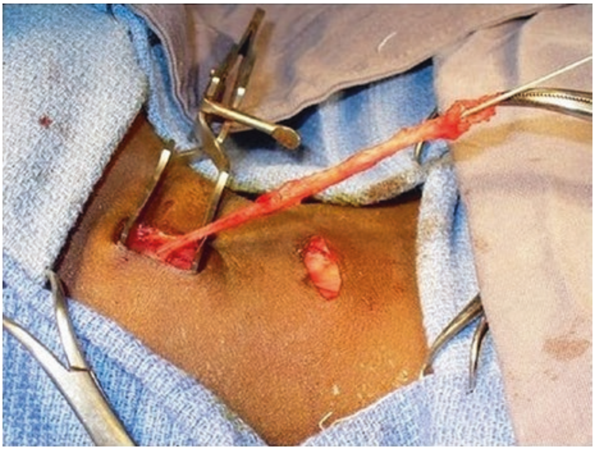


Fig. 20.28 Branchial cleft sinus excision

For malformations that present with infection, incision and drainage may be necessary in addition to antibiotics. Definitive excision of the lesion should not be undertaken in the setting of active infection due to surrounding inflammation.

Cystic masses in the neck may also include branchial cleft remnants. Their presentation and the spectrum of disease also vary greatly, from a large cyst to a small punctum draining saliva. It would be unusual to have to intervene for remnants in the neonatal period as they are generally asymptomatic. The most common type is the type II remnant, reliably located in the midsternomastoid. For a cystic mass, ultrasound may be helpful in identifying cystic or solid nature but likely not diagnostic. Remnants may be composed of true cystic masses but also may be long sinus tracts with origin in the hypopharynx. If excision is undertaken, a probe in the sinus tract may be helpful to guide the dissection. The tract may course between the carotid/internal jugular vein and also near other critical structures in the neck. In some circumstances they may also course through the thyroid gland. If the punctum is low in the neck with a long sinus tract, a "stepladder"-type incision above the original incision may be necessary for adequate exposure (Fig. 20.28). The most proximal aspect of the sinus tract should be ligated; nonetheless recurrence is possible. As with lymphatic malformations, definitive excision should not be undertaken in the context of active infection. Indications for excision are similar to lymphatic malformations. These cysts if left untreated are not thought to be malignant precursor lesions, but in the setting of chronic infection for years, carcinoma has been reported. Recurrence rates are much higher if the lesion is excised after a history of prior infection, and families should be counseled about this accordingly.

Thyroglossal duct remnants are also a common congenital neck mass (Fig. 20.29). These are midline lesions related to the development and descent of the thyroid from the base of the tongue. They can be found anywhere from the base of the tongue in the midline superiorly to the sternal notch inferiorly. They are generally cystic mobile masses; they may move with tongue protrusion. Incision and drainage

Fig. 20.29 Thyroglossal duct cyst

may be needed if there's an abscess, but definitive excision is recommended subsequently. The most critical aspect of definitive excision is not only of the cyst but the tract through the hyoid bone; the central part of the bone should be excised with the cyst (Sistrunk procedure) and a tract above the bone followed up to the base of the tongue. This tract above the bone is generally a thick band of tissue that one may ligate en masse. Often the proximal tract has multiple branches, and a wide excision will help to avoid inadequate incision. Again, in cases that have been previously infected, risk of recurrence is significantly higher.

In high HIV incidence LMICs, some masses may more likely represent infection—such as tuberculosis and bacterial infection—and these should be considered in the differential.

Management of Common Subspecialty Conditions

Hydrocephalus and Spina Bifida

Hydrocephalus

Hydrocephalus, or the abnormal collection of cerebrospinal fluid (CSF) in the ventricles, is a relatively common pediatric neurosurgical condition. In Western countries it is most likely due either to congenital occlusion of the aqueduct of Sylvius, acquired blockage by clot in premature babies, or secondary to brain tumors and in babies with spina bifida. In low-resource settings, half the cases appear to be infectious in etiology—due to untreated or poorly treated neonatal encephalitis or meningococcal meningitis in the older child. Congenital, neoplastic, and neural tube-related cases are also encountered.

The clinical presentation of hydrocephalus reflects the increase in intracerebral pressure, causing bulging and failure of closure of the fontanels, prominent scalp

Fig. 20.30 Neonatal hydrocephalus

veins, and sunset eyes (Fig. 20.30). Obstruction of CSF flow can also result in CSF infection, and the common denominator is progressive brain damage.

Treatment, aimed at reducing the intracranial pressure, is therefore urgently needed. In extremis a simple ventricular tap (with a 20 gauge needle) can be used to temporarily reduce the pressure and also examine the CSF for bacteria and white cells. The definitive treatment remains internal bypass of the obstruction, either using a shunt catheter or endoscopic ventriculostomy. The commonest shunt type is a ventriculoperitoneal shunt (VPS), with other drainage sites (pleural cavity, pericardium, gallbladder) reserved for unique situations. An endoscopic third ventriculostomy (ETV) is a fenestration performed in the floor of the third ventricle, thus allowing CSF drainage into the basal cisterns.

Both procedures are very meticulous and require special expertise and are therefore to be avoided by any surgeon without the needed expertise. Complications, both infectious and mechanical, eventually occur in at least half the shunt placements, requiring frequent shunt exteriorizations and/or revisions. Shunts are well known to block, to migrate, to cause bowel obstruction, and to erode through the bowel, vagina, or skin. Each complication typically worsens the neurological status of the child, often irreversibly.

Spina Bifida

There are several neural tube defects, including spina bifida, myelomeningocele, myeloschisis, and tethered cord. Spina bifida (Fig. 20.31) is mostly of the aperta (open) type, clearly visible at birth along the spinal canal. It is a major neurological

Fig. 20.31 Spina bifida. Myelomeningocele; lipomeningocele

defect associated with multiple other significant abnormalities. Affected children often develop hydrocephalus, may have severe kyphosis and uncal herniation (as in the Chiari II malformation), may be paraplegic, and often have bowel and urine incontinence, club feet, and other rarer manifestations (like lumbar hernias and uterine prolapse).

Investigations are seldom needed beyond the ultrasound for ventriculomegaly (encountered in two-thirds of patients) and hydronephrosis. Treatment includes early closure of the spinal defect to prevent its infection, followed by ongoing treatment of all the other manifestations as they appear: shunting or ETV for hydrocephalus, casting for the club feet, bowel and urine continence measures, and eventually surgery for kyphosis and other skeletal deformities. The commonest cause of death in these children is renal failure, and daily clean intermittent catheterization (CIC) is the treatment of choice to prevent urinary infections and vesicoureteric reflex (VUR). In low-resource settings, most children are not offered multiple continence procedures such as Mitrofanoff conduits and antegrade colonic enemas (ACE). Instead, daily digital disimpaction and CIC with the possible addition of oxybutynin appear to be quite efficient in providing social continence and renal preservation.

As in other specialty areas, the visiting non-neurosurgeon is discouraged from performing the often challenging spinal defect closure and to work in close collaboration with existing urologists and orthopedic surgeons in managing the other long-term complications of this condition.

Cleft Lip and Palate

These are discussed in Chap. 21 Plastic Surgery for the Non-Plastic Surgeon in the Low Resource Setting.

Club Foot

This and other pediatric orthopedic conditions are discussed in Chap. 16 Essential Orthopedics for Global Surgery.

Hypospadias

Hypospadias, or the abnormal opening of the urethra proximal to its normal glandular location, is a relatively common condition. It is typically divided into distal types (glandular, coronal, distal shaft) and proximal (proximal shaft, penoscrotal, and perineal). The proximal forms are typically associated with chordee or curvature of the shaft and may merge into ambiguous genitalia (disorders of sexual differentiation, DSD).

Hypospadias is readily identifiable at birth but remains largely asymptomatic. It is typically isolated but may coexist in syndromes. The presence of palpable gonads typically differentiates it from DSD. No extra investigations are required, except for an abdominal ultrasound.

Repair of hypospadias is typically done before 1 year of age, though patients in resource-poor settings often come much later, even in their teens. The repair is the same regardless of age and is dictated primarily by the location of the abnormal meatus. Distal defects are repaired by primary urethroplasty, most commonly through a tubularized incised plate (TIP) repair as described by Warren Snodgrass [92, 93]. Glandular forms require even simpler localized repairs, and in fact the need for repairing them is questionable.

Proximal forms typically need both a urethroplasty and an orthoplasty (for chordee or curvature). Mild forms of curvature often correct once the penis is degloved but, if not, can be corrected by posterior plication. Severe forms require division of the shorter urethral plate. This can be done as one step with the urethroplasty but often requires staging (chordee release and creation of new urethral plate, followed by urethroplasty). Most repairs require a dripping stent for infants and special indwelling catheter for older children, for 5–10 days postoperatively.

There is a multitude of procedures for hypospadias, testimony to the fact that none are perfect. Complications occur in up to 30% of hypospadias repairs, especially in the proximal types. They include meatal stenosis, fistula, and repair breakdown. Iatrogenic urethrocutaneous fistulas require fistula repair 6 months later. Repeated failures, not uncommon in low-resource settings, result in “hypospadias cripples” whose penis has lost most skin coverage. These require complex repairs with replacement of the mucosa with the buccal mucosa or dermis.

As with other elective procedures outside the Western pediatric surgical spectrum, repair of hypospadias is best left for urologists or plastic surgeons with appropriate expertise.

Appendix: Commonly Used Drugs in Children in LMICs

Group of drugs	Drug names	Dosages
Analgesics and anesthetics		
	Morphine	Oral: 0.1–0.5 mg/kg/dose 4–6 hourly
		IV: 0.05–0.2 mg/kg/dose 6–8 hourly (do not exceed 0.1 mg in neonates)
	Paracetamol (acetaminophen)	IV: 10–15 mg/kg/dose 4–6 hourly
		oral: 15 mg/kg 4–6 hourly
		Rectal: 20 mg/kg 4–6 hourly (do not exceed 75 mg/kg/day)
	Ketorolac	0.5 mg/kg/dose, 6 hourly
		Not to exceed 5 days
		Not advisable <2 months
	Ibuprofen	4–10 mg/kg/dose, 6 hourly
	Diclofenac	75–100 mg po q day in 3 divided doses if child <12
	Ketamine	Anesthesia induction: 4–5 mg/kg IM x 1 or IV 1–2 mg/kg
		Sedation: 6–10 mg/kg po 30 mins before procedure; 5–20 mcg/kg/min
	Bupivacaine	>12 years old max dose 175 mg; 225 mg (with epinephrine); can repeat in 3 h
	Lignocaine (lidocaine)	Max 4.4 mg/kg
Antibiotics		
	Amoxicillin	50 mg/ kg po tid
	Ampicillin	50 mg/kg po q 6 h
	Ampiclox	250 mg po q 6 h age <2; 500 po q 6 h >2
	Amoxicillin + clavulanic acid	30 mg/kg/day divided bid age < 3 months
		25 mg/kg/day divided bid age > 3 months
	Cloxcillin	50–100 mg/kg/day divided q6
	Chloramphenicol	25–50 mg/kg/day
	Ciprofloxacin	10–20 mg/kg q day po bid
	Ceftriaxone	50 mg/kg/day IV q day
	Cefuroxime	30 mg/kg/day po if age >3 months
	Gentamicin	7.5 mg/kg/day divided q3 h
		5 mg/kg/q day div. bid
	Metronidazole	10 mg/mg/dose IV tid

Group of drugs	Drug names	Dosages
Antiparasitic drugs		
	Albendazole	>6 months: 400 mg single dose
		>6 months, <10 kg: 200 mg single dose
		Hydatid disease: 10–15 mg/kg/day in 2 divided doses. Give continuously without break
	Mebendazole	>6 months: 100 mg BD for 3 days
		>6 months, <10 kg: 50 mg BD for 3 days
		Hydatid disease: 40-50 mg/kg/day in 3 divided doses
	Metronidazole	For Amoebic infestation:
		35–50 mg/kg/day in 3 divided doses
		Give for 5 days for colitis and 10 days for liver abscess
	Tinidazole	For amoebic infestation:
		50 mg/kg QD for 3–5 days
Sclerotherapy of lymphangioma		
	Doxycycline	10–20 mg/ml concentration in normal saline
	Bleomycin	0.5–1 mg/ml aqueous solution. Maximum cumulative dose is 5 mg/kg
Seizure control in head injury		
	Phenytoin	Loading: 20 mg/kg iv
		Maintenance: 5–10 mg/kg/day, 12 hourly IV or oral
	Phenobarbitone (phenobarbital)	Loading: 20 mg/kg IV
		Maintenance: 5–10 mg/kg/day, 12 hourly IV or oral (to start 12 h after loading dose)

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Plastic Surgery for the Nonplastic Surgeon in the Low-Resource Setting

21

Louis L. Carter Jr.

Introduction

It is often surprising to surgeons in the West that there are so many cases requiring "plastic surgery" in low-resource settings (LRS); however, these are often not the typical plastic surgery cases seen in the West. The cases in LRS include conditions such as noma, vesicovaginal fistula, urethral stricture, nasoencephalocele, or ameloblastoma. Most of these cases are rarely seen in the West, and when seen, they are seen by subspecialists and not general surgeons. In the LRS they present to the general surgeon since there are so few subspecialists and reconstructive surgeons. In addition, patients present late and their disease processes are frequently far advanced. There are other disorders requiring reconstruction that are seen all over the world including congenital and post-traumatic deformities malformations as well as burn contractures. In the LRS these are often treated differently due to the lack of equipment and supplies and the lack of therapists.

This chapter will cover common plastic surgery conditions seen in LRS including chronic wounds, burns, burn contractures, lower extremity reconstruction, unilateral cleft lip, hand trauma and infections, and hypertrophic scars and keloids. Facial hemangiomas are discussed since these can be life threatening and since a new protocol using propranolol is now available. Conditions such as noma or ameloblastoma are beyond the scope of this chapter.

Disabilities and deformities in the LRS and especially the obvious ones in children are often associated with a stigma, a curse, or even a judgment from God. It is imperative that these be treated with a sense of urgency with an attempt to correct the disfigurement prior to the child starting school.

L.L. Carter Jr., MD, FACS
Plastic and Orthopaedic (Hand) Surgery, University of Tennessee College of Medicine, Chattanooga Unit, Erlanger Hospital, Chattanooga, TN 37350, USA
e-mail: llcartermd@comcast.net

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Congenital Conditions

Cleft Lip and Cleft Palate

The Essentials

- *Cleft lip and palate are common congenital anomalies worldwide.*
- *Cleft lip carries a stigma in low-resource settings if not repaired.*
- *Without special instruments, lighting, and anesthesia, cleft palates can be difficult to repair.*
- *Best timing of surgery: cleft lip 3 months and cleft palate 9 months, definitely before the child begins to speak at about 2 years of age.*

There are numerous illustrations of cleft lip repair in the literature and also online. Smile Train has produced videos of cleft repairs. Clefts can be unilateral or bilateral and they may be incomplete or complete. The left side is the most common. There is always a nasal deformity associated with the cleft lip, less with the incomplete cleft (Fig. 21.1).

Most surgeons around the world use the Millard, rotation-advancement, repair since it is a "cut as you go" method and leaves one with good philtrum columns and Cupid's bow. This method can be used for all unilateral clefts and with some modifications for the wide clefts. Wide clefts, unilateral or bilateral, should be "taped" by their caregivers as early as possible to reduce the width of the defect before surgery. Appliances, such as the Latham appliance are often not available, and tape may help to narrow the defect. Thin, 1/2 in. tape is taped across the lip and back to the ear on each side for 6–8 weeks. This will narrow the deformity and surgery will be easier. The parents can be taught to reapply the tape daily or when the tape becomes wet.

Fig. 21.1 Left complete cleft of lip and palate

Surgery should be delayed until the child is 10 weeks old and has a hemoglobin of 10 and weighs 10 lbs or 5 kg. Ideally, cleft lips should be repaired by 3–6 months of age under general endotracheal anesthesia. In some areas, due to unsatisfactory or marginal anesthesia, surgery may be delayed until 1 year of age. Cleft lip surgery may also be performed under ketamine alone or in combination with local anesthesia with or without adrenaline. The addition of local anesthesia gives local pain relief and adrenaline reduces bleeding. Lidocaine local anesthesia is most commonly used. Lidocaine 1% has 10 mg/ml. The dose of lidocaine 1% is 5 mg/kg. If lidocaine with adrenaline is used, then 7.5 mg/kg may be given since absorption is slower with vasoconstriction. Most lidocaine in sub-Saharan Africa is 2% or 20 mg/ml, and one must be very careful in calculating the correct dose.

Example: The maximum dosage of lidocaine for a 10 kg child is 50 mg of plain lidocaine or 75 mg of lidocaine with adrenaline. Therefore, if 1% lidocaine is used, only 5 ml may be used in a 10 kg child. If 1% of lidocaine with adrenaline is used, 7.5 ml may be used. If lidocaine 2% is used, then only 2.5 ml of plain lidocaine may be used. Therefore, the 2% lidocaine *must* be diluted with a saline solution 1/1 or 2/1. Most surgeons would use adrenaline to limit bleeding.

In young adults, local anesthesia alone can be used. This requires infraorbital blocks with 2–3 ml of anesthetic injected into the infraorbital nerve just below the infraorbital rim. One finds the infraorbital foramen by gentle palpation in the mid-pupillary line just below the infraorbital rim. This will give near-complete anesthesia of the upper lip on the ipsilateral side. If necessary, the same can be given on the opposite side. Once markings for the dissection are made, a small amount of the local anesthetic with adrenaline can be injected into the lip for good hemostasis. When the techniques are discussed, the side of the cleft is called the cleft side, and opposite side is the non-cleft side.

The key markings for a unilateral cleft lip repair are: (Fig. 21.2)

The advancement flap is created first, dotted line on cleft side in Fig. 21.2. The orbicularis muscle on the cleft side is dissected free from overlying skin and

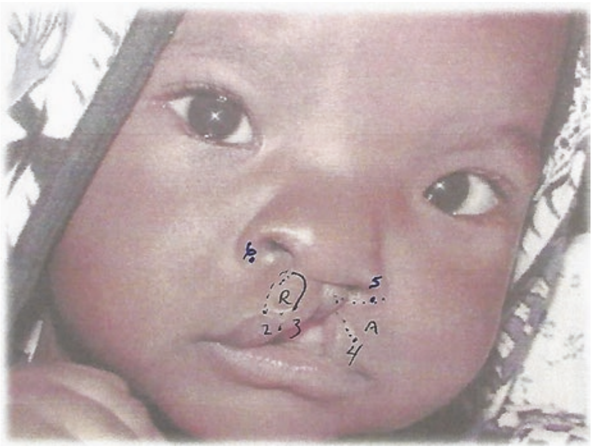


Fig. 21.2 Markings for cleft lip repair. *1* Midline Cupid's bow. *2* Height Cupid's bow non-cleft side. *3* Height of Cupid's bow cleft side. *4* Fullest point cleft side. *5* Base of alar base non-cleft side. *6* Base of alar base cleft side. *A* Advancement flap, *R* rotation flap. *Dotted line* cleft side—advancement flap. *Dotted line* non-cleft side—philtrum column

underlying mucosa for 5 mm. to create a muscle flap. See forceps holding this muscle flap in Fig. 21.3. This allows the muscle to be approximated to the muscle on the non-cleft side. The lip segments are released from the maxilla by sharp dissection just above the periosteum and up to the infraorbital nerve on the cleft side. In creating the flaps, the lip is divided perpendicular to the white roll or vermillion border at 3 and 4, and the mucosa is incised parallel to the vermillion border giving a 3–4 mm mucosal flap which may be used to reconstruct the nasal mucosa or alveolus if necessary (Figs. 21.3, 21.4, and 21.5).

The mucosa is closed with 5-0 chromic or Vicryl sutures. The two muscles from A and R, advancement and rotation flaps, are then approximated with three 4-0

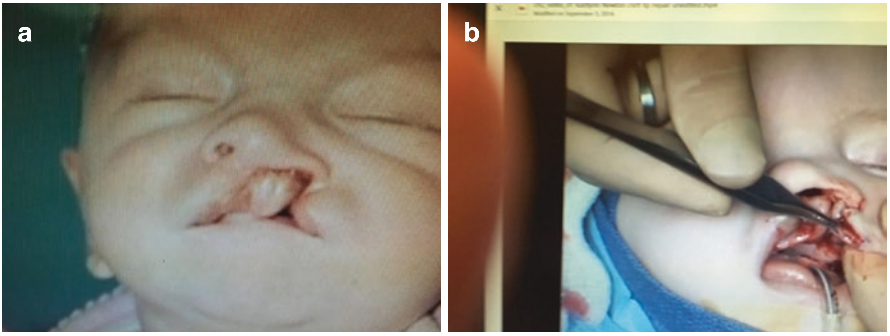


Fig. 21.3 Complete left cleft lip. On the right, forceps holding orbicularis flap. The advancement flap is created on the cleft side, and the underlying orbicularis muscle is dissected out to enable a good muscle closure (Photo image courtesy of Dr. Larry Sargent)

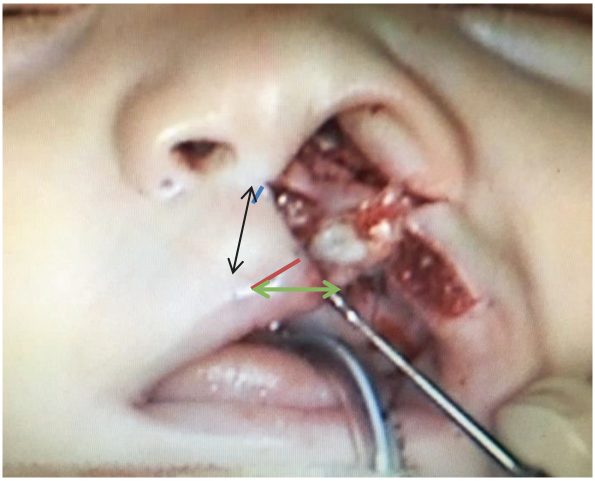


Fig. 21.4 On the non-cleft side, a rotation flap is created (see Fig. 21.2). Cupid's bow must be transverse, and if Cupid's bow is not transverse, *red line* above, a backcut must be made. This is the *blue line* at end of rotation flap. It is important that the backcut does not cross the philtrum column of the non-cleft side, *black line* with *arrows* above. This backcut will allow Cupid's bow to lay transversely, *green line* above and Fig. 21.5 (Photo image courtesy of Dr. Larry Sargent)

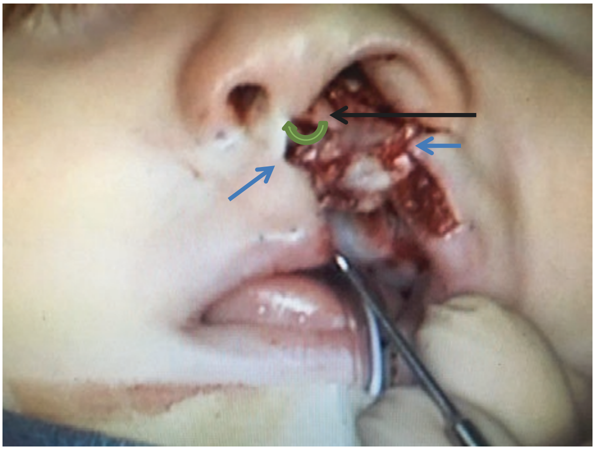


Fig. 21.5 The C flap, *black arrow*, is closed in order to lengthen the columella, *green arrow*. The tip of the advancement flap (**a**) is then advanced into the defect, *blue arrow* to *blue arrow*, *left* by the rotation of the rotation flap (*R*) and the backcut (Photo image courtesy of Dr. Larry Sargent)

Fig. 21.6 The completed lip repair (Photo image courtesy of Dr. Larry Sargent)

Vicryl sutures. The skin is closed with 5-0 or 6-0 nylon suture starting at the vermillion border. The nasal lining is finally closed with chromic or Vicryl sutures (Fig. 21.6).

Summary of the Millard Technique

(a) Markings as found in many resources.
(b) Rotation (R) flap: this flap on the non-cleft side rotates down so that the Cupid's bow is transverse. Failure to completely rotate this flap will result in a notching in the upper lip. If the lip does not rotate down completely, then a backcut should be

made at the end of the flap and parallel to the philtrum column. See blue arrow in Fig. 21.4. This backcut should not cross the philtrum column but be parallel to it.

(c) Release of the cleft side lip just above the periosteum up to the infraorbital nerve.

(d) The advancement flap from the cleft side must be inserted into the base of the rotation flap or backcut. Many cleft surgeons in the West do not make this incision around the alar base of the cleft side. In LRS where patients come in late and where preop orthotics is not available (Latham appliance), this advancement flap must be extended around the alar base (Fig. 21.2, dotted line below **#5**).

(e) The orbicularis oris must be freed up along the edges of the lip, approximately 5 mm on the cleft side and 2 mm on the non-cleft side.

(f) Ideally, the nose and nasal cartilages are freed up so that the alar base on each side lies horizontal, and equal distance from the columella and the alar rims are symmetrical. This requires skill and experience to release of the nasal cartilages in order to gain a symmetrical nose. Most surgeons in LRS do not have this training and experience, and these techniques are not described here. The goal in the LRS is to get a good lip closure without tension and leave nasal surgery until later.

Bilateral clefts are more difficult, and if the complete bilateral cleft lip presents late, there will likely be a protruding premaxilla, and the palatal arches may be closed behind the premaxilla. When the premaxilla protrudes beyond the palatal shelves, these children require orthodontic care which is often not available.

A lip adhesion procedure sutures the lateral lip elements to the prolabium on each side. If this procedure is performed in the first few months, it will push back the premaxilla in line with the palatal shelves until a proper lip repair can be done. As mentioned above tape across the lips and premaxilla will help with early lip closure and prevent the premaxilla from protruding beyond the palatal shelves (arches).

Ideally, the palate is closed before the child begins to speak. In the West, many centers close the lip at 3 months and the palate at 9 months. Some surgeons fear that early palatal closure at 9 months will delay midface growth and then a LeFort I procedure maybe necessary later in life, but this is rarely necessary. When the palate is repaired after 2 years of age, there is always a speech impairment which can never be corrected even with a good speech therapist. When the palate is closed early before the child begins to speak, then good speech is usually preserved.

The cleft palate operation is difficult. It is down in a “hole” and not on the surface as a cleft lip procedure. It requires general endotracheal anesthesia with special sutures and instruments including a Padgett retractor. Many of the sutures are placed deep in the oral cavity. After surgery the patient requires close observation for 24 h, ideally in an ICU.

A poorly done cleft palate procedure may leave the patient worse off than if the cleft palate was never corrected, especially if a fistula results. A redo cleft palate procedure is often very difficult. For the most part, palate surgery is not recommended in the LRS unless an experienced cleft surgeon is available.

Wounds

The Essentials

- *Acute wounds must be closed before 7 days directly or with a skin graft or flap to prevent an infected wound.*
- *If left open, the wound must be kept moist continuously with saline or honey.*
- *If a wound dries out, it will become infected and lead to a chronic wound.*
- *Delayed closure leads to infection and a chronic wound.*
- *Chronic wounds are a financial burden to both the patient and hospital.*
- *Chronic wounds must be radically excised (radically debrided) prior to closure in order to create a fresh, clean wound.*
- *Granulation tissue is red but it is infected. It must be debrided down to good clean tissue prior to closure or grafting. Clarify this.*
- *Honey or the vacuum-assisted closure (VAC) will debride and prepare a wound for closure. One must have continuous suction for the VAC.*
- *The Humby knife or Weck blade can also be used to sharply debride a wound in preparation for closure. It is especially good for removing infected superficial granulation tissue.*
- *Wounds that are never closed may develop Marjolin's ulcer (squamous cell carcinoma).*

One of the most common problems seen in LRS is the unhealed or chronic wound. Most wounds are caused by trauma and burns. Chronicity is due to inadequate, delayed, or inappropriate care. There are not enough trained surgeons in the LRS to care for all the wounds. Most but not all chronic wounds involve the lower extremity, a site of common and repeated trauma and diminished blood supply. Immune deficiency disorders must always be considered with any chronic wound (Fig. 21.7a–c).

Acute Wounds

Acute open wounds should be treated with a sense of urgency. Acute wounds are much easier to treat and close than chronic wounds. Acute wounds should be closed immediately if possible. When acute wounds cannot be closed because there is loss of skin, skin grafts or even flaps may be used acutely. There is no need to wait for granulation tissue as is often done in the LRS, as this will lead to a chronic wound. A clean acute wound will readily take a skin graft. If wounds are too contaminated to close acutely, debridements should be carried out every 2 days and the wound closed when it is clean and certainly within 7–10 days. Otherwise, after 7–10 days, it will become a chronic wound with bacterial colonization, and radical debridement will be necessary before closure (see Fig. 21.7a–c). If possible an experienced

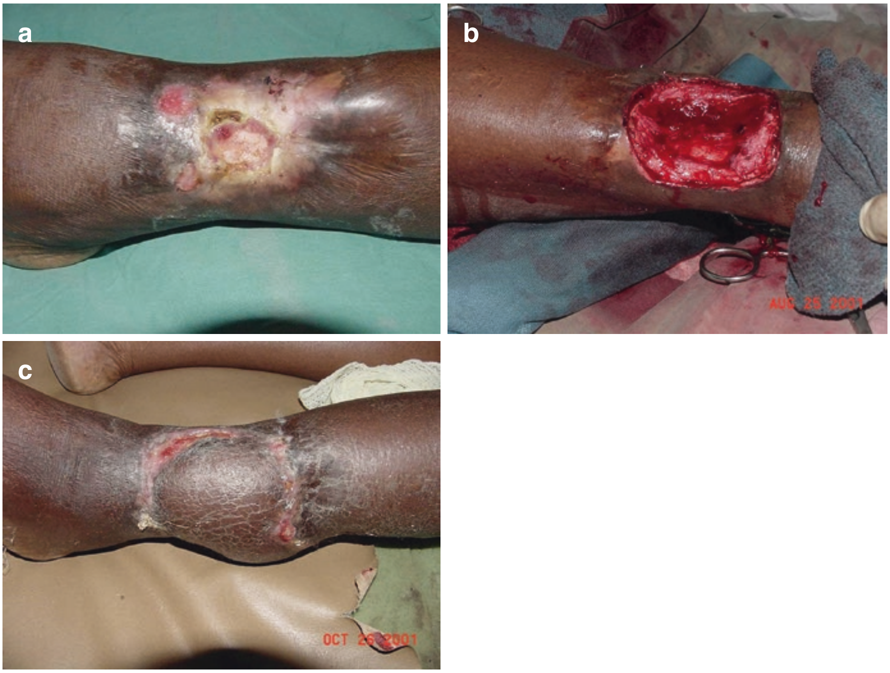


Fig. 21.7 (**a**–**c**) Chronic wound treated by radical excision down to normal, bleeding tissue. Delayed reconstruction with a reverse sural artery flap

surgeon should care for these chronic wounds. Ideally, when a complex and contaminated wound first presents, it should be cared for by a senior surgeon who will “own” the wound. “Ownership” of a severe injury with daily care is necessary for adequate healing and prevention of a chronic wound.

If a wound cannot be closed acutely, then it must be kept moist and elevated between debridements. Keeping the wound moist accelerates healing and prevents desiccation. Methods used to keep the wound moist:

1. Wet dressings and wetting the dressing again before it becomes dry, usually every 2–3 h. This requires excellent nursing care, often not available in LRS. This is not “wet to dry” dressings which will dry out and desiccate before they are wet again.
2. Dripping a saline solution (IV solution) in the wound continuously—just a slow drip. This is best done with a Mackintosh (rubberized mat) under the wound to help keep the bed dry. This is not ideal but may work in some situations. Solutions other than saline are not recommended though water can be used if nothing else is available.
3. Gauze impregnated with silver sulfadiazine ointment (homemade) has also been used. For large wounds silver sulfadiazine will be expensive. Certainly, other antibiotic-impregnated gauze has been used but will also be expensive. Most health-care professionals change these gauze dressings once a day.

4. In New Zealand and southeast Australia, there are manuka (*Leptospermum scoparium*) flower trees, and honey from these trees has been found to have not only antibacterial but also antifungal properties. This honey has been used in New Zealand for many years, and gauze has been commercially impregnated with this honey for wound dressings. Most important honey keeps wounds moist and deodorizes the wounds, and its hyperosmolarity draws fluid and exudate into the honey and away from the wound. In recent years it has been found that any raw honey, not just from manuka trees, has the same qualities as manuka honey except it is not antifungal. Raw honey, not processed, has now been used around the world, and it continues to show great promise for wound care. The author would recommend that honey be used to cover wounds or burns after debridement. A thin layer can be applied to the wounds, and dressings can be changed every 1–2 days and further debridement carried at each dressing change until the wound is clean and ready for closure. Honey can be held on the wound by dressings or by Saran (food) wrap which is now found in most countries. (Manuka honey has been imported into Canada from New Zealand and packaged as MediHoney for export to the USA. There are now dressings with impregnated manuka honey available in the USA.)
5. An additional method to debride and clean up a wound in the LRS is with vacuum-assisted closure (VAC) or negative pressure therapy (NPT). The products and equipment for this procedure are commercially manufactured by KCI and Smith & Nephew, but the technique can be used with locally available items. These include foam rubber from cushions used in making furniture or just gauze, Saran (food) wrap to hold the foam rubber or gauze on, suction tubing or N/G tubing, and wall suction or a heavy-duty suction machine that will run continuously without stopping. The foam rubber is cut into various sizes, 3–5 cm thick, and then steam sterilized. The wound is first surgically debrided. The sterile foam rubber is cut to the exact size of the wound and laid on the wound, or several layers of gauze are placed on the wound. A #12–14 F catheter is inserted into the foam rubber (with a hemostat) or laid on the gauze. Saran or food wrap is wrapped around the extremity or torso to hold the dressing in place. Tape is used at each end to prevent air leak. The food wrap sticks to itself but not to the skin. If one has a sticky drape such as Ioban, this may be wrapped around the dressing without the need for tape. The suction tube is then hooked to the suction machine with 75–125 mmHg suction pressure. The dressings are changed every 2–3 days and further debridement carried out. Just as with honey, this method does not eliminate the need for surgical debridement. The VAC/NPT debrides the wound and keeps the wound moist and removes unwanted exudate and bacteria. This suction also leads to angiogenesis and clean granulation tissue which can be grafted on with minimal debridement. This method can be used for several weeks or until the wound is clean and can be closed (Fig. 21.8a–e).

If the suction is not continuous, the closed wound will become infected. If there is a problem with continuous suction, then one should open the wound and use honey as described above.

Fig. 21.8 (**a–e**) A 16-year-old boy suffered a large open fracture of his right leg secondary to a farm accident. He had a 5 cm segmental loss of the tibia with distal a severely contaminated distal fibula which was embedded into the ground (**a, b**). The distal fibula was removed and remaining fibula telescoped into distal tibia and external fixator applied (**c**). After debridement, negative pressure therapy used for 6–8 weeks and then the clean wound was grafted (**d**). Healed wound and fracture after 16 weeks (**e**)

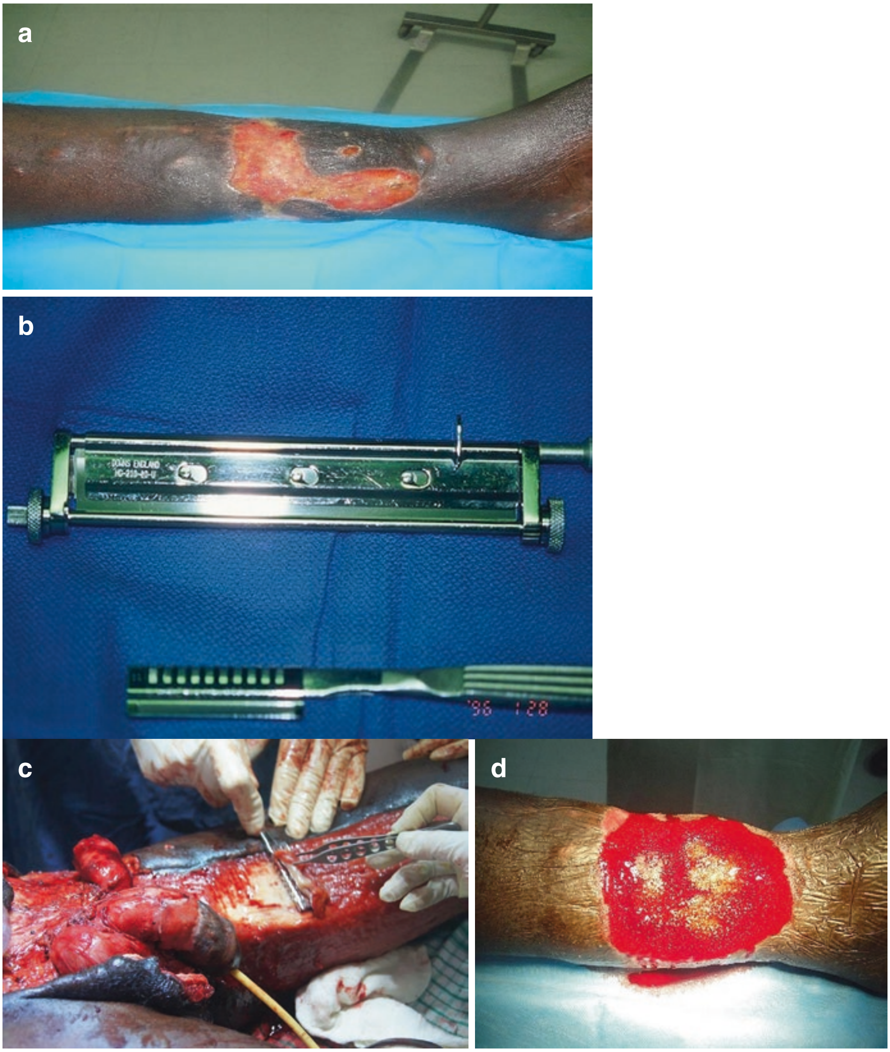


Fig. 21.9 (**a–d**) Chronic wound: honey was applied every other day with surgical debridement at each dressing change. Debridement was with a Weck blade down to bleeding subcutaneous tissue (**c**). A Humby or Watson dermatome blade may also be used (**b**). A meshed skin graft was used (**d**)

Chronic Wounds

When confronted with a chronic wound, initial sharp debridement should be carried out after the patient is evaluated for any systemic conditions such as diabetes, anemia, or AIDS that might delay wound healing. The author uses a Weck blade on a Goulain handle from Teleflex Medical (www.teleflex.com) to tangentially excise the wound down to bleeding tissue. A Humby or Watson dermatome blade may also be used (see Fig. 21.9b). When an old chronic wound is first seen, several excisional debridements every 2–3 days must be carried out before the wound can be closed. Once good bleeding tissue is reached, the wound can be grafted. If there is any question, as often there is, the wound should be kept moist with honey, negative pressure therapy or wet gauze if honey is not available. A repeat debridement is carried out 2 days later and the wound closed if possible. When the wound is clean, a meshed skin graft should be used as this will allow drainage of blood and serum and prevent loss of a graft. A meshed graft also molds into the crevices that are often present. Unless absolutely necessary, meshed skin should not be used on the face, neck, and dorsum of the hands. If there is exposed bone or tendons, a flap should be used to cover the wound (Fig. 21.9a–d).

Lower Extremity Reconstruction

The Essentials

- *Open and chronic wounds due to trauma, diabetes, and HIV are common in the lower extremity.*
- *There are few underlying muscles, and diminished blood supply with delayed healing is present in the lower third.*
- *Few flaps are readily available to cover wounds in the lower third.*
- *Reverse and perforator flaps are commonly used for coverage in the LRS.*

For the upper and middle third of the leg, the gastrocnemius and soleus muscle flaps are used to cover wounds with open fractures. These are well described in many texts such as PAACS Principles of Reconstructive Surgery or other plastic surgery texts. (See references section.)

Wounds of the distal third of lower extremity are often chronic and difficult to close. It is crucial to close these as soon after trauma as possible. These are often associated with fractures of the tibia and fibula. These distal lower extremity open fractures were once treated by casting or external fixators, but today they are often treated by early SIGN nailing. Even comminuted fractures may now be treated with SIGN nailing by experienced orthopedic or general surgeons in LRS. Open wounds are discussed under wound care, but often closure is delayed because of the complexity of the injury and lack of skilled orthopedic surgeons or reconstructive surgeons. SIGN nailing is an intramedullary interlocking nailing system that enables the patient to start ambulation early, often the day after surgery. SIGN stands for "surgical implant generation network."

Most hospitals now have external fixation devices, and these also allow the surgeons to treat open wounds. These wounds should be debrided and loosely closed acutely—with just a few sutures. This keeps the wound edges approximated and the wound moist until the next debridement 2–3 days later. Repeat wound care should be carried out every 2–3 days with complete closure by 7–10 days, either directly or with a skin graft or a flap. Skin grafts take well on acute wounds. If the wound is not closed by 10 days, one has a chronic wound which will require extensive debridement prior to closure. If continuous suction is available, negative pressure therapy (NPT or VAC) not only keeps the wound moist but also stimulates angiogenesis with clean granulation tissue which may be grafted or closed with a flap. When negative pressure therapy is used in conjunction with repeated debridements, closure of the wound can be delayed to allow for complete debridement and establishment of a clean wound for closure.

The lower third has always been a difficult area to close, but with NPT or VAC, these wounds may granulate and later be closed with a graft or flap. In the Western world, free microvascular flaps have been used to cover this lower third area. Now with reverse perforator flaps, these areas may be closed without the need for microvascular surgery. The most commonly used perforator flap is the reverse sural artery flap off perineal artery perforators 5 cm above the lateral malleolus. Reverse flaps off the posterior tibial arteries may also be used.

Burns

The Essentials

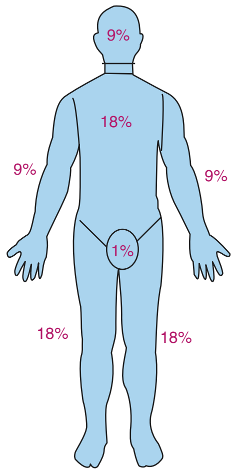
- *Burns greater than 10% BSA should be hospitalized.*
- *Accurate assessment of burn depth and size is critical in determining treatment and fluid resuscitation.*
- *Parkland formula is still a useful tool in determining amount of fluid resuscitation.*
- *Urine output is the best way to determine adequacy of fluid resuscitation.*
- *Silver sulfadiazine is still used for topical treatment, but raw honey is also usually available and cheaper.*
- *Antibiotics are not recommended in the initial treatment.*
- *A shower is best for daily debridement—not a bath or Hubbard tank.*
- *Splinting in position of protection prevents contractures.*
- *Early excision and grafting is only done when burns are less than 20% BSA, when blood is available, and when there is good anesthesia.*
- *Unhealed burn wounds lead to contractures and Marjolin's ulcer.*

Key Aspects of Burn Care

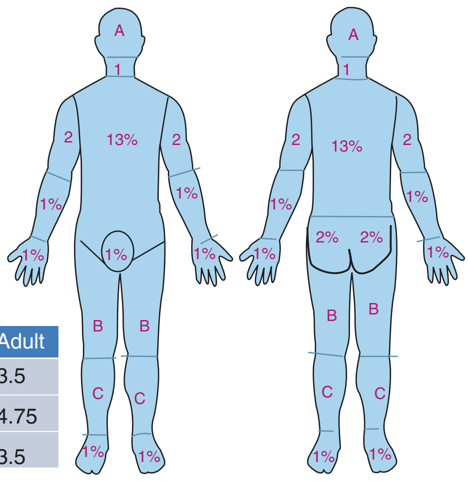
Burns greater than 10% body surface area (BSA) should be admitted. Burns of the face, hands, and genitalia should also be admitted. See Fig. 21.10a, b.

Accurate assessment of burn depth and extent of the burn is important. The rule of nines is a popular and fairly accurate method for determination of the body surface area burned (Fig. 21.10a, b). Depth of the burn can be difficult to determine. It is most important to determine the amount of second-degree (deep partial-thickness)

Rule of nines body surface area estimation



Lund and Browder chart



Age	0	1	5	10	15	Adult
A	9.5	8.5	6.5	5.5	4.5	3.5
B	2.75	3.25	4	4.5	4.5	4.75
C	2.5	2.5	2.75	3	3.25	3.5

Fig. 21.10 (**a, b**) Body surface area calculations: (**a**) adults on *left* and children on *right*. This chart gives the different surface areas in children (**b**) according to age for the head, thigh, and lower leg

and third-degree (full-thickness) burns in order to calculate the amount of fluid that is necessary in early resuscitation. Superficial partial-thickness burn (first degree) is not included in this determination. It is sometimes difficult to initially differentiate between deep partial-thickness and full-thickness burns, but this is not important in the early management. It is important to identify possible areas of circumferential burns that could lead to a compartment syndrome if an immediate escharotomy is not carried out. There is no need to measure compartmental pressure. Escharotomy is an incision just through the skin and into the subcutaneous tissue. In cases of full-thickness burn, this procedure can be carried out with simple povidone (Betadine) prep and without the need for anesthesia. In electrical burns with compartment syndrome, a fasciotomy is necessary with the deep muscle fascia divided. With thermal burns the compartment syndrome is from an external compression by the circumferential burn. With electrical burns, the compartment syndrome is usually caused by a deep injury and swelling of tissues. Therefore a fasciotomy must be done as soon as possible and under anesthesia for electrical burns.

If the combination of deep partial-thickness and full-thickness burns is greater than 40%, it is not likely the patient will survive. Since a completely accurate determination may not be possible, one should still carry out early aggressive resuscitation for a few days. When the burn is deep and widespread and likely >70%, conservative, nonaggressive palliative care may be carried out.

Accurate fluid resuscitation is important. The Parkland formula has been used around the world for nearly 50 years. It is easiest to remember: 4 ml × kg BW × % BSA burned = the amount of fluid necessary for the first 24 h. For example, a 50 kg individual with a 40% body surface area burn would receive $4 \times 50 \times 40$ or 8000 ml of fluid in the first 24 h. Ringer's lactate or Hartmann's solution is best, but normal saline or half-strength Darrow's (sodium 61 mmol/L, potassium 17 mmol/L, chloride 52 mmol/L, and lactate 27 mmol/L) may be used. Glucose solutions should not be used in adults as this will give an osmotic diuresis and a falsely high urine output. Glucose solutions should be used in children, and half-strength Darrow's with glucose is especially good in children. Only deep second and full-thickness burns are included in this fluid determination.

One half of the 8000 ml or 4000 ml should be given in the first 8 h, the time when most of the fluid is lost. One fourth or 2000 ml is given during each of the next 8 h. If the patient presents late, then the first 4000 ml should still be given during the first 8 h from the time of the burn. Additional fluids may be necessary if the urine output falls below 1 ml/kg per hour. Therefore a Foley catheter is necessary in all burns >10% BSA. Anytime the urine output falls, the extent of the burn needs to be recalculated as often the actual BSA of the burn is greater than first determined. Early blood transfusions may be needed as the hemoglobin always falls after a major burn. Due to fluid loss, the hemoglobin is initially high but falls rapidly.

Antibiotics are not recommended initially as these may give rise to resistant microorganisms.

It is then important to determine which topical antibiotic agent will be used on the burn wound. Silver sulfadiazine has been used since 1975. Brand names include Silvadene, Flamazine, and Thermazene. It is not perfect but it is the most readily available. It is expensive to use for large burns as in most areas it comes only in tubes and not jars. Recently raw honey has been used on acute burns. It can be held in place by gauze or food (Saran) wrap. Raw honey is discussed above for use on wounds. Neither the use of Silvadene nor raw honey is an excuse for no debridement. Silvadene dressings should be changed at least once a day. Honey may be left on for 2 days if the wound is clean. Ideally, the Silvadene and honey are washed off in a warm shower and not in a tub (Hubbard tank) since there is frequent cross

Fig. 21.11 (**a, b**) This is a good method to suspend the perineum and keep it clean. The bar is attached to the ankle areas by plaster of paris and then suspended above the bed with a rope tied to a bar or IV pole

contamination in a tub no matter how well it is cleaned out between patients. When there are burns in the perineum, the perineum should be elevated off the bed (Fig. 21.11a, b). The wooden piece is tied to a bar above the bed.

Splinting in the position of protection or safe position is most important to prevent burn contractures. In addition the axilla should be held in extension with an overhead bar or IV pole (Fig. 21.12a–g).

Splints should be left in place until the wound heals and the patient is able to begin full range of motion exercises.

Early excisional debridement and grafting (by day 7–10) may be carried out when the patient is stable. This is only done in the LRS when the burn is less than 20%, when one has good anesthesia, and when sufficient blood is available for transfusions. Only areas that will likely not heal are excised and grafted. The important areas to graft are the dorsal hands and over joints. Grafting of the face, neck, and genitalia may be delayed as these areas will often heal as they have excellent blood supply. Also the dermis of back skin is thick and will likely heal. Only 5% of BSA should be excised and grafted at one time as any excision adds to the amount of burn if grafts do not take.

Tangential excision is best performed with a Weck blade or Humby knife. Layer by layer is removed until one reaches good bleeding tissue, either the deep dermis or subcutaneous tissue. Bleeding is best controlled with gauze or lap sponges soaked in dilute Adrenalin (epinephrine) solution—2 cc of 1/1000 Adrenalin in 100 cc saline. This is the 1/1000 concentration of Adrenalin that is used for cardiac injections, and it comes in 1 ml ampule. (Lidocaine with Adrenalin has 1/100,000 Adrenalin.) After these dressings are removed, any further bleeding can be controlled with the electrocautery. Grafting is usually done with meshed skin grafts, but if plenty of skin is available, one should use

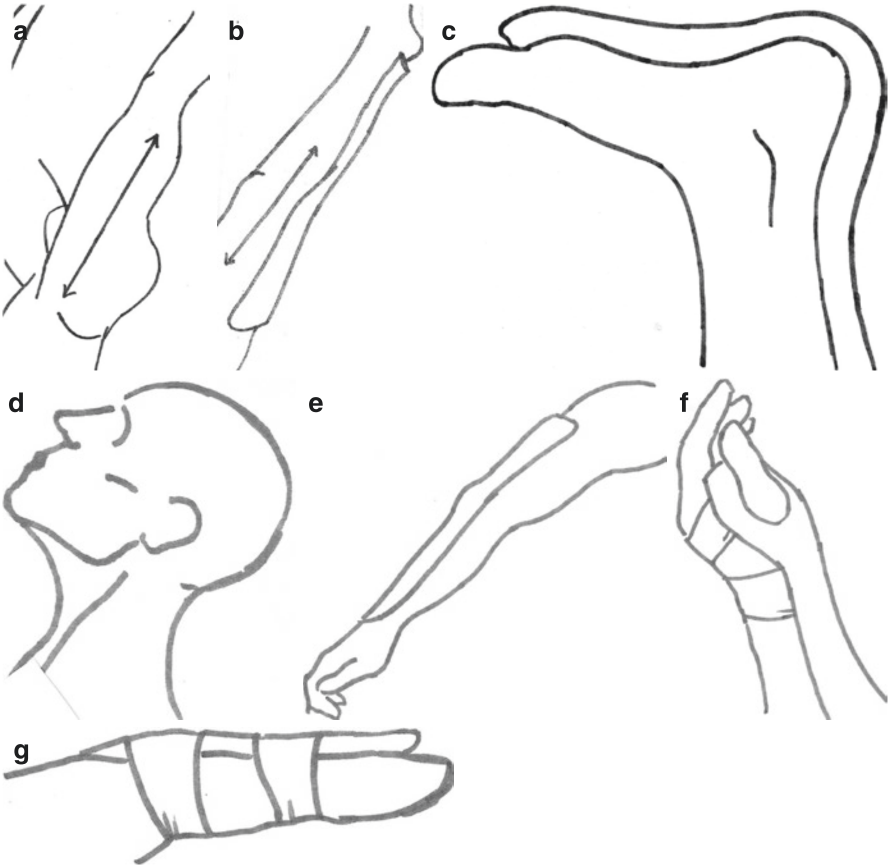


Fig. 21.12 Positions of protection for splinting. All sketches courtesy of Dr. Daniel Sutphin. (**a**) Hip extended. (**b**) Knee extended. (**c**) Ankle neutral. (**d**) Neck in extension. (**e**) Elbow extended. (**f**) Wrist in 20–30° extension, MPJ flexed 90°. (**g**) Fingers: PIPJ and DIPJ in extension (Sketches for **a–g** courtesy of Dr. Daniel Sutphin)

non-meshed, sheet grafts on the dorsum of the hand. The grafts should be covered in the following manner: first nonadherent gauze as Vaseline gauze or Xeroform, wet cotton balls or wet gauze, dry gauze, and a splint followed by a crepe or Ace bandage to hold the splint and dressing on. Wet cotton is especially useful to hold the skin graft in crevices. If split-thickness skin grafts are used, the dressing can be removed after 5 days. If a sheet graft is used, the wound should be inspected at 2–3 days for any bleeding or infection. Once the graft has taken, early motion can be carried out, but nighttime splinting may still be necessary for several weeks. (Warning: Many hospitals make their own Vaseline/petroleum jelly gauze and sterilize it in basins. This gauze is often used on several patients

Fig. 21.13 Marjolin's ulcers or squamous cell carcinomas: (**a**) because prosthesis was not available and there was no caretaker, debridement and local care was used without an amputation in order to give patient a better quality of life. An amputation would likely leave the patient bedridden with early death. (**b**) Is a rare superficial Marjolin's ulcer. In (**c**) is a Marjolin's ulcer with metastasis in a 14-year-old girl who had a burn at age 2. Six months before she had a small 1 cm wound

by removing the gauze with sterile forceps. Even with every attempt to keep the remaining Vaseline gauze sterile, inevitably it becomes infected and there is cross contamination. The author has found that sterilizing the basin of Vaseline gauze between each patient use is best. It is also important to thin out and remove excess Vaseline if it is real thick on the gauze.) Tangential excision of burns is always followed by skin grafting.

The advantage of early excision and grafting is early coverage of the burn wound, decreased incidence of infection, and early initiation of range of motion exercises. Disadvantages are blood loss and an additional area of "burned" body surface area. Excisions may be carried out every 3–5 days if the patient is stable, ample blood is available, and there is good anesthesia coverage.

Burned wounds that are not grafted and remain unhealed for years may progress to Marjolin's ulcer or squamous cell carcinoma. This is the same for all chronic wounds, no matter the etiology. Therefore, there should be an urgency to close all wounds when first seen, acute or chronic (Fig. 21.13a–c).

Burn Contractures

The Essentials

- *Most burn contractures can be prevented by adequate splinting and early grafting.*
- *The joints should be splinted in position of protection.*
- *Contracture releases should be delayed 6–12 months until the wounds are mature.*
- *If a skin graft is used for reconstruction, splinting is necessary for several months postop.*
- *If flaps are used, splinting is necessary only until wounds are healed.*

Burn contractures are the result of poorly treated and inadequately splinted burn wounds. Burn wounds over joints must be splinted in the position of protection or safe position until they are well healed (Fig. 21.12). Burns over joints that are not splinted will often flex into a position of comfort. This reduces the patient's pain, but contractures will develop as the burn heals by secondary intention. These contractures will be disabling. A scar near a joint in children will not grow as the child grows, and a contracture will result and progress as the child grows (Fig. 21.14a, b).

Contractures are best prevented. This requires physician ownership to maintain the patient in the splint and also patient compliance. An occupational or physical therapist can be very helpful. These splints should be used before and after grafting.

Treatment of contractures should be delayed until wounds are healed and mature, usually 6 months to a year. If a wound contracture continues to break down with constant use, then earlier correction of contracture should be carried out. Contractures can be reconstructed with skin grafts or flaps. If a skin graft is used for reconstruction after a contracture has been released, then the joint must be splinted continuously for several months and at night for several additional months (Fig. 21.14a, b). If a flap is used, a splint is not necessary after the wounds have healed (Fig. 21.15a–c).

Ideally, flaps are used for reconstruction. Minor contractures may be treated with Z-plasties, Y-V advancement flaps, and rotation flaps. Z-plasties should only be used when there is good skin on both sides of a tight weblike contracture that is less than 60°. Burned skin adjacent to contractures is not supple and does not advance even with undermining. Y->V advancement flaps should only be used when there is good skin on one side of the contracture and less than 60° contracture. It is ideal for the axilla and elbow but not for the popliteal fossa where the skin is not mobile. A saphenous fasciocutaneous pedicle flap is best for the popliteal fossa (Fig. 21.16a, b).

Contractures are released by gentle pushing down with the scalpel at the midpoint of contracture or at its tightest point. The joint is extended as one is pushing down,

Fig. 21.14 (**a, b**) Burn contracture of the neck in a young man. The contracture was released years later. A thick STSG was applied and he was placed in a neck collar continuously for 6 months. This was followed by nighttime use of collar for several years. Silastic sheeting was available and used under collar at night. Contracture release was a one-stage procedure

not cutting, with the scalpel. At any joint, the release must extend from mid-axis to mid-axis or from the mid-lateral line on each side. With gentle pushing vital structures such as nerves and vessels will not be damaged. Rarely, the joint capsule may require releasing. Once the contracture is released, bleeding is controlled and then the released joint is reconstructed. The best reconstruction for a large contracture is a flap. A full-thickness skin graft is used if a flap is not available as for the fingers. The next best is an unmeshed split-thickness graft, called a sheet graft, but re-contracture is common unless the joint is splinted in extension for several months. When full-thickness skin grafts are used for the fingers, K-wires are used to hold finger joints extended, while the graft heals in 2–3 weeks. In small children, #21 hypodermic needles may be used in place of K-wires especially if there is a limited supply of K-wires. When grafted joints heal, early range of motion is carried out during the day, but the joint should be re-splinted at night for several more weeks. If a flap is used, splinting will not be necessary. (Often, a flap will not cover the entire released area. The flap is placed directly over the joint and grafts are used above and below the flap. A splint is used until the grafts have healed.)

Fig. 21.15 (**a–d**) Severe left axillary contracture and moderate contracture in the right axilla (**a, c**). Left reconstructed *with* parascapular flap with lateral half of latissimus dorsi included in flap (**b**). The right axilla was reconstructed with Y->V flap. Postop (**d**)

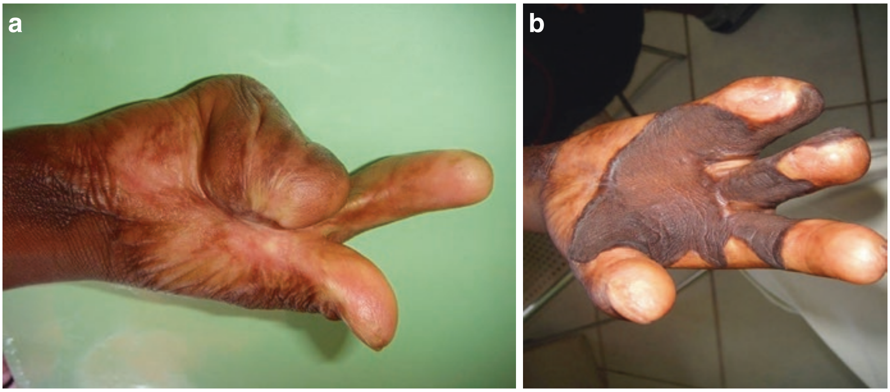


Fig. 21.16 (**a, b**) In some areas skin grafts must be used as in contractures of the finger joints, MPJ, PIPJ, and DIPJ. Full-thickness grafts (*FTSGs*) are best for the fingers as they are more durable and pliable than STSG. In dark-skinned individuals, the palmar skin is *white*, but FTSG grafts always remain dark—something that should be mentioned in preop discussions with the patient and family

Hypertrophic Scars and Keloids

The Essentials

- *Occur in dark-skinned individuals. Infection and tension on wound edges are primary causes.*
- *Hypertropic scars are self-limited and remain within the wound.*
- *Keloids grow beyond the border of the wound and do not regress.*
- *Keloids on chest and shoulders do not respond to treatment.*
- *If excised, recurrence is frequent and the recurrent keloid is larger.*
- *Low-dose irradiation is the most promising treatment for keloids.*
- *Triamcinolone may help in small keloids.*

Hypertrophic scars are self-limited and raised and remain within the border of the wound. Hypertrophic scars occur in persons of any age and at any wound site, either surgically created or by a traumatic injury. They tend to regress in size over time and are more responsive to treatment than keloids (Fig. 21.17).

On the other hand, keloids are identified by the continued excessive growth of the scar beyond the border of the actual wound. These can be extremely disfiguring. Keloids are less common than hypertrophic scars but have a genetic component that primarily affects African and Asian populations or dark-skinned individuals. Keloids usually occur after damage to the skin from an injury, infection, or from surgery. Often the patient cannot remember an injury. They do not naturally regress in size but may continue to enlarge over time. They occur in wounds where there is tension as on the chest wall or infection. Any surgery around the shoulder is prone to keloid

Fig. 21.17 Infected beard with keloids

formation. Keloids on the face, neck, arms, and chest are most troublesome; earlobe keloids are common after piercing of the ears for earrings. Any infected or slow to heal wound is prone to keloid formation as in infected beard wound (Fig. 21.17).

Ideally, the best treatment for keloids is prevention after a wound or surgery. Keloids are commonly seen across the chest or shoulder regions, and these should never be treated surgically as they often return larger than before. Early treatment for hypertrophic scars or keloid-prone wounds is the injection of 10–40 mg of triamcinolone with repeat injections every month for 3–4 months. Care must be taken that this steroid is not injected into soft tissue with resulting depigmentation and fat necrosis. Pressure is another modality that can be used for hypertrophic scars or early keloids. Earrings are available to give pressure on a small ear keloid before or after surgery. (Search "pressure earrings.") Another treatment method is intra-keloidal excision where a rim of 3–4 mm is left around the edge of the keloid. This treatment is different from complete keloidal excision as it does not stimulate new keloid formation with a new wound. The resulting defect can be closed with sutures through the rim that is left, or a skin graft can be used, also with sutures in the rim. This method does leave a scar though much smaller than the original keloid. The most promising method is low-dose irradiation immediately after excision of the keloid. This works especially well with ear keloids. An appointment is made at a local irradiation facility. After complete excision, the patient goes directly for irradiation with usually one or two treatments. This treatment requires that such an irradiation center is locally available. Many other methods have been tried but none have yet been proven.

When keloids have been caused by infection, the area may be excised with antibiotic coverage and the wound carefully closed directly *without tension* or with a skin graft or flap (Fig. 21.18a–d).

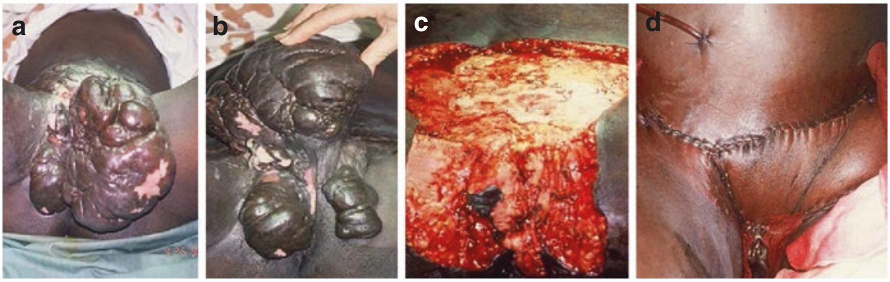


Fig. 21.18 (**a–d**) Large perineal keloids were likely secondary to infection. Excision and reconstruction with mobilization of local flaps, an abdominoplasty-like flap and a thigh flap (TFL flap)

Injuries of the Hand

The Essentials

- *Knowledge of hand anatomy and relationships is important.*
- *Hand wounds can be washed out and loosely closed until someone is available to repair tendons, nerves, and bones—Clean Closed Wound Concept.*
- *In general, hand fractures should not be opened without skilled therapists available.*

Hand injuries will not be discussed in detail in this chapter, but a few important points will be made.

Knowledge of hand anatomy and relationships is very important for anyone treating upper extremity injuries. A book on hand anatomy is essential in every operating theater.

Repair of hand injuries can be delayed if the wounds are debrided and irrigated well and closed loosely with sutures 1 cm apart—the Clean Closed Wound Concept. Nerves and tendons should be labeled with different color sutures for later identification. The wound can be reopened several days to weeks later and important structures repaired by someone with hand surgery knowledge and experience.

A neurological and musculotendinous exam of the hand should be done on initial presentation:

Radial nerve

- Motor–loss of extension of the index finger while other fingers are flexed
- Sensory–loss of sensation dorsal side of first web space

Median nerve

- Motor–unable to snap thumb and long finger together
- Sensory–loss of sensation on volar side of distal phalanx of index finger

Ulnar nerve

- Motor–unable to spread fingers apart
- Sensory–loss of sensation on volar side of distal phalanx of small finger

Hand injuries should be closed loosely in one layer to allow for swelling, and all hand injuries should be splinted and well elevated.

When flexor tendons are repaired, Ethibond or silk should be used as core sutures using the Bunnell or modified Kessler technique. Prolene or nylon may be used for extensor tendons, but one can also use Ethibond or silk. A running circumferential epitendinous suture should also be used to smooth the surface for better excursion. If two flexor tendons are injured, only one should be repaired to give more room for excursion.

Fractures should not be opened in the LRS. If a C-arm is not available to reduce and pin fractures, then the fracture should be splinted and early range of motion carried out. If open surgery is performed, a stiff hand will most likely be the result.

If dislocations cannot be reduced closed, they may be opened. For the common metacarpophalangeal joint (MPJ) dislocations involving the thumb, index, or small finger, the obvious dorsally angulated dislocation is usually easy to reduce. The bayonet-shaped dislocation often requires open reduction.

Soft Tissue Infections of the Hand and Extremities

The Essentials

- *Hand infections must be treated promptly to prevent loss of a finger or limb.*
- *Consequences of an infection often limit one's ability to work.*
- *Felon and tenosynovitis are closed-space infections like an abscess and must be treated urgently.*
- *Necrotizing fasciitis requires wide and repeated debridements.*

Soft tissue infections of the hand and extremities in the LRS often leave a patient incapacitated and unable to use their hands for work. Many hand infections occur in arid areas where there are many thorns. Other hand infections occur at work and especially in those who farm. Patients often report late for care. These must be treated urgently to prevent loss of the limb. Most are caused by *Staphylococcus*, but gram-negative and anaerobic infections are common especially from farm injuries and road traffic accidents.

Felon

Felons are frequently seen in areas where thorns are common. Felons are usually caused by puncture wounds resulting in a closed-space infection in the pulp of the distal phalanx. Where therapy is delayed, osteomyelitis and tenosynovitis are common complications (Fig. 21.19a–g).

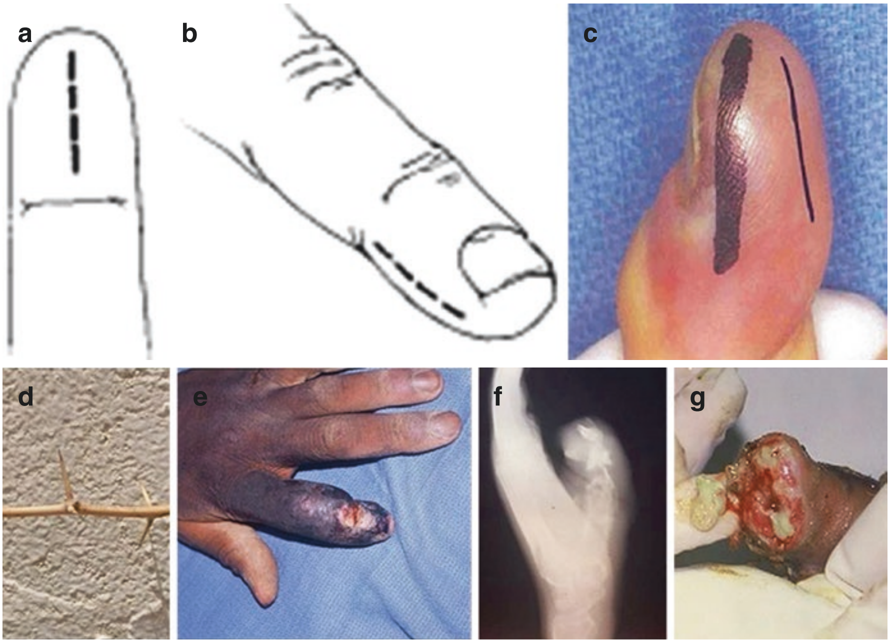


Fig. 21.19 (**a–g**) Felons are frequently seen in areas where thorns are common. Where therapy is delayed, osteomyelitis and tenosynovitis are common complications. A felon is a closed soft tissue infection of the distal phalanx pulp. Complications include osteomyelitis and tenosynovitis. This is best treated by longitudinal incision through the pulp (**a**). A "fish mouth" incision is commonly mentioned in textbooks but not recommended (**b** and **c**). Panel **e**–**g** show osteomyelitis as a complication of felons. Full-thickness grafts (*FTSGs*) are best for the fingers as they are more durable and pliable than STSG. In dark-skinned individuals, the palmar skin is white, and FTSG grafts always remain dark—something that should be mentioned in preop discussions with the patient and family

Tenosynovitis

Tenosynovitis is a closed-space infection in the tendon sheath in "no man's land" or between MPJ (A-1 pulley) and DIPJ (Fig. 21.20a, b). The etiology may be from a felon or from a penetrating injury directly into the tendon sheath. There is no route of escape for the infection in this closed space. It may rupture into the deep palmar spaces. The findings are Kanavel's four classic signs: swelling, flexed posture, tenderness along tendon sheath, and the distinctive symptom of severe pain on extension of the finger or thumb.

The treatment is opening the tendon sheath at the MPJ area (distal palmar crease) and also at the DIPJ level. Once small incisions have been made in the tendon sheath proximally in the palm and distally, the sheath is irrigated in both directions using an IV cannula inserted into the tendon sheath. This irrigation should be repeated daily and IV antibiotics given.

If the patient presents late, the final result will be a stiff nonfunctioning finger (Fig. 21.20b). When one has a nonfunctioning finger, the entire hand will not

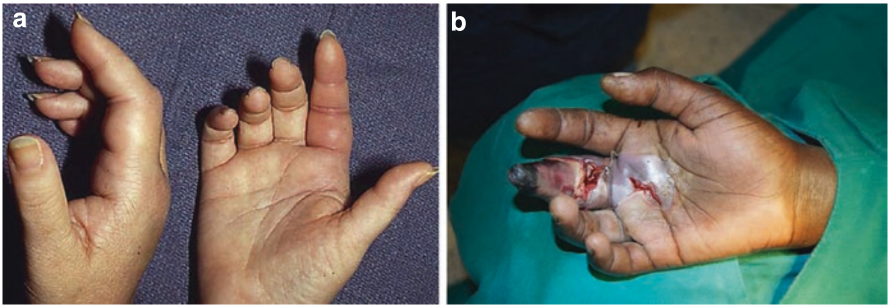


Fig. 21.20 (**a, b**) Tenosynovitis. This patient had Kanavel's four classic signs: swelling, flexed posture, tenderness along flexor tendon sheath, and severe pain when the index finger extended

Fig. 21.21 Necrotizing fasciitis

function properly. In this case, an early ray amputation is the best treatment and will allow the other fingers to function normally and will give the patient a functioning hand. Often the patient and family will not agree to an amputation at first. Once it is obvious that the patient cannot make a fist with the other fingers, they may consent to the amputation, often too late for the patient to regain good hand function.

Necrotizing fasciitis is a polymicrobial infection with aerobic and anaerobic bacteria that spreads quickly just beneath the superficial fascia layer (as under Scarpa's fascia in the abdomen). Whenever this is suspected, the patient should be evaluated for any immune deficiency disease as diabetes or AIDS. This infection will quickly lead to a foul-smelling brownish discharge, generalized sepsis, and death. Debridement must be immediate and thorough and repeated every other day until one is sure the infection is not spreading. Most often the overlying skin cannot be saved, and a large skin graft will be required if the patient survives (Fig. 21.21).

Neoplasms

A number of neoplasms and neoplastic-like conditions are seen in LRS, especially in Africa, that need surgical reconstruction after extirpation. Examples include Burkitt's lymphosarcoma, acral lentiginous melanoma, ameloblastoma, neurofibromatosis, nasal encephalocele, and noma. Elaboration on the management of these tumors is beyond the scope of this chapter but is addressed in detailed in the PAACS Principles of Reconstructive Surgery, a free e-book obtained through PAACS.

Other conditions in the LRS should be cared for by other subspecialists, but often the reconstructive surgeon is called in to help. This includes conditions such as maxillofacial injuries and fractures, vesicovaginal fistula and urethral strictures.

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