Rebecca A. Fisher
Kamran Ahmed
Prokar Dasgupta
Editors

Introduction to Surgery for Students

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Foreword

I would like to congratulate the authors of this remarkable book for their initiative in spotting the niche that it occupies. The contents serve two key purposes. The first is to maximise the benefit that medical students derive from surgical placements. All too often time is wasted feeling bewildered and in trying to understand how the system works. Access to a guide such as this should prove invaluable in providing orientation and a scaffold of basic knowledge that will allow students to focus on learning from their placements. The second is to inform postgraduate trainees considering surgery as their choice of specialty. It is so crucial that trainees make the most informed choice possible, rather than stumbling into a specialist area almost by accident. The contents of this book provide a rich mine of information that will assist trainees in navigating through the complex choices that they need to make.

At a personal level, while I was attracted to surgery, I did not have access to all the facts that would have allowed me to make a fully informed decision. My surgical skills had to wait until my PhD research when I learnt to transplant kidneys, in rodents! If I had been given a copy of this excellent book, who knows what career choice I might have made!

King's College London, London, UK
King's Health Partners Academic
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Robert Lechler

Introduction

This book was borne out of a passion for surgery amongst medical students at King's College London sitting the Surgical Sciences intercalated BSc course. Although there is a wealth of books covering surgical topics, we felt that for a medical student with an interest in surgery there was no go-to book to consult that we could be confident was aimed at the right level, and that would cover the basics we need to appreciate what is going on in clinical practice. This was especially clear when approaching placements in theatre, as in our experience most medical schools teach surgical skills in a patchy way, with students arriving in theatre expected to already know how to scrub and how to behave in a sterile environment. From this, we decided that students needed a one-stop resource for surgery that will help them learn the basics of their surgical placements, whilst nurturing an interest in surgery and helping interested students to move into a surgical career.

Although time in theatre will always appeal to those keen for a career in surgery, most students feel like their days spent there are not productive, and their time can be better spent elsewhere. We hope to increase your productivity by helping you understand what's going on in the procedure, with each specialty providing a brief step-by-step guide to what happens in some of their most common operations. We hope that having our guide with you whilst on a surgical rotation will help you orientate yourself, and arm you with the knowledge to make the most out of your placement.

This book has been written by a team of 73 students, trainees and consultants who have worked together to provide information that is crucial for undergraduate medical exams and reflects current practice in the UK. We hope that students being involved in writing means the content will be the perfect companion to your medical studies and for building the foundations of your future surgical career.

Edinburgh, UK — Rebecca A. Fisher, BSc(Hons)
London, UK — Kamran Ahmed

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1 The History of Surgery

Lydia L. Thurston

Introduction

> "It has been said that there are only two periods in the history of surgery – before Lister and after Lister"
>
> Harvey Graham (1939-)

Surgery has come a long way since the days of Hippocrates when operations were often deemed to be the last resort, and doctors preferred to practice conservative measures before reaching for the knife. The past 2000 years have seen huge paradigm shifts in the theories of science and medicine, and surgery was by no means separated from this. Without the advent of germ theory, the discovery of both asepsis and antibiotics, and the development of anaesthesia, surgery as we know it today would simply not exist. However, surgery did not only have these scientific barriers to deal with, but it also had to overcome millennia of negative publicity surrounding the profession.

Despite these hurdles, the practice of surgery can be traced back as far as pre-historic times, before the advent of written historical records. Indeed, excavations of Ancient Egyptian burial sites have revealed splints made of bark which were used to immobilise a fractured forearm, and ancient tomb paintings reveal the practice of circumcision [3]. The pictures of a variety of surgical instruments inscribed onto the tomb of Kom Ombo, suggest that the repertoire of the Ancient Egyptian surgeon spanned beyond just those two procedures [2] (Fig. 1.1).

The origin of the word surgery comes from the Latin *'chirurgia'*, which in turn comes from the Greek *'cheir-'* and *'ergon'*, literally meaning 'hand' and 'work'. The name itself sets the precedent for the general opinion of the speciality from Antiquity until the eighteenth century. Surgery was thought to be 'handiwork', suitable for craftsmen who might be just as deft at lithotomy as they were at carpentry. The profession had a massive fight on its hands to become recognised as a true partner to medicine.

Ayurveda

> "The patient who has been fed, does not faint, and he who is rendered intoxicated, does not feel the pain of the operation"
>
> Suśruta (c.600 BC)

In Ancient India, around 1500 BC, brotherhoods of priests existed who preached the Sanskrit philosophy of *Veda* ("knowledge"). Vedic writings reveal macro-religious ideas about health and medicine and the worship of individual deities to prevent certain diseases. As well as herbs being used as remedies for illness, some forms of surgery are recorded, such as urinary

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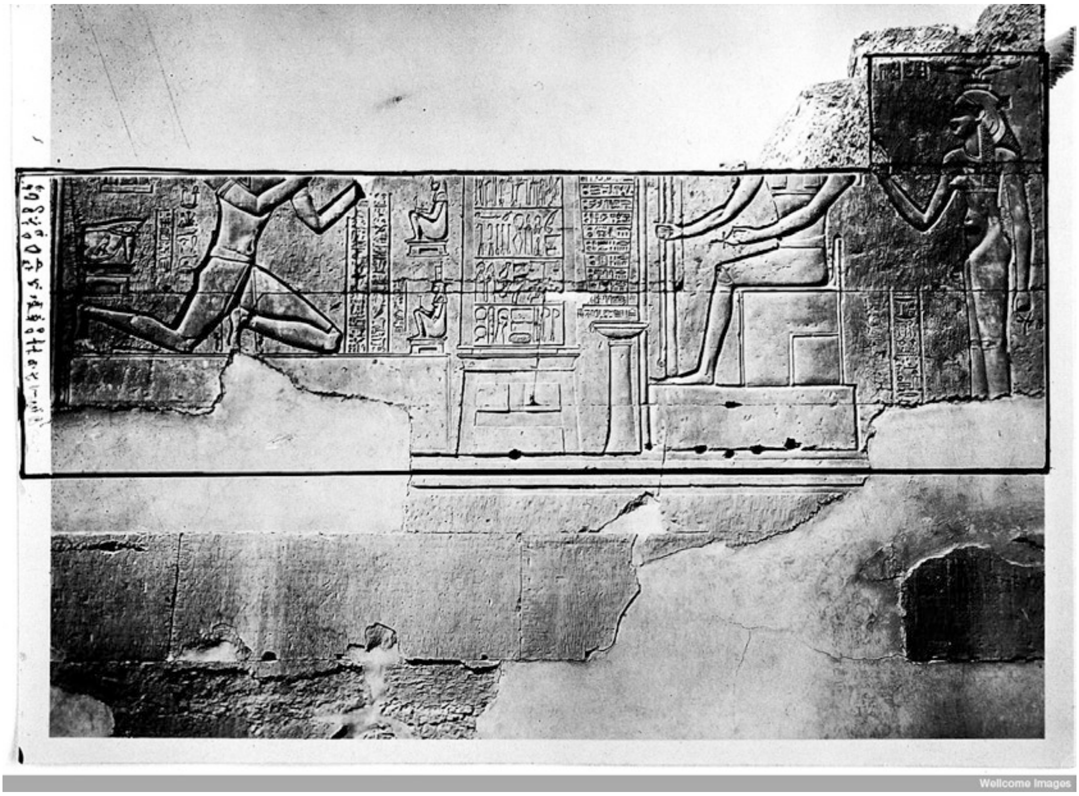

Fig. 1.1 Egyptian surgical instruments – on a bas-relief in the "Birth House" at Kom Ombos, Egypt, B.C. 146 (Wellcome Library, London. Wellcome Images)

catheterisation with reeds to relieve urinary retention, and the cauterisation of wounds to stem bleeding.

Ayurvedic medicine was established hundreds of years later, not long after the birth of Christ. The first and most defining texts of Ayurvedic medicine are the *Caraka Samhita* and the *Suśrutasaṃhitā*. The latter is attributed to Suśruta, a physician who taught surgery and advocated the use of dead animals and vegetables for practising various procedures. In reality, the text has been revised many times, and is unlikely to be written by Suśruta's own hand but is thought to be based on his oral teaching (Fig. 1.2). Surgical procedures discussed in his text include cataract couching and forehead rhinoplasty, whereby he remodels the nose of a patient using skin from their forehead. Over one hundred surgical instruments are described in the *Suśruta*, including details about their manufacture, but unfortunately none of these ancient instruments have survived. One theory is that surgery was given up by caste Brahmins and delegated to other artisan surgeons who continued to practise well into the mid-twentieth century [8].

The Classical Period

> "He who wishes to be a surgeon should go to war"
> Hippocrates (460–371 BC)

Legend has it that Hippocrates (460–371 BC) was born on the island of Cos and was a true descendent of Asclepius, the Greek God of Medicine. As well as being revered as the 'father of modern medicine', Hippocrates' name is also attributed to the Hippocratic Corpus; a body of around sixty medical manuscripts that were actually drawn together around 250 BC, long

Fig. 1.2 Portrait of Suśruta by H. Solomon (Wellcome Library, London. Wellcome Images)

after Hippocrates' death. How much of the Corpus was actually written by Hippocrates himself is a subject for debate, but nevertheless it formed the foundations of medical knowledge for the next thousand or so years. The Corpus contains some advice on the management of surgical conditions, in particular head injuries, wounds, fractures, bladder stones and gangrenous limbs. However, it mostly advocated conservative medical treatment over 'dangerous' surgical intervention. For example, catheterisation was opted for over lithotomy for bladder stones, and amputation was only performed as a last resort. In fact, the Hippocratic Oath itself seems to forbid the practice of cutting by physicians: "I will not cut, and certainly not those suffering from stone, but I will cede this to men who are practitioners of this activity". However, there has been much discussion about whether this denotes surgery as a whole, or is an early concept of surgical specialism [4].

Hippocratic medical theory was based on *vis medicatrix naturae* ("the healing power of nature") and the balance of the four 'humours', namely phlegm, blood, bile and black bile. The equal distribution of these bodily fluids in the human microcosm was deemed essential for health. Illness struck when there was an imbalance, therefore treatment was focused on maintaining an equilibrium [1].

Fig. 1.3 Line engraving of Galen (Wellcome Library, London. Wellcome Images)

A few hundred years later in Ancient Rome, Celsus (25 BC–AD 50) wrote *Artes,* essentially an encyclopaedia of medical and surgical theories. His work is divided into eight books, the last two of which discuss surgical conditions and their treatment. Celsus is the author of the terms *calor, dolor, rubor* and *tumor*, which every doctor is familiar with today as the cardinal signs of inflammation.

Perhaps the most famous physician of the Roman period was Galen (AD 129–c. 216). Born in Pergammon, Galen (Fig. 1.3) conducted his medical studies in Alexandria, before returning to his home city, where he became an expert in trauma surgery by working as a surgeon to the gladiators. He arrived in Rome in AD 162 where he truly made his name. Galen was an avid dissector, and his works formed the basis of anatomical knowledge until the Renaissance period. He wrote almost 350 separate works, all of which were based on Hippocratic medicine and Humoral theory. Surgical reflections are spread throughout some of these, including a description of the removal of nasal polyps [3].

The Medieval Period

> "It is impossible to be a good surgeon if one is not familiar with the foundations and general rules of medicine [and] it is impossible for anyone to be a good physician who is absolutely ignorant of the art of surgery"
>
> Henri de Mondeville (1260–1320)

It would be wrong to discuss medicine in the medieval period without mentioning the developments in medicine and surgery that were taking place in the Middle East. At the time, the Arab World had found itself under a variety of ethnic influences, especially from the Byzantine Empire and the persecuted Syriac-speaking Christians. These groups passed on the principles of medical knowledge, which had mostly been acquired from the teachings of Greek medicine in Alexandria. In the ninth century the Greco-Arabic translation movement got underway, and the majority of Greek medical texts were translated into Arabic; forming the foundations of the development of Islamic medicine. Key figures in this development include the famous Avicenna (d. 1037) (Fig. 1.4), whose *Canon of medicine* (a medical encyclopaedia divided into five books) was hugely successful, and was still used as a textbook in European universities up until the eighteenth century; Ibn al-Nafīs (d. 1288), an Arabic philosopher and physician who discovered the pulmonary transit centuries before Realdo Colombo (1516–1559) and William Harvey (1578–1657); and Al-Rāzī (c. 865–925), a physician who lived and worked in Baghdad and wrote a multitude of treaties on medicine and philosophy [7]. Lists of surgical instruments and operations performed can be found in some surviving Byzantine manuscripts, and al-Rāzī discusses surgical procedures in many of his works. However, there is no evidence that the surgery discussed was actually ever carried out [10].

Fig. 1.4 Portrait of Avicenna (Wellcome Library, London. Wellcome Images)

Albucasis (c. 936–1013) was a Muslim physician who practised in Cordoba, and is recognised for his contribution to surgery, in particular his illustrations of surgical instruments used at the time. He specialised in cautery, ‘incisions and perforations’, and bone-setting [6].

Significant surgeons in the ‘Medieval West’ included Henri de Mondeville (1260–1320), Guy de Chauliac (1298–1368) and John of Arderne (1307–1370). Mondeville was born in Normandy and studied in Bologna, before moving back to France. He was a military surgeon to the French royal family and lectured extensively on surgery. He developed a new technique for wound healing; simple bathing of the wound, immediate closure and dry dressings, thus promoting dry healing without suppuration, which had been advocated by Hippocrates. Chauliac wrote the *Chirugia Magna*, an extensive reference in which he tried to portray surgery as a learned art. John of Arderne was an English surgeon who developed a treatment for anal fistulas, performed by placing the patient in the lithotomy position.

In Northern Europe in particular, there remained a wide gulf between surgeons and physicians, and the teaching of surgery was mainly organised on a guild basis. In Paris, a surgeons’ organisation was established at the College of St Cosme (1210), with practical training and the opportunity to gain a degree and licence to practise. The Fellowship of Surgeons was founded in London in 1368, and a Company of Barbers in 1376. It wasn’t until 1540 that this Company joined with the Guild of Surgeons, forming the Barber-Surgeons Company, which was chartered by Henry VIII (Fig. 1.5).

The Renaissance Period

> “A chirurgien should have three diverse properties in his person… that is to say, a heart as the heart of a lion, his eye like the eyes of a hawk, and his hands as the hands of a woman”
>
> John Halle (1529–1568)

The Renaissance period involved the cultural rebirth of classical ideas and theories, across all academic fields. It was the age of philosophical revival and the celebration of classical works. This resulted in the mass re-translation of original Greek and Latin texts, aided by the recent invention of the printing press (1450) and spurred by the fear that several medical mistranslations had occurred throughout the ages. The resurgence of the classics also spread to the world of art, which celebrated the form of the human body, and sparked interest in anatomy. Galen’s *de anatomicus administrandis* (“On the handling of anatomical matter”) was discovered anew in 1531, and contained a step-by-step guide on how

Fig. 1.5 King Henry VIII granting a Royal charter to the Barber-Surgeons Company. Wood engraving by H.D. Linton after H. Holbein (Wellcome Library, London. Wellcome Images)

to carry out a dissection. The true father of anatomy in the renaissance however, was Vesalius (1514–1564) (Fig. 1.6). Vesalius was an avid dissector, and believed that true anatomy could only be learnt from cadavers. Although he was a supporter of Galen, he soon discovered through his dissections that there was some discrepancy between the anatomy before him on the table, and that described by Galen. It came to light that Galen had actually carried out all of his dissection on animals, and therefore physicians and surgeons had been learning erroneous anatomy for centuries. This was a momentous event in the history of anatomy and led to the creation of Vesalius' masterpiece *De humani corporis fabrica.* The development of anatomy was essential for the progression of surgery as a specialty, as although it was taught by physicians, the dissection itself was often carried out by surgeons. It was also essential for the understanding of physiology, and led in turn to the most recognised discovery of the pulmonary transit by Colombo (excluding of course Ibn al-Nafīs' discovery in the thirteenth century) and to the discovery of circulation by Harvey.

Despite these developments in the foundations of surgery, the specialty itself did not advance much beyond the battlefield. Minor conditions such as fractures, burns, lacerations and increasingly commonly, gunshot wounds, remained a renaissance surgeon's staple diet. Military surgeons were the reigning experts of this era, such as William Clowes (1556–1643), an active member of the Barber-Surgeons Company and a naval surgeon who was appointed to the British fleet in the Spanish Armada; John Woodall (1556–1643) who was the surgeon to the East India Company and author of the naval surgeon's handbook, *The Surgeon's Mate;* and Richard

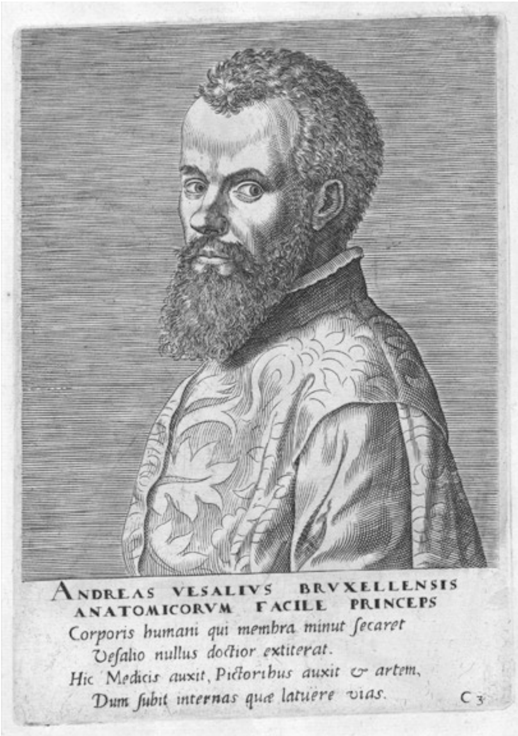

Fig. 1.6 Portrait of Andreas Vesalius 1572 by Phillippe Galle (Wellcome Library, London. Wellcome Images)

Fig. 1.7 Ambroise Paré using the ligature when amputating on the battlefield at the siege of Bramvilliers, 1552. Oil painting by Ernest Board (Wellcome, Library, London. Wellcome Images)

Wiseman (1621–1676), who is known as the 'father of early English surgery'. Wiseman gained his experience in the Civil War and wrote eight treatises on military and naval trauma surgery [8].

Perhaps the most renowned surgeon of this era is the French military surgeon, Ambroise Paré (1510–1590) (Fig. 1.7). Paré started his career at the Hôtel Dieu in Paris, and was later appointed military surgeon in France's campaign against Italy in 1537. During this campaign he made a great discovery on the treatment of gunshot wounds, which had until that point in time been bathed in burning oil. Paré ran out of hot oil, and had to suffice with rose oil, turpentine and egg yolk, which to his great surprise proved to give much better success rates. As well as his work on wound healing, he also introduced the ligature technique to stem bleeding during a limb amputation. Prior to this, hot irons had been used to cauterise the bleeding, and patients had been left with extensive burns, not to forget yet more pain to add to an already agonising procedure (before the advent of anaesthesia). Paré's work became so famous that he was appointed to the service of King Henri II of France, being present as one of his surgeons when the King was fatally wounded in a jousting match in 1559 [5].

Renaissance surgical procedures were mostly simple, routine and principally safe, with wound dressings and blood-letting remaining the most common. There were some attempts at more extreme procedures, such as Gaspare Tagliacozzi's (1545–1599) rhinoplasty technique (Fig. 1.8), which was borrowed from Ayurvedic practice and involved attaching a skin flap from the patient's arm, whilst still attached to their arm, to their nose. The patient had to keep this uncomfortable position for 14 days, until the flap was detached [8].

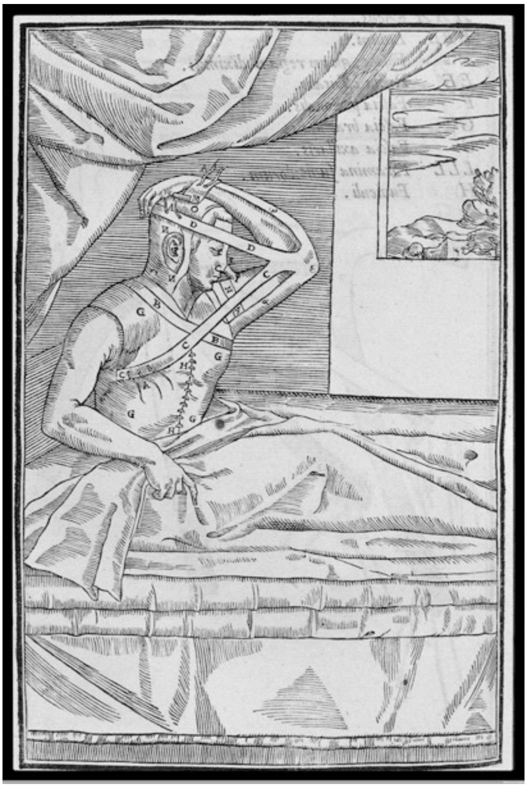

Fig. 1.8 Gaspare Tagliacozzi's rhinoplasty technique 1597 (Wellcome Library, London. Wellcome Images)

The Eighteenth Century

> "I have made many mistakes myself… the best surgeon, like the best general, is he who makes the fewest mistakes"
>
> Astley Paston Cooper (1768–1841)

The eighteenth century covers a period also known as the Age of Enlightenment. The Enlightenment was an era of scientific exploration and discovery, whereby old ideas were challenged, and rationality prevailed. In relation to medicine and surgery, this meant a transition from Hippocrates' age-old humoral theory of medicine to a scientific and observation-based medicine, influenced by the advancement of pathology. This era saw the development of new therapies and treatments such as inoculation and vaccination, as well as the development of new institutions such as hospitals and medical societies as well as the revival of Hippocratic bedside teaching.

There were also some improvements in surgical techniques, such as Jacques de Beaulieu's (1651–1719) lateral cystolithotomy for the treatment of bladder stones, which was quicker and involved less damage to the prostate gland than previous techniques. The method was also adopted by William Cheselden (1688–1752), a London surgeon who worked at St Thomas' Hospital and prided himself on his speed, claiming to be able to remove a bladder stone in under 1 min. Jacques Daviel (1696–1762), a French ophthalmic surgeon, also developed a new technique for cataract removal.

The eighteenth century saw some rise (albeit small) in the standing of surgery, especially in France. The teaching of the subject switched from being apprenticeship-based to being taught in the format of lectures and anatomy demonstrations. In 1724, the College of St Côsme was given permission by King Louis XV to teach surgical courses, which led to the establishment of a surgical school. Perhaps the King's affection for the surgeons had been influenced by his predecessor King Louis XIV, whose anal fistula was successfully operated on by the surgeon C. F. Félix (1650–1703) in 1678. By 1794, medicine and surgery were taught to all French students as a combined subject, thereby putting an end to surgery's venerable struggle for recognition.

Although much of the enlightenment took place in France and Continental Europe, England and Scotland were not far behind. Alexander Munro (1697–1767) was a Scottish surgeon who transformed Edinburgh into a major centre for the teaching of medicine and surgery by the creation of Edinburgh Medical School. Munro was responsible for the training of William Cullen (1710–1790), a naval surgeon who went on to become a Professor of Medicine at Glasgow University and was in turn responsible for the teaching of William Hunter (1718–1783). William Hunter established a successful school of anatomy, first in Covent Garden and then in Piccadilly, where his younger brother, John Hunter (1728–1793) (Fig. 1.9) became a fervent dissector and established himself as the leading surgeon of the eighteenth century. His contribution to the study of anatomy and physiology

Fig. 1.9 John Hunter (1728–1793), surgeon and anatomist. Oil painting after Sir Joshua Reynolds (Wellcome Library, London. Wellcome Images)

helped to increase surgery's professional standing as a scientific discipline. He was also a seasoned, albeit nervous lecturer, teaching the likes of Edward Jenner (1749–1823) who was responsible for the discovery of smallpox vaccination, and Astley Cooper (1768–1841), a surgeon based at Guy's Hospital in London who twice served as President to the Royal College of Surgeons, and was greatly responsible for the passing of the Anatomy Act which allowed legal procurement of cadavers for dissection [8].

The Nineteenth Century

> "If a man came in with a compound fracture, he got erysipelas. It was considered part of hospital life"
>
> George Dock (1860–1951)

The momentous scientific discoveries of the nineteenth century caused a revolution in the world of surgery. This was the age that surgeons had dreamed of for centuries, the age of anaesthesia and antisepsis. The Enlightenment had resulted in the Hospital Movement: the development of large teaching hospitals throughout Europe. These provided the perfect playgrounds for modern surgeons, and operations became shows, open to the public and medical students alike to watch.

Influential surgeons in nineteenth century England included George James Guthrie (1765–1856), a military surgeon who specialised in ophthalmic surgery and the treatment of chest wounds, and who advocated battlefield amputations. In France, there was Dominique Jean Larrey (1766–1842), Napolean's Surgeon General who advocated hypothermia for battlefield amputations, developed the concept of the field hospital, and invented the 'ambulance volante', a horse drawn ambulance used to evacuate casualties from the battlefield (Fig. 1.10). Over the border in Germany, Johan Friedricj Diffenbach (1794–1847), a Professor at the Berlin Charité, developed a technique for cleft palate surgery. Across the pond in America, gynaecological surgery was also developing. Ephraim McDowell (1771–1830) performed the first ever ovariotomy, and James Marion Sims (1813–1883) established a treatment for vesicovaginal fistulas.

Until the nineteenth century, "anaesthesia" was achieved with very limited success using alcohol and opium, and relied on the sheer speed of the surgeon operating: the quicker, the better. In October 1846, William Thomas Green Morton (1819–1868), an American dentist, demonstrated the anaesthetic properties of inhaled ether whilst removing a neck tumour from a patient. The procedure was a success and news of this anaesthetic spread like wildfire, with the London surgeon Robert Liston (1794–1847) successfully amputating a thigh from a patient under the effects of ether, as early as December that same year (Fig. 1.11). Ether was found to be irritating to the lungs, and so when James Simpson (1811–1870) discovered the sleep-inducing effects of chloroform, it was used as a replacement. A key moment in the history of anaesthesia occured when Queen Victoria was given chloroform to help her give birth to Prince Leopold in 1853. The anaesthetic

Fig. 1.10 A model of the 'flying ambulance' invented by Larrey in the 1790s (Wellcome Library, London. Wellcome Images)

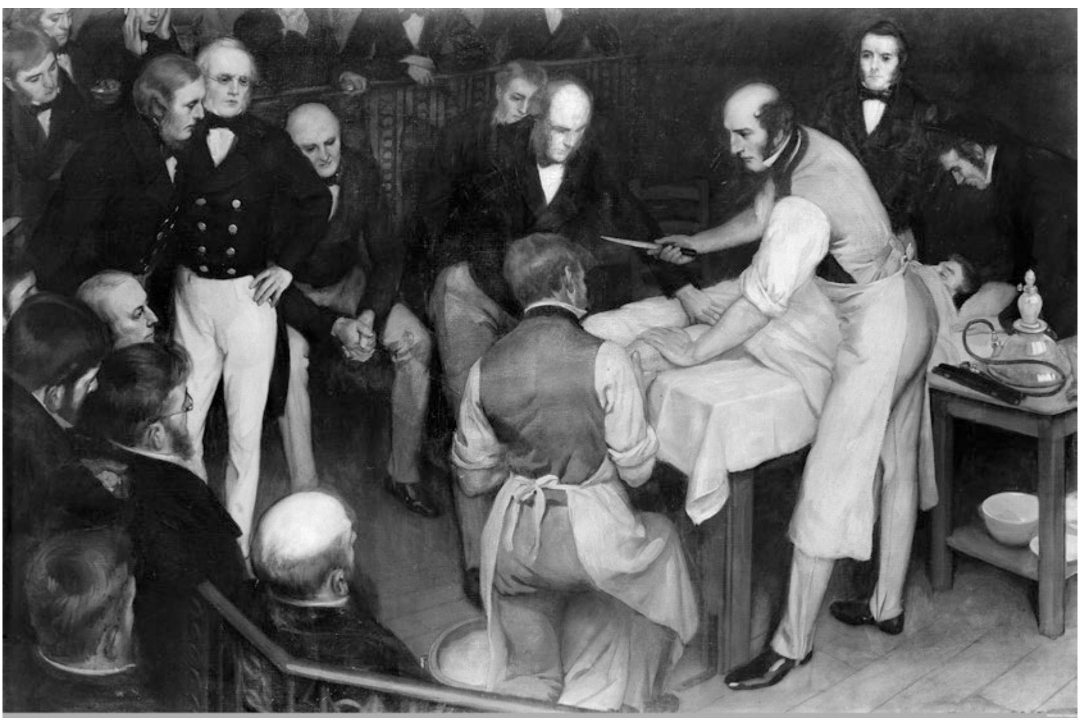

Fig. 1.11 Robert Liston operating, by Ernest Board, circa. 1912 (Wellcome Library, London. Wellcome Images)

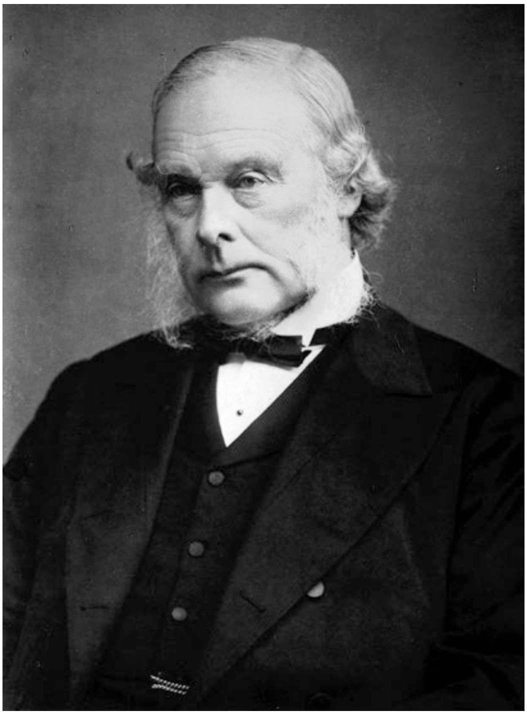

Fig. 1.12 Portrait of The Right Honourable Joseph Lister by Elliot & Fry c.1900 (Wellcome Library, London. Wellcome Images)

was administered by John Snow (1813–1858), and was laced with controversy and public outcry, since women had been giving birth for centuries without the need for pain relief, birth was seen by many Christians as God's punishment for the sin of Eve. The development of local anaesthetic soon followed in 1885, when Carol Koller (1857–1944) succeeded in using cocaine to numb the eye in ophthalmic surgery [11].

Infection was the second major barrier to the development of surgery. At the start of the century, post-operative mortality remained at approximately 40%, largely due to infection. On 16th March 1867, Joseph Lister (1827–1912) published the results of his first antisepsis trial (Fig. 1.12). When Lister dressed eleven cases of compound fractures with his concoction of lint soaked in linseed oil and carbolic acid, none of the patients died. Continuing to use the same technique, Lister found that his death rates post limb amputation dropped significantly from 45.7% without antisepsis, to 15.0% with antisepsis [8].

Lister's antisepsis was initially met with some opposition. His ideas were controversial as they came out before Louis Pasteur (1822–1895) had argued his case for germ theory. Prior to this there had been two schools of thought with regards to infection: miasma theory and contagion theory. The first presumed the existence of 'bad air', caused by rotting vegetation, which in turn led to infection and disease. Contagion theory was the idea that infection and disease could spread from person to person (as in smallpox, or the Black Death), with the concept of spontaneous generation accompanying this theory (the notion that 'animalacules' or tiny disease-causing particles were spontaneously generated by God). Lister was a fan of Pasteur's early work, and believed that there were microbes living in the air that caused sepsis. Pasteur published his germ theory in 1878 in front of the French Academy of Medicine. Germ theory was strengthened by Robert Koch (1844–1910) and his meticulous work on microscopy and bacterial culture. His four postulates still form the basis of microbiology today.

Surgical rubber gloves were introduced in 1889 by the American surgeon William Halsted (1852–1922) to overcome the phenol dermatitis of his scrub nurse, and fiancée, Caroline Hampton. Ernst von Bergmann of Prussia (1836–1907) was the first to use the concept of steam sterilisation for dressings, gowns and instruments in 1886, whilst the Polish surgeon Johannes von Mikulicz (1850–1905) was the first surgeon to wear a surgical mask in 1897. Other attempts at asepsis took a while to catch on, and many surgeons continued to wear their own clothes or old and blood-stained surgical cloaks (Fig. 1.14).

The Twentieth Century and the Evolution of Modern Surgery

The course of surgery probably changed more in the few years after Lister than it had during the previous two millennia. Suddenly a whole new world had opened up to the surgeon. With anaesthesia and a better understanding of postoperative

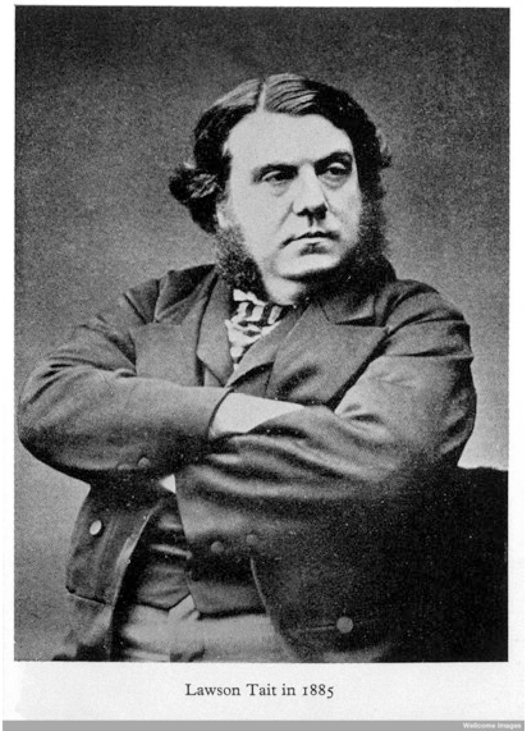

Fig. 1.13 Photographic portrait of Robert Lawson Tait in 1885 (Wellcome Library, London. Wellcome Images)

sepsis, the world was their oyster. Open surgery, which had up until then been unheard of due to high mortality rates, suddenly became plausible. The routine procedures that the specialty had been associated with for hundreds of years took a definite backseat. Procedures that had hitherto been too complex or dangerous to carry out, such as cardiothoracic, abdominal or intracranial surgery, became possible. This was an exciting time for surgery and surgeons found their profile increasing overnight.

Some important figures at the start of this era were:

- The Mayo brothers: William (1861–1939) and Charles (1865–1939). They were famous for William's abdominal and Charles' thyroid surgery. They established the Mayo Clinic in Rochester (Minnesota), carrying out an astounding 23,628 operations in the year 1924.
- Theodor Billroth (1829–1894), a pioneering German surgeon who carried out the first Gastrectomy in 1881 and became known as the founder of modern abdominal surgery. He was also the first to advocate regular postoperative temperature monitoring.
- Robert Lawson Tait (1845–1899) performed the first English appendicectomy in 1880 (Fig. 1.13).
- Carl Langenbuch (1846–1901) was a German surgeon who carried out the first cholecystectomy in 1882, in Berlin.
- E. B. Wolcott (1804–1880) performed the first known nephrectomy to remove a large kidney tumour in 1861.

There are countless names of surgeons who made their mark by being the first to perform new operations. The new profile of surgery developed an attitude that surgery was the answer to any medical problem. This caused a vogue for certain bizarre operations, such as hysterectomies to cure female neuroses.

The progression of surgery was further aided by new diagnostic techniques, such as endoscopy. The first oesophagoscope was introduced by John Bevan, a surgeon at Guy's Hospital, London, in 1868, followed by the first gastroscope that same year. Karl Wilhelm Röntgen's discovery of X-rays in 1896 also opened up a whole new world of exploration for surgeons, and the first barium swallow was carried out in 1904. Ultrasound developed later in the century, followed by Godfrey Hounsfield's invention of computerised axial tomography, or CT scan as we know it today. PETT (positron emission transaxial tomography) and MRI (magnetic resonance imaging) soon followed suit. The ability to look inside the body without reaching for the knife changed the face of diagnostics and allowed surgeons to prepare better for operations.

New diagnostic techniques led to the formation of new surgical specialties, such as thoracic surgery and neurosurgery. Victor Horsley (1857–1916) became the world's first specialist neurosurgeon and worked at Queen's Square Hospital, London (Fig. 1.15). Harvey Cushing (1869–1939) was also a leading neurosurgeon in America, claiming to have successfully removed thousands of brain tumours.

Fig. 1.14 Photograph of Mount Stuart Royal Naval Hospital in Bute. Depicts surgical staff performing an operation without gloves or masks (Wellcome Library, London. Wellcome Images)

Cardiac surgery was another daunting new field which developed quickly. Cardiac catheterisation was first carried out on a patient in 1940 by the American physicians, André Cournand (1895–1959) and Dickinson Richards (1895–1973), although a German medical student named Werner Forssmann (1904–1979) had already successfully inserted a catheter into his own right atrium in 1929. Angioplasty soon followed in 1964, by the Swiss surgeon Andreas Grünzig (1939–1985). Helen Taussig (1898–1986) was an American paediatric cardiologist who made the important discovery that babies who had both Tetralogy of Fallot and a patent ductus arteriosus seemed to be less symptomatic than those who just had Tetralogy of Fallot alone. She deduced that the patent ductus must allow some of the blood to bypass the pulmonary artery stenosis and reach the lungs for oxygenation. She consulted with Alfred Blalock (1899–1964), a cardiothoracic surgeon, who with the help of his research technician, Vivien Thomas (1910–1985), successfully developed a procedure for creating a shunt between the subclavian and pulmonary artery. They performed their first successful operation in 1944 and over the next decade helped to significantly decrease the mortality rate of these 'blue babies'.

The First World War spurred the development of skin transplants as an answer to treating horrific burns and facial injuries. Harold Gillies (1882–1960) being a pioneer in this field, established a plastic surgery unit at Aldershot. The field of transplant surgery developed further with research into immunosuppression and organ rejection. In 1954, the first successful kidney transplant was performed on identical twins by J. Hartwell Harrison and Joseph Murray; and 1967 saw the first ever successful heart transplant by Christian Barnard (1922–2001) in Cape Town, South Africa.

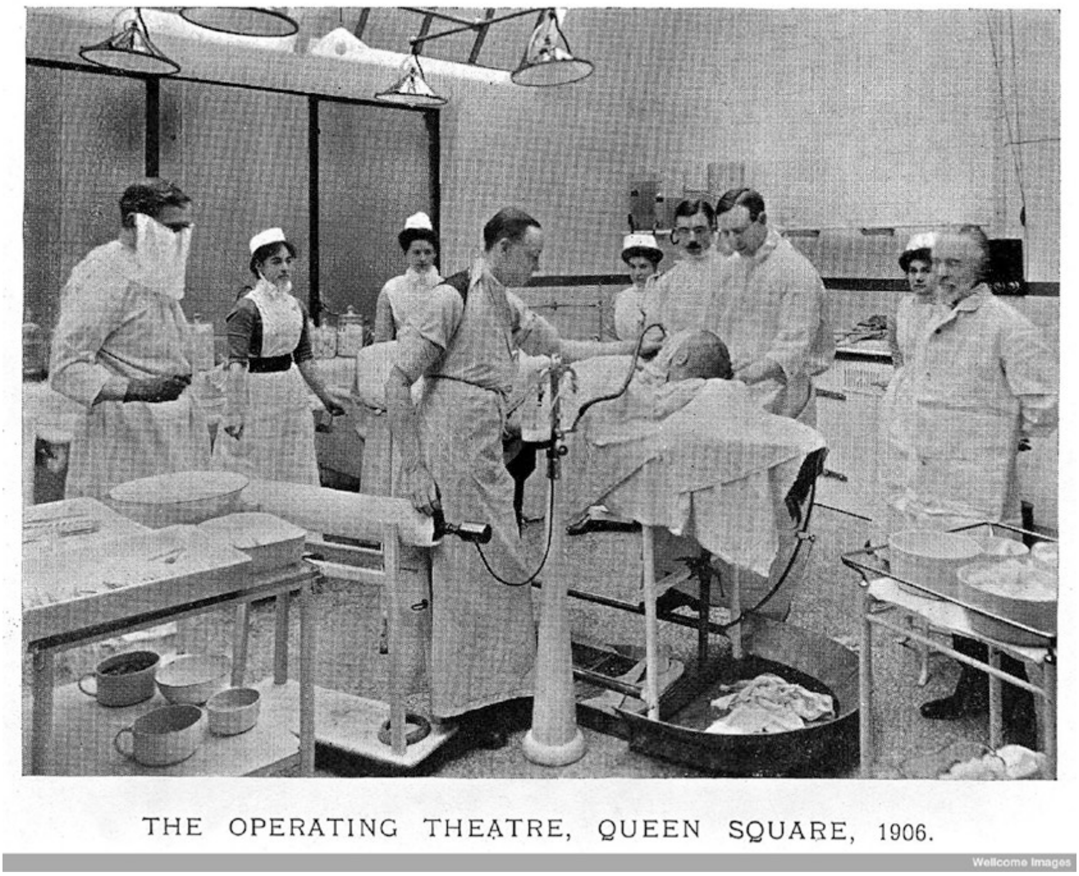

Fig. 1.15 Photograph of Victor Horsley operating at Queen Square, London. 1905 (Wellcome Library, London. Wellcome Images)

Orthopaedic surgery also expanded beyond the days of bone-setting and war wounds. The first total hip replacement in the UK was performed in 1938 by Philip Wiles (1899–1966) at the Middlesex Hospital. Wiles performed six of these operations but his results were lost to follow-up as the Second World War intervened. In the 1950s, Kenneth McKee (1906–1991) was the first to use metal on metal hip replacements, using screw fixation for the cup and a modified Thompson's femoral prosthesis. In the next decade, John Charnley (1911–1982) developed a successful total hip replacement formed of a metal femur with a high-density polyethylene (HDP) acetabulum. Charnley also commandeered the use of bone cement to fixate the prosthesis. Since then further developments in engineering and prosthetic materials, such as higher density plastics and ceramics, have revolutionised the world of orthopaedics and joint replacements [9].

Further Reading

This chapter is intended to be a very brief introduction to the history of surgery. It does not by any means mention every individual who played a role in the development of the specialty, nor does it discuss every event or procedure. The history of surgery is a fascinating and extensive subject in its own right which is well worth investing time in studying further. If you find that this chapter has whet your appetite to find out more, please do refer to the bibliography for further reading.

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2 Anatomy for Surgeons

Ross A. Jones and Jeremy W. Mortimer

Introduction

The aim of this chapter is to focus on those aspects of anatomy that are most commonly encountered by medical students and junior doctors in general and orthopaedic surgery, since these specialties represent the 'bread and butter' of early surgical training.

In a chapter of this length, selection of material is key. In this regard, comprehensive descriptions of regional anatomy have been omitted in favour of an approach that emphasizes key facts and general principles that recur time and again. The reader should refer to the standard texts to 'add flesh to the bones' of the basic descriptions that are given here, and a recommended reading list is included at the end of the chapter.

Anatomical knowledge underpins every stage of the surgical approach, from differential diagnosis to definitive management, and it is not simply limited to the anatomy that is encountered in the operating theatre. To reflect this, the chapter is divided into two parts:

1. **Anatomy for physical diagnosis**
   Anatomy required for clinical diagnosis – history taking and physical examination.
2. **Anatomy for operative surgery**
   Anatomy encountered in common surgical procedures – presented regionally.

Included in the chapter are a series of schematic diagrams illustrating key structures from the regions discussed, including some additional content outside the scope of the accompanying text. Further anatomical details in relation to individual sub-specialties will be covered in the later chapters.

Anatomy for Physical Diagnosis

Analysis of Abdominal Pain

Diagnosis of abdominal pain can only be understood by consideration of the sensory nerve supply of the abdominal wall and viscera (Plate 2.1). Additionally, it is useful to recall the embryological division of the gut into ***foregut*** (supplied by the ***coeliac trunk***), ***midgut*** (***superior mesenteric artery, SMA***) and ***hindgut*** (***inferior mesenteric artery, IMA***).

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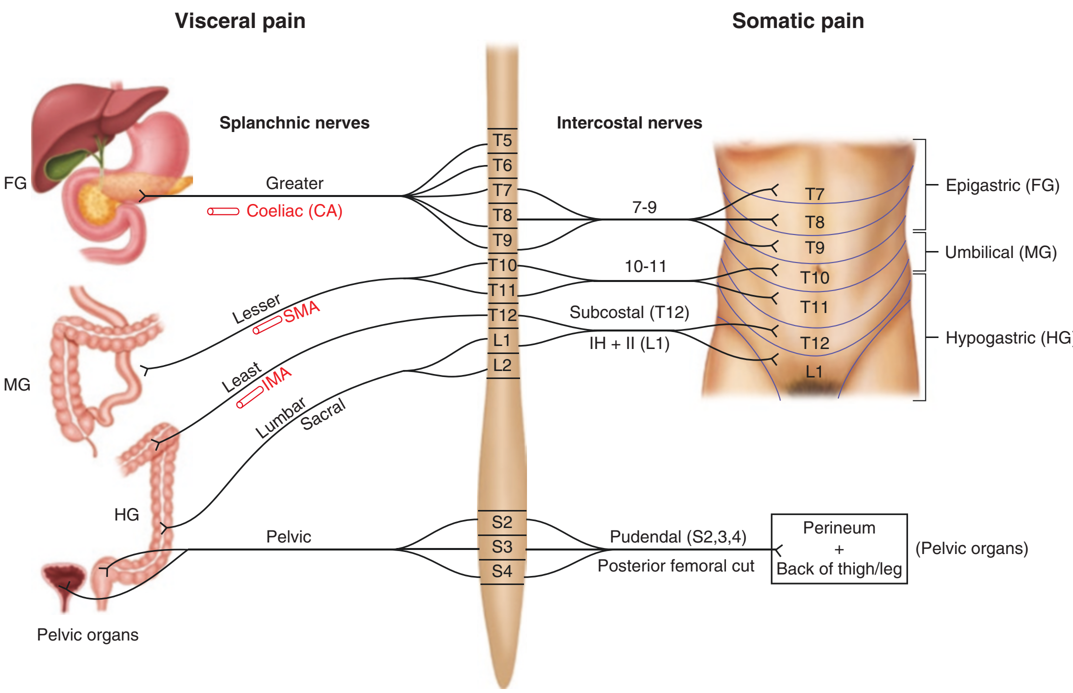

Plate 2.1 Sensory supply of abdominal viscera and body wall.
The figure can be read from *left to right* in order to 'map' a given source of visceral pain to its conscious appreciation on the body wall, or vice versa, as in the usual context of attempting to diagnose the underlying cause of abdominal pain.
Splanchnic nerves (to abdominal viscera) are shown on *left of figure*; somatic nerves (to body wall) on *right*. Spinal cord segments contributing to each nerve (or set of nerves) are shown centrally. In the case of the thoracic (greater, lesser and least), lumbar and sacral splanchnic nerves, the course of the nerve fibres through the sympathetic chain has been omitted for clarity – it is more important to note their levels of origin from the spinal cord.
FG foregut, *MG* midgut, *HG* hindgut, *CA* coeliac axis, *SMA* superior mesenteric artery, *IMA* inferior mesenteric artery, *IH* iliohypogastric nerve, *II* ilioinguinal nerve

Sensory Nerve Supply

Sensation from the abdominal wall (skin externally, parietal peritoneum internally) is conveyed by the ***lower 6 intercostal nerves*** (spinal cord segments T7-12) and the ***iliohypogastric*** and ***ilioinguinal nerves*** (L1).

Sensation from the abdominal organs (covered in visceral peritoneum) is conveyed by ***sympathetic supply*** from the ***3 thoracic splanchnic nerves*** – ***greater*** (T5-9), ***lesser*** (T10-11) and ***least*** (T12) – and the ***lumbar*** and ***sacral splanchnic nerves*** (cord segments, L1-2). Sensory fibres from the foregut and its derivatives travel back alongside branches of the coeliac trunk to the greater splanchnic nerves (T5-9). Those from the midgut (and gonads) travel along branches of the SMA to the lesser splanchnic nerves (T10-11), and those from the hindgut (along with the urinary tract and uterus) along branches of the IMA (or via a retroperitoneal course) to the least, lumbar and sacral splanchnic nerves (T12-L2).

Additionally, sensation from the pelvic organs (rectum and bladder) is also conveyed by the ***parasympathetic supply*** in the ***pelvic splanchnic nerves*** to spinal cord segments S2,3,4.

The spinal cord therefore receives 2 sources of sensory input, ***somatic*** (body wall) and ***visceral*** (organs), which both relay in segments T7-L2. It is this 'sharing' of the spinal cord segments which accounts for the phenomenon of ***referred pain***. For example, visceral pain from a midgut structure (e.g. the appendix), conveyed by the lesser splanchnic nerve (T10-11), is referred to the T10-11 dermatome of the abdominal wall by the corresponding intercostal nerves, and is experienced as pain around the umbilicus. Similarly, foregut pain is experienced in the T7-9 dermatomes (epigastrium) and hindgut pain in the T12-L2 dermatomes (hypogastrium). Additionally, pain from pelvic organs can be referred to the S2,3,4 dermatomes and is experienced as pain in the perineum and back of the leg (and easily misinterpreted as sciatica).

Clinical Correlation

The significance of this anatomical principle is further appreciated when assessing the acute abdomen. It is important to realize that although there are many possible diagnoses in the acute abdomen, there are essentially ***only 2 presentations*** – ***obstruction*** (of a hollow organ) and ***inflammation*** (peritonitis, either local or general).

Obstruction of a hollow organ (intestinal, biliary, renal and uterine tracts) presents as ***colic*** – (spasmodic) visceral pain referred to the corresponding dermatomes of the relevant splanchnic nerves.

Inflammation may be localized to an organ and its visceral peritoneum (a local '-itis' – appendicitis, cholecystitis, etc) or generalized throughout the abdomen, involving both visceral and parietal peritoneum (a general peritonitis – e.g. secondary to a perforated ulcer or tumour). If the inflammation is localized to an organ, (constant) visceral pain will be experienced in the dermatome to which it refers. However, once the inflamed organ makes contact with the overlying parietal peritoneum, (constant) somatic pain will be experienced in the precise location of the overlying intercostal nerve fibres – manifesting as ***peritonism*** on examination.

This principle explains the ***shifting pain of appendicitis*** – early umbilical colic (visceral) secondary to obstruction of the lumen by a faecolith, shifting to late right iliac fossa pain (somatic) secondary to inflammation of the overlying abdominal wall.

If these underlying principles are applied in a logical manner to the analysis of abdominal pain, the initially overwhelming number of possibilities in the acute abdomen will be reduced to a relatively short list of differential diagnoses, each with a clear anatomical basis.

Assessment of the Limbs

When considering history and examination with regard to the limbs, it is essential to recall the basic tissue types and their organization in the region under review. A logical view is to first consider the internal bony skeleton, with focus on the joint, and then the overlying arrangement of soft tissue, with focus on the muscles and neurovasculature. Attributing a likely pathological process to each structure will then provide a comprehensive list of differential diagnoses.

The Joint

The major joints in the limbs are ***synovial*** joints, as distinguished from ***fibrous*** and ***cartilaginous*** joints. They feature a ***joint cavity***, ***articular cartilage*** and a ***joint capsule***, and are usually reinforced by ligaments.

The shape of the articulating surfaces of the two bones comprising the joint, the ***bony congruency***, defines movement and influences stability of the joint. Seven types of synovial joint exist – ***plane, pivot, hinge***, ***saddle***, ***ellipsoid***, ***condyloid*** and ***ball and socket*** – each allowing a different range of movement. Joints specialized for a high degree of movement are more likely to dislocate. However, bony congruency does not necessarily afford stability, which is more attributable to ligaments and, especially, muscles.

Articular cartilage consists of ***hyaline cartilage*** (as distinguished from ***fibrocartilage*** and ***elastic cartilage***) on the articular surfaces of synovial joints. It provides resistance to wear and a smooth gliding surface. Repetitive friction over time causes ***degenerative joint disease*** – osteoarthritis – particularly in weight-bearing areas, which is an irreversible process due to the avascularity of hyaline cartilage. Some joints also contain discs of fibrocartilage, such as the ***labrum*** of the acetabulum and the glenoid, or the ***menisci*** of the knee, which increase joint congruency, but can also undergo degeneration and may tear.

The joint capsule is the fibrous casing surrounding the joint surfaces of the articulating bones. It is lined by ***synovium***, the vascular membrane that produces the ***synovial fluid*** of the joint cavity, which may become inflamed in ***inflammatory joint disease***.

In certain areas the fibrous capsule may be thickened to form ***intrinsic ligaments*** to provide reinforcement. Tearing of the ligament fibres (a "sprain") occurs when the joint is pulled beyond its normal range of movement. Where intrinsic ligaments do not exist, the capsule may be weaker or deficient, predisposing to the direction of joint dislocation. ***Extrinsic ligaments*** also reinforce the joint, yet are discrete from the capsule. A complete tear may produce joint space widening on radiograph; however if their fibres are stronger than the attached bone, they may ***avulse*** a bony fragment.

Muscle fibres, or their tendinous attachments to bones, may also similarly tear (a "strain") or cause bony avulsion. Attrition from pathological bony osteophytes or fractures may cause tendon ruptures. ***Bursae*** are synovial lined sacs that exist to cushion muscles and tendons from bony prominences, however they may become inflamed (bursitis) in combination with tendon microtrauma, or discretely infected.

Articular arteries often form significant ***anastomoses*** around joints to maintain perfusion with the joint in different positions. However it is important to appreciate that fractures can disrupt perfusion and lead to ***avascular necrosis***.

Hilton's Law states that the nerves supplying the muscles that move the joint also supply sensation to that joint and the skin overlying the joint. Joint capsules and ligaments are richly innervated and will readily transmit pain.

The Muscles and Neurovasculature

Body wall musculature develops segmentally in the embryo, with migrating primitive musculature taking its nerve supply with it. The limbs develop from limb buds on the body wall and similarly as the limb muscles undergo migration and rearrangement they maintain their embryonic nerve supply (Plate 2.2).

Muscles migrate into ***flexor*** and ***extensor*** compartments. Their nerves arise from ***plexuses*** of *ventral* (***anterior) primary rami*** derived from cervical and lumbar enlargements of the spinal cord, namely the ***brachial plexus*** to the upper limb and the ***lumbosacral plexus*** to the lower limb. Anterior divisions of these plexuses supply the flexor compartment and posterior divisions supply the extensor compartment.

The muscles and deep neurovascular structures supplying them are bound by an investing, ***deep fascia***, and divided into compartments by ***intermuscular septa*** or ***interosseus membranes***. The fascial compartments allow the muscles to slide freely in contraction, but can cause a ***compartment syndrome*** when a muscle pathologically swells, requiring surgical ***fasciotomy*** of the compartment. Any anatomical compartment carrying neurovascular structures may cause ***neuropathic*** or ***ischaemic*** symptoms if the compartment space is reduced or traumatized, for example with inflammatory swellings or fractures (e.g. carpal tunnel syndrome, supracondylar fractures).

Knowledge of myotomes and dermatomes is essential for understanding the effects of spinal nerve lesions on muscular behaviour and sensory skin changes in the limbs. A ***myotome*** is an amount of skeletal muscle innervated by a single segment of spinal cord. As a general rule, joint movement is governed by a ***spinal centre***, usually four segments long, where the upper two segments innervate one action, and the lower two innervate the opposite action. Furthermore, the next more distal joint along the limb will be governed by a spinal centre that is (all together) one segment lower in the cord (see Table 2.1).

A ***dermatome*** is an amount of skin innervated by a single segment of spinal cord. The segmental dermatome pattern of the upper limb is relatively clear when considering the position of limb development (Plate 2.3). The lower limb appears more complex, due to the medial rotation and extension of the lower limb from the flexed foetal position. Remember that the ***peripheral nerve*** cutaneous sensory map (Plate 2.4) is a map of the distribution of discrete named peripheral nerves, which may carry multiple ***spinal segmental nerves***.

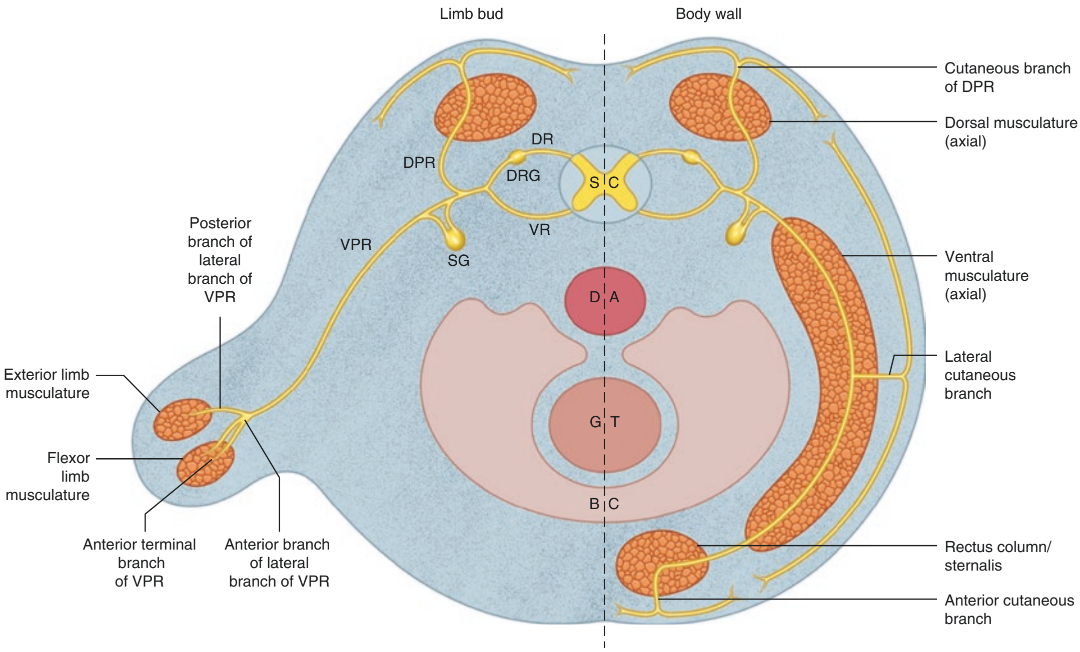

Plate 2.2 Development of limb musculature.
Transverse section of schematic embryological development of the limbs.
The *right side of the diagram* shows development of the standard body wall at a thoracic/abdominal segmental level, and the *left* shows a segmental level of limb development. Note the correlation in neuromuscular origin.
The limb buds are ventral structures developing from the lateral branch of the VPR. This lateral branch divides into a posterior branch for innervation within the extensor compartment of the limb, and an anterior branch (fused with the anterior terminal branch of the VPR) for innervation within the flexor compartment.
BC body cavity, *DA* dorsal aorta, *DPR* dorsal primary ramus, *DR* dorsal root, *DRG* dorsal root ganglion, *GT* gut tube, *SC* spinal cord, *SG* sympathetic ganglion, *VPR* ventral primary ramus, *VR* ventral root

Anatomy for Operative Surgery

Abdomen: Exploratory Laparotomy

In principle, the abdomen can be opened anywhere – in practice, one of the standard incisions will (usually) be chosen. This requires knowledge of the abdominal wall (Plate 2.5). Once the abdomen is opened (say through a midline incision), the cavity that contains the immediately visible organs is termed the ***greater sac***. The ***lesser sac*** is an outpouching of the greater sac sandwiched between the stomach in front and the pancreas behind. It is the site of a pancreatic pseudocyst, and should be searched if a perforated *posterior* gastric ulcer is suspected.

Upper Abdomen

The ***subphrenic spaces*** (right and left) and ***hepatorenal pouch*** (of Morison) (right subhepatic space) are explored first; these dependent sites may contain pus and liver/kidney tumours can be palpated. The lesser sac (left subhepatic space) communicates with the hepatorenal pouch through the ***epiploic foramen*** (of Winslow).

The gallbladder will be visible. ***Calot's triangle***, important in relation to cholecystectomy, is defined in (Plate 2.6). The ***cystic artery*** is (usually) a branch of the ***right hepatic artery***; both arteries (usually) run *behind* the ***common hepatic duct***, with the cystic artery then *crossing* Calot's triangle to reach the gallbladder. Careful dissection of Calot's triangle in cholecystectomy is essential to avoid damage to the ***common bile***

Table 2.1 Myotomes of the limbs

Upper limb[a]		Lower limb	
Shoulder flex/abd/lat rotation	C5	Hip flex/add/med rotation	L2,3
Shoulder ext/add/med rotation	C6,7,8	Hip ext/abd/lat rotation	L4,5
Elbow flexion	C5,6	Knee extension	L3,4
Elbow extension	C7,8	Knee flexion	L5,S1
Radioulnar supination	C6		
Radioulnar pronation	C7,8		
Wrist extension	C6,7	Ankle extension (dorsi-flexion)	L4,5
Wrist flexion	C6,7	Ankle flexion (plantar-flexion)	S1,2
		Subtalar & midtarsal inversion	L4
		Subtalar & midtarsal eversion	L5,S1
Finger extension	C7,8	Hallux extension (dorsi-flexion)	L5
Finger flexion	C7,8	Hallux flexion (plantar-flexion)	S1,2
Hand (intrinsic)	T1	Foot (intrinsic)	S3

[a]Note that the upper limb does not conform as well to the formula. Distal to the elbow spinal segments have split up to control more precise movements

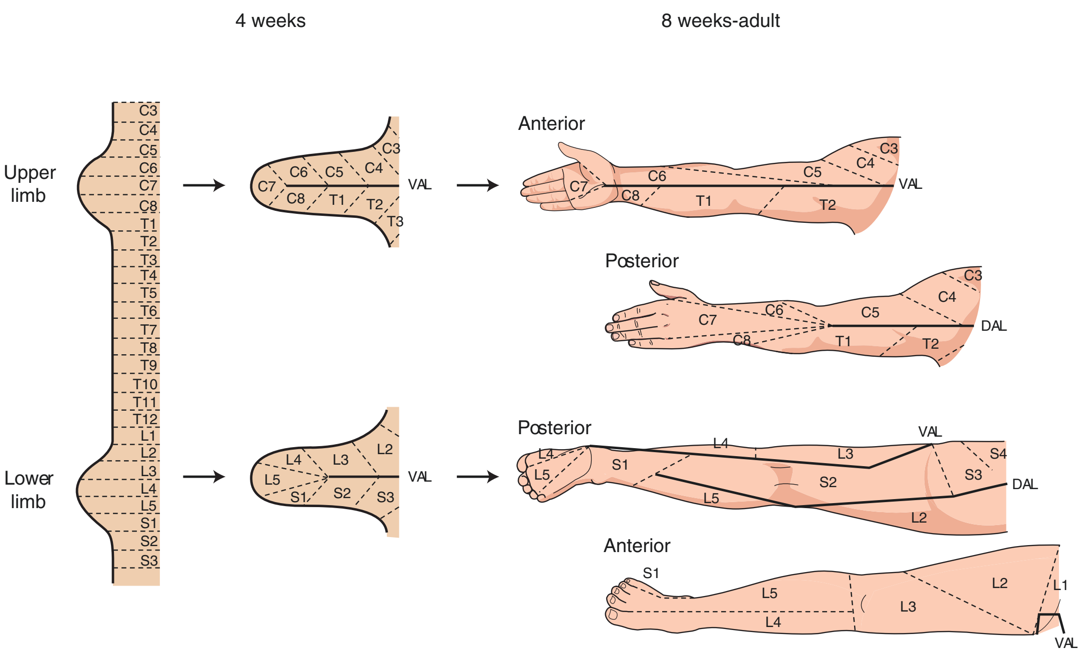

Plate 2.3 Dermatome map and development. Schematic development of foetal to adult limb dermatomes. The segmental derivation is illustrated. Limb buds arise at 4 weeks in the foetus and full morphology is established in the 8th week. During the 7th week the upper limb undergoes 90° lateral rotation and the lower limb 90° medial rotation, distorting the dermatomal pattern particularly in the lower limb. Considerable overlap occurs between adjacent dermatomes (*broken lines*); however demarcation is acute at the *axial lines* (*heavy lines*), representing non-adjacent spinal nerves. Multiple dermatome charts exist, but here is presented a schematic adaptation from Foerster (1933).
DAL dorsal axial line, *VAL* ventral axial line

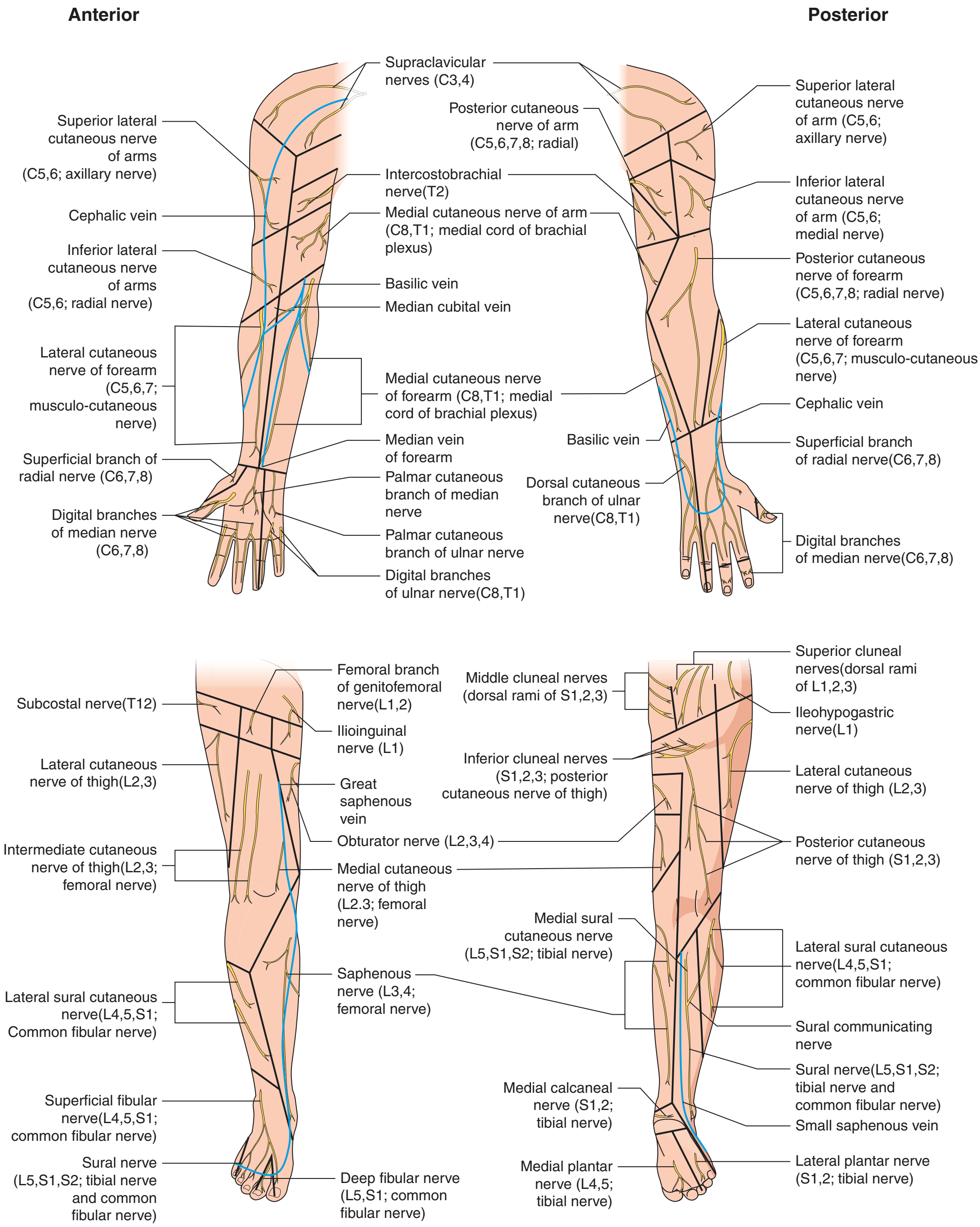

Plate 2.4 Peripheral nerve cutaneous sensory map. The superficial neurovascular structures of the limbs. Displayed are the main peripheral sensory nerves in the limbs as they pierce the deep fascia to become superficial, with their area of cutaneous innervation. *Parentheses* show the spinal nerve level(s) and, where applicable, the named terminal branch of the limb plexus, from which they derive.

The major superficial venous structures are also depicted. Note how certain nerves run with the veins in sections of the limb

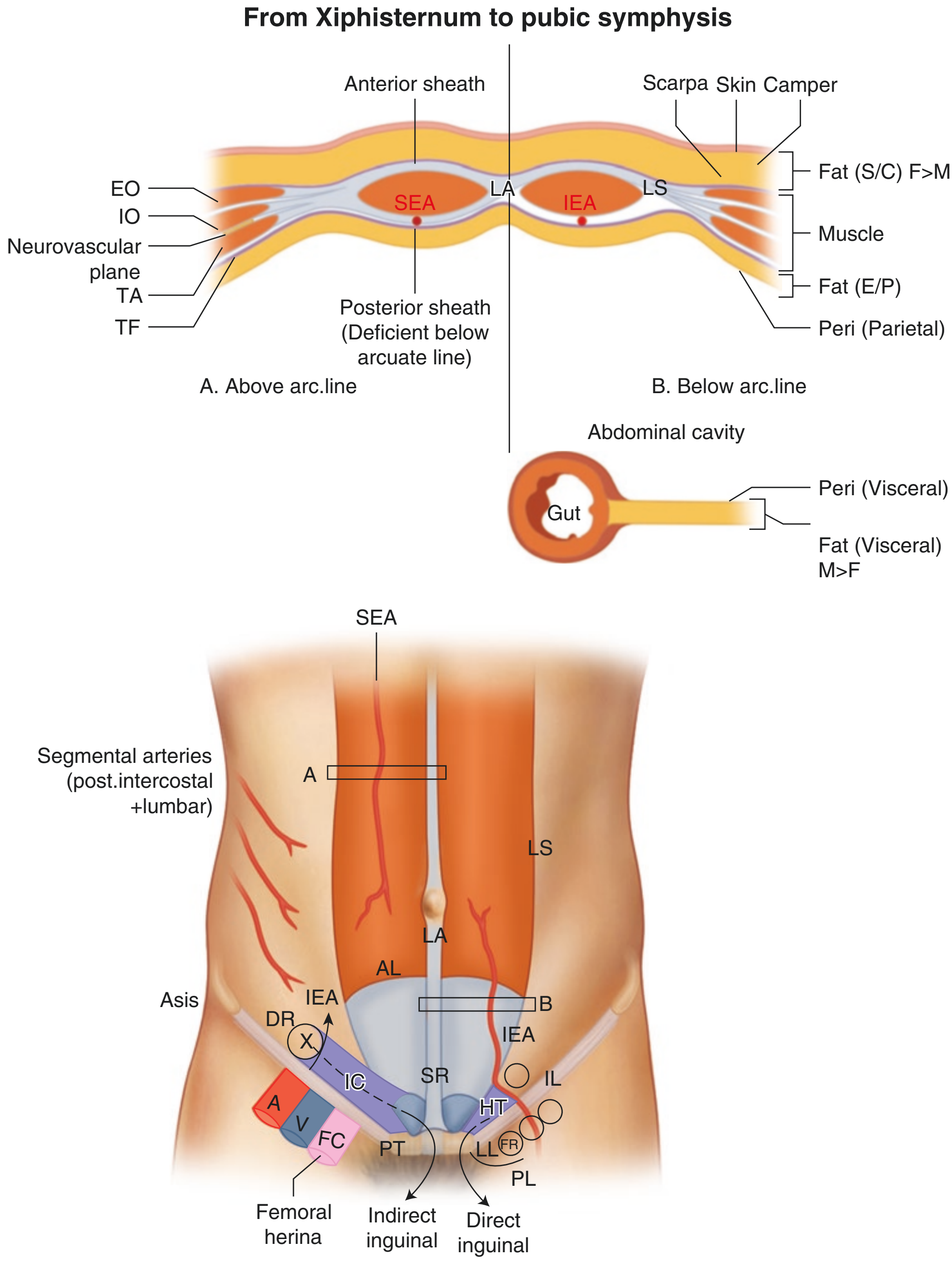

Plate 2.5 Abdominal wall and inguinal region.
Cross-sections (*above*) relate to *boxed areas* on abdominal wall (*below*). Note difference in formation of rectus sheath above and below *arcuate line*. Also note difference in fat distribution (subcutaneous vs. visceral) between males and females.
Inguinal region is illustrated in relation to the common groin herniae – inguinal (direct and indirect) and femoral. Direction of herniation is shown by the *arrows* – note their position in relation to pubic tubercle (femoral vs. inguinal) and inferior epigastric vessels (direct inguinal vs. indirect inguinal). Recall that a direct hernia passes through Hesselbach's triangle; an indirect hernia recanalizes the embryological processus vaginalis.
EO external oblique, *IO* internal oblique, *TA* transversus abdominis, *TF* transversalis fascia, *LA* linea alba, *LS* linea semilunaris, *AL* arcuate line, *SEA* superior epigastric artery, *IEA* inferior epigastric artery, *ASIS* anterior superior iliac spine, *DR* deep ring, *SR* superficial ring, *IC* inguinal canal, *FC* femoral canal, *PT* pubic tubercle, *HT* Hesselbach's triangle, *FR* femoral ring, *IL* inguinal ligament, *LL* lacunar ligament, *PL* pectineal ligament

duct (CBD), as the associated inflammation can distort the biliary anatomy.

The ***greater omentum***, hanging from the greater curvature of the stomach, obscures the initial view of other organs. Lifting it superiorly reveals its attachment to the transverse colon, and brings the small and large bowel into view. The lesser curvature of the stomach is attached to the liver by the ***lesser omentum***, whose free edge contains the ***portal triad*** (portal vein, hepatic artery and CBD).

The pancreas and renal tract are retroperitoneal and will not be visible. The spleen should be left alone – unless it is bleeding.

Lower Abdomen

Large bowel is distinguished from small bowel by the presence of ***taeniae coli*** – these represent the outer longitudinal muscle split into 3 bands, and their contractions account for the ***haustrations*** of the large bowel, seen as partial folds on AXR. The small bowel is attached to the posterior abdominal wall by a ***mesentery*** which passes diagonally from the LUQ to the RLQ. The small bowel is orientated by 'walking' it between finger and thumb in both directions – to the duodenum proximally and the caecum distally. The ***jejunum*** and ***ileum*** are distinguished on AXR by the presence of ***plicae circulares/ valvulae coniventes*** in the jejunum, which are seen as complete folds – the ileum is featureless on AXR.

The ***ascending*** and ***descending*** colon are ***retroperitoneal***, plastered to the posterior abdominal wall on the right and left sides of the abdomen, respectively. Their gas patterns are therefore fixed on AXR. The ***transverse*** and ***sigmoid*** colon are on ***mesenteries*** and free to move (along with their gas patterns on AXR). They are easily distinguished, as the transverse colon is also attached to the ***greater omentum*** – this is especially useful to remember at trephine colostomy, when trying to pull out the correct loop of colon through a small circular incision (a 'trephine').

The ***appendix*** is located by tracing the taeniae of the caecum to its base, where they rejoin to invest the appendix in a complete longitudinal coat of muscle. The appendix has its own mesentery, the ***mesoappendix***, containing the ***appendicular artery*** (a branch of the posterior caecal, itself a terminal branch of the ileocolic). The position of the appendix is variable, but it often overlies the *external iliac artery*; the pulse provides the important distinction when trying to fish it out blind at appendicectomy.

The ***rectum*** lies within the pelvic cavity. The upper part is retroperitoneal, the lower part lies below the level of the pelvic peritoneal reflection. Strictly speaking, the rectum commences at the point where the sigmoid colon loses its mesentery; this is at the level of the 3rd sacral segment (as seen on CT and MR scans), and approximates to where the taeniae rejoin to form a complete coat (which actually occurs in the distal sigmoid). The ***rectouterine pouch*** (of Douglas) (***rectovesical pouch*** in the male) can harbour pus in a similar manner to the subprenic and subhepatic spaces.

Limbs: Joints and Soft Tissues

The surgical exposure of a particular structure in the limb is variable, but always aims to provide the best visualization with limited damage to the surrounding topography. On the approach, knowledge of ***cutaneous nerves*** and the ***superficial venous system*** (Plate 2.4) is key to avoiding neuroma formation and a bloody operative field. Understanding how the ***deep fascial system*** surrounds the muscles, dividing them into compartments and allowing route of the major neurovascular structures, can then allow deeper dissection in a safe and avascular plane.

Hip

Surgical approaches to the hip encounter large muscle bulk which must be divided, in close proximity to large neurovascular structures. In a posterior approach, ***gluteus maximus*** is split laterally, avoiding the innervation from the ***inferior gluteal nerve*** that originates medially. The short external rotators of the hip (including ***piriformis***, ***obturator internus*** and its 'twins' – the ***superior*** and ***inferior gemelli***) are detached from their insertion on the greater trochanter, avoiding the ***sciatic nerve*** passing more medially on the posterior aspect of the gemelli and obturator internus.

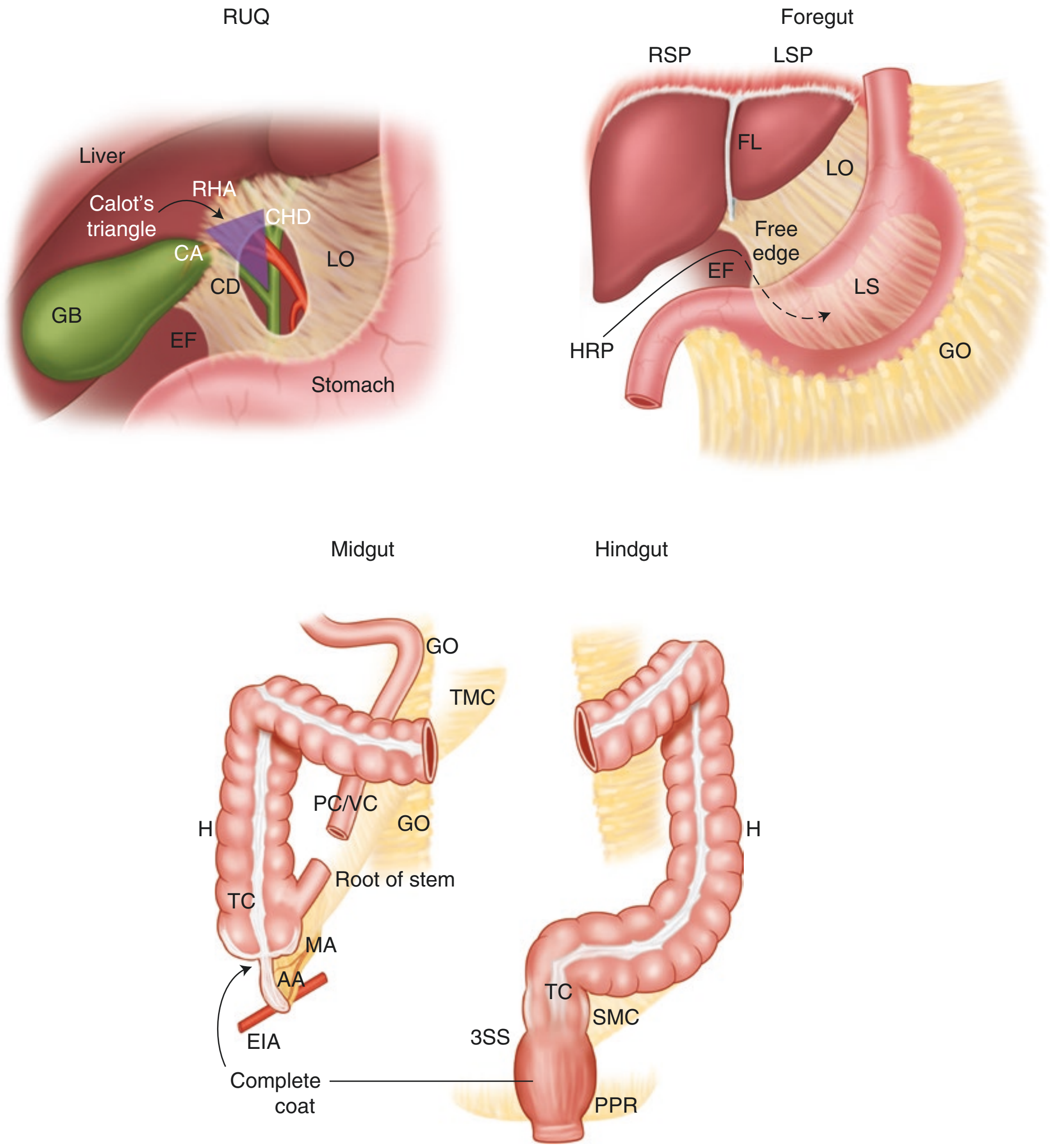

Plate 2.6 Basic anatomical landmarks for exploratory laparotomy.
Foregut, midgut and hindgut are depicted separately – each part has own blood supply.
Foregut – *Arrow* illustrates communication between greater and lesser sacs through epiploic foramen. *Free edge of lesser omentum* (*highlighted*) contains portal triad. *Inset* is a detail of *right upper quadrant*. *Calot's triangle* (*highlighted*) is bounded by liver, cystic duct and common hepatic duct. Note course and relations of cystic artery.
Midgut & Hindgut – Most of small bowel is omitted; note (radiological) difference between jejunum and ileum. Appendix and rectum have complete muscular coats. Colon has taeniae coli (shown in caecum and sigmoid) and haustrations (shown in ascending and descending); transverse and sigmoid have mesenteries; transverse also adheres to greater omentum. Note relations of appendix and transition from sigmoid to rectum.
RHA right hepatic artery, *CA* cystic artery, *CD* cystic duct, *CHD* common hepatic duct, *RSP* right subphrenic space, *LSP* left subphrenic space, *FL* falciform ligament, *HRP* hepatorenal pouch, *EF* epiploic foramen, *LS* lesser sac, *LO* lesser omentum, *GO* greater omentum, *TMC* transverse mesocolon, *SMC* sigmoid mesocolon, *SBM* small bowel mesentery, *PC* plicae circulares, *VC* valvulae conniventes, *H* haustrations, *TC* taeniae coli, *MA* mesoappendix, *AA* appendicular artery, *EIA* external iliac artery, *3SS* 3rd sacral segment, *PPR* pelvic peritoneal reflection

A more lateral surgical approach encounters the ***gluteus medius*** and ***minimus***, attaching on the lateral and anterior surfaces of the greater trochanter, respectively. Care is taken to avoid the ***superior gluteal nerve***, supplying both of these muscles in addition to the tensor fascia lata, by dividing the muscles near their insertion onto the greater trochanter.

The fibrous capsule of the hip must be opened to access the head of the femur. The capsule attaches anteriorly onto the ***intertrochanteric line*** of the femur, but posteriorly attaches to the femoral neck proximal to the ***intertrochanteric crest***. The capsule is reinforced by the ***iliofemoral***, ***pubofemoral*** and ***ischiofemoral*** ligaments.

The blood supply to the head of the femur is distributed via reflections of the synovial membrane and fibrous capsule along the neck of the femur. These ***retinacular folds*** conduct blood primarily from the ***medial circumflex femoral artery***, with a lesser contribution from the ***lateral circumflex femoral artery***. The artery of the head of the femur (ligamentum teres) provides only a small and variable contribution to the femoral head, meaning a ***displaced intracapsular femoral neck fracture*** will leave the head at high risk of ***avascular necrosis***.

Knee

The process of knee arthroscopy is a tour of intracapsular knee anatomy, allowing visualization of the 3 knee articulations (***medial and lateral articulations*** between ***femoral and tibial condyles***, and between ***patella and femur***) and the intra-articular ligaments (***cruciate ligaments*** and ***menisci***). The ***suprapatella bursa (pouch)***, the extension of the joint cavity superior to the patella and deep to the quadriceps tendon, should also be explored.

The crescentic ***medial*** and ***lateral menisci*** lie on the articular surface of the medial and lateral tibial condyles, and attach to the fibrous capsule at their external margin. ***Coronary ligaments*** attach the external meniscal margins to the tibia while the internal margins are free. The ***anterior cruciate ligament (ACL)*** and ***posterior cruciate ligament (PCL)*** are named based on their origins from the intercondylar area of the tibia. The ***ACL*** prevents posterior displacement of the femur on the tibia and knee hyperextension, and the ***PCL*** prevents anterior displacement of the femur on the tibia and knee hyperflexion. The ***ACL*** is weaker and has a poorer blood supply. The ***tendon of popliteus*** may also be visualized from within as it enters the capsule to attach to the lateral femoral condyle.

The extracapsular ligaments [***medial (tibial) collateral ligament, lateral (fibular) collateral ligament, patellar ligament, oblique popliteal ligament*** and ***arcuate popliteal ligament***] strengthen the capsule but are not visualized on arthroscopy. Of note, the medial collateral ligament is attached to the medial meniscus whereas the lateral collateral ligament is not attached to the lateral meniscus. This leads to the clinical phenomenon of the ***"unhappy triad"*** of knee injuries, where tearing of the ***medial collateral ligament*** can consequently lead to ***medial meniscus*** and ***ACL*** injury.

Ankle

The superficial anatomy of the ankle contains a circumferential arrangement of important neurovascular structures that should be avoided in both open and arthroscopic surgery. On the lateral aspect of the ankle lie the ***small saphenous vein*** and ***sural nerve***, running together posterior to the lateral malleolus, and the ***cutaneous branches of the superficial fibular nerve*** anterior to the lateral malleolus. On the medial side lie the ***great saphenous vein*** and ***saphenous nerve***, running together anterior to the medial malleolus (see Plate 2.4).

The ***tibiotalar*** articulation can typically be accessed anteriorly between ***extensor hallucis longus*** and ***extensor digitorum longus***, with care to avoid the intervening neurovascular bundle of the ***anterior tibial vessels*** and ***deep fibular nerve***.

Access to the clinically-described 'posterior malleolus' of the tibia is usually posterolateral, posterior to ***fibularis longus*** and ***fibularis brevis***, since a posteromedial approach encounters the deep structures beneath the ***flexor retinaculum*** (namely, from anterior to posterior – ***tibialis posterior, flexor digitorum longus***, the ***posterior tibial vessels***, ***tibial nerve*** and ***flexor hallucis longus***).

The inherent stability of the ankle mortise is due to the ankle ***'syndesmosis'***. This clinical term refers to the ***distal tibiofibular articulation*** (a fibrous syndesmosis joint) maintained anatomically by the ***interosseous ligament***, ***inferior transverse ligament***, and ***anterior (inferior)*** and ***posterior (inferior) tibiofibular ligaments***. This syndesmosis is also maintained by the deep lamina of the ***deltoid ligament*** (part of the medial ligament of the ankle joint itself – the ***talocrural*** joint). Recreation of the ankle syndesmosis may be achieved surgically with a syndesmosis screw, in order to prevent ***talar shift*** in the coronal plane.

Shoulder

Shoulder surgery is often carried out arthroscopically, as an approach to the ***subacromial space*** and the ***rotator cuff***. Note however that these are essentially extracapsular structures to the true shoulder (***glenohumeral***) joint.

The ***subacromial space*** lies beneath the acromial portion of the ***coracoacromial arch***. This strong osseoligamentous arch is formed by the ***acromion*** and ***coracoid process*** of the scapula, with the interconnecting ***coracoacromial ligament***, and resists superior glenohumeral dislocation. The subacromial space contains the ***subacromial bursa***, and vigorous debridement in the area may disturb branches of the ***thoracoacromial artery***.

The ***rotator cuff*** is the musculotendinous cuff around the glenohumeral joint formed by the ***supraspinatus***, ***infraspinatus***, ***teres minor*** and ***subscapularis***. Inferiorly it is absent. Clinically, this predisposes to an anteroinferior direction of glenohumeral dislocation through the area of capsule that lacks reinforcement.

In open surgery, an anterior approach to the shoulder makes use of the intermuscular plane between the ***deltoid*** and ***pectoralis major*** muscles. The ***cephalic vein*** is in danger of damage here as it passes through this ***deltopectoral groove*** to enter the axillary vein. More lateral and posterior approaches can endanger the ***axillary nerve***, which winds around the posterior aspect of the surgical neck of the humerus. The close relationship of the axillary nerve to the inferior aspect of the glenohumeral joint capsule dictates that axillary nerve (cutaneous sensory) function should always be tested in joint dislocations and fractures of the surgical neck of the humerus.

Wrist

The most common operation performed around the wrist (carpus) is carpal tunnel decompression. The ***carpal tunnel*** is an osseofibrous space through which run the ***median nerve***, and the tendons of ***flexor digitorum superficialis*** (4), ***flexor digitorum profundus*** (4) and ***flexor pollicis longus***. The roof of the carpal tunnel is formed by the ***flexor retinaculum*** (transverse carpal ligament). It stretches between the ***scaphoid*** and ***trapezium*** on the radial side of the carpus, and the ***pisiform*** and ***hamate*** on the ulnar side, and is surgically divided to release the median nerve.

Despite the multitude of important neurovascular structures on the flexor (volar) side of the wrist (including the ***median nerve***, ***ulnar nerve and artery***, and ***radial artery***), distal radius fractures may be approached from this side. Skin incisions aim to avoid the ***palmar cutaneous branch of the median nerve***, arising proximal to the flexor retinaculum, and the ***superficial branch of the radial nerve*** (see Plate 2.4). With retraction of the flexor tendons, median nerve and radial artery, the radius can be exposed beneath ***pronator quadratus***.

The extensor (dorsal) aspect of the wrist lacks the major neurovascular structures of the flexor side, and may offer a safer exposure. A central approach avoids the ***dorsal cutaneous branches*** of the ***ulnar*** and ***radial nerve***, which wind onto the dorsum of the hand from each side of the wrist (see Plate 2.4). The radial artery lies on the radial side in the ***anatomical snuff box***. The extensor tendons at the wrist are clinically described as an arrangement of ***6 fascial compartments*** from the radial to ulnar aspect of the dorsal wrist, with an approach usually between the 2nd and 3rd, or 3rd and 4th, compartments.

Recommended Reading

The following texts come highly recommended. Multiple editions of all the books exist, therefore only their titles are listed. For those with a keen interest in anatomy, it is well worth trying to source the out-of-print titles, as their clarity of description and illustration is outstanding.

- Last – Anatomy, Regional and Applied
- Ellis – Clinical Anatomy
- Grant – A Method of Anatomy, Descriptive and Deductive
- Cunningham – Manuals of Practical Anatomy (in three volumes)
- Jamieson – A Companion to Manuals of Practical Anatomy
- Jamieson – Illustrations of Regional Anatomy (in seven sections)

Radiology for Surgeons

3

Benjamin L. Jones, Priyan Tantrige, and Oliver V. Cawley

"…the vascular catheter can be more than a tool for passive means for diagnostic observations: used with imagination it can become an important surgical instrument."
Dr. Charles Dotter, 1963

Introduction

Radiology offers a diagnostic and therapeutic service to surgeons across the specialties, in both the emergent and elective care setting.

The role of the house surgeon is to request radiological investigations, interpret simple imaging and act on radiological reports appropriately. These tasks are an excellent learning opportunity, as they require comprehensive knowledge of the patient, details of any surgery, and the management plan.

The high volume of radiological studies in surgical practice is reflected in undergraduate and postgraduate surgical exams. The aim of this chapter is to equip you with radiological vocabulary, empower you to organise the appropriate study or procedure with confidence, and to convey what key pathologies look like radiographically. Although there is a plethora of descriptive terms and signs, it must be emphasized that radiological diagnosis is ultimately a visual enterprise. We would therefore also recommend looking up these concepts on radiology websites that provide a larger number of images.

Due to the confines of space available, we have taken a more itemized approach in order to convey the radiology most efficiently. Under each clinical setting, we have sought to relay the most relevant imaging modalities, along with brief descriptions of key appearances and corresponding images where possible.

Core Knowledge

Radiological Studies

The majority of radiological studies are greyscale images. This enables us to utilize the rod photoreceptors in our retinas to resolve fine differences between different tissues. Colour imaging may be used to demonstrate large differences in tissue characteristics. The presently widely available radiological studies include:

- Plain radiography (X-Ray)
- Computed tomography (CT)
- Fluoroscopy
- Ultrasonography (US) and Contrast enhanced ultrasonography (CEUS)

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R.A. Fisher et al. (eds.), *Introduction to Surgery for Students*, DOI 10.1007/978-3-319-43210-6_3

- Magnetic resonance imaging (MRI)
- Nuclear medicine (NM)
- Fusion studies (e.g. PET-CT, fMRI)
- Image guided biopsy, aspiration, or drain placement
- Interventional radiology (IR)

Radiology is rapidly evolving in line with technological advancement. New modalities and techniques are in various stages of development, and clinical guidelines are frequently updated to reflect this. Consultation with a radiologist is recommended when there is uncertainty regarding study selection or interpretation.

Requesting a Scan

Urgent inpatient radiological investigations require discussion between the clinical team and the radiologist to determine:

1. The optimal study for diagnostic accuracy and patient safety.
2. The timing of the study and patient preparation.

There Are Two Approaches to the Discussion

1. Ask a question to confirm or exclude a diagnosis, define the extent of a disease, or monitor the progress of a disease – the radiologist suggests a study.
2. Request a specific study as per hospital protocol, or following prior discussion.

Radiological Request Checklist – Details to Have at Hand

1. *Patient demographics*: personal details, location, mode of transport, escort requirements (level of supervision/oxygen), ability to lie down/stand, and infection status.
2. *Patient safety*: allergies, renal function, MRI contraindications, last menstrual period (LMP)/pregnancy status, and patient co-operation.
3. *Clinical details*: working diagnosis and provisional management plan, with details of how this was determined from the history, examination, bedside tests, bloods tests, and previous radiological investigations.
4. *Contact details*: for communication of urgent findings, and the patient's consultant.

The radiologist needs this information to legally justify that the harm caused by the study outweighs the benefits.

Possible Patient Preparation Requirements

- Inform the patient about the study and what it involves
- Nil by mouth
- Bowel preparation
- Menstrual cycle timing
- Intravenous access (specific minimum gauge requirements for some studies)
- Pre-hydration
- Antibiotic cover
- Renal function optimization/monitoring (consult renal team regarding patients with nephropathy)
- Up-to-date blood results
- Blood products (for interventional radiology)

Radiological Techniques and Safety

Ionising Radiation (X-Ray, CT, Fluoroscopy, NM, Fusion Studies, IR)

X-Ray Studies X-rays are generated de novo by electron bombardment of an anode such as tungsten or molybdenum in an X-ray tube. The X-rays are collimated to the target body part, and then pass through filters to remove non-diagnostic energy rays. Within tissues, X-rays are attenuated to varying degrees in proportion to tissue or contrast density. The X-rays which pass through the patient and reach the detector are quantified in intensity per 2-D coordinate to construct a radiograph.

- *Plain radiographs* – colloquially referred to as X-rays, they are static 2-D images of X-ray attenuation that, by convention, demonstrate air (black), soft tissues or fluid (grey), and bone (white). Cheap and readily available, they remain the most frequent radiological investigation and are routinely interpreted by clinicians.

- *Fluoroscopy* – a series of low dose radiographs may be taken sequentially at a rate of multiple frames per second to generate a video loop. Frequently enhanced with a contrast medium to delineate the structure of interest, fluoroscopy is used to demonstrate dynamic function of the region of interest.
- *Computed Tomography (CT)* – multiple detectors are used to determine the relative X-ray attenuation of tissues in a thin transverse slice through the body. Multiple slices are obtained which may be reconstructed into sagittal, coronal and 3-D reformats to examine the region of interest for detailed assessment, in thousands of shades of grey.

Nuclear Medicine gamma rays (in-vivo diagnostics), and alpha and beta particles (not used in-vivo) are generated by radioactive decay. Gamma rays interact with matter and their level of uptake in different tissues is measured, reflecting cellular activity, which may be correlated with physiological or pathological levels.

Ionising Radiation Safety the (potential) harmful effects must always be weighed up against the proposed diagnostic benefits when considering any radiological investigation. This is particularly the case when ionising radiation is to be prescribed, which incurs risks such as carcinogenesis. Table 3.1 below illustrates the average relative doses of radiation incurred across commonly performed investigations. Most students are aware that radiation exposure is a disadvantage from imaging, yet are shocked when shown this table. Preventable harm is carried out to the patient through inappropriate ordering of scans.

The framework governing the diagnostic use of ionising radiation is the Ionising Radiation Medical Exposure Regulations (IRMER), and there is no upper dose limit, *provided the perceived benefit outweighs the risk.*

Table 3.1 Comparative doses for common ionising-radiation investigations

Diagnostic procedure	Equivalent number of chest X-rays	Approximate equivalent period of natural background radiation
Chest X-ray	1	3 days
Hip X-ray	20	2 months
Abdominal X-ray	35	4 months
CT head	100	10 months
CT chest	400	3.6 years
CT abdomen	500	4.5 years

Magnetic Resonance Imaging (MRI)

Magnetic fields, typically over 30,000 times the strength of Earth's magnetic field, are used to align the hydrogen atoms in the body along the same axis, and images are constructed via algorithms that measure signals when the protons relax. MRI provides unparalleled soft tissue definition of structures beyond accurate reach of ultrasound (US). It has a lower spatial resolution than CT but can resolve adjacent structures of similar density better than CT, where there is a difference in hydrogen atom relaxation.

MRI Safety the magnetic fields applied are not known to cause harm to biological tissues, including in pregnancy, but may displace or disrupt MRI incompatible devices or foreign bodies. An MRI safety checklist provides guidance on MRI suitability and the information required includes model numbers of the in-situ devices, date of insertion and present position. Magnetic objects brought into proximity of the magnet become lethal projectiles and there are strict rules on entering the safety zone.

Ultrasound (US)

Current is passed through piezoelectric crystals in a transducer, causing vibration and emission of sound waves, which travel through soft tissues. The waves are reflected or refracted to various degrees, and return to the transducer to vibrate the crystals to generate an electric current for conversion into an image. US offers dynamic imaging in any plane, with or without contrast, and measurement of tissue stiffness or compressibility. US may resolve infinitely small structures, provided they have different acoustic impedance to the adjacent soft tissue. US is often used to measure flow within blood vessels.

Ultrasound Safety risks are practically negligible, although there is slow tissue heating if the probe is held over the same area for a very long time.

Contrast Media

A contrast medium is used to enhance the differences between similar tissues and to characterize abnormalities. The classification slightly varies between study types. For X-rays, contrast media are positive (iodine and barium), or negative (air and carbon dioxide). For MRI, they are paramagnetic or superparamagnetic, but other means are also used to examine the bowel or the vagina. In ultrasound, the contrast is micro-bubbles. For most contrast media, there are various routes and timings of administration, indications and contraindications, and alternatives. The radiology department provides guidance and protocols for each study for diagnostic accuracy and patient safety. Of note, iodine contrast media are nephrotoxic and contraindicated in patients with nephropathy. MRI contrast media are also excreted via the kidneys. However, MRI and US with contrast are alternatives to CT in patients allergic to iodine.

A favourite surgical examination question is regarding the type of contrast media administered enterally for upper and lower GI tract fluoroscopy studies. Broadly speaking, there are barium sulphate and iodine based water-soluble contrast media. Barium provides superior mucosal coating, but causes peritonitis if it extravasates into the peritoneum and should not be used for assessment of a bowel anastomosis or in a patient who may undergo abdominal surgery. Iodine based water soluble contrast media are safe in the peritoneum. On the other hand, iso- or hypoosmolar iodine-based water-soluble media are relatively safe if extravasated into the lung or mediastinum, while hyperosmolar media draw in water and cause pulmonary oedema, and barium may cause pneumonitis.

Core Imaging: Chest X-Ray

Appearance on Film

- ***Black*** – air/gas
- ***Dark grey*** – fat
- ***Light grey*** – soft tissue/fluid
- ***White*** – bone, calcified structures
- ***Bright white*** – metal

Interpretation of Film

When confronted with a complicated chest X-ray, it is easy to flounder. Having a system is important as it provides something to fall back on. There is a very easy system to remember when reporting chest X-rays: **RIP…ABCDE!**

Firstly, is the radiograph of diagnostic quality? This is referred to as the film "adequacy" and is comprised of three parts:

Rotation

- Are the heads of the clavicles symmetrical either side of the manubrium?

Inspiration

- Ribs: 2 components of the ribs on PA Film are seen.
  - Posterior ribs (easier to see and orientated horizontally: 9–10 normally visible)
  - Anterior ribs (harder to see and orientated at a 45 degree angle: 5 normally visible)

Penetration

- One should just about be able to define the lateral borders of the vertebral bodies behind the sternum.
- At this point also assess for any man-made objects in situ and the appropriateness of their positioning.
  - ET tube: >4 cm (ideally 5 cm) above the carina, as the ET tube can descend upon neck flexion

- – Chest drain: note where the tip of the drain lies
- – NG tube: the tube should remain central throughout its course in the mediastinum, the tip lying below the level of the left hemi diaphragm.
- – Central lines: tips should be '*projected*' over the SVC
- – Valve replacements
- – Mediastinal drains
- – Pacemakers: number of leads and any breaks in the leads
- – Sternotomy wires: any breaks and whether well aligned

Secondly, the **ABCDE** system can be used to examine all necessary structures on the radiograph.

Airways

- Visible on X-ray: trachea, right and left main bronchus.
- Remember that the right main bronchus is more vertical and wider than the left, meaning aspirated objects (including NG tubes) often pass into the right.
- Tracheal deviation: unequal intra-thoracic pressure between right and left sides.
  - – Deviation away from affected side: pneumothorax, pleural effusion, large mass
  - – Deviation towards affected side: collapse, lobectomy, pulmonary fibrosis

Bones

- 4 bones easily visualized: ribs, clavicle, sternum and vertebral bodies.
- Look for: fractures and increased/decreased density, which may suggest metastatic disease.

Cardiac Silhouette

- Cardiothoracic (CT) ratio = max horizontal cardiac width/max horizontal thoracic width.

  Cardiomegaly (>50 % CT ratio) may be due to heart failure, pleural effusion, hypertrophy (aortic stenosis, HTN) or dilatation (myocardial damage).

  Remember heart size is accurate on PA film, but not AP film. Mediastinum may be widened (>8 cm) due to poor technical quality.

Diaphragm

- The right hemi-diaphragm should be higher than the left due to the liver beneath it. However it should not be >5 cm higher. If diaphragmatic paralysis is suspected, phrenic nerve palsy secondary to mediastinal malignancy should be ruled out.
- Causes of elevated hemi-diaphragm: diminished lung volume, phrenic nerve palsy and hepato/splenomegaly.
- Small pocket of air visible under left hemidiaphragm represents air in the stomach ('gastric air bubble').

Everything Else: "Review Areas"

- Look for: meniscus sign (pleural effusion), changes behind the heart, hilar enlargement (malignancy, infection, sarcoidosis, pulmonary HTN), changes below the diaphragms, sternoclavicular joints, rib deposits, Riggler's sign (see later), shoulder fractures, and mastectomy.

Core Imaging: Abdominal X-Ray

A standard abdominal radiograph (AXR) is a supine projection with the patient lying down on his or her back. In some circumstances, an erect AXR is requested; its advantage over a supine film is the visualization of air-fluid levels.

Interpretation of Film

Again, it is important that the technical details of an AXR are assessed. The date the film was taken and the name, age, and sex of the patient are all worth noting. Next ask what type of AXR it is: supine, erect, or decubitus?

The following system can then be used to examine the radiograph.

Intra-Luminal Gas

- Look at the amount and distribution of gas in the bowels (intraluminal gas).
- Work backwards: start by looking to see if there is any gas in the rectum and then work

proximally to where you would expect to see large bowel and then small bowel.

- Gas presence gives you a lot of information (remember gas appears black on X-rays).
  - Stomach- gas always present
  - Small bowel- gas in 2 or 3 loops
  - Sigmoid and rectum- gas almost always present

Seeing more than this suggests obstruction.

Extra-Luminal Gas

- Gas outside the bowel lumen is invariably abnormal. The largest volume of gas you might see is likely to be under the right diaphragm due to a perforated viscus.
- Gas within the peritoneal cavity is termed 'pneumo-peritoneum'.

Soft Tissues

- Evaluate the outlines of the major abdominal organs.
- Assess the size and position of the liver and spleen. The kidneys should be lateral to the midline at T12-L2 (T12, the lowest vertebrae to give off a rib serves as a reference point). The renal outline is usually 3½ vertebral bodies in length.
- Look for the clear outline of the psoas muscle shadow(s).
- Try to identify the outline of the bladder, seen more clearly if full, within the pelvis.

Bones

- Evaluate the spine and pelvis for evidence of bony pathology.
- Osteoarthritis frequently affects the vertebral bodies, the femoral and the acetabular components of the hip joint, and may result in femoral neck fractures in the elderly.

What You May Find

- ***Rectum*:** absence of gas secondary to proximal obstruction
- ***Large/small bowel*:** distension, volvulus (large only), perforation
- ***Kidneys*:** enlarged (obstruction, tumour) or small (rectal artery stenosis, chronic pyelonephritis)
- ***Ureters and bladder*:** calculi, gas in bladder (e.g. infection)
- ***Liver/spleen, gallbladder*:** hepatomegaly, splenomegaly, gallstones (only 10 % radio-opaque)
- ***Vertebral column/ribs*:** fractures, metastatic disease

OSCE Advice for Radiological Stations

(1) Use a systematic approach
(2) Link abnormalities to the clinical scenario
(3) Suggest management/further investigations

A Recommended Approach Is Detailed Below

- **First identify the patient and the <u>type</u> of imaging**
  - *'This is a chest/abdominal radiograph (<u>don't say "X-ray"</u>) of Mrs. Peters taken on the 3rd September 2014 at 15.30 pm. It is a PA/AP/supine image, which is of adequate R.I. and P…'*

- **Describe any obvious abnormality FIRST**
  - *'The first abnormality to comment on is…'*
  - If you cannot see an obvious abnormality: *'no obvious abnormality is apparent to me on initial inspection so I am now going to go through the film systematically.'*

- **Systematic approach**
  - '*I will now talk through the rest of the image systematically*.'
  - Make sure you try to use anatomical terms (e.g. '*the cardiac silhouette seems to be of normal size and there is no evidence of hilar enlargement*').
  - If unsure whether something is normal or abnormal <u>do not ignore it</u> in fear of exposing your uncertainty: '*I am not sure whether*

the trachea is deviated, however it does not seem to be directly central.' You can always come back to an area; discussing the rest of the image may provide you with information to make a conclusion.

- **Review and summarize**
  - Never forget to summarize. This is the last impression the examiner will have of you so practice your summary until you are able to succinctly review an image in one clear sentence. A confident and concise summary will greatly boost your marks and make you shine out from other candidates. Remember, this does not simply mean reiterating your systematic approach but try to relate it to the clinical scenario, to show you are able to relate radiological findings to a real patient.
  - *'In summary, this chest radiograph demonstrates evidence of… These findings are consistent with the clinical picture of…'*
  - Stronger candidates will also be able to suggest initial management or investigations without prompting. *'In this situation, I would manage the patient by…'*

Core Imaging: Lines, Drains and Catheters

Common Lines and Tubes

Chest Drains

- Inserted within the borders of the "Safe Triangle" (anterior border latissimus dorsi, lateral border pectoralis major, a line superior to the horizontal level of the nipple, and an apex below axilla). This position minimizes risk to underlying structures (internal mammary artery), and avoids damage to muscle and breast tissue (↓scarring).

Nasogastric (NG) Tubes

- Used to feed patients and aspirate stomach contents.
- Passed through the nostril, down the pharynx and oesophagus into the stomach. At least 10 cm of the tube must lie distal to the gastro-oesophageal junction (GOJ) to ensure there is no risk of aspiration when fluid is passed down.
- Position can be determined by checking pH of the aspirate, but more accurately with CXR. On CXR, the tip needs to be seen below the diaphragm and the GOJ. If in any doubt regarding the tube's position, it should not be used.

Endotracheal Tube

- Used for ventilation of patients. The tube should lie above the carina – if too low, it can cause obstruction of the left main bronchus and collapse of the left lung.

Central Venous Catheters

- Used for administering medication, blood sampling and CVP monitoring.
- The CVC tip should be located in the SVC, ideally slightly above the right atrium (placement within the atrium can cause arrhythmias or tamponade).
- Examples: subclavian line, peripherally inserted central catheter (PICC) line, internal jugular line.
- Complications: failure to place catheter (22 %), arterial puncture (5 %), catheter malposition (4 %), pneumothorax (1 %), subcutaneous hematoma (1 %), and asystolic cardiac arrest (<1 %).

Did You Know?

Catheters have radiopaque markers along their length and a radiopaque tip, in order to be able to determine their position on a radiograph.

Interventional Radiology and Vascular Imaging

General Principles

- ***Indication***: weigh up benefits and risks of any procedure. Remember one of the biggest rules of medicine is "do no harm".
- ***Imaging***: check any previous imaging and consider any additional imaging that may be required (e.g. CT liver before TIPSS).

- ***Fitness***: ensure the patient is fit for the procedure, including any allergies, recent GFR and coagulation status.
- ***Patient preparation***: consider any special preprocedural requirements (e.g. fasting before a RIG).
- ***Monitoring and staff***: ensure availability of nursing staff/anaesthetists. Bear in mind that sedation and analgesia will be needed.
- ***Consent and competency***: taken and evaluated by the radiologist performing the procedure.

Basic Terms and Equipment

- ***Seldinger technique:*** the method of gaining safe access to vessels and other lumina by introducing a guidewire through a hollow needle that has previously been used to puncture the target lumen. Once the guidewire is in place, catheters can in turn be sheathed over the wire in order to perform diagnostic/therapeutic work.
- ***Wires:*** Long and flexible metal springs used to position an intraluminal catheter. Two broad types: "spring" (stainless steel) and "nitinol" (which have hydrophilic coatings such as Teflon to help with manipulation). Within these two categories, there are an array of different wires varying in length, stiffness and shape, depending on the anatomy in question and what is ultimately to be sheathed over the guidewire.
- ***Catheters:*** narrow tubes which are sheathed over guidewires. A unit "French" is a 1/3 mm diameter (e.g. 6 F catheter is 2 mm diameter). There are five broad types of catheter:
  1. Diagnostic angiographic catheters
  2. Microcatheters: for distal/smaller vasculature (e.g. smaller brain vessels)
  3. Drainage catheters (e.g. pigtail for abscesses)
  4. Balloon catheters (e.g. for angioplasty)
  5. Central venous lines
- ***Introducer sheath:*** a tube that is inserted into a lumen to provide an established access point through which other instruments can be introduced.
- ***Contrast media***: liquid used to delineate anatomy and assess flow of luminal contents. Usually a water soluble and non-ionic iodinated contrast media that attenuates X-rays, thus showing up as radiopaque.

Procedural Basics

Diagnostic

- *Angiography*: intraluminal injection of contrast using a diagnostic catheter, in order to assess the anatomy and flow with X-ray based techniques, such as fluoroscopy.
- *Arteriography*: evaluation of arteries. Often used synonymously with angiography.
- *Venography*: evaluation of veins. Now largely replaced by duplex/Doppler ultrasound scanning.
- *Lymphography:* evaluation of lymphatic drainage. More commonly used for the lower limb.
- *Percutaneous biopsy:* removal of a specific sample of tissue, accessed through puncturing of the skin, for pathological assessment. Ultrasound guided biopsies have the benefit of being dynamic and using no radiation but, as a general rule of thumb, biopsies should be performed under the modality that best locates/visualises the tissue in question (e.g. CT for lung).

Therapeutic

- *Radiologically Inserted Gastrostomy (RIG):* tube inserted through the anterior abdominal wall into the stomach for temporary or prolonged enteral feeding; less commonly to bypass a gastric outlet obstruction. The procedure is usually performed under sedation, where the stomach is **insufflated** with an NG tube (or by drinking effervescent liquid). This makes the margins of the stomach more identifiable under X-ray guidance and brings the wall of the stomach into contact with the anterior abdominal wall (helping to avoid puncture of bowel and other solid abdominal organs).

  Percutaneous punctures are then made to fix the stomach to the anterior abdominal wall with 2 or 4 "T-shaped" fasteners, in a process known as **gastropexy**. An incision in the middle of the fasteners is then made in order to insert the gastrostomy catheter over an 18 gauge needle with a stiff wire. A balloon is inflated to keep the tip of the **gastrostomy** tube in place before injection of contrast to confirm an intra-gastric position.

- *Embolization*: the injection of pro-thrombotic material through a catheter in order to restrict blood flow into a bleeding or feeding vessel. Often used to stop active haemorrhage but also in the debulking of cancers and devascularisation of fibroids. Various embolic agents exist, some of which are designed to cause temporary occlusion (such as gelatin, sponge pledgets or autologous blood clots), as well as permanent occlusion (such as coils and PVA particles). Coils can be used for larger diameter/proximal vessels.
- *Angioplasty*: balloon catheters are used to expand stenosed lumens in order to regain blood flow.
- *Stent placement*: specialized catheters with collapsed stents at one end (expanded once in desired location) to treat aneurysmal or damaged vessel walls.
- *Thrombolysis*: angiographic introduction of clot busting/lysing agents (commonly streptokinase, urokinase and r-tPA) in order to re-establish luminal flow. A precipitating lesion, such as a stenosis, is often found after blood flow is re-established and can be treated simultaneously (e.g. with angioplasty).
- *Nephrostomy*: with the patient positioned prone, a hollow needle is advanced through the skin of the back into the renal collecting system, in order to provide external means of drainage when there is urinary obstruction/hydronephrosis. Usually there is flashback of urine before a wire is advanced and a draining catheter is sheathed over that wire under fluoroscopic guidance.
- *Pigtail drainage of abscess:* insertion of a draining catheter into an abscess. Often, an abscess should be of a reasonable size (more than several centimetres in diameter) in order for the benefits of the procedure to outweigh the risks.
- *Inferior venal cava filter*: an expandable filter is usually inserted into the infra-renal IVC to protect the pulmonary circulation from large emboli. Filters can be temporary/retrievable or permanent and can be inserted via the internal jugular vein or femoral vein. Venography is essential before placement in order to assess the vessel diameter and to check for variant anatomy such as a double IVC.
- *Aortic stent grafting:* often used for treatment of aneurysmal disease, the endovascular implantation of a stent has many advantages over open surgical repair, including less blood loss, shorter post-operative hospital stay and quicker recovery. The stent graft is expanded across an aneurysm or occlusive disease segment in order to exclude it from the pulsatile forces of the aortic lumen, thus reducing the risk of rupture. The radial force of the stent keeps it in situ.
- *Transjugular Intrahepatic Portosystemic Shunt (TIPSS):* difficult procedure in which an artificial communication is made between the hepatic portal vein and hepatic vein in order to bypass a congested liver capillary bed, thus reducing portal vein pressures and the morbidity associated with portal hypertension.

Tips for Student Placement

- If you are in the radiology department as part of a taster week, keep a diary and reflections of the sessions that you have attended.
- Contribute to a current departmental audit or research project. In a short period of time this may involve data entry or making a poster from work already completed.
- Look at the in-house radiology teaching library on PACS to preview the cases you'll face at various stages of training.
- Practice explaining the basics of radiological studies to patients (frequently features in medical school exams).
- Take an opportunity to visit a tertiary centre, such as major trauma, stroke, or transplant, to observe the role of a full time subspecialty radiologist.

Radiology as a Career

The UK National Application Process

There is a centralized national recruitment process for a run-through training number. Approximately half of trainees enter directly from foundation training, the other half having reached various levels of other specialty training. There is no evidence for or against prior specialty training in terms of performance in radiology exams or success in securing a consultant post.

UK Radiology Training

Core Training (Years 1–3) training varies between deaneries. However, most trainees obtain experience in all imaging modalities and complete 2–4 month rotations in radiology subspecialties.

Higher Training (Years 4–5 [+6 for IR]) trainees specialize in a radiology subspecialty and continue to take part in the general radiology and on-call rota to maintain their core training competencies. Following attainment of certificate of completion of training (CCT) trainees are eligible to apply for a fellowship in further subspecialty training if desirable, or a consultant post.

Exams Fellowship of the Royal College of Radiologists (FRCR)

- Year 1: First FRCR – Physics and Anatomy (2 exams)
- Years 2–3: Final FRCR 2a – Subspecialty exams (6 exams). Set to change in 2017–18.
- Year 4: Final FRCR 2b (3 exams)

Consultancy Most consultants practice general radiology and a subspecialty (some only a subspecialty). The subspecialties are: chest, gastrointestinal, genitourinary, breast, musculoskeletal, paediatrics and neuroradiology (NB each specialty may involve further interventional subspecialisation and nuclear medicine).

Pros and Cons for a Career in Radiology

Pros

- Run-through training in the UK – getting a "number" is a big positive.
- High level of one-to-one training in radiology – very well supported.
- Technological advances in radiology are forever offering new ways to characterise disease, presenting exciting new challenges and huge research opportunities.
- Approximately 95 % of patients pass through the radiology department in any hospital stay. The radiologist is often the first to see or be aware of all the interesting pathologies that present.
- There is increasing demand for radiologists worldwide meaning there's plenty of work, both public and private.
- Radiologists are able to change subspecialty (e.g. from chest to GU) through higher level training with relative ease. This promotes lifelong learning, as well as intellectual and professional satisfaction.
- No more ward rounds, bleeps or patient notes!
- Radiology lends itself well to a shift-work model, allowing you to plan your personal life with confidence.
- Diagnostics Consultants currently do their on-call shift from home.

Cons

- No patient ownership and less patient interaction.
- Lots of exams before getting your CCT (completion of training).
- Some regard radiology as a lonely specialty.
- Culpable for every word in your report, which can be stressful.
- Vetting scans, especially during on call duties, can lead to heated and unpleasant conversations.

4 Role of the Surgeon

Catherine E. Lovegrove and Vanash Patel

Introduction

In recent years, the role of the surgeon has come under much scrutiny as a consequence of investigations into professional practice. The Frances Report of 2013 identified problems in working culture as being responsible for "appalling care" and creating "a culture of fear in which staff did not feel able to report concerns; a culture of secrecy in which the trust board shut itself off from what was happening in its hospital and ignored its patients; and a culture of bullying, which prevented people from doing their jobs properly" [4].

A positive working environment has been shown to promote workers' motivation and happiness, increasing productivity and reporting of problems as a knock-on effect. This is affected by a wide range of factors, ranging from individual actions to group-work and institutional regulation on a larger scale, as demonstrated in "To Err is Human", a publication by the Institute of Medicine [3]. This chapter will examine the role of the surgeon in different settings, considering interactions with the workforce and subsequent effects on patient care.

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Leadership

Surgeons frequently have a role leading a multidisciplinary team. Defining "leadership" as a concept is difficult and many have attempted to summarise the role of a leader in one sentence. The role of a "leader" has undergone much change over time; in 1954, esteemed surgeon Sir Heneage Ogilvie, lectured on surgical leadership, stating:

> "The effectiveness of the treatment depends on the services of one man – the surgeon – on his correct assessment, his timely decision, his skilful manipulation, and his unremitting care" [6]

Meanwhile, in the twenty-first century, attitudes have evolved and the Royal College of Surgeons directly contradict Ogilvie's attitude:

> "Consultant surgeons should develop a partnership with management to focus on team working and its positive effect on patient safety. Trust management must be involved in team development."

Common to modern descriptions of leadership is the importance of effective leadership and the benefits that this brings. In the surgical setting, tangible advantages are gained by patients, staff, the surgical team and the healthcare service as a whole (Fig. 4.1). As well as a myriad of definitions, various theories exist regarding how best to lead (Fig. 4.2) and the qualities of a good leader (Fig. 4.3) [7].

Transactional and transformational leadership theories are among the leadership models

R.A. Fisher et al. (eds.), *Introduction to Surgery for Students*, DOI 10.1007/978-3-319-43210-6_4

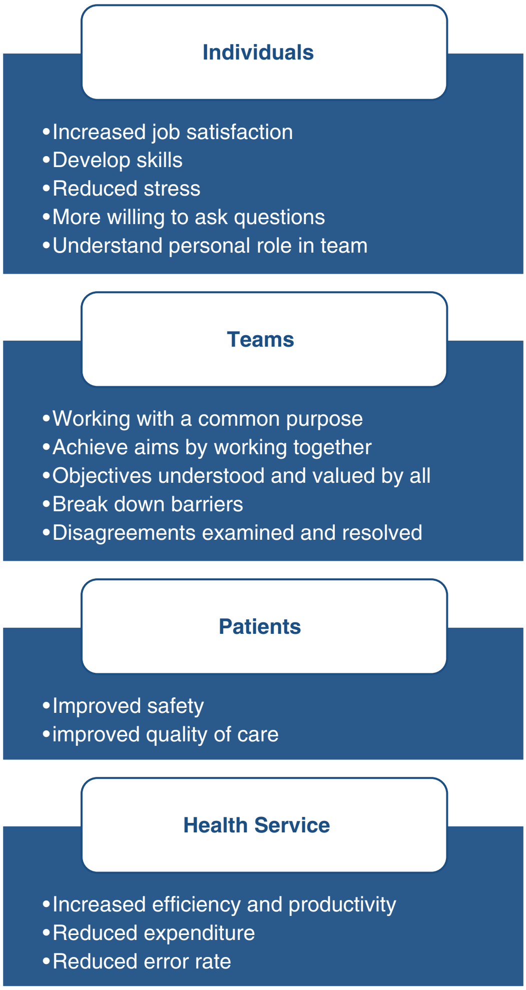

Fig. 4.1 Benefits of effective leadership

most commonly compared. Whereas transactional leadership is based on the premise that followers will only respond with the desired behaviour when motivated by the promise of receiving something in return, transformational leadership aims to alter the beliefs and actions of followers so that they match those of the leader and the team advances together [1]. The latter is important within the surgical team as it reduces any hierarchy, promoting unity and increasing the efficiency with which aims and objectives are met.

The Surgical Team

The multi-disciplinary team is fundamental to medical practice in the twenty-first century and consists of leaders and followers. The setting of patient care dictates what professionals are involved and what their role entails. Different clinical teams, consisting of a variety of individuals, are involved in patient care at different stages of the patient journey (Fig. 4.4) [8].

Within the surgical team, doctors and surgeons with different levels of experience work in a multidisciplinary team with nurses, physiotherapists, dieticians and an array of allied health professionals. Though led by a consultant surgeon, they themselves will not necessarily operate on every patient, for example when supervising the training of others in their given specialty. Nevertheless, the consultant takes responsibility for patient care and maintenance of good standards within the surgical team at all times. Other members of the surgical team may include:

- Associate specialist surgeons
- Specialty/staff grade surgeons
- Specialty surgical registrar (StR) (Previously known as Specialist surgical registrar (SpR))
- Core training doctors (CT1, CT2)
- Foundation doctors (F1, F2)
- Anaesthetists
- Theatre nurses
- Operating department practitioner
- Surgical assistants

Effective leadership and communication are integral to the function of any team and provide substantial additional benefits. Functional teams have demonstrated a reduced rate of error, which corresponds with a fall in hospital-associated mortality, reducing costs and time saving. As well as being beneficial to patient safety and wellbeing, efficient teamwork confers advantages to staff, creating a supportive environment which is enjoyable to work in, and has been shown to reduce sickness absence.

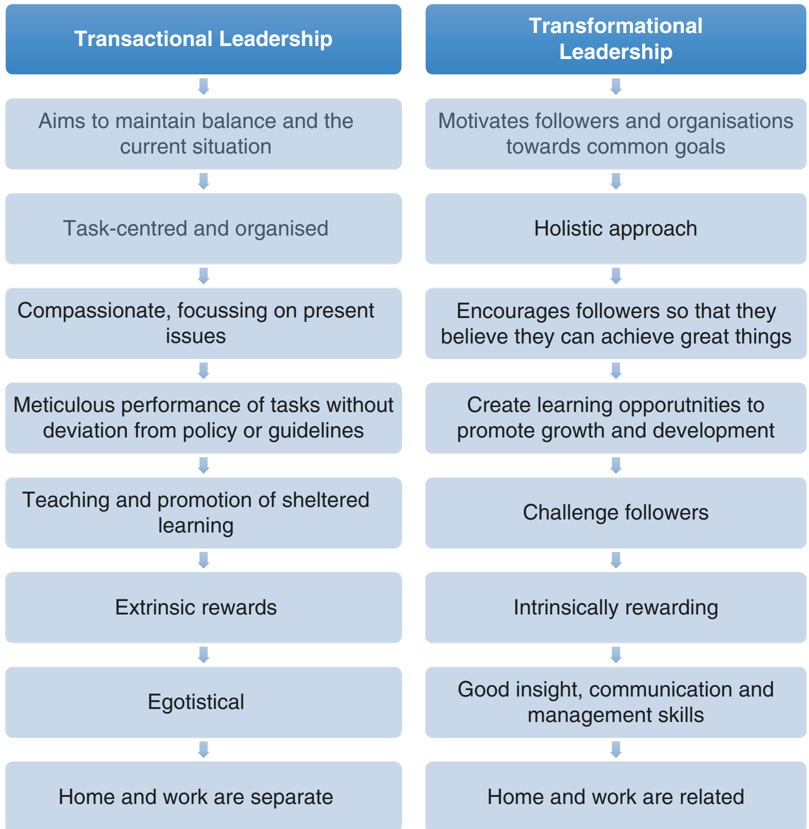

Fig. 4.2 Transactional vs. transformational leadership

Attributes of a Good Surgeon

Realising the benefits that good leadership and teamwork can deliver requires commitment from all those involved in patient care. From the surgeon's viewpoint there are numerous desirable attributes which are developed through medical school education, foundation training, core training and into professional practice [9]. These are outlined below [10]:

1. ***Clinical Care***
   An obvious consideration of what makes a "good surgeon" is the care provided to patients throughout the patient journey. This includes technical ability in the operating theatre and non-technical skills.
2. ***Maintenance and Improvement***
   Remaining up-to-date with innovations in surgical practice and patient care is an important attribute of a good surgeon. In doing so, one is able to inform patients and explain the reasons for and against procedures, allowing them to make an informed decision. Willingness to learn from others and improve from others by reviewing personal practice forms part of Continuing Professional Development; this is a requirement in a portfolio to meet revalidation and recertification criteria.
3. ***Teaching, Training and Supervision***
   Educating others forms part of professional development and surgeons frequently oversee projects for medical students or trainees. This requires knowledge of the objectives of the

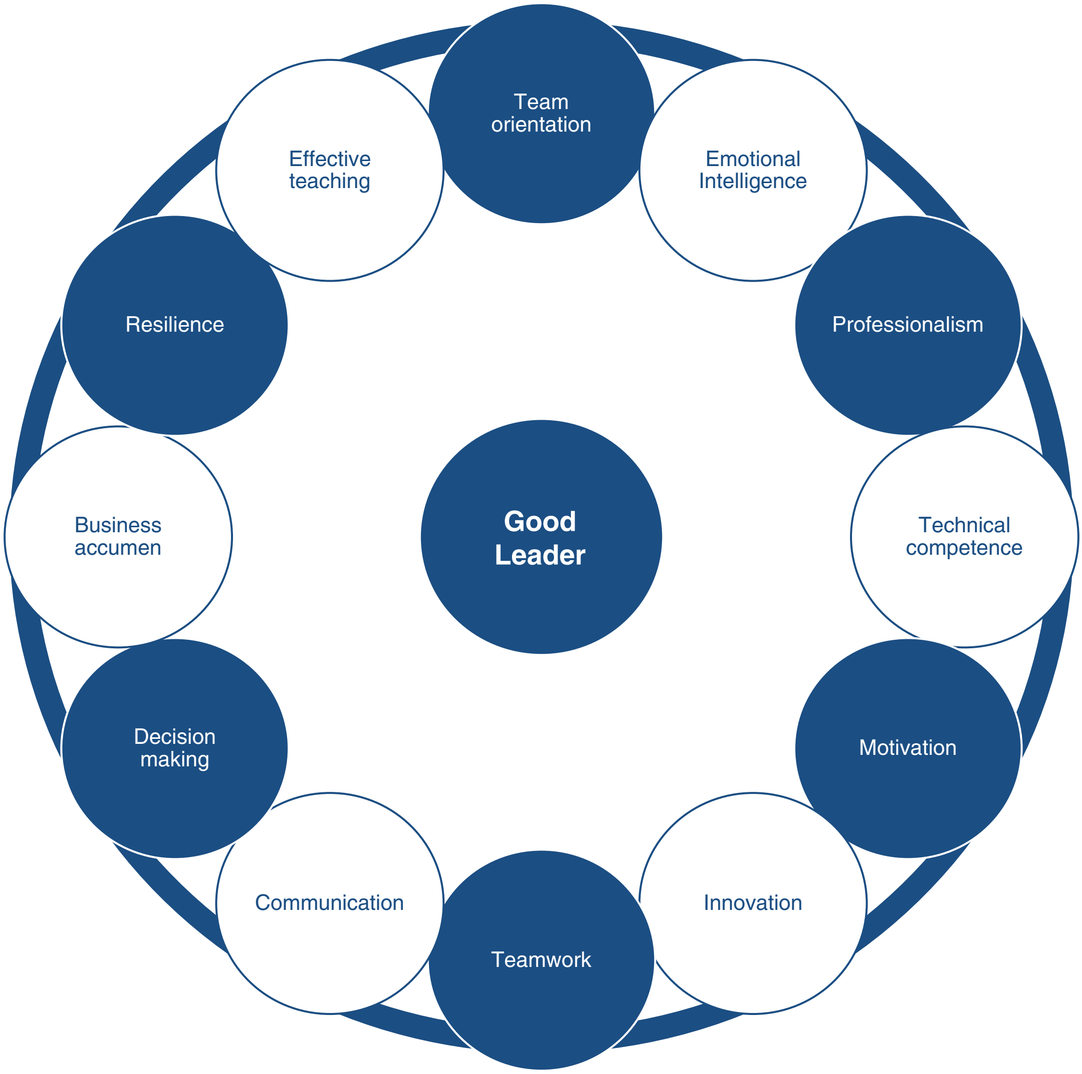

Fig. 4.3 Qualities of a good leader

tasks undertaken, knowledge of what technical and non-technical skills should be improved and knowledge of how to encourage the development of these skills. The mentor-mentee relationship should work both ways, such that the mentee is able to approach their supervisor for assistance and is accepting of any constructive criticism delivered.

4. ***Relationships with Patients***
   Relationships with patients are fundamentally based on trust; the patient trusts that the surgeon will do all in their power to help them and their surgical journey. Obtaining informed consent prior to clinical care is based on trust and allows patient autonomy to be upheld. Developing relationships with patients begins from the first consultation and is continued after the day of an operation being undertaken. Acknowledging the needs of the individual and employing effective communication helps in developing an open relationship. In this way patients disclose their medical history and admit underlying fears, allowing better patient care to be delivered.
5. ***Relationships with Colleagues***
   Partnership with all members of the multidisciplinary clinical team, management, technicians and support staff fosters healthy working relationships. Consequently, patient

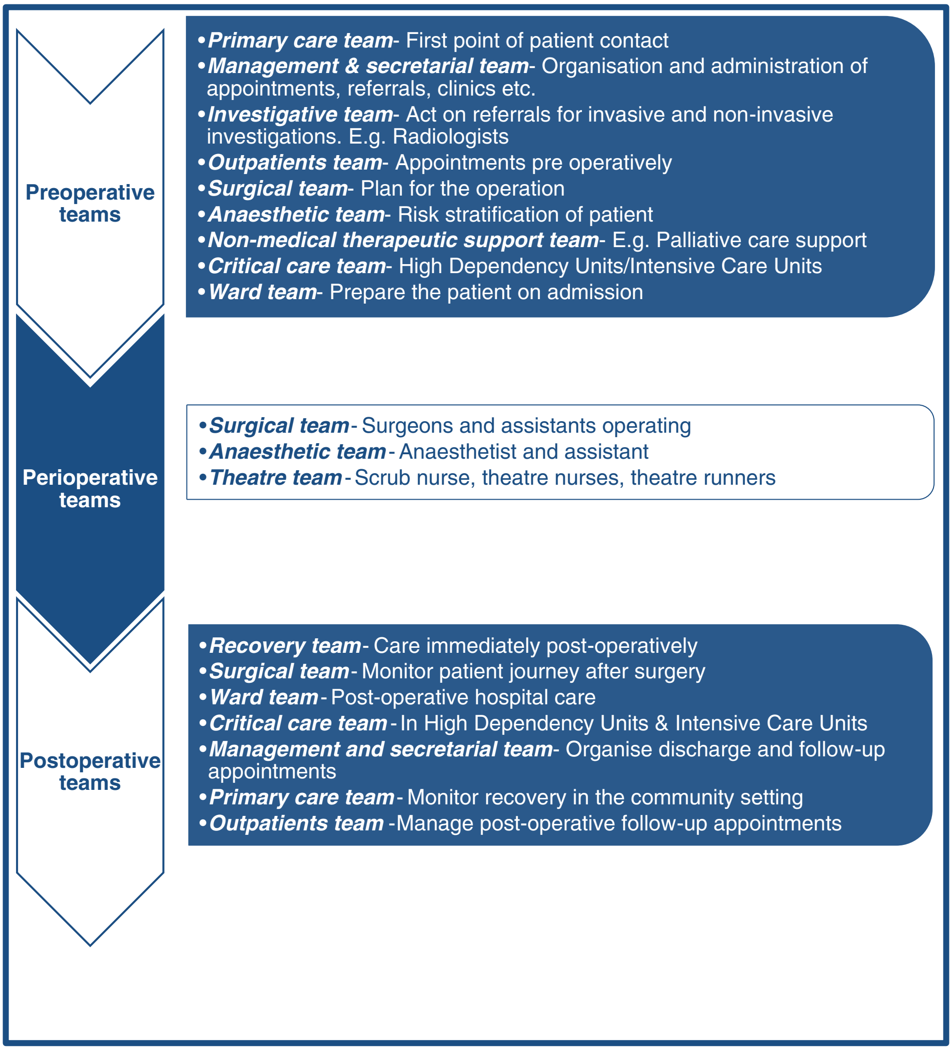

Fig. 4.4 Examples of clinical teams throughout the patient journey

care is enhanced through communication, enhanced productivity and an improved team dynamic. Understanding how a colleague works and taking action to facilitate a positive working environment is beneficial to all. Emotional intelligence forms an important component of working relationships, through the ability "to understand and recognise emotional states and to use that understanding to manage one's self and other individuals or teams" [2].

6. ***Health***

   Maintenance of good personal health and knowing when you must stop working is important in the protection of patient safety. The relevant senior staff must be informed of communicable disease or blood-borne disease transmission. In addition, being vigilant of the health of colleagues forms part of protecting patient safety, for example, failure to report suspicion that the consultant consistently operates after several glasses of wine or that the CT2 has been seen smoking drugs can facilitate the propagation of errors in the workplace. Finally, surgeons are renowned for working at all hours, however acknowledgement that we all need rest is crucial in good patient care.

Communication: The SBAR Tool

Effective communication between individuals within a team and between teams can enhance the benefits gained from teamwork including efficiency and patient safety. A specific framework has been designed to help clinicians share information about a patient's status and requirements. Adopting a structured approach to communicating patient information ensures that important details are not overlooked and that action can be taken promptly to meet the needs of patients. The SBAR mechanism includes details that are essential when discussing any case (Fig. 4.5) [5]. It is important to practice your ability to communicate a patient's information using the SBAR tool as it is frequently examined in OSCEs.

Situation

Primarily, one must set the scene for the individual receiving information. Ensure that they are not distracted by others but are listening and are ready to take notes if necessary. In many cases, communication between wards over the phone will require you to explain who you are, what your role is and from where you are calling. A brief overview of the relevant patient and why you have made contact should be given. For example:

> "Hello, it's Catherine Lovegrove speaking, I'm one of the CT2 doctors in ward 10. I am calling regarding Mr. Cooke in bay 5 who underwent a total hip arthroplasty two days ago. We have just reviewed him and are satisfied with how his wound is healing, his vital signs are all within normal range and he is looking well. I wonder can we arrange for a physiotherapist to come up to the ward and initiate rehabilitative exercises?"

Background

After setting the scene, more details about the case at hand can be explained. This includes information regarding the patient, their reason for

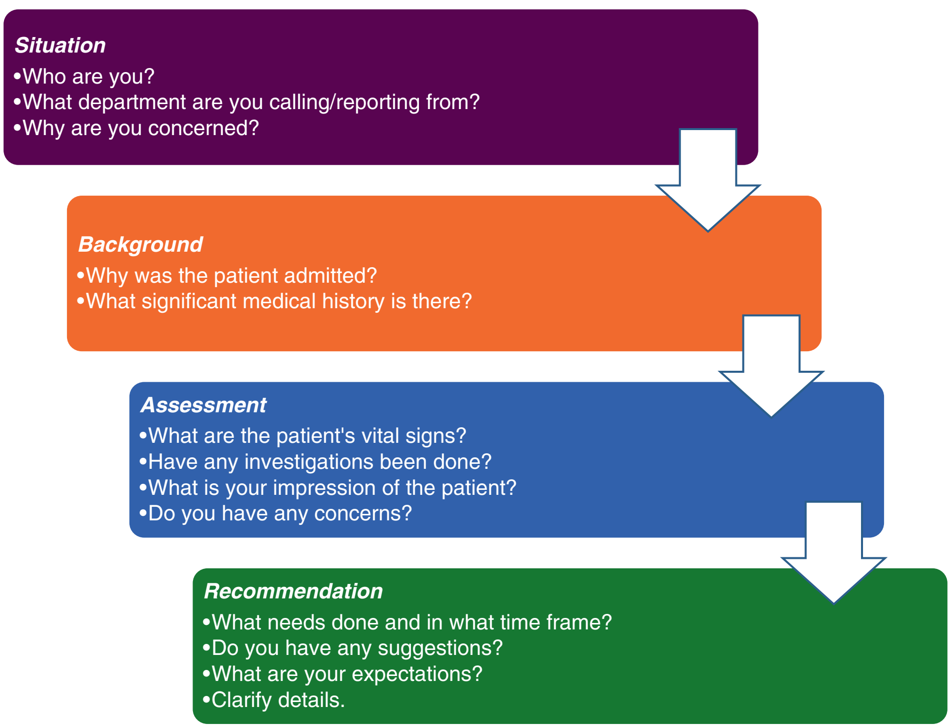

Fig. 4.5 SBAR framework for communication

admission and any relevant past medical history before elaborating in more depth on the patient's case. In describing the background, details regarding their condition, admission history and investigations should be communicated. For example:

> "Mr. Cooke is a healthy 70 year old man who came in two days ago with an intracapsular fracture to the femoral neck after slipping and falling on ice on the paving stones in his garden. After reviewing his x-ray results, he underwent total hip arthroplasty on the same day, which proceeded without complication. He suffers from type 1 diabetes, which is well controlled with insulin. We are monitoring the wound for infection, thus far all is well; urine output is good, oxygenation is satisfactory and his blood pressure was 134/73 mmHg on last measurement. Mr. Cooke lives independently at home with his wife and is a keen golfer in the summer."

Assessment

When describing your assessment of the patient's condition, use objective information such as results from investigations. In addition, it can be useful to call on information from other sources, such as nursing staff that have been regularly monitoring the patient. For example:

> "Given the fact that his progress is satisfactory I feel that he is ready to meet with a physiotherapist to discuss future rehabilitation. The nursing staff have said that he has been alert, but he has expressed concern that his quality of life will be limited if he does not resume activity soon. I think it would be beneficial and reassuring to him to initiate contact with the occupational therapy and physiotherapy departments so that he can be prepared when the time for his discharge comes."

Recommendation

Finally, conclude the conversation by explaining what you feel should be done, indicating when, by whom and how. As with any communication, make sure that your colleague has understood what you have told them and what you need to happen. This avoids unnecessary confusion that is inefficient and delays patient care. For example:

> "Can we arrange for a physiotherapist to come to the ward tomorrow morning and meet Mr. Cooke and explain how his rehabilitation will be structured and what he can expect in the coming days and weeks? I would also appreciate if an occupational therapist could consult Mr. Cooke about what adaptations he may need at the time of discharge so that he can continue to live as independently as possible. Does that make sense? Do you think someone will be able to come then?"

Using SBAR in an OSCE Setting

It is common in some medical school rotations to be asked to perform an SBAR to the examiner at the end of an OSCE station. In our experience, this is often after emergency/resuscitation stations, where you are expected to synthesise your findings into a succinct format to allow help to come as quickly as possible. In this case, your SBAR may be expected to be much shorter than the example above:

"*Situation:* Hello I'm Annabel Darling, one of the FY1 doctors in A&E. A 20 year old girl, Miss Charlotte Mason came in 30 min ago with a severe asthma attack which came on 2 h ago. Despite salbutamol nebulisers and high flow oxygen, her CO_2 is now rising and is currently 7.1 kPa. She is looking increasingly tired and her respiratory rate is now just 14 breaths per minute.

Background: She has been to ITU 3 times before with severe attacks, and is well known to the department. She has no other medical conditions.

Assessment: I am very worried about Charlotte, and her worsening type 2 respiratory failure needs to be acted upon immediately as I suspect she is getting tired and could become very unwell very quickly.

Recommendation: If you agree, I think we should get a bed in ITU for Miss Mason for intubation and mechanical ventilation. Would you be able to help me with this? How long will it take to secure this? Is there anything you would like me to do in the meantime?"

Student tip: "It is helpful to ask "Is there anything you would like me to do in the meantime?" after you do an SBAR. As well as being useful in reality, if you use it in an exam it may make you appear more on top of things and seem more competent than other students!" Rebecca Fisher, Medical Student, Edinburgh University.

Conclusion

The role of the surgeon within the surgical team and the multi-disciplinary environment has effects on patient care through various pathways. Healthcare efficiency, team dynamics and the patient experience are all heavily influenced by how a surgeon interacts with their colleagues and patients. Maintaining a careful balance in leadership style, and encouraging the use of effective communication are important considerations when thinking about the role of the modern surgeon. The diverse range of skills required should be continuously reviewed and assessed to ensure good practice.

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5 Preoperative Care

Catherine E. Lovegrove and Fahd Khan

Introduction

Surgery puts patients at the mercy of various stresses, both physiological and psychological. Good pre-operative care of surgical patients is essential for optimum post-operative recovery and long-term morbidity. This requires a multi-disciplinary approach with allied healthcare professionals, GPs, nurses, anaesthetists and surgeons collaborating for the best outcome of the patient.

Preoperative Assessment

History

Taking a patient's medical history is usually dictated by the circumstances. It may be possible to gain a thorough understanding of the cause of admission, though often not in emergencies. In elective cancer cases, the multi-disciplinary team (MDT) has the opportunity to thoroughly consider each patient to maximise the success of the surgery.

When taking a history, a systematic approach will help to gain a more complete understanding of the patient's needs. Several considerations should be made:

History of Presenting Complaint (HPC)

- Why does the patient need surgery?
  - This may be obvious e.g. elective hernia repair. These patients can be optimised for surgery to maximise success and minimise complications.
  - This may be less obvious in emergency surgeries e.g. suspected appendicitis. In such cases, surgery may have an exploratory nature to it and carry greater risk.
- What is the current state of the patient?
  - Consider if adjuncts to surgery are necessary.
  - Are they having trouble breathing? An anaesthetist should secure the airway and stabilise the patient prior to surgery.
  - Has there been mass haemorrhage? Fluid replacement with a blood transfusion could be indicated.
  - Are they dehydrated? Consider the cause of dehydration; vomiting or diarrhoea may call for crystalloid fluid replacement whereas low blood volume could call for colloid replacement. In cases of burns patients, dehydration is a pertinent risk and fluid replacement should be organised as a priority.

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Past Medical History (PMH)

- Consider patients' comorbidities that will affect their surgery. For example:
  - ***Asthma***: the respiratory system should be monitored closely during surgery.
  - ***Diabetes***: the form of diabetes (e.g. insulin dependent or independent) may have implications on operating. Patients with diabetes are often prioritised in the daily theatre list to avoid extended periods of fasting and the risk of hypoglycaemia. Patients with diabetes are at greater risk of infection, so the importance of good post-operative wound care is especially important.
  - ***Coronary heart disease***: can the patient withstand the physiological stresses of surgery on the cardiovascular system? Exercise testing pre-operatively to assess cardiac function may be undertaken.
  - All of the above considerations can be optimised prior to surgery. This is often undertaken by a GP or at a nurse-led clinic. For example, well-controlled asthma can be facilitated through respiratory clinics, and the importance of good glycaemic balance can be emphasised at a diabetes clinic.
  - Consider previous surgeries with implications for the surgical approach. For example:
    - ***Location of previous surgery***: patients with a history of abdominal surgery will often be unsuitable for laparoscopic hernia repair due to the difficulties associated with adhesions. Here, an open approach may be favoured.
    - ***Success of previous surgery***: if the patient had an adverse reaction to anaesthesia, this should be avoided.
  - Patients who experienced successful surgery previously may express similar treatment. For example, choosing general anaesthetic over local anaesthetic.
  - Patients who suffered complications such as wound infection, DVT or re-operation may express a preference for a different approach or mode of care. Where appropriate, their preference should be facilitated.
- Consider existing medication and how this will interact with anaesthesia and surgery:
  - Particularly important in patients with cardiovascular comorbidities. For example, patients on warfarin, aspirin or clopidogrel should have medication stopped prior to surgery to avoid excessive haemorrhage.
  - Patients on immunosuppressive treatment should be identified due to increased risk of wound infection.
  - Oral contraceptives can place patients at an increased risk of DVT or PE, and in many cases is discontinued over a month pre-operatively.
  - Opiate analgesia may precipitate respiratory depression.
- Consider any allergies important to the surgical setting.
  - Do they or their family have a history of the allergy?
  - What is their reaction? Is it severe enough to warrant avoiding medication?
  - Weigh up the risks and benefits of the reaction vs. the medication: a reaction of a mild skin rash may not warrant eliminating a drug from the treatment plan, whereas anaphylactic shock would.
  - Important allergies in the surgical setting include:
    - ***Penicillin***: antibiotic cover is often used for infection control protocol and varies according to hospital microbial guidelines.
    - ***Anaesthetic***: Malignant Hyperpyrexia is an inherited autosomal dominant disorder causing an excessive rise in temperature in reaction to anaesthesia. This is associated with 10 % mortality. Any personal or family history should be discerned as a priority.
    - ***Latex***: patients should be prioritised.
    - ***Elastoplast***: plaster and tape are widely used when securing tubing and monitoring cables intra-operatively. Seek an alternative.

Social History

- Illicit drugs: patients may have a history of intravenous drug use so beware of blood-borne

viruses. Similarly, be aware of interactions with surgery, such as opiates and depressed respiratory drive.
- Alcohol: identify alcohol dependence and aim to avoid withdrawal symptoms.
- Smoking: optimise in the community with smoking cessation clinics to improve respiratory function and promote post-operative recovery.

Examination

Depending on the timing of surgery, thorough examination may not be possible. Where circumstances allow, a full, systemic examination of the patient should be conducted. General examination includes:

- The nutritional status of the patient, their hydration and weight. Assess for weight loss and determine whether this was intentional, unintentional or related to a lifestyle change such as exercise or diet.
- Consider non-specific symptoms such as fever, oedema, finger clubbing, anaemia or jaundice. These are important factors for surgery, although they're not specific to one pathology.

Assessing Risk and Preoperative Testing

Several objective measures of a patent's risk from surgical complications exist. Risk stratification is related to recommendations for pre-operative investigations to facilitate the preparation of necessary surgical adjuncts and the monitoring of patients throughout surgery and recovery [4].

Possible pre-operative tests include:

- Blood tests
  - Full blood count
  - Biochemistry
  - Clotting factors
  - Glucose
  - Arterial blood gas
  - Liver function tests
- Urinalysis
- Lung function test
- Sickle cell test
- Pregnancy test
- Chest X-ray
- Resting electrocardiogram (ECG)

Different grading schemes focus on patient comorbidities, the severity of surgery, or the patient's physiological state.

Surgical Grading

Surgical grading is based on the severity of the procedure being undertaken (Table 5.1).

American Society of Anaesthesiologists (ASA) Grading

ASA grading is based upon the ability of the patient to tolerate anaesthesia according to the

Table 5.1 Surgical severity grading

Surgical grade	Definition	Example
1	Minor	Excision of skin lesion; drainage of breast abscess
2	Intermediate	Primary repair of inguinal hernia; excision of varicose vein(s) of leg; tonsillectomy/adenotonsillectomy; knee arthroscopy
3	Major	Total abdominal hysterectomy; endoscopic resection of prostate; lumbar discectomy; thyroidectomy
4	Major +	Total joint replacement; lung operations; colonic resection; radical neck dissection
Neurosurgery	–	–
Cardiovascular surgery	–	–

Table 5.2 ASA grading

ASA grade	Definition	Example	Typical mortality (%)
I	"Normal healthy patient" (Without any clinically important comorbidity and without clinically significant past/present medical history)		0.05
II	"A patient with mild systemic disease"	Occasional use of GTN spray for stable angina (2–3 times per month) Well controlled diabetes with no obvious complications	0.4
III	"A patient with severe systemic disease" Note: Disease is not a constant threat to life.	Regular use of GTN spray (2–3 times per week) for unstable angina) Poorly controlled diabetes, diabetic complications (e.g. claudication, impaired renal function)	0.45
IV	"A patient with severe systemic disease that is a constant threat to life"		25
V	"Not expected to survive 24 h with or without surgery"		50

extent of their disease (Table 5.2). In addition, it provides an indication of the mortality risk associated with each level [1].

Fifty percent of surgery is carried out on patients from Grade I. As grading increases, so too do associated comorbidities, thus increasing the risk of post-operative morbidity and mortality.

Key Points

- A more thorough investigation of a patient's history reduces the likelihood of unanticipated complications arising at any stage of the patient's journey.
- Careful consideration of pre-operative investigations is beneficial to patients and hospital spending.

Capacity and Consent

What?

In twenty-first century healthcare in the UK, patients choose their pathway of care. This relies on two elements: capacity and consent.

"Capacity" refers to the *ability* "to make decisions about their care, and to decide whether to agree to, or refuse, an examination, investigation or treatment" [3]. This relies upon the provision of information, risks, benefits and alternatives by a doctor. To have capacity, a patient must be able to satisfy the following conditions:

- Understand and retain information regarding the treatment
- Evaluate the risks and benefits of treatment
- Reach a decision regarding their course of treatment
- Communicate their decision to the clinician

At all stages, doctors and surgeons must act to facilitate the capacity of patients. This involves presenting information in a way that the individual can understand, and using several means of communication where necessary. Capacity is dependent on the situation and may change according to the setting. For example, a deaf patient may lack capacity to choose treatment for their inguinal hernia when a surgeon talks to him/her, but may be able to do so when presented with the information in written form.

"Consent" is the patient's decision to accept or reject a path of care. In doing so, patients place great trust in information provided by their surgeon. This trust is established early in the doctor-patient relationship and is subject to the patient's experience.

When?

Consent is required when accepting or rejecting treatment. This includes everything from straightforward procedures such as measuring blood pressure to complex end-of-life decisions.

Oral or written consent are appropriate in many situations and consent may be implied; for example, the patient places their arm on the desk for a blood pressure measurement. Oral or implied consent can be sufficient in cases of minor treatment, such as venepuncture or the administration of local anaesthesia. However, in cases that carry greater risks, completion of a written consent form is essential. Where this is not possible, such as emergency treatment, advanced-directives or attorneys must be taken into account. Where these do not exist, treatment must proceed in the best interests of the patient but be limited to the emergency situation (i.e. when undertaking an emergency laparotomy for obstructed bowel, the patient's appendix should not be removed "in case of future appendicitis").

Who?

Doctors

Where possible, the doctor initiating the treatment or procedure should obtain consent from the patient. Where this is not possible a colleague can obtain a patient's consent when the following conditions are satisfied:

1. They are of the appropriate training and proficiency that they could prescribe the treatment or operate on the patient if necessary
2. They understand the procedures and risks within treatment being undertaken
3. They ensure the patient's consent and capacity at all stages of treatment.

Patients

Ideally, individuals make decisions relevant to their own care. This relies on them having "Capacity" (the ability to understand, retain, weigh up and decide upon the information provided by a clinician). In some circumstances there are exceptions or this may not be possible:

- Children and young people [2]
  - At the age of 16 years, patients are presumed to have capacity. Younger individuals can consent to treatment where deemed to have capacity, however cannot refuse life-saving treatment.
  - Children under 16 who lack capacity should be helped to understand their care, though parental consent is required.
  - 16–17 year-olds who lack capacity are managed differently according to national legalities:
    - England, Wales and Northern Ireland; parents may consent to treatment in the young person's best interests. Decisions may be over-ridden if they are not in the patient's best interests
    - Scotland; individuals will be considered as adults who lack capacity and be managed as such
  - Seek legal advice if uncertain
    - Adults who lack capacity in the specified situation
  - Mental illness does not mean that an individual lacks capacity; capacity is situation-dependent.
  - Where an individual lacks capacity, adults are considered under the *Mental Capacity Act 2005 (England and Wales)* or the *Adults with Incapacity (Scotland) Act 2000).*
  - A medical attorney may be appointed to make decisions for the patient
  - Unconscious patients will be treated in their best interests to provide life-saving treatment from the situation at hand

How?

Informed consent requires effective communication with patients. Details of the treatment, risks, potential benefits and alternatives must be delivered. Patients often have questions regarding related articles from media sources. It is paramount that surgeons remain up-to-date on recent research and controversies regarding therapies, both in the mass media and medical or scientific journals.

Information should be accessible to patients; where appropriate, use verbal explanations, visual aids, drawings, audio-visual media and leaflets. The consultation environment is an important

Table 5.3 Consent form criteria

Consent form	When to use
I	When an individual is consenting to his or her own treatment or investigations
II	When an individual with parental responsibility is consenting to a child's treatment
III	When an individual or one with parental responsibility is consenting to investigation or treatment that will not impair consciousness
IV	When an adult patient lacks capacity to give or withhold consent to treatment

additional consideration; ensure a quiet, private room where you are not disturbed. A private, light and quiet room with minimal distraction from other staff, patients or décor is ideal.

There are four main consent forms for use in the clinical setting, each serving a different role according to the patient being considered (Table 5.3. Consent form criteria).

Key Points

- Required in all aspects of patient care.
- May be implied, written, verbal or video demonstrations.
- Where possible obtain consent from the patient themselves.
- Where possible the surgeon operating should obtain consent, if not a suitably qualified colleague.
- Special arrangements exist for consenting in cases of children, patients with mental incapacity, emergencies and advanced directives.

Enhanced Recovery Programmes

Given the stressful effects of surgery on patients' physiologically and psychologically, a framework exists to minimise the duration of hospital stay and complications encountered. Enhanced recovery programmes will be discussed in greater depth in the Post-Operative Care chapter, though here the pre-operative considerations will be discussed.

Pre-operatively, structured management of the patient can accelerate post-operative recovery. Factors to be considered can be found in Fig. 5.1.

Summary of Preoperative Care

Patients are optimised in the community prior to admission; ideally smokers, overweight patients, diabetic patients and those with respiratory disease will have been well prepared for the procedure which they are to undergo. Hospital admission is ideally on the day that an elective surgery is scheduled to take place. Prior to reaching the operating theatre, several steps should be followed systematically (Fig. 5.2). This is a simplified representation of the pre-operative care pathway, but serves as a useful reminder of the plethora of considerations that must be made before even reaching the operating theatre to ensure maximum success peri-operatively. Many factors continue to be monitored peri-operatively, such as thrombo-prophylaxis and infection prevention, however establishing them early upon admission can serve to maximise the success of surgery.

Surgeons' Favourite Questions for Students

1. Describe how to take a thorough history from a patient.
2. Explain the relevance of risk stratification.
3. What is the difference between "consent" and "capacity"?
4. What conditions must be met for a patient to have "capacity"?
5. Who can obtain consent from a patient?

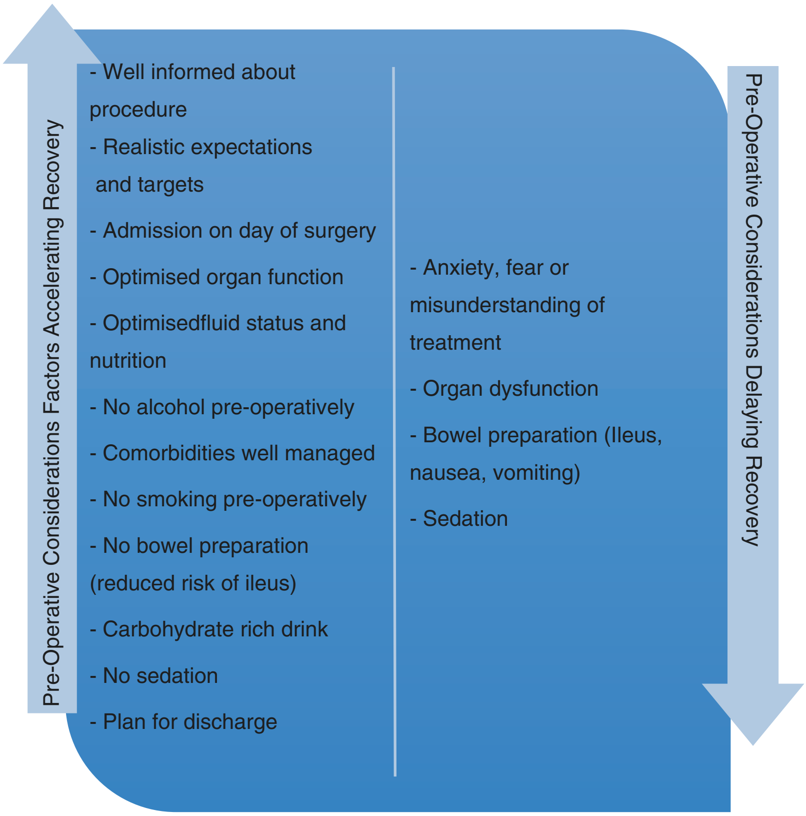

Fig. 5.1 Pre-operative considerations within the enhanced recovery programme

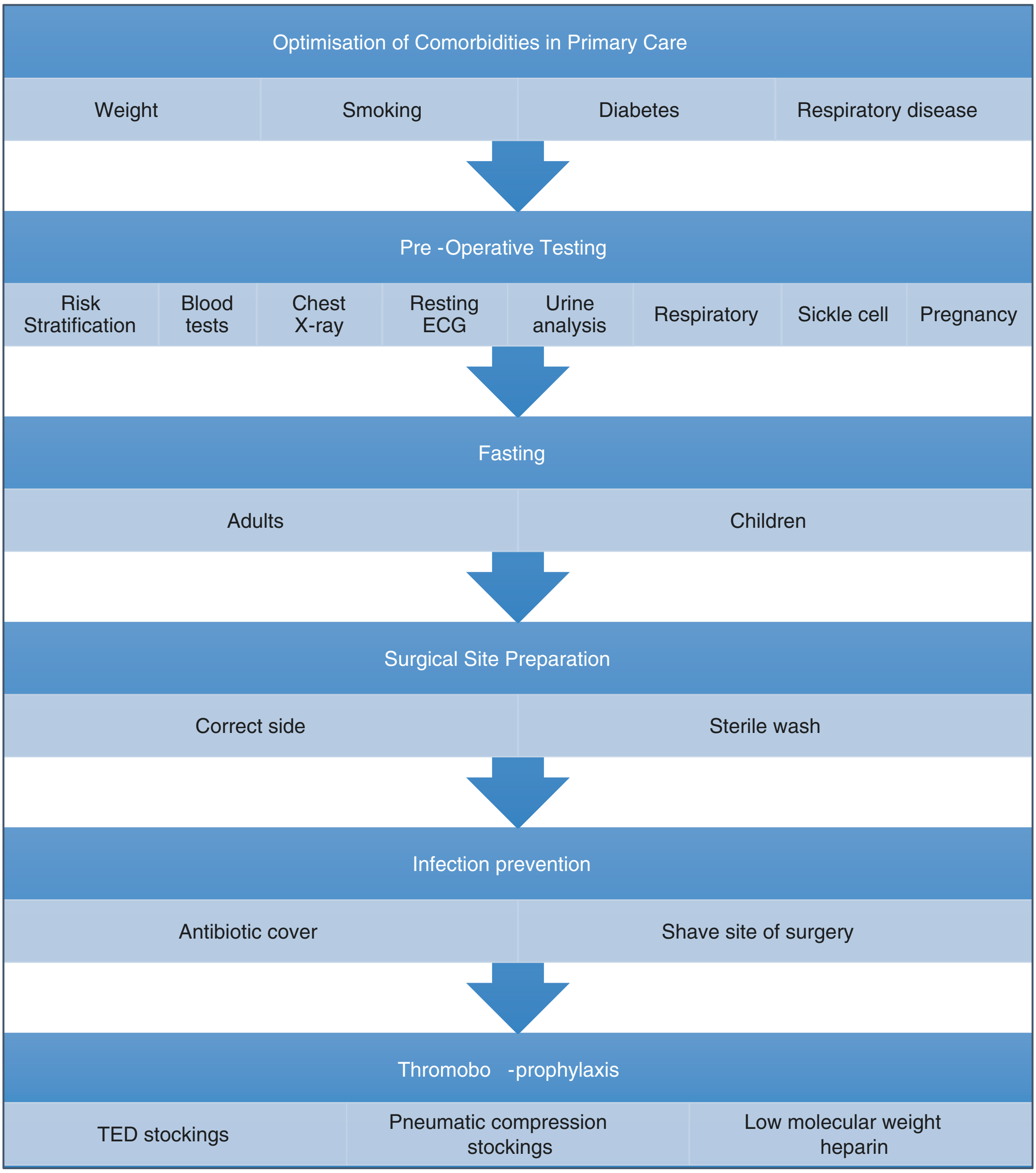

Fig. 5.2 Summary of pre-operative care pathway

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6 Anaesthetics

Edward T. Robinson and Akhil Gupta

Introduction

Anaesthesia (*Greek: an- without* and *–aesthesis sensation*) is the art of inducing a reversible loss of awareness and sensation. In general anaesthesia this is achieved with an additional reversible loss of consciousness, whereas in local and regional anaesthesia, a specific, targetted part of the body becomes temporarily insensate.

Before the development of modern anaesthesia in the nineteenth century, surgical procedures were usually very brutal and a last resort, typically involving unbearable pain, variable success, and requiring considerable force to restrain the patient. At best, sedatives such as alcohol were available, but were not administered to every patient. The advent of modern anaesthetic practice, and the development of the intravenous and inhalational agents used today have made innumerable invasive and surgical procedures possible.

Anaesthetic Assessment

The anaesthetist plays a vital role in the management of any surgical patient (Fig. 6.1). A pre-operative assessment is carried out by a multidisciplinary team including nurses, anaesthetists and other medical professionals to ascertain the patient's physiological status, identify those at high risk of perioperative complications, and to determine what investigations and interventions may optimise the patient's condition for surgery. An intra-operative management plan is then developed, taking into consideration the patient's general physiological state, the nature of the surgery, and patient choice. In some patients, a general anaesthetic is too risky and it may be more optimal to use a regional technique. For example, in a patient with severe respiratory disease undergoing lower limb surgery (e.g. hip replacement) a spinal anaesthetic may be most appropriate [3].

In the post-operative setting, the anaesthetist may provide an enhanced level of care in the high dependency unit (HDU) or intensive care unit (ICU) as well as playing an important role in general patient follow-up, management of analgesia and post-operative nausea and vomiting.

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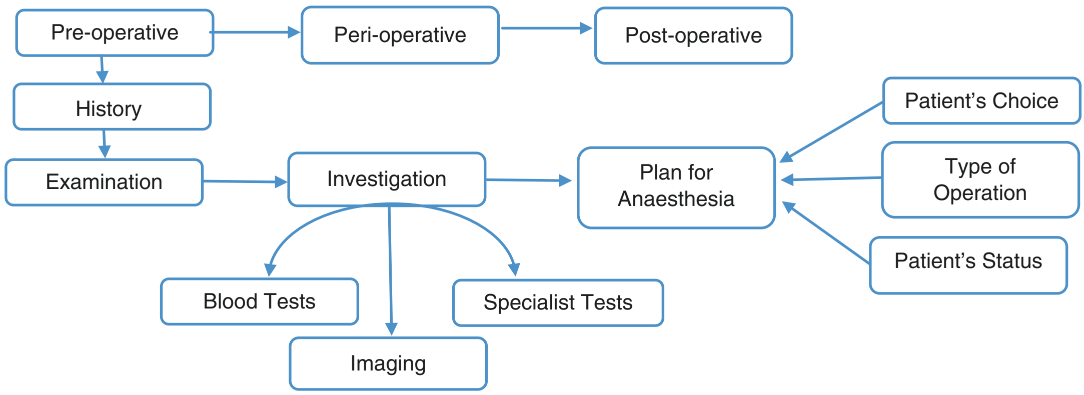

Fig. 6.1 Role of the anaesthetist (Image drawn by Akhil Gupta 2014)

Types of Anaesthetic

- Local
- Regional
  - Central Neuraxial blocks
    - Spinal
    - Epidural
  - Peripheral Nerve Blocks
  - Intravenous regional anaesthesia (Bier's block)
- General

Local and Regional Anaesthesia

Local anaesthesia works in a small, defined area around the location it is administered by means of topical creams, sprays or superficial injections. Note that local anaesthetics are not directly deposited into a nerve, but in the perineural tissue surrounding it. Administering agents with adrenaline increases their duration of action by constricting blood vessels, which limits local bleeding and reduces the likelihood of toxicity. However, adrenaline-containing local anaesthetics must never be administered into tissue where perfusion depends on end vessels (e.g. the digits) as this may lead to ischaemia and necrosis.

There are two classes of local anaesthetic:

- **Aminoamides**
  - Lidocaine, bupivacaine, mepivacaine
  - Metabolised by liver amides
- **Amino-esters**
  - Procaine, cocaine, benzocaine
  - Metabolised by tissue and plasma esterases
  - Have a higher incidence of allergic reactions.

Indications

- Minor procedures
  - Tooth extraction
  - Biopsy
- Wound Infiltration
- Regional anaesthesia
- Anti-arrhythmic (Class Ib)

Mechanism

The mechanism of local anaesthetic drugs is dependent on the degree of ionisation at any given pH (Fig. 6.2). Following administration, at physiological pH (7.4) the unionised lipophilic molecules cross the cell membrane by diffusion. The intracellular pH is lower than plasma pH causing the unionised molecules to become ionised and therefore trapped in the intracellular space. These molecules then bind to the intracellular surface of the cell membrane sodium channels, preventing the propagation of action potentials and stopping nerve transmission. Smaller nerve fibres which transmit pain are blocked more readily than larger nerve fibres for light touch.

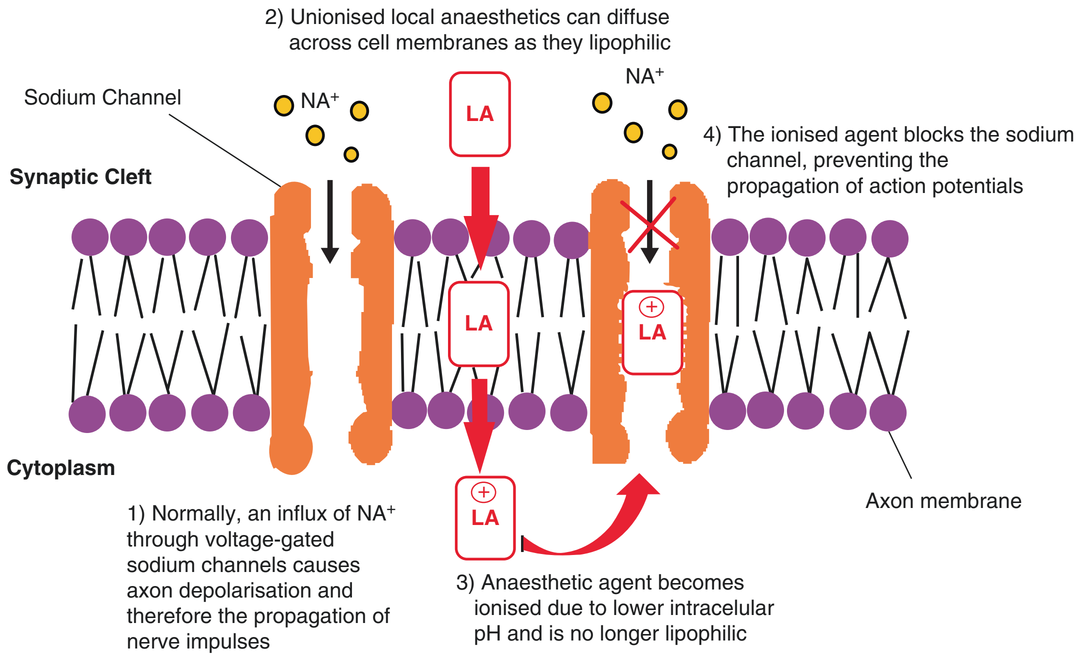

Fig. 6.2 Mechanism of local anaesthetics (Image drawn by Akhil Gupta 2014)

Factors Affecting the Potency of Local Anaesthetics

pKA The pKA of a substance is the pH at which it is 50 % ionised and 50 % unionised. The further away the pKA is from the physiological pH, the greater the ionised fraction of drug. An agent with a pKA close to plasma pH will have a faster onset, as a greater proportion of it will be unionised when administered.

Lipid solubility A more lipid-soluble agent has a higher potency as it can more readily enter the nerve cell.

Protein binding Greater protein binding increases the duration of action.

Potential Complications and Contraindications

Complications of local anaesthetic can either be localised or systemic. Localised reactions are rare, but mostly caused by an allergic reaction to the metabolites of the drug. This is more common with amino-esters than amino-amides.

Systemic Toxicity

Systemic toxicity is caused by high plasma levels of local anaesthetic agent. Typically toxicity presents with immediate and delayed systemic features mostly affecting the central nervous and cardiovascular systems, with some effects on the haematological and immune systems (Table 6.1).

Systemic toxicity is treated by administering an intravenous lipid infusion (lipid rescue) which draws out the lipophilic local anaesthetic agent from the blood stream and any affected tissues.

Regional Anaesthesia

Regional anaesthesia involves the administration of a local anaesthetic over a wider area allowing for more invasive procedures than superficial administration e.g. inside body cavities, without the need for a general anaesthetic. Agents may be injected into either the epidural or subarachnoid spaces surrounding the spinal cord, space around large nerve plexuses or large peripheral nerves and intravenously to achieve a Bier’s block.

Epidural (Extradural)

In epidural anaesthesia, local anaesthetic is injected into the potential space (extradural space) surrounding the Dura mater. This space extends from the craniocervical junction to the sacral hiatus and contains the segmental spinal nerves. A *Tuohy* needle may be inserted between vertebrae with the help of an air or fluid-filled syringe to administer the agent (Fig. 6.3). Indications for the use of an epidural include achieving surgical anaesthesia of a specific region of the body, (in the treatment of pain, both chronic and acute) treating acute or chronic pain e.g. in labour, or post-operatively. In addition to local anaesthetics, drugs including opioids, steroids and other medications may be given down the epidural as a one-off injection, or as a continuous infusion.

Examples include:

- Lumbar epidural – pelvic and lower limb surgery
- Thoracic epidural – thoracic surgery
- Caudal epidural (more common in paediatrics) – procedures below the umbilicus
- Cervical epidural –neck surgery, chronic pain
- Injection of opioids for pain relief
- Injection of steroids e.g. pain relief for spinal stenosis or IV disc herniation

Table 6.1 Features of systemic local anaesthetic toxicity

System	Effects
Central nervous system	Tinnitus (Ringing in the ears) Metallic taste Tingling sensation in the tongue Dizziness Seizures Unconsciousness
Cardiovascular	Bradycardia Tachycardia Arrhythmias Myocardial depression Cardiovascular collapse ± cardiac arrest
Haematological	Methaemoglobinaemia – A process by which the oxygen-carrying potential of haemoglobin is altered resulting in cyanosis and hypoxia (inadequate oxygen perfusion)
Immune system	Anaphylaxis (systemic rapid immune response which can be fatal)

Spinal (Intrathecal)

Spinal anaesthesia involves the injection of local anaesthetic directly into the cerebrospinal fluid (CSF) within the subarachnoid space. This space lies between the pia and arachnoid mater and in addition to CSF, contains blood vessels, spinal nerves and the spinal cord. In adults, the cord extends down to the level of L1/2, and therefore to avoid damage to the cord, the needle may only

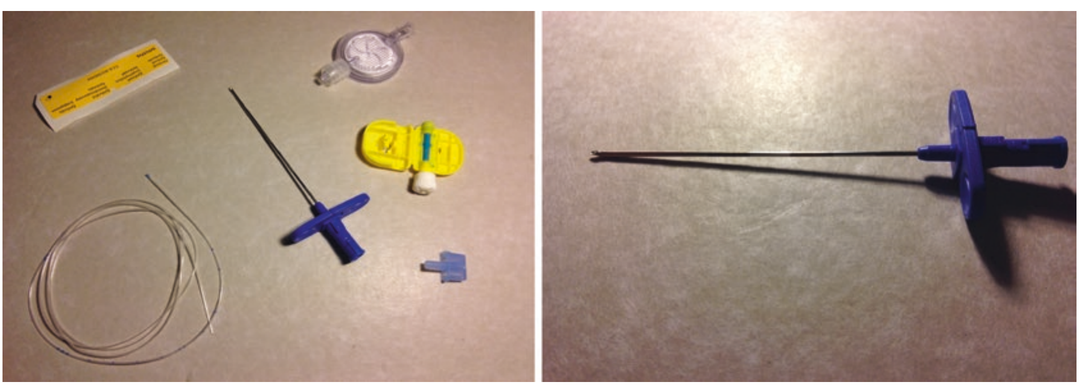

Fig. 6.3 An epidural kit – note that the Tuohy needle is slightly curved at the end (Photos: Taken by Akhil Gupta 2014)

Table 6.2 A comparison of epidural and spinal blocks

Procedure	Injection site	Technique	Typical injected dose	Onset	Indications	Potency
Epidural	Extradural space at cervical/thoracic/lumbar sites	A catheter is left in the epidural space, and may be used for a continuous infusion or single injection	10–20 ml	5–15 min	Surgical anaesthesia Acute pain relief Chronic pain treatment	Typically produces a less dense block
Spinal	Subarachnoid space below L2	One-off injection	1–3.5 ml	~5 min	Surgical Anaesthesia	Dense block produced

be inserted below the 2nd lumbar and above the 1st sacral vertebra. A single injection is used which acts for a limited amount of time, providing a denser block with a smaller volume of anaesthetic compared to an epidural (Table 6.2).

Peripheral Nerve Blocks

Regional anaesthesia can also be achieved by blocking specific peripheral nerves. This is effective for operations on the limbs, with the brachial and lumbosacral plexuses being excellent targets. Moreover, a peripheral nerve block provides a suitable alternative for managing peri- and post-operative pain in patients who are already taking large doses of painkillers such as opiates, therefore avoiding side effects such as respiratory depression and constipation.

Procedures include:

- **Cervical plexus blocks**
  - Carotid surgery
  - Trigeminal neuralgia
- **Brachial plexus blocks – (interscalene, supraclavicular, axillary)**
  - Upper limb pain
  - Upper limb surgery
- **Lumbar plexus ± sciatic nerve**
  - Lower limb surgery
  - Hernia repair
- **Specific peripheral nerves**
  - Median or ulnar nerve for finger surgery
  - Fascia iliaca for hip pain relief
  - Fibular/Peroneal, Tibial, Sural and Saphenous nerves for foot surgery

IV Regional Anaesthesia: Bier's Block

The Bier's block is a seldom-used technique to provide anaesthesia **intravenously** to perform brief surgical procedures on the limbs, e.g. management of distal forearm fractures.

- The limb is exsanguinated (drained of blood) through the use of a double cuff applied at the top of the arm with initially only the upper cuff inflated.
- Local anaesthetic is injected into the limb through a catheter.
- The limb is checked for anaesthesia before inflating the lower cuff and deflating the upper cuff. The catheter is removed.
- Surgery may then be performed on the limb assuming sufficient anaesthesia.
- One cuff must remain inflated for at least 20 min to ensure that the anaesthetic agent is absorbed into local tissue to avoid systemic toxicity.
- The lower cuff is deflated and the patient is monitored for toxicity.

Benefits of Regional and Local Anaesthesia

- Patient preference
- Patient factors

  - Avoids specific complications if there are risk factors – malignant hyperpyrexia/hyperthermia
  - Reduces risk of post-operative nausea and vomiting.
  - Disease factors – severe systemic disease makes it more risky to administer general anaesthesia
- Effective perioperative analgesia, e.g. a total knee replacement

General Anaesthesia

General anaesthesia is a reversible drug-induced loss of consciousness that facilitates surgical procedures that would otherwise cause pain and distress. The discovery and development of general anaesthetics in the 1840s, paved the way for modern surgery and without them much of modern medicine would be impossible. An ideal general anaesthetic drug will cause a physiological state including:

- Analgesia
- Suppression of sensory and autonomic reflexes and stress responses
- Skeletal muscle relaxation
- Amnesia
- Loss of consciousness

And will have:

- A rapid onset of action
- A rapid reversal of effects after discontinuation
- Minimal after-effects
- Minimal drug interactions
- Minimal side-effects

No single drug satisfies all of these 'ideal' criteria and while it is possible to achieve a state of anaesthesia suitable for surgery using a single agent, normally a combination of drugs is used. Modern anaesthesia utilises a combination of the following agents:

- **Intravenous** e.g. for induction
- **Inhalational** e.g. maintenance of anaesthesia
- **Local Anaesthetics or nerve blocks** provide perioperative analgesia
- **Muscle relaxants** control ventilation and the surgical field relaxing the patient's skeletal muscle to provide better operating conditions
- **Opioids** e.g. *fentanyl* provide strong pain relief since most general anaesthetics do not specifically block pain
- **Antiemetics** e.g. *ondansetron* to combat nausea and vomiting

General anaesthetics are classified based on the route of administration:

- **Inhaled agents**
  - Sevoflurane
  - Isoflurane
  - Desflurane
  - Nitrous Oxide (Entonox with 50 % O_2)
- **Intravenous agents**
  - Propofol
  - Thiopental sodium – used in obstetrics and status epilepticus
  - Ketamine – paediatric patients/cardiac instability/developing world
  - Etomidate (rarely used)

It is not actually known how anaesthetic agents work at the cellular or molecular level. IV induction agents are thought to promote the role of the inhibitory neurotransmitter – GABA – and suppress excitatory NMDA receptors of the CNS, therefore suppressing excitatory action potentials and nerve transmission [1]. Inhaled agents however 'compartmentalise' by diffusing into fatty tissue, crossing the bilipid membrane. This causes the intracellular pressure to increase and splints transmembrane proteins apart, which act as receptors for excitatory neurotransmitters, thereby preventing action potential transmission.

Minimum Alveolar Concentration (MAC)

The potencies of different inhaled anaesthetics are described in terms of their minimum alveolar concentration (MAC), expressed as a percentage

Table 6.3 Factors leading to an altered MAC

Factors causing reduced MAC	Factors causing increased MAC
Elderly Hypotension Hypothermia Hypothyroidism Administration with opioids Administration with N_2O Acute alcohol consumption (sedative effect)	Infants (A higher body water content results in slower compartmentalisation) Pyrexia (fever) Pregnancy Hyperthyroidism Chronic alcohol consumption due to the induction of liver enzymes

of alveolar gas mixture at atmospheric pressure. The MAC of an agent is the minimum end-tidal alveolar concentration which will prevent a purposeful response to a standard noxious stimulus in 50 % of the population, e.g. a skin incision during surgery. Therefore, an agent with a low MAC e.g. Halothane will be more potent than an agent with a high MAC e.g. Sevoflurane, as less of the agent is required to produce the same depth of anaesthesia. The value of the MAC of an inhaled agent may be altered under a number of conditions which must be taken into account by the anaesthetist (Table 6.3). This is particularly useful since it can increase the effectiveness of the agent, while avoiding the adverse effects of an increased dose.

Complications of General Anaesthesia

- Post-operative nausea and vomiting
- Damage to teeth when intubating
- Pulmonary aspiration of gastric contents – The gastroesophageal sphincter may fail due to muscle relaxants causing reflux and aspiration
- Iatrogenic e.g. a pneumothorax caused by central line insertion
- Anaphylaxis – An allergic reaction to the anaesthetic agent
- Malignant Hyperpyrexia/hyperthermia – A rare genetic predisposition resulting in a reaction to inhaled general anaesthetics causing a sudden rise in temperature and ultimately leads to metabolic acidosis, hypercalcaemia and cardiac arrhythmia. This is an emergency that must be treated with **dantrolene.**

Airway Management

Effective airway management is necessary to ventilate patients who are unable to do so themselves, or to administer inhaled agents for induction and maintenance of anaesthesia. The patency of the oropharynx depends on muscles as there is no bony support, and therefore unconsciousness may compromise the airway due to the loss of muscular tone. Typically, the tongue of a supine patient falls back over the pharynx, causing airway obstruction. Airway manoeuvres such as the head-tilt, chin-lift and jaw thrust, are performed to lift the tongue and clear passage to the larynx, allowing the placement of airway adjuncts (Fig. 6.4).

Airway Adjuncts

These are simple devices designed to help maintain airway patency and include:

- Nasopharyngeal airway (NPA)
- Oropharyngeal (Guedel) airway
- Laryngeal Mask airway (LMA)

Nasopharyngeal Airway (NPA)

NPAs (Fig. 6.5) are inserted into nasopharynx via a nostril and consist of a bevelled end, which is inserted, and a flanged end which remains outside to hold the adjunct in place. In drowsy or semiconscious patients who need airway support, NPAs are the best tolerated airway adjunct, without the need for sedation.

Oropharyngeal (Guedel) Airway

Oropharyngeal airways (Fig. 6.6) are inserted into the oral cavity to create a clear passage from the outside to the supraglottic space. The flanged end sits between the incisors, and the small end

Fig. 6.4 Head-tilt, chin lift and jaw-thrust manoeuvres

Fig. 6.5 Nasopharyngeal airway (Photos: Taken by Akhil Gupta 2014)

sits in the oropharynx. Oropharyngeal airways are often used in unconscious patients to assist ventilation, often after the induction of anaesthesia during surgery. They are not well tolerated by patients who are awake or semi-conscious and are likely to induce a gag reflex and vomiting.

Fig. 6.6 Oropharyngeal (Guedel) Airway (Photos: Taken by Akhil Gupta 2014)

Laryngeal Mask Airway (LMA)

LMAs (Fig. 6.7) are used for both spontaneous and controlled ventilation and essentially function as an oxygen mask that sits over the larynx. Although it does not definitively secure the airway, it is an effective alternative to intubation.

Endotracheal Tube

The gold standard method to provide a definitive secure airway, often referred to as intubation. This tube (Fig. 6.8) is passed through the larynx using a laryngoscope, such that the cuff is placed below the vocal cords and inflated with air via a syringe.

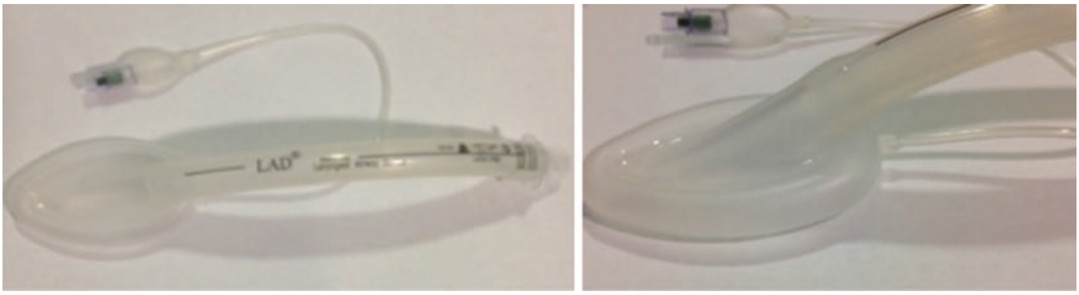

Fig. 6.7 Laryngeal mask airway (Photos: Taken by Akhil Gupta 2014)

Fig. 6.8 Endotracheal tube (Photos: Taken by Akhil Gupta 2014)

Surgeons' Favourite Questions for Students

1. Explain the role of the anaesthetist in the pre-operative setting
2. Explain the mechanism of local anaesthesia
3. How is an epidural block different to a spinal block?
4. What are the benefits of regional anaesthesia over general?
5. Describe the ideal properties of a general anaesthetic
6. What is the gold standard airway adjunct to establish a definitive secure airway?

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Perioperative Care

7

Oliver Brunckhorst

Introduction

The perioperative period is at the centre of a surgical patients journey through care. As a student it is often not necessary to get bogged down with the specific details of every surgical procedure, however, it is essential to become familiar with the general principles of the operating theatre and surgery in general. Knowledge of the operating environment and equipment, along with being acquainted with basic intraoperative patient care is crucial to ensuring that you are a safe member of the team when in theatres. Theatres are additionally like no other place in the hospital, seeming very alien when first encountered. There are a large variety of people, equipment and even its own set of rules present. This chapter therefore aims to provide a broad overview of the intraoperative setting and care pathway to ensure that you can get the most out of your surgical rotations.

The Theatre Environment

Theatre Dynamics

The history of the operating theatre spans over 300 years. Previously surgery was conducted in the wards, consulting rooms and even the patient's homes [1]. As the need for teaching students increased, large theatres with galleries for observing surgery became increasingly common with surgeons "performing" surgery as if on a stage. With sterility becoming increasingly important, theatres became specifically designed to ensure that infection is minimised and the old gallery style theatre has now become a thing of the past. These rooms retain their stage-like origins through their name but despite this, little else is still similar from the original operating theatres design. Modern operating rooms are arranged in a very specific manner to reduce infection risks and it is important to have an idea of the common operating theatre layout.

Having a basic idea of how the theatres are organised and how it is designed to minimise infections is very useful for medical students. It ensures you can navigate your way around and can minimise the risk of infection to patients as an observer. Theatres are designed not as a single room but as interconnecting parts, which are utilised for varying purposes (Fig. 7.1). The anaesthetic room is adjacent to the operating room and is where the patients are induced if undergoing general anaesthetic or where regional and local anaesthetics are applied. These rooms are usually stacked full of anaesthetic equipment and are where the majority of the drugs required during surgery are kept. The main reason for keeping this room separate is to ensure that the patient isn't exposed to the chaotic and often frightening operating room whilst conscious. In addition to the

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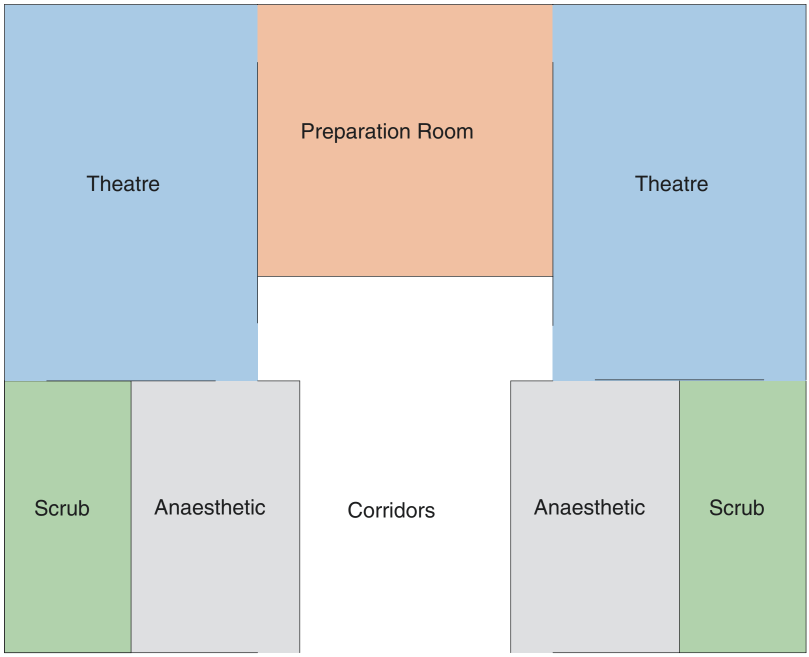

Fig. 7.1 Example of theatre layout

anaesthetic room a preparation room will often be attached to the theatre and is where the majority of equipment is stored and where nurses will prepare trolleys and equipment for operations. This room is sometimes shared between two operating theatres so can be quite large. Finally, there may additionally be a separate scrub room where surgeons and nurses can scrub up for procedures. However, in many theatres this isn't necessarily done in separate rooms, with sinks also present in one of the corners of the theatre.

Between each of these rooms, a set of doors will be present and it is important that these remain closed during surgery. This ensures patient privacy and is also important for maintaining a sterile environment. Theatres have a laminar airflow system, with air flowing into the main theatre to maintain a positive pressure within them, minimising dirty air entry from the corridors into the rooms. By keeping the doors open, particularly to the main corridors, you are unbalancing this pressure system, thereby increasing the chance of infection to the patient. This is one of the reasons surgeons will often get angry with students who constantly walk in and out of the theatres or those who keep the doors open for long periods of time. In procedures with a high risk of surgical site infection, such as orthopaedic joint replacement procedures, theatres are often designed with an additional ventilation system above the operating table. This pumps a laminar flow of air specifically around the operating table, thereby further reducing the risk of infection. Again, this is important to be aware of as a student, as you should not stand inside this flow of air when observing procedures unless scrubbed up.

The Surgical Team

In theatres, a whole range of team members are present and it is useful to have an idea of what to expect prior to your first visit. Whilst there is large variation on the exact people present you can expect to see the following in the majority of procedures:

- Consultant Surgeon
- Trainee Surgeon
- Anaesthetist
- Scrub Nurse

- Operating Department Practitioner/Assistant (ODP/ODA)
- Circulating Nurse

Each of these individuals has an important role to play within the surgical team and it is imperative they work together to ensure the best outcomes for the patient. The surgeons will generally be in charge of the technical aspects of the procedure and are therefore usually scrubbed next to the patient. They rely heavily on the scrub nurse, a fully scrubbed nurse, for assistance with the instruments during a procedure. Next the circulating nurse has a very broad role within the team. Not only will they help with getting extra equipment required for the operation from the preparation room, but they will additionally be available to help out with a wide array of tasks the sterile team cannot perform such as adjusting various equipment settings. The anaesthetist role is vital for the patient in theatres. They will be responsible for the induction of anaesthesia and maintaining the patient stable throughout the procedure and are assisted by the ODP/ODA. Additionally, should the patient become haemodynamically compromised; the anaesthetist will take a central role in the management process.

Whilst the personnel mentioned above will usually be present it is not uncommon for a large array of additional members to be present. A collection of people may be present intermittently as additional tasks are required or may be there for the entire duration of the procedure to assist with additional equipment and parts of an operation. In general, the more complex a procedure or equipment utilised during the procedure the more staff will be required. Some of the staff that you may expect to find includes:

- Technician/trained nurse – e.g. robotic procedures
- Radiographers – where x-ray imaging is required intraoperatively
- Runner – to take samples to the lab
- Porters
- More nurses
- Nurse in Charge/Team Manager

Theatre Etiquette

Many people are nervous about their first experience in theatres, but in truth by following a few simple steps there really is nothing to worry about. It is important to realise that in theatres there is one primary priority; the patient. As a student you must ensure that you are not hindering patient safety and hence your teaching will always come second to this. However, despite this, theatres are a great place to learn anatomy and get some good hands on experience whilst still at medical school.

The day before going to theatres ask the consultant whether he or she is happy for you to be in theatres with them and ask when you should arrive. Many surgeons will expect you to clerk the patients and present the cases to them prior to the operations, so you may have to come earlier or go to the ward the night before. Make sure you know what operation is planned and have a read about it prior to the case if possible. In the morning don't miss breakfast, as this is a common cause of students fainting in theatres. Once you arrive ensure that you:

- Change into scrubs – hospitals will differ in the colour of the surgical scrubs worn.
- Wear appropriate footwear – either change into clogs or put blue shoe covers on.
- Long hair is tied back.
- Cover your hair with a surgical hat.
- Ensure you are not wearing any jewellery or wrist watches.
- Keep your medical student ID visible at all times.
- Do not leave valuables in the changing rooms, as you will often not have a locker.

Once ready to get into theatre make sure you go into theatres through the correct door. The main door directly into theatres from the corridors is best avoided if the patient is on the table, so go in through the anaesthetic room or the scrub room. When inside make sure that you introduce yourself to the surgical team and theatre sister, ensuring everyone knows who you are. A few simple rules to follow once in theatre include:

- Don't touch anything covered in blue/green as this is sterile, especially on tables and trolleys.
- Don't touch the surgeons after they have gowned up.
- Some surgeons will want you to wear masks whenever instruments are open.
- If you feel faint, don't try and hide it as you may end up hurting yourself. Let someone know, have a seat and a drink of water – don't worry it happens to everyone.
- Be prepared to help in theatres especially with transferring the patients and be available and aware of other potential jobs. Being proactive will often mean you get better teaching.
- When scrubbed make sure you don't take instruments from the scrub nurses table without being specifically directed.

By following these basic steps you can make sure you get the most out of your time in theatres. If at any time you are unsure what to do, just ask one of the theatre staff and they will be more than happy to help you. However, most importantly have fun and enjoy your time in theatres!

The Theatre Environment: Key Messages

- Several interconnecting areas designed for specific purposes are present within theatres.
- Theatres are maintained in a positive pressure to minimise infection risks and doors should remain closed to preserve this.
- As a multidisciplinary environment several theatre staff are usually present within the operating rooms.
- Before going to theatres make sure you have not skipped breakfast and are changed into appropriate clothing.
- When in the operating room make sure you don't touch gowned areas and let someone know if you feel faint.

Preparing the Theatre and Patient

Order of the List

Whilst as a student you are a few years away from planning your own theatre lists, this is something surgeons often quiz students about. In reality there is however no simple way of organising a theatre list, and a great deal of collaboration and consideration of lots of factors are required. It is important that there is liaison between the ward and administrative staff, in addition to any changes and cancellations being communicated to the various members of the team. Ultimately, there is a great deal of personal preference within creating the lists but some important things to consider include:

- **Operating times** – some surgeons may want to perform the longer and more complicated cases early or vice versa.
- **Procedure** – day cases are usually performed earlier to give the patient sufficient time to recover and go home the same day.
- **Equipment** – is there enough kit for the procedure at that time? What's required in other lists?
- **Staff** – are any specialist staff required and/or available at the time? Is a collaborative surgeon available?
- **Elderly and Children** – these are generally placed first.
- **Allergies** – those with latex allergies should be placed first on the list after a deep clean to reduce the risk of latex contamination.
- **Comorbidities** – diabetics are usually placed early on the list to avoid problems with prolonged fasting and the need for an insulin sliding scale.
- **MRSA** – to reduce the risk of infection to others these are often placed last.

Patient Positioning

Before any procedure can start the patient must be placed in the appropriate position that allows the best access for a specific procedure. With the

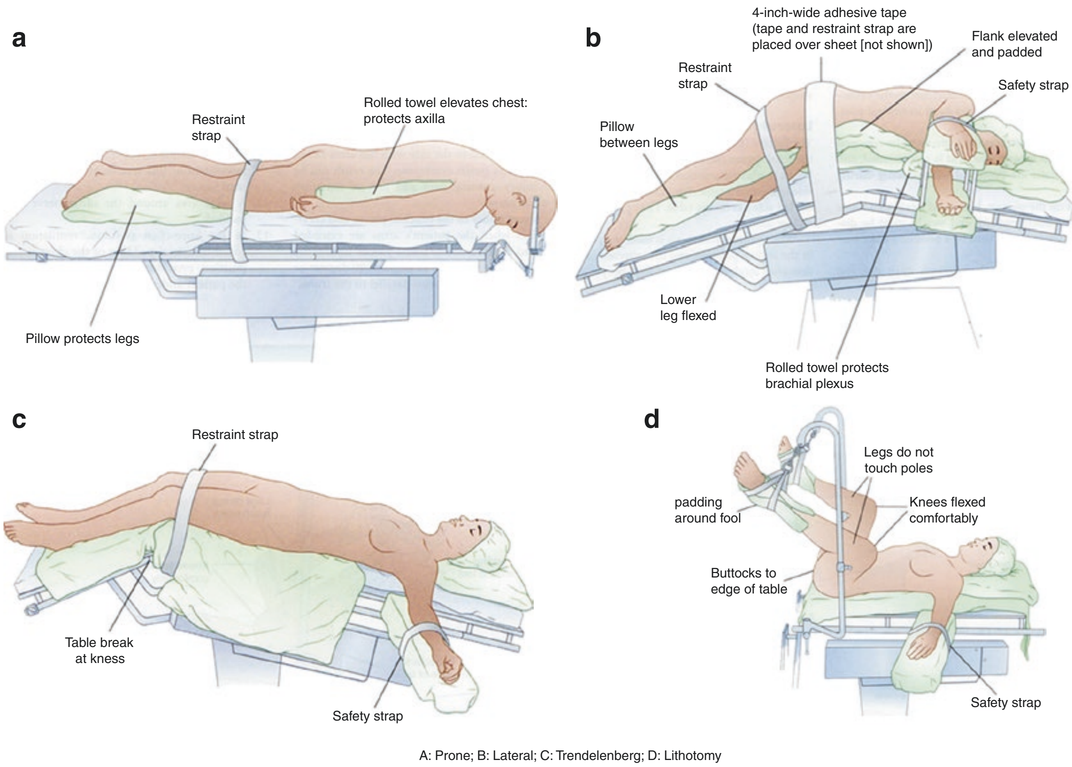

Fig. 7.2 Common surgical positions

individual remaining in the same position for a prolonged period of time, there is the risk of compression and nerve injuries developing over pressure points. This can lead to peripheral nerve injuries such as ulnar or brachial plexus injuries in the upper limbs, or sciatic and femoral nerve damage in the lower limbs. These are devastating surgical complications and have been estimated to occur in anywhere between 0.03% and 1.5% of procedures [2]. These are however very avoidable with simple gel or other padding over any points of pressure, or by avoiding excessive stress and strain on the limbs. Additionally, with certain positions it is essential to strap the patient to avoid any movement and the patient falling off the table. It is important that this is tight but not constricting to once again avoid any potential damage to the patient.

The position of the patient will vary vastly according to the procedure type and once again knowledge of a few of the basic positions (Fig. 7.2) can come in handy when being questioned by a surgeon. Examples include:

- **Supine** – the patient lies flat on their back and is the commonest position for most open abdominal/pelvic procedures.
- **Prone** – the patient is on their abdomen and chest and is used when a posterior approach is required such as in spinal and kidney stone surgery.
- **Lateral** – the individual is placed on their right or left side and strapped to avoid any movement. This is utilised when a lateral incision is made such as during a thoracotomy or renal surgery.
- **Trendelenberg** – a modification of the supine position with the head tilted down. This is used in lower abdominal or pelvic procedures to move visceral organs out of the way.
- **Reverse Trendelenberg** – Similar to trendelenberg but patient is placed with their head tilting up. Used for upper abdominal procedures, such as laparoscopic cholecystectomy, and head and neck surgery.
- **Lithotomy** – The patient is placed in a supine position with their legs raised and abducted to

expose the perineal region. This is a common position in urological and gynaecological procedures.

Venous Thromboembolism Prophylaxis

Considering venous thromboembolisms (VTE) is of vital importance for surgical patients. When considering Virchow's Triad of hypercoagulability, endothelial injury and venous stasis, it is easy to understand why this is the case. There is an activation of clotting factors during surgery that increases coagulability along with the direct endothelial injury that may occur and the venous stasis during prolonged procedures. Such is the problem in hospitals that an estimated 25,000 patients in the UK die from a hospital-acquired VTE every year [3]. These are preventable and within surgery clearly set out guidelines have been made by NICE (Fig. 7.3) for the prophylaxis

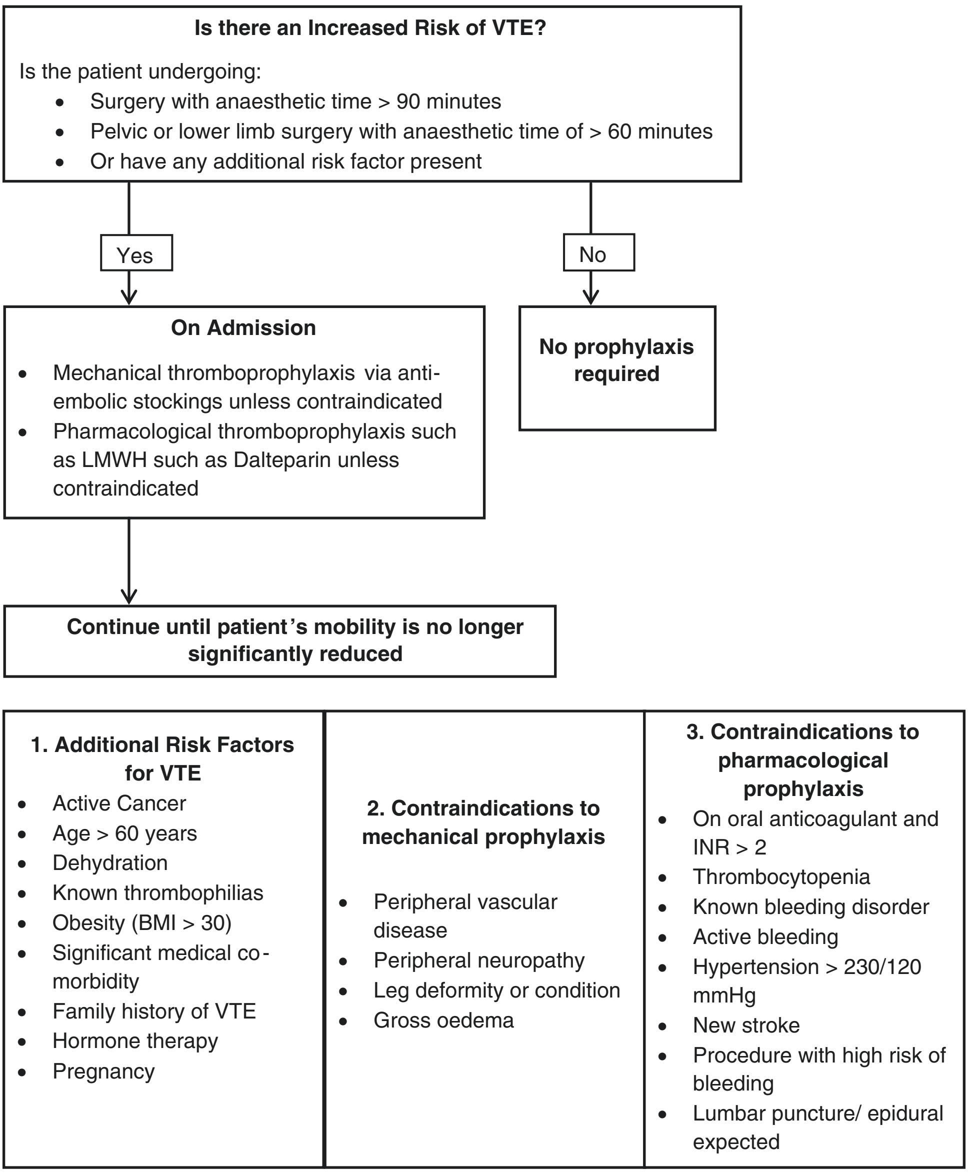

Fig. 7.3 VTE prophylaxis guidelines (Adapted from NICE guideline 92 [4]

of VTE [4]. It is highlighted in the guidelines that most but not all patients should be placed on mechanical (e.g. TED/anti-embolism stockings) or pharmacological (e.g. Low Molecular Weight Heparin) prophylaxis, with patient selection for this being key. Additionally, if possible utilization of regional anaesthesia offers lower risk than general anaesthesia. As a medical student it isn't necessary to know exactly who must undergo prophylaxis and at what doses the medications must be given, but having knowledge of the principles of prophylaxis is extremely useful.

Preparing the Theatre and Patient: Key Messages

- The order of the operating list is dependent on patient factors and surgeons personal preference.
- Various surgical positions for best exposure during an operation exist, each with their own potential dangers and considerations.
- Nerve injuries due to inappropriate positioning are a major complication and therefore appropriate padding and strapping is vital.
- Venous thromboembolisms are a concern in surgical patients and appropriate mechanical and pharmacological prophylaxis is often.
- Surgical site infections can be minimised by utilising chlorhexidine or iodine to disinfect the patients' skin.

Antisepsis, Disinfection, Sterilisation

Surgical site infections cause great distress to the patients and are extremely costly for the hospital. Hence, ensuring an appropriate antiseptic field and good sterilization of equipment is vital prior to the start of any procedure. The scrub nurse will ensure that the required sterile equipment is still within its sterile date and appropriately laid out on a trolley and ready for the procedure. Additionally, once the patient has been appropriately positioned for the procedure, the area surrounding the surgical incisions can be disinfected, ensuring a good antiseptic area is created. Within the United Kingdom two main alcoholic solutions are utilised to achieve this: chlorhexidine gluconate and povidone iodine. There is little evidence to support one solution over the other so it is often down to a surgeons personal preference as to which is used. For example, some surgeons prefer iodine as they can see exactly which area has been sterilized due to its brown colour. When applying the antiseptic solution it is important to ensure that the solution is first spread at the incision site, and then spread outwards away from this, allowing the solution to air dry prior to beginning the procedure [5]. Once this is completed drapes can then be placed in the surrounding area of the incision, further ensuring a good antiseptic area is maintained. Through these very simple steps, which should be conducted prior to any procedure starting, the risk of infections can be minimised.

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Patient Safety

8

Anam Parand

To err is human

Alexander Pope [1]

Patient Safety

Patient safety took the spotlight when the public became increasingly aware that hospitals were not safe places for patients [2]. High profile reports in the US and UK highlighted the negative impact of medical errors [3, 4]. They emphasised the high prevalence of medical errors and the importance of learning from them. Preventable deaths caused by medical errors in US hospitals were reported to range between 44,000–98,000 per year [5]. In the UK, a review of 1014 patient records showed that over 10 % of patients suffered an adverse event in hospital, half of which were considered preventable [6]. Since then, the figure of 1 out of 10 patients being harmed has been supported and a case made that a significant number of these are unacceptable and preventable [7].

The operating theatre is one of the most hazardous settings for the patient, holding a record for the highest number of adverse events [8]. Over half of such adverse events are considered to be preventable and these figures are also specialty-dependent, with vascular surgery and colonic surgery holding the highest number of preventable adverse events [9].

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Surgeons undoubtedly understand the doctrine of 'first, do no harm', which begs the question – why are avoidable incidents so high? As Reason [10] explains, errors are not caused by individuals alone. His 'Swiss cheese model of organisational accidents', suggests that it is an alignment of 'active errors' (individual mistakes, slips, lapses and violations) and 'latent failures' (dormant system problems) that lead to harmful outcomes [10]. Accordingly, strategies to reduce surgical errors today are aimed at improving healthcare systems and their processes.

The World Health Organization (WHO) surgical safety checklist has been the largest strategy to reduce errors in surgery [11]. It was introduced with the aim of reducing the rates of death and major complications post surgery. The checklist comprises of a set of procedures with tick boxes at three time points: before ('sign in'), during ('time out') and after ('sign out') an operation. Procedures include checking known allergies of the patient, confirming all team members have introduced themselves and checking whether there are any equipment concerns.

The checklist is now mandatory in all UK operating theatres, following a longitudinal evaluation study across eight hospitals in eight countries that showed a significant reduction in mortality and morbidity outcomes [12]. Generally safety checklists have been found to improve perceived communication and teamwork-related errors in the operating theatre [13].

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Although some patients are unaware that these processes exist and do not feel that they have a role to play with the WHO checklist, efforts should be made to involve patients in their own safety in order to help reduce errors [14]. Involving patients in a very simple way before their surgery could prevent catastrophic never events such as wrong site surgery.

The other person to consider on the subject of surgical incidents is the surgeon themselves. Adverse events can be traumatic for the surgeon too and junior surgical trainees would particularly benefit from speaking to senior staff if they felt that they needed support after complications arising from operations that they were part of [15].

Key Points

- Approximately 1 out of 10 patients suffer an adverse event in hospital
- A high proportion of hospital adverse events are preventable and result from medical errors
- The operating theatre is one of the most hazardous settings for the patient
- The World Health Organization (WHO) surgical safety checklist is a mandatory initiative that aims to minimise errors in surgery
- Approaches to preventing errors should consider involving patients
- Junior surgeons should consider their own well-being after surgical complications and seek support if needed.

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9 Preparing the Surgeon

Ankit Mishra and Michael C.B. Morgan

Introduction

Visiting the operating theatre and being part of the surgical environment can be an extremely fulfilling experience for a medical student, even in the pre-clinical years. However, students are typically not formally taught the basic practical skills that are necessary to make any surgical exposure worthwhile. These skills include scrubbing, gowning and gloving, and being able to identify surgical instruments and equipment. This chapter will cover these basics and more, and we recommend that you give it a read-through at the beginning of any hands-on surgical rotation – particularly if you are about to embark on a surgical elective!

Most of all, remember that theatre staff strive for safety in their work, and so it is very important for you to be honest about what you are able to do. It is always better to ask for someone to supervise you while you scrub for the first few times as it will give them (and you) peace of mind and ensure that you learn correctly.

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The Surgical Scrub

Preparation for Scrubbing

Personal cleanliness is extremely important for staff in the operating theatre. Frequent hair washing, a daily shower and care of the hands and fingernails are vital. Nails should be trimmed so that they do not protrude over the tips of the fingers and should also be free from any polish or nail treatments. This will prevent them from puncturing gloves and make them easier to clean. If there is an infection, rash or open lesion on ones hands, nails or arms it should be reported to the person in charge. You should also attempt to use the restroom facilities before scrubbing to avoid having to leave the operating room once the procedure has begun.

Jewellery

Wrist watches and jewellery of any kind are a hazard in theatres and must not be worn. If possible, wedding rings should be removed before scrubbing as they harbour bacteria, although plain bands are permitted by most hospitals. There is a risk of earrings falling into the wound and they should also not be worn. Before any clinical contact with patients, staff should be bare below the elbows.

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Hats

Hair must be completely covered with a clean disposable scrub that is changed daily, and on leaving the department or if it becomes visibly contaminated. The hats prevent falling hair or dandruff contaminating the sterile field. Beards must be covered with a hood.

Footwear

Closed-toe non-slip footwear is usually available for theatre staff. If there is a high risk of heavy blood or other fluid loss, boots should be worn.

Masks

The primary purpose of surgical masks is to protect the patient from the bacteria exhaled by the theatre staff. The scrub team is required to wear masks. It is at the discretion of the consultant in charge whether or not the other theatre members should wear a mask. If a prosthesis or implant is being surgically placed, all members of the theatre staff should wear a mask. The mask should be worn before the scrubbing procedure takes place and is not considered sterile. The mask should be changed between procedures as the barrier it provides can be disrupted by the mask becoming damp. This would allow droplets from the nose or mouth to penetrate the mask. A mask must fit snugly to the face to stop the passage of air around the sides and to prevent the fogging of glasses, if they are worn.

Scrubbing

The surgical scrub is part of establishing surgical hand antisepsis and is performed before donning the surgical gown and gloves. It aims to reduce the number of resident and transient microflora of the hands, wrists, and forearms, as well as inhibit their re-growth [1]. The first part of scrubbing is the hand wash with scrub solution (usually povidone-iodine or chlorhexidine) and should last for 5 min. The following steps involve a sterile nailbrush and sponge and should last for 3 min (Figs. 9.1–9.12).

Gowning and Gloving

The sterile surgical gown and gloves are donned in a rather complex manoeuvre to avoid contaminating their outer surfaces. Both procedures require the aid of a circulating person, to open the unsterile packages and tie the gown at the back. The only parts of the surgical gown that are considered sterile are the sleeves (except the axillae), and the front between the neck and waist [5].

We have included step-by-step guides on gowning and gloving, but don't worry if you can't remember it all precisely! If you need to scrub up, theatre staff in the scrub room will be happy to help you (Figs. 9.13–9.39).

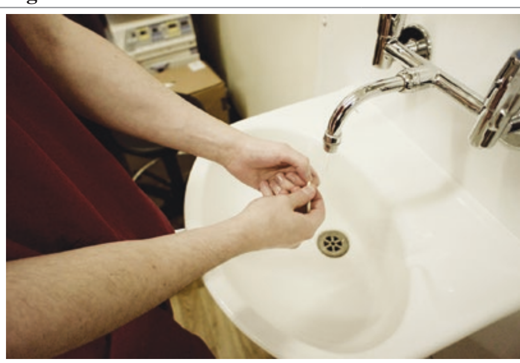
Incisions and Closures

Surgical Incisions

The surgical incision is a cut made through the skin (typically using a scalpel) by the surgeon in order to access internal viscera. The placement and length of incisions depend on the surgical procedure taking place, and in some cases multiple incisions may be necessary. Any surgical incision is traumatic and will impinge on the post-surgical stress response, the risk of surgical site infection (SSI), and the final cosmetic outcome. As such, it is important to minimise the size of an incision by placing it appropriately while at the same time allowing sufficient access to carry out the operation. Incisions may sometimes have to be extended, for example in order to remove a larger than expected mass or organ. The rationale behind reducing incision size has played a part in the development of minimally invasive surgical techniques, such as laparoscopy.

There are a number of common incisions, particularly in the thorax and the abdomen, which it will be useful to know as a medical student.

Figs. 9.1–9.12 Guide to surgical scrubbing

Ensure the temperature and flow of the water is to your liking **(Fig. 9.1).** Open the nailbrush package and place the nailbrush (still contained in the packaging) at the back of the scrub sink	 **Fig. 9.1**
Wet your hands and arms with the prescrub wash. Create a heavy lather and wash from your hands all the way to your elbows **(Fig. 9.2)**	 **Fig. 9.2**
Hands and arms should be rinsed thoroughly allowing water to run from the hands to the elbows. Do not retrace or shake your arms, rather let the water drip from the elbows **(Fig. 9.3)**	 **Fig. 9.3**
Open the sterile brush and pick's package and remove them. Use the pick to clean underneath fingernails and then discard it. **(Fig. 9.4)**	 **Fig. 9.4**

(continued)

Figs. 9.1–9.12 (continued)

Use the sponge side of the brush to lather the fingertips. Then use the bristle side of the brush to scrub the spaces under the fingernails on both hands **(Fig. 9.5).** When scrubbing it is essential that the hands remain above the level of the elbows and distant to the theatre wear to avoid splashing and contamination	 **Fig. 9.5**
Using the sponge side of the brush, lather and wash the all sides of the finger **(Fig. 9.6)**	 **Fig. 9.6**
Ensure the hands are scrubbed in the following order: (1) Palm to palm (2) Right palm over left dorsum and left palm over right dorsum (3) Palms together with the fingers interlaced (4) Palms to the dorsum of the opposing fingers interlocked (5) Rotational washing of right thumb in left palm and vice versa (6) Clasp fingers of right hand in left palm and rub. Repeat on opposite side Wash the arms up until the two thirds of the forearm to avoid compromising the cleanliness of the hands Rinse the hands and arms thoroughly from the fingertip to the elbow without retracing **(Fig. 9.7).** Ensure water drips from the elbow before moving on to the gown pack	 **Fig. 9.7**

Figs. 9.1–9.12 (continued)

The gown pack should be opened for you. Pick up a single hand towel from the gown pack and step away from the table **(Fig. 9.8)** Open the towel fully ensuring the towel does not contact anything unsterile – including unsterile parts of your body. Keep your hands and arms above elbow level whilst simultaneously keeping your arms away from your body **(Fig. 9. 9)**	 **Fig. 9.8**  **Fig. 9.9**

(continued)

Figs. 9.1–9.12 (continued)

Grasp the towel in one hand and use it to dry the fingers of the opposite hand using a blotting motion **(Fig. 9.10)** Continue this down the arm from forearm to elbow using the dry areas of the towel. Do not retrace any areas. Once completed discard the towel **(Fig. 9. 11)** Repeat the previous steps with the second towel using the other hand **(Fig. 9.12)**	 **Fig. 9.10**	 **Fig. 9.11**
	 **Fig. 9.12**	

Figs. 9.13–9.17 Guide to gowning

Using one hand pick up the entire pre-folded gown from the packaging by grasping the gown through all of its layers. Ensure that only the inside top layer – which is exposed- is touched. Move away from the trolley or shelf **(Fig. 9.13)**	 **Fig. 9.13**

Figs. 9.13–9.17 (continued)

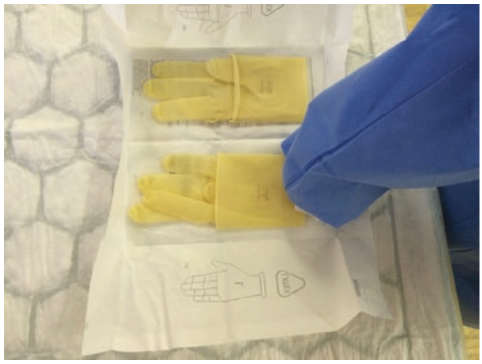
Hold the gown as shown in the corresponding image – near the gowns neck and allow it enable it to unfold whilst ensuring it does not touch any unsterile object or the body **(Fig. 9.14)**	 **Fig. 9.14**
Slip arms partially into the sleeves of the gown whilst keeping hands at the level of the shoulders and away from the body **(Fig. 9.15)**	 **Fig. 9.15**

(continued)

Figs. 9.13–9.17 (continued)

Slide arms in the gown sleeves up until the fingertips touch to proximal boundary of the cuff. Using the thumb and index finger grasp the interior of the seam at the cuff hem ensuring that no part of the hand protrudes out of the cuff **(Fig. 9. 16)**	 **Fig. 9.16**
A circulating individual should now assist to help position the gown over the gowning individual's shoulders by grasping the interior surface of the gown at the seams of the shoulder. The circulating person can now adjust the gown comfortably over the persons shoulder The circulating individual's hands should only be in contact with the interior surface of the gown **(Fig. 9.17)** The circulating individual now prepares to secure the gown. The neck and back are secured using Velcro tabs or ties. They tie the gown at waist level at the back This method prevents contaminated surfaces at the posterior of the gown contacting anterior portions of the gown	 **Fig. 9.17**

Figs. 9.18–9.25 Guide to gloving

Using the index finger and thumb contained still contained in the proximal cuff edge, open the inner package of the gloves and pick up one glove **(Fig. 9.18)**	 **Fig. 9.18**
Put the glove palm down on the opposite gown's sleeve. The glove fingers should be pointing in the direction of the shoulder. The palm inside the sleeve should be facing upwards **(Fig. 9.19)**	 **Fig. 9.19**
The gloves rolled cuff edge should overlay the seam between the gown sleeve and cuff. Pinch the bottom of the rolled cuff edge of the glove using the thumb and index finger **(Fig. 9.20)**	 **Fig. 9.20**

(continued)

Figs. 9.18–9.25 (continued)

While still pinching the gloves cuff edge with the ipsilateral hand, grasp the uppermost edge of the glove cuff with the opposite hand. Do not let the fingers protrude from either gown cuff **(Fig. 9.21)**	 **Fig. 9.21**
Whilst still grasping the glove, stretch and unroll the glove cuff over the hand contained in the gown **(Fig. 9.22)**	 **Fig. 9.22**
The opposite sleeve covered hand should grasp both the glove cuff and sleeve cuff seam and pull the glove over the hand **(Fig. 9.23)**	 **Fig. 9.23**

Figs. 9.18–9.25 (continued)

Use the hand that is now gloved to repeat the process on the other hand **(Fig. 9.24)**	 **Fig. 9.24**
When gloving is completed correctly, no part of the skin should have touched the exterior surface of the glove. Check that the cuff of the gown is covered completely by the glove. Adjust fingers of the glove as necessary to ensure a snug fit **(Fig. 9.25)**	 **Fig. 9.25**

Figs. 9.26–9.30 Guide to the final gown tie

The scrubbed person will hold the belt tab proximal to any boundary line – here indicated in blue – in the right hand. The left hand will hold onto the left tie. Pull the tab with the right hand and give it to the circulating assisting person **(Fig. 9.26)**	 **Fig. 9.26**

(continued)

Figs. 9.26–9.30 (continued)

The circulating person will take hold of the tab distal to any indicating line **(Fig. 9.27)**	 **Fig. 9.27**
The circulating person will walk clockwise around the scrubbing person **(Fig. 9.28)**	 **Fig. 9.28**

Figs. 9.26–9.30 (continued)

The scrubbing person will turn if necessary to receive the tie that is being carried by the circulating person When the scrubbing person is properly positioned to receive the circulating tie, they can take hold of it without touching the tab. The scrubbing person now pulls the tie free from the tab leaving the tab in the hands of the circulating person (Fig. 9.29)	 **Fig. 9.29**
The scrubbing person can now secure the ties on the left side (Fig. 9.30)	 **Fig. 9.30**

Figs. 9.31–9.39 Guide to disposing of the gown and gloves

The circulating person unties the neck **(Fig. 9.31)** and back ties **(Fig. 9.32)**

Fig. 9.31

Fig. 9.32

Figs. 9.31–9.39 (continued)

The scrubbing person now grasps the gown at the shoulders **(Fig. 9.33)** and pulls the gown forward and down over the arms and gloved hands **(Fig. 9.34)**

Fig. 9.33

Fig. 9.34

(continued)

Figs. 9.31–9.39 (continued)

Keeping the arms away from the body, the scrubbing person now folds the gown ensuring the outside is folded inwards. The gown is then discarded in the appropriate bag/container **(Fig. 9.35)**	 **Fig. 9.35**
Using a gloved hand, grasp the outer surface of one hand **(Fig. 9.36)** and peel off **(Fig. 9.37)**. This is a **'rubber to rubber'** peel. The glove is then discarded in the appropriate container	 **Fig. 9.36**  **Fig. 9.37**

Figs. 9.31–9.39 (continued)

The second glove is removed by placing the fingers of the ungloved hand inside the cuff of the gloved hand **(Fig. 9.38)**. This is a **'skin to skin'** peel. The glove is then pulled up off the hand and then discarded into the appropriate container **(Fig. 9.39)**

Fig. 9.38

Fig. 9.39

While some incisions, such as the midline, are utilised in many surgical procedures, others are commonly associated with one operation in particular. It is therefore possible to deduce a little of a patient's medical history just by observing their surgical scars.

Horizontal Versus Vertical Incisions

Horizontal (transverse) incisions follow Langer's lines (the general direction that collagen fibres are organised in the dermis) and typically yield better cosmetic results with less pain. Vertical incisions are faster, may afford better exposure of internal structures, and are more easily extensible, but are more likely to become infected or dehisce (fall apart) [8].

Common Thoracoabdominal Incisions (Fig. 9.40)

- **Midline laparotomy –** A vertical incision is made along the *linea alba* except where it curves to avoid the umbilicus. It can be longer either above (upper) or below (lower) the umbilicus, or extend from the xyphoid process to the pubic symphysis. This latter variation is typically employed in trauma cases as it offers clear access to the majority of the abdominal cavity.

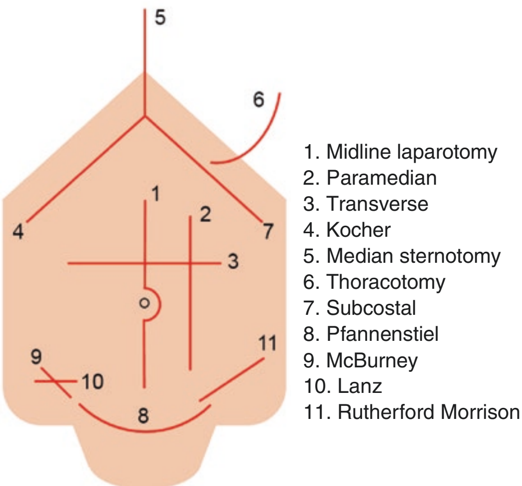


Fig. 9.40 Common thoracoabdominal incisions

- **Paramedian** – Any vertical incision placed laterally to the midline. It provides access to lateral abdominal structures, e.g. kidneys, and can be used in simple nephrectomy.
- **Transverse** – Any horizontal abdominal incision. They afford better exposure to the abdominal cavity than vertical incisions in children and obese patients due to their increased transverse abdominal length.
- **Kocher** – A right-sided subcostal incision used to access the gallbladder and biliary tree in open cholecystectomy.
- **Median sternotomy** – A midline thoracic incision made along the sternum, with a division of the sternum itself. It is often used in open cardiac surgeries, such as coronary artery bypass.
- **Rooftop** – Bilateral subcostal incisions, with improved access to upper abdominal structures (e.g. oesophagus, stomach, adrenal glands) compared to the Kocher. Also known as a chevron or gable incision.
- **Mercedes (–Benz)** – A median sternotomy (without the division of sternum) combined with a rooftop incision. It is named after its resemblance to the Mercedes-Benz logo and affords better access to the upper abdominal organs and is used in hepatectomy.
- **Thoracotomy** – An incision made between two ribs to access the thoracic cavity in cardiothoracic surgical procedures. It is typically placed in the sixth intercostal space.
- **Pfannenstiel** – A convex 10–15 cm long incision located 2 cm above the pubic symphysis. It is typically used in abdominal hysterectomy for smaller uteruses (≤20 weeks gestation size). Also known as a bikini-line incision.
- **McBurney** – An oblique incision centred at McBurney's point (two-thirds along a line from the umbilicus to the right anterior superior iliac spine). It is used in appendectomy. Also known as a grid-iron incision.
- **Lanz** – A transverse incision centred at McBurney's point. It is also used in appendectomy, and is deemed to give a better cosmetic result than the McBurney [7].
- **Rutherford Morrison** – An oblique, lower quadrant, muscle-cutting incision. It can be used to access the lower abdominal viscera in colectomies, and is also used in acute appendectomy.

Methods of Closure

After the surgical procedure, it is important to correctly approximate and close incisions. Failure to achieve proper closure leads to poor cosmesis, impaired wound healing, increased rates of infection, and dehiscence. There are several methods of incisional closure available:

- **Sutures** – The most common method of surgical closure, where the incision margins are stitched together. Various suture types are available, including monofilament vs. braided and absorbable vs. non-absorbable.
- **Staples** – Both absorbable and non-absorbable surgical staples are available for incisional closure. Non-absorbable staples are made from stainless steel, offering both high tensile strength and low tissue reactivity. Absorbable polymer staples may give a better cosmetic outcome.
- **Tissue adhesives** – These adhesives can be biological or synthetic, and are used to glue incision margins together. Although this closure method has a lower tensile strength than both sutures and staples, it has similar rates of infection and dehiscence while being faster to use.

- **Adhesive strips** – Placing adhesive strips across the incision is a non-traumatic method of closure, but the strips will not stick to moist areas or areas under tension [3].

Surgical Instruments

Instruments in Open Surgery

A wide variety of instruments are available to the surgeon, each designed to perform specific tasks during the course of an operation. While each surgical field makes use of specialised instruments particular to their own fields, there are many surgical instruments that will be found in any operating theatre. It will be useful for a medical student observing in theatre to be able to recognise these commonly used instruments (Fig. 9.41).

Surgical instruments come in various lengths and come in curved and straight forms (apart from scalpels). Their differences in length (Fig. 9.42) and degree of curvature (Fig. 9.43) best suit them to different tasks. Many of these common instruments have their counterparts in microsurgery, which are smaller, and laparoscopic surgery, where the instrument is at the tip of a long rod in order to pass through a trocar (laparoscopic port). You are not required to know the names of these instruments whilst at medical school, but the most common ones are outlined below to help you orientate yourself.

Common Surgical Instruments

- **Scalpels –** A bladed instrument with a BP (Bard-Parker) handle and disposable blade used to make incisions and in sharp dissection. Both the handles and blades come in a variety of sizes and shapes to perform specialised tasks (Figs. 9.44, 9.45, 9.46, 9.47, 9.48, 9.49 and 9.50).
- **Scissors –** Surgical scissors come in various types and are used for both cutting through tissues and also separating them in blunt dissection. For this reason, surgical scissors typically have rounded tips to avoid damaging structures. Scissors can be straight, for cutting sutures, or curved, for cutting tissue. Examples include Mayo, Metzenbaum, and Nelson (Figs. 9.50, 9.51, 9.52 and 9.53). Surgical scissors are held in the same way as surgical clamps (Fig. 9.54).
- **Dissecting forceps –** In a surgical context, 'forceps' typically refers to these non-locking dissecting instruments. Although they are essentially tweezers, don't refer to them as such if there's a surgeon nearby! Dissecting forceps can be toothed, for grasping skin and promoting bleeding, or non-toothed, to atraumatically grasp tissues and needles. They should be held in a pencil grip. Examples include Debakey, Gillie, Lane, and McIndoe (Figs. 9.55, 9.56, 9.57 and 9.58).
- **Haemostats** – Locking clamps used to occlude vessels and control bleeding. Also called artery forceps or clips. Examples include Dunhill, Frazer, Kilner, Lahey, Roberts, and Spencer Wells (Figs. 9.59, 9.60, 9.61, 9.62, 9.63 and 9.64).

Fig. 9.41 Selection of common open surgical instruments. *Upper row* (L-R): Duval tissue graspers, Crile-Wood needle holders, Robert haemostat, Metzenbaum scissors. *Bottom row*: Debakey dissecting forceps, scalpel, Watson-Cheyne retractor, Langenbeck retractor

Fig. 9.42 Length range in surgical instruments

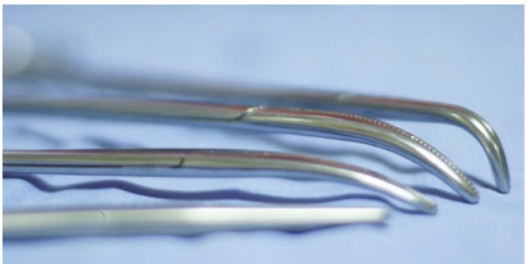


Fig. 9.43 Tip angulation in surgical instruments

Fig. 9.44 BP scalpel handles

Fig. 9.45 Disposable no. 15 scalpel blade

Fig. 9.46 Scalpel with no. 4 BP handle and no. 20 blade

Fig. 9.47 Scalpel with no. 7 BP handle and no. 15 blade

Fig. 9.48 Scalpel in a pencil grip

Fig. 9.49 Scalpel in a palmar grip

Fig. 9.50 Mayo scissors, 6″ straight

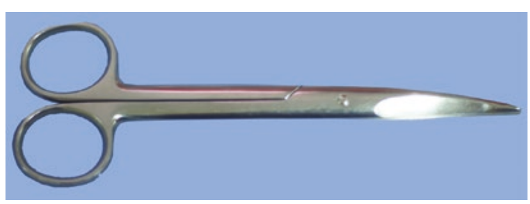


Fig. 9.51 Mayo scissors, 6″ curved

Fig. 9.52 Metzenbaum scissors, 9″ curved

Fig. 9.53 Nelson scissors, 9″ curved

Fig. 9.54 How to hold surgical scissors and clamps

Fig. 9.55 Debakey dissecting forceps, 7″ non-toothed

Fig. 9.56 Gillies dissecting forceps, 6″ toothed

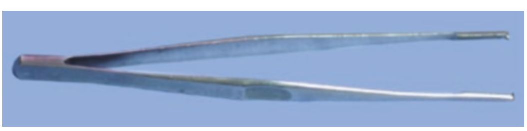


Fig. 9.57 Lane dissecting forceps, 7″ toothed

Fig. 9.58 McIndoe dissecting forceps, 6″ non-toothed

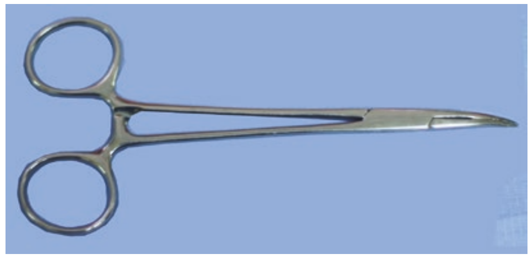


Fig. 9.59 Dunhill haemostat, 7.5″ curved

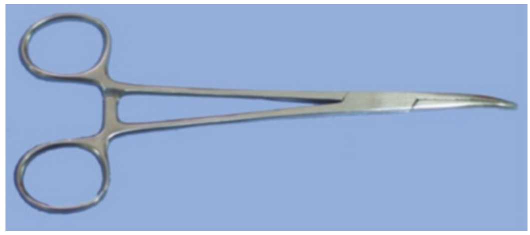


Fig. 9.60 Frazer haemostat, 7.5″ curved

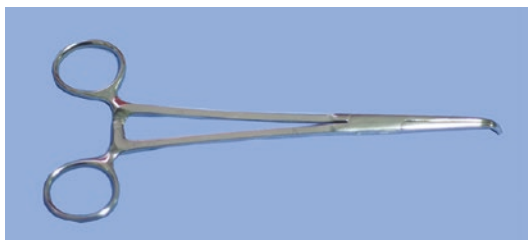


Fig. 9.61 Lahey haemostat, 7.75″ curved

Fig. 9.62 Kilner haemostat, 5″ curved

- **Needle holders –** Locking clamps used to safely hold needles while suturing. Needle holders can be distinguished from haemostats by the crossed knurling on the gripping surface of their tips. This allows the needle holder to maintain a firm grip on the needle at all angles. Examples include Crile-Wood and Mayo (Figs. 9.65 and 9.66).
- **Tissue graspers** – Locking clamps used to grasp and manipulate tissue. Examples include

Babcock, Duval, Judd-Aliss, and Lane (Figs. 9.67, 9.68, 9.69 and 9.70).

- **Sponge/Towel holders –** Locking clamps used to hold surgical sponges and towels. Examples include Lane towel graspers and Rampley sponge holders (Figs. 9.71 and 9.72).
- **Retractors –** Surgical devices used move apart tissues and organs to allow surgical access or a better view. Examples include Deaver, Morris, Langenbeck, and Ogilvie (Figs. 9.73, 9.74, 9.75, 9.76, 9.77 and 9.78).
- **Probes –** Simple instruments used in dissection. Examples include the straight probe, MacDonald dissector, and Watson-Cheyne retractor (Figs. 9.79 and 9.80).

Fig. 9.63 Roberts haemostat, 8″ curved

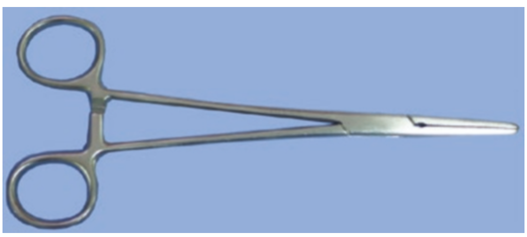


Fig. 9.64 Spencer Wells haemostat, 7″ straight

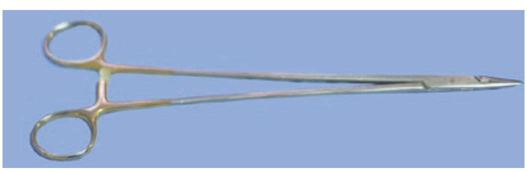


Fig. 9.65 Crile-Wood needle holder, 9.5″ straight

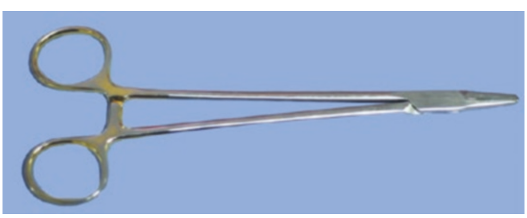


Fig. 9.66 Mayo needle holder, 6.5″ straight

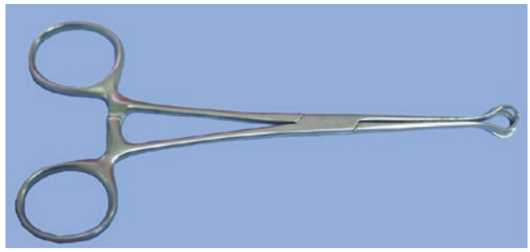


Fig. 9.67 Babcock tissue graspers, 8″

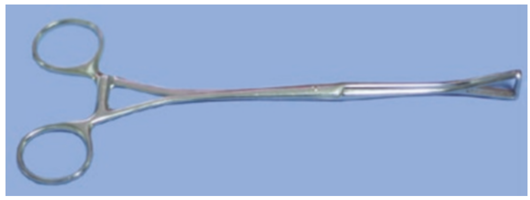


Fig. 9.68 Duval tissue graspers, 8″

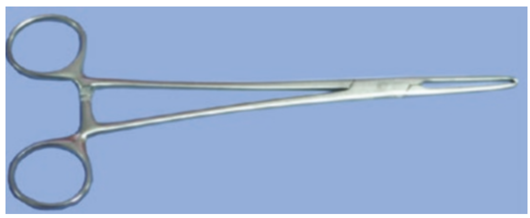


Fig. 9.69 Judd-Aliss tissue graspers

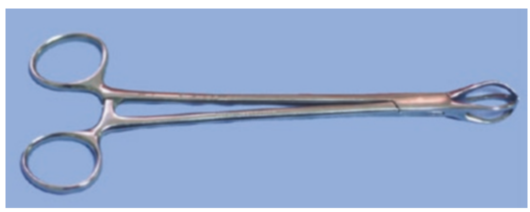


Fig. 9.70 Lane tissue graspers, 8″

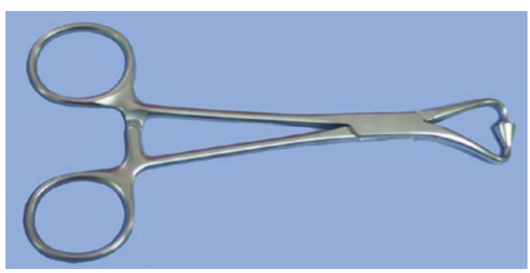


Fig. 9.71 Mayo ball and socket towel clips

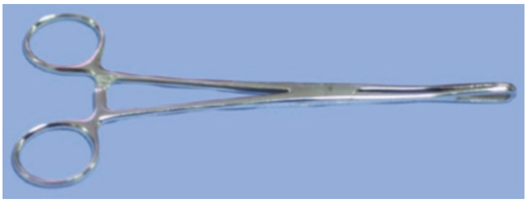


Fig. 9.72 Rampley sponge holders, 9.5″

Fig. 9.73 Deaver retractor, 2″

Fig. 9.74 Morris double-ended retractor

Fig. 9.75 Langenbeck retractor, medium

Fig. 9.76 Ogilvie retractor, 1.25″ small

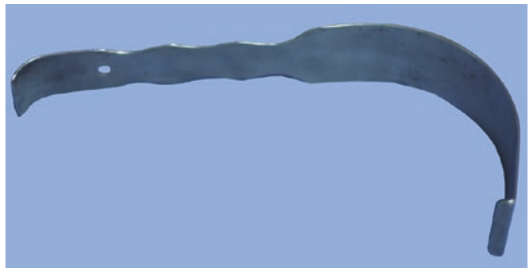


Fig. 9.77 Ogilvie retractor, 1.75″ medium

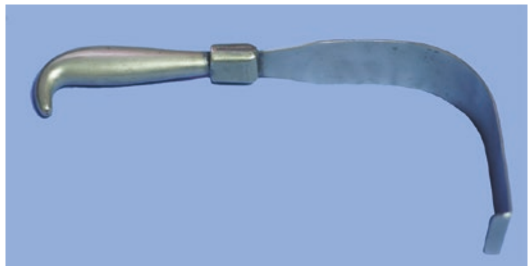


Fig. 9.78 Ogilvie retractor, 2″ large

Fig. 9.79 MacDonald dissector

Fig. 9.80 Watson-Cheyne retractor

Instruments in Laparoscopic Surgery

The primary difference between laparoscopic and open surgical instrumentation is that laparoscopic instruments must be both narrow enough to pass through a trocar (Figs. 9.81 and 9.82) and long enough to reach deep tissues in the insufflated abdomen. As such, laparoscopic instruments typically consist of specialised instrument tips at the end of a standard-length shaft. Many laparoscopic instruments are versions of open instruments, such as the Mayo and Metzenbaum scissors shown in Fig. 9.83. As with their open counterparts, there is a vast array of instrument tips used across many specialties. It is not important for a medical student to know the precise names and uses for every laparoscopic instrument; the ones shown in Figs. 9.84 and 9.85

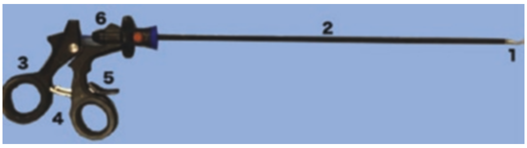


Fig. 9.81 Laparoscopic instrument

Fig. 9.82 Laparoscopic needle holder

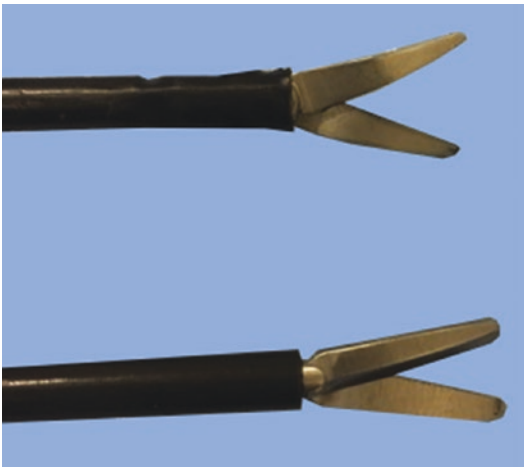


Fig. 9.83 Laparoscopic scissors instrument tips. *Upper*: Mayo; *Lower*: Metzenbaum

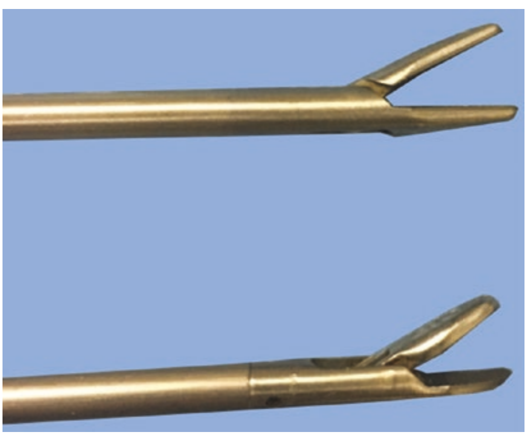


Fig. 9.84 Laparoscopic needle holder instrument tips. *Upper*: *straight*; *Lower*: *curved*

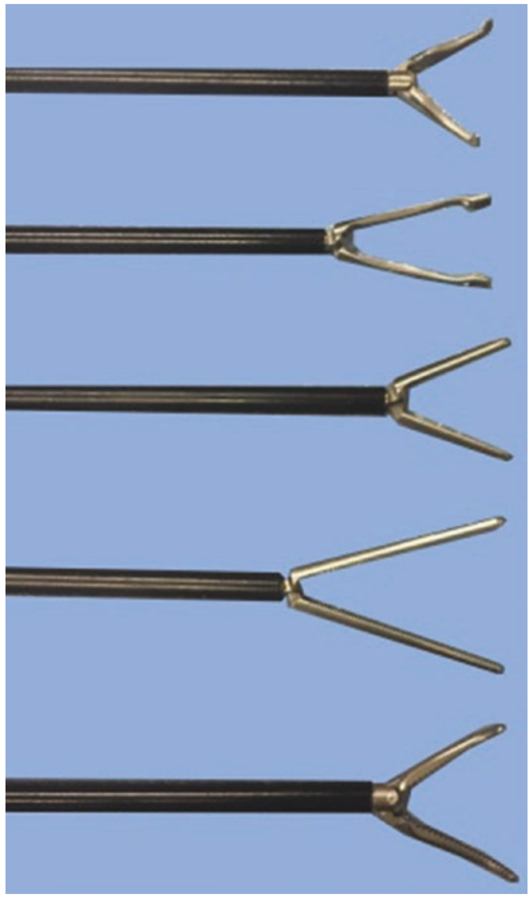


Fig. 9.85 Laparoscopic grasper instrument tips

Fig. 9.86 How to hold a laparoscopic instrument

are provided to give an indication of some common instrument tips.

Using laparoscopic instruments for the first time can be difficult, particularly when combined with with 2D camera systems that confound depth perception. Another factor to keep in mind if you are called upon to assist in laparoscopic surgery is the 'fulcrum effect', which inverts movements and affects the perception of scaling [6]. Figs. 9.86 and 9.87 demonstrate the correct way to hold laparoscopic instruments.

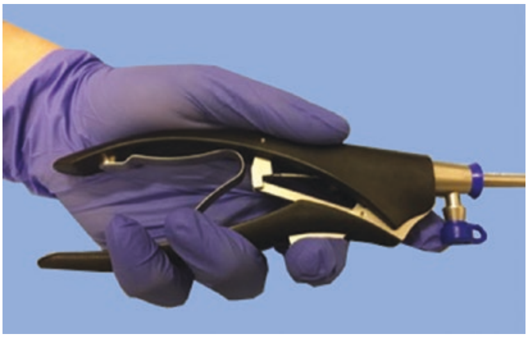


Fig. 9.87 How to hold a laparoscopic needle holder

Sutures and Ties

Sutures

Sutures are used to hold skin, organs, blood vessels and other tissues of the body together after they have been disrupted by trauma – including surgery. The closure they create aids in wound healing. If a suture is used on a wound it can be said to be healing by 'primary intention'.

Sutures are generally classified into two groups, absorbable and non-absorbable. Other ways to classify sutures include their construction, number of filaments and whether they are synthetic or natural. The ideal sutures is non-toxic, hypoallergenic, flexible and strong.

Absorbable Versus Non-absorbable

Absorbable sutures are broken down by the body's tissue over time. Absorbable sutures tend to be used internally as it removes the requirement for the wound to be re-opened. Non-absorbable sutures resist being broken down by the body.

Monofilament Versus Braided

Monofilament sutures pass more easily through tissues but do not hold knots as well as braided sutures, with an increased risk of dehiscence. Braided sutures generally grip better and are coated in a range of materials such as silicon, wax or calcium stearate. However, the crevices between the filaments of the braid can harbour microorganisms, resulting in higher infection rates.

Reactivity

As with all foreign materials in the body, sutures may elicit an inflammatory tissue reaction. Natural materials (e.g. catgut, cotton, silk) will elicit a more intense inflammatory reaction than synthetic ones. Nylon and steel are among the least reactive suture materials.

Suture Size

The diameter of sutures are designated according to the United States Pharmacopeia in descending thickness from 10 to 12-0. After 0, the next thinnest suture is 1-0, then 2-0, etc. It is useful to think of the first number (**1**-0, **2**-0, etc.) as the number of decimal places, making 12-0 much smaller than a 1-0. Sutures above 0 size tend to be used in orthopaedics.

Special Sutures

Some procedures make use of special suture types, such as wires in a median sternotomy, deep tension sutures in mass closure, and barbed sutures in urological anastomoses.

Surgical Needles

The needles used in suturing vary in size, curvature, and cross-section. Surgical needles are usually curved, and the degree of curvature is designated as a fraction of a circle. A needle may be round-bodied (circular cross-section), cutting (triangular cross-section, sharp edge inside the curve), or reverse-cutting (triangular cross-section, sharp edge on the outside of the curve) (Fig. 9.88). While some needles are eyed, most modern examples are swaged and come pre-attached with the suture. The suture pack details the properties of the suture and needle (Fig. 9.89).

Surgical Knots and Ties

A useful hand tie for a medical student is the reef knot (Fig. 9.90), which can be used in simple sutures e.g. to affix an arterial line. Figures 9.91–9.108 are a step-by-step guide on how to tie the reef knot. The surgeon's knot is a modification of the reef knot, with an extra turn in the first throw to provide more grip (Fig. 9.90). As well as by hand, this knot is commonly tied with instruments as part of a stitch. Figures 9.109–9.116 are a guide on tying the surgeon's knot and Figs. 9.117–9.133 are a guide on performing a simple interrupted stitch with instrument tie (surgeon's knot). Other common stitches using an instrument-tied surgeon's knot are the continuous stitch and mattress stitch.

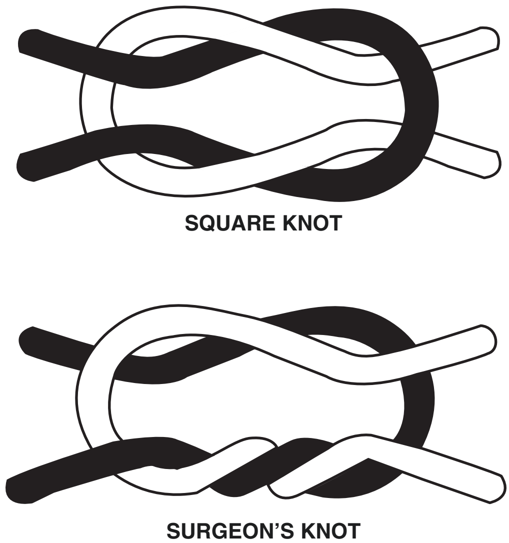
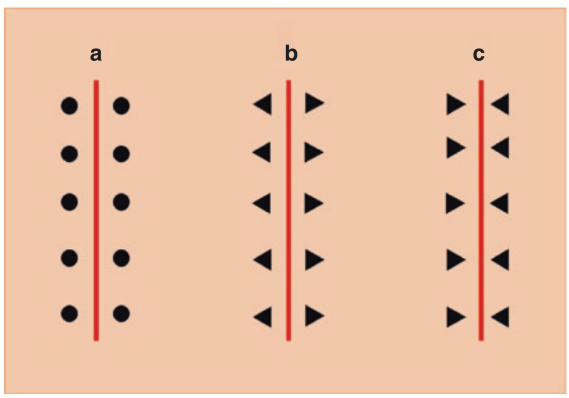


Fig. 9.90 Reef knot and surgeon's knot

Fig. 9.88 Surgical needle cross-sections



This figure demonstrates the shape of the puncture holes as surgical needles of a particular cross-section pass through the wound edges. A–round-bodied, B–cutting, C–reverse-cutting.

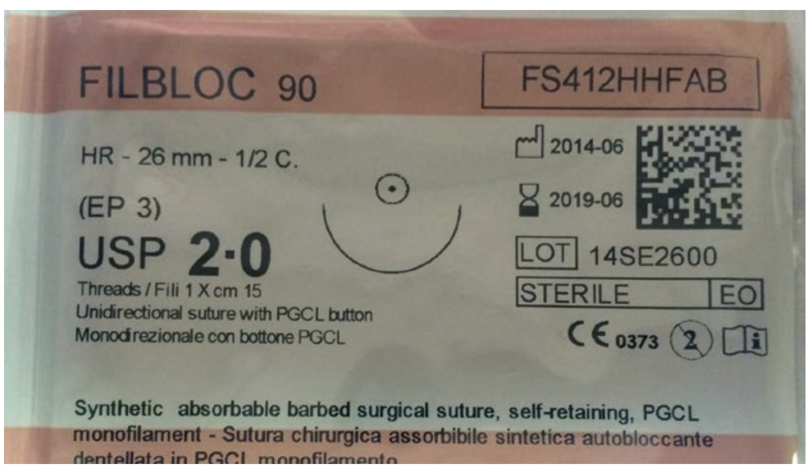
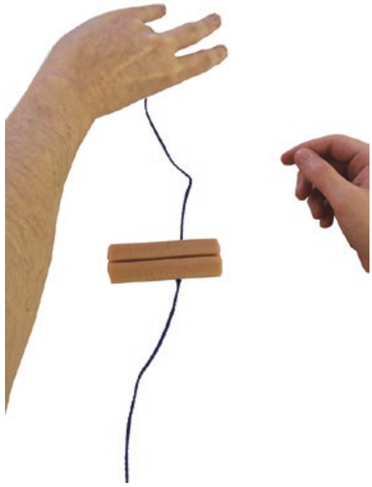
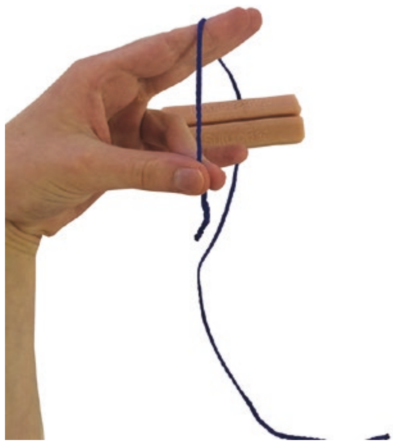
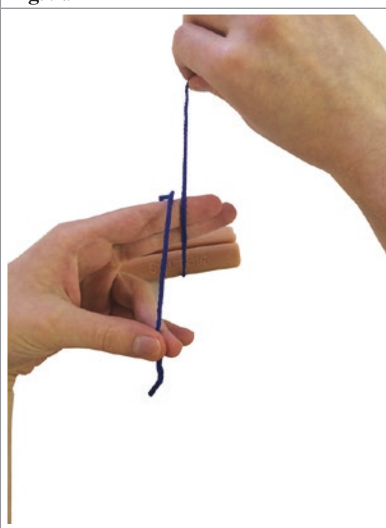


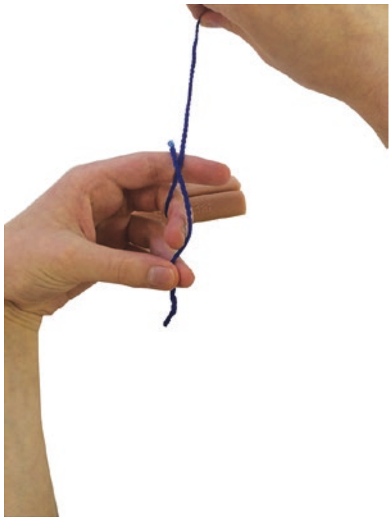
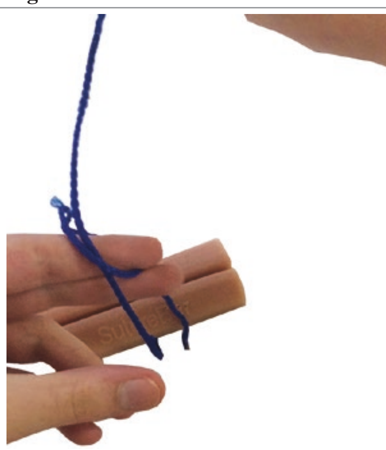
Fig. 9.89 Suture pack

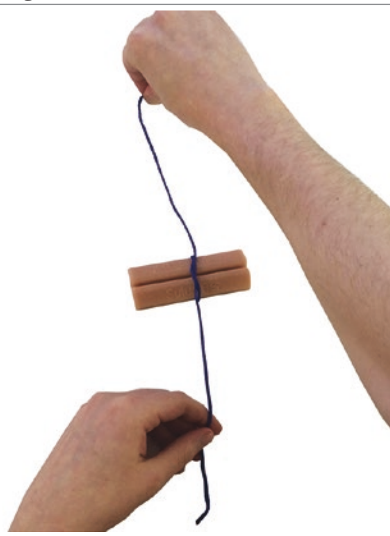
Fig. 9.91–9.108 Guide to hand-tying a reef knot

Grasp the suture between the ring finger and thumb of your non-dominant hand **(Fig. 9.91)**	 **Fig. 9.91**
Bring the distal end of the suture over the area you are tying. Make sure it wraps around your index and middle fingers **(Fig. 9.92)**	 **Fig. 9.92**
Whilst keeping your non-dominant hand in the same position, use your dominant hand to pick up the other end of the suture and bring it over the index and middle fingers of your non-dominant hand parallel to the distal suture **(Fig. 9.93)**	 **Fig. 9.93**

(continued)

Fig. 9.91–9.108 (continued)

Use the middle finger of the non-dominant hand to pull the dominant hands suture towards the non-dominant hand. Keep the index finger in place **(Fig. 9.94)**	 **Fig. 9.94**
Grasp the non-dominant hand's suture between the index finger and middle finger **(Fig. 9.95)**	 **Fig. 9.95**
Let go of the non-dominant hand's ring finger and thumb grip **(Fig. 9.96)**	 **Fig. 9.96**

Using the middle finger and index finger of the non-dominant hand, pull the end of the suture through the loop and towards yourself **(Fig. 9.97)**. Make sure the dominant hand stays on the other side of the area you are tying over **(Fig. 9.98)**	 **Fig. 9.97**
	 **Fig. 9.98**
Oppose both ends of the suture so that the tie sits squarely over the area **(Fig. 9.99)**	 **Fig. 9.99**

(continued)

Fig. 9.91–9.108 (continued)

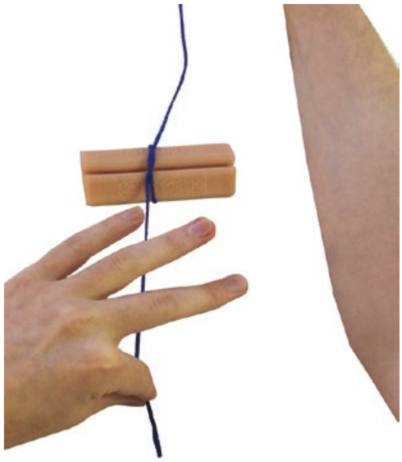
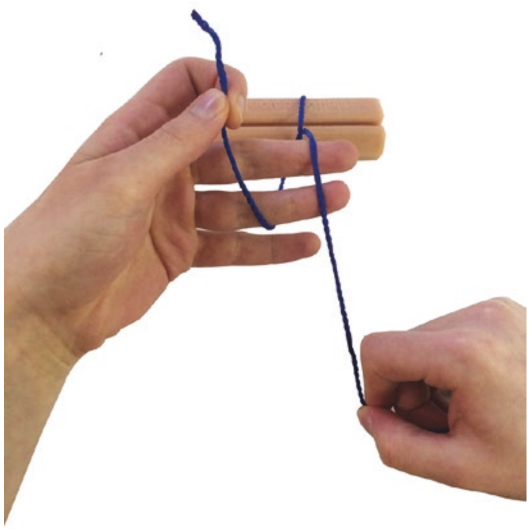
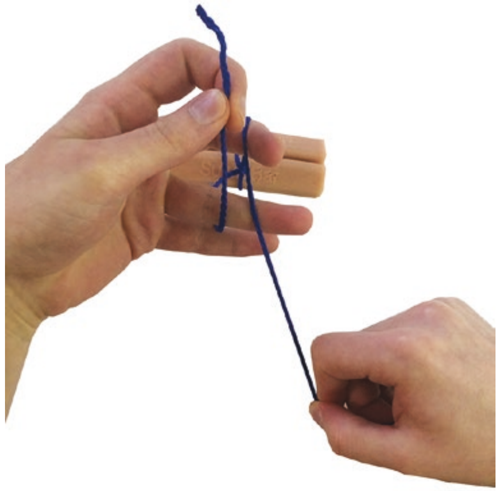
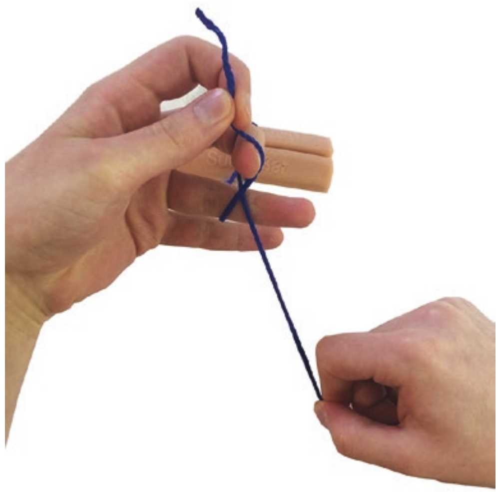
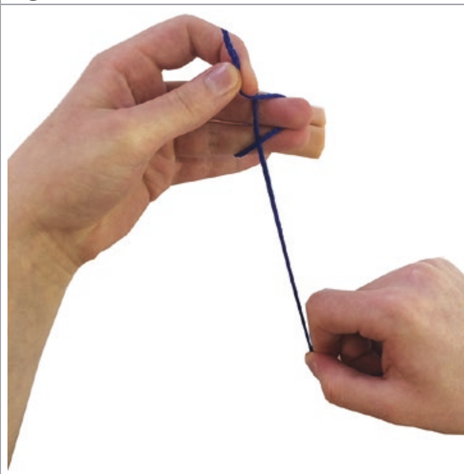
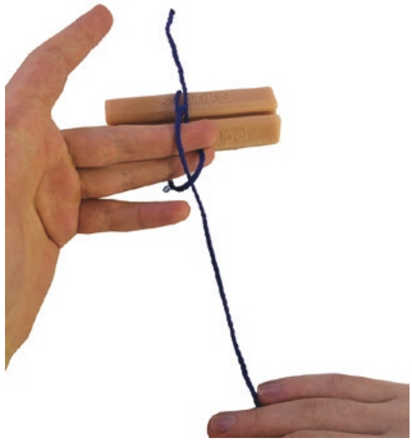
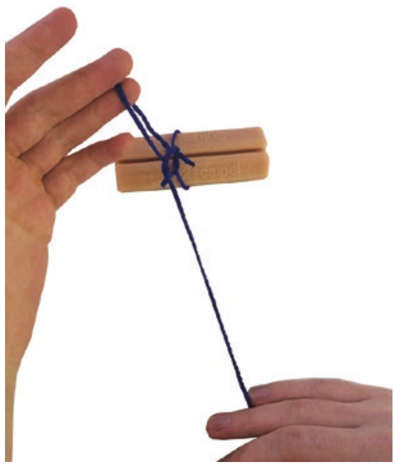
The second part of the tie involves picking up the now proximal end of the suture with the index finger and thumb of the non-dominant hand **(Fig. 9.100)**	 **Fig. 9.100**
Rotate the suture around the middle and ring fingers so that the proximal suture is now pointing distally **(Fig. 9.101)**	 **Fig. 9.101**
Grasp the distal end of the suture with the dominant hand and bring it over the middle and ring fingers of the non-dominant hand **(Fig. 9.102)** Use the middle finger to pull the dominant hands suture **(Fig. 9.103)**	 **Fig. 9.102**

Fig. 9.91–9.108 (continued)

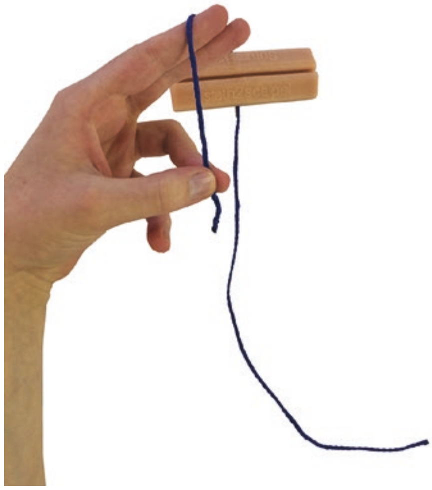
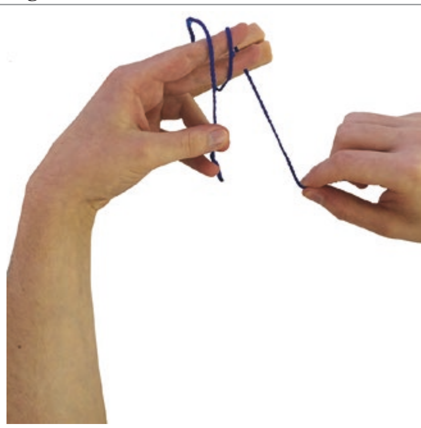
	 **Fig. 9.103**
Using the middle finger, pull the dominant hands suture behind the non-dominant hands suture. The non-dominant hands suture should now be on the dorsal surface of the middle finger **(Fig. 9.104)**	 **Fig. 9.104**
Grasp the non-dominant hands suture between the middle finger and the ring finger **(Fig. 9.105)**	 **Fig. 9.105**

(continued)

Fig. 9.91–9.108 (continued)

Let go of the thumb and index finger grasp of the non-dominant hand **(Fig. 9.106)**	 **Fig. 9.106**
Using the middle finger and ring finger, pull the suture through the loop **(Fig. 9.107)**	 **Fig. 9.107**
A figure that looks somewhat like an 8 should form. Pull this flat over the wound **(Fig. 9.108)**	 **Fig. 9.108**

Figs. 9.109–9.116 Guideto hand-tying a surgeon's knot

Grip the distal suture between the thumb and ring finger of the non-dominant hand just like in the ***Reef knot***. Rotate the suture around the index and middle finger of the non-dominant hand **(Fig. 9.109)**	 **Fig. 9.109**
Grasp the proximal part of the suture with the dominant hand and lay it on top of the non-dominant hand's index and middle finger **(Fig. 9.110)**	 **Fig. 9.110**
Wrap the suture held in the dominant hand around the middle and index fingers of the non-dominant hand **(Fig. 9.111)**	 **Fig. 9.111**

(continued)

Fig. 9.109–9.116 (continued)

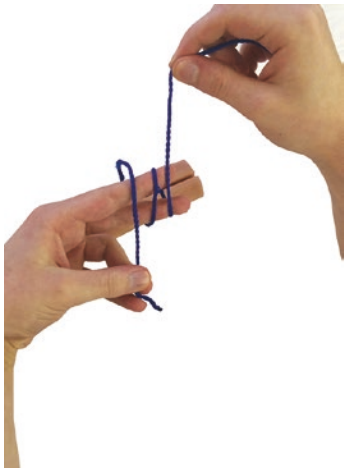
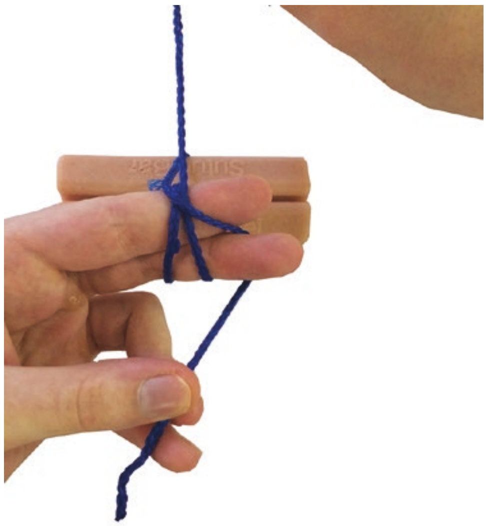
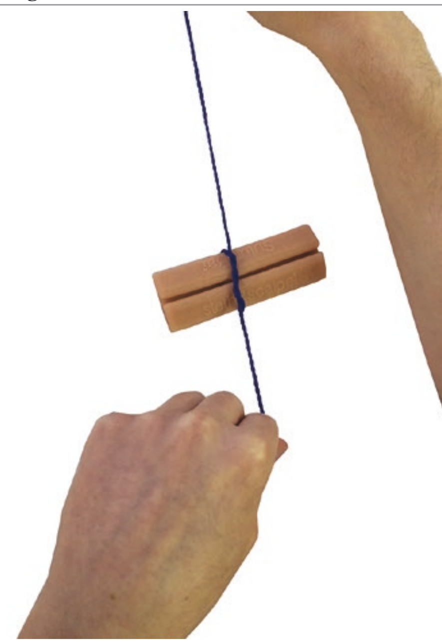
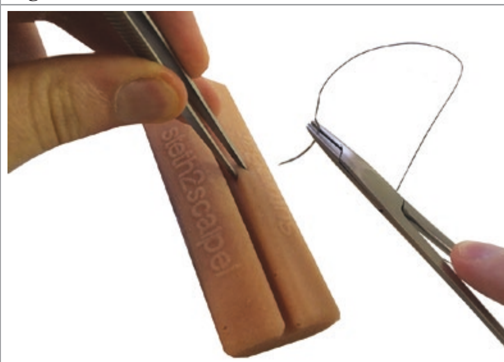
There should be three parallel lines of suture over the middle and index fingers of the non-dominant hand **(Fig. 9.112)** This is a doubling of the firs throw of the ***Reef Knot***	 **Fig. 9.112**
Bring the distal suture held in the non-dominant hand's thumb and ring finger between the non-dominant hand's index and middle finger **(Fig. 9.113)**	 **Fig. 9.113**
Pull the index and middle finger of the non-dominant- whilst still grasping suture-through the two loops of suture. Let go of the suture with the thumb and ring finger of the non-dominant hand to allow the passage of the suture through the two loops **(Fig. 9.114)**	 **Fig. 9.114**

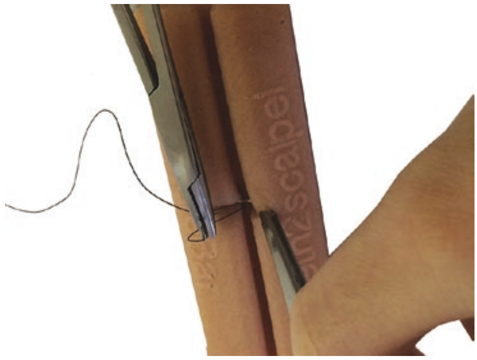
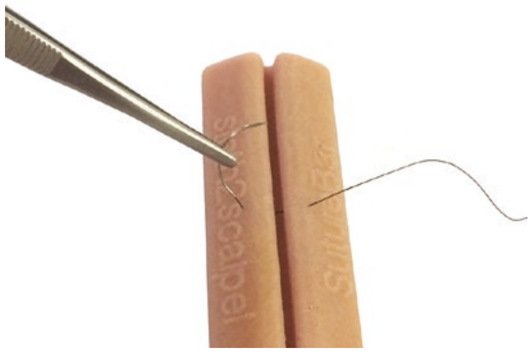
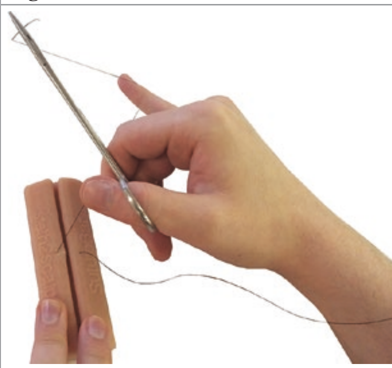
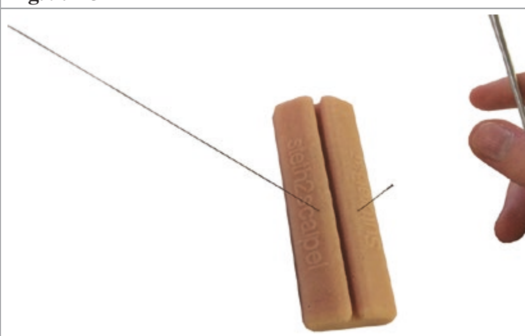
Fig. 9.109–9.116 (continued)

Once through the loops, re-grasp the suture with a grip that is comfortable (index finger and thumb) and pull the two ends of the suture away from each other **(Fig. 9.115)**	 **Fig. 9.115**
This is the completed first throw of the ***Surgeons knot.*** Now carry out the second and optional third throw of a ***Reef knot*** to complete the ***Surgeons knot*** **(Fig. 9.116)**	 **Fig. 9.116**

Figs. 9.117–9.133 Simple interrupted stitch with instrument tie

Grasp the needle of the suture 2/3's of the way along its length with a pair of needle holders **(Fig. 9.117)**	 **Fig. 9.117**
Lift the edge of the initial point of suturing with a pair of toothed forceps **(Fig. 9.118)**	 **Fig. 9.118**
Drive the needle through the initial edge. Use a pair of non-toothed forceps to finish driving the needle through the first part of the skin **(Fig. 9.119)**	 **Fig. 9.119**
Ensure that the needle of the suture has been completely through the first part of the skin. Use the non-toothed forceps to hold the needle in position for the needle holders to grasp them for the second part of the driving **(Fig. 9.120)**	 **Fig. 9.120**

Figs. 9.117–9.133 (continued)

Ensure the second bite of the suture lines up with the first bite. Use the toothed forceps to raise the edge again to make the drive easier **(Fig. 9.121)**	 **Fig. 9.121**
Finish the drive of the needle with the non-toothed forceps. Re-grasp the suture with the needle-holders **(Fig. 9.122)**	 **Fig. 9.122**
Pull the suture through wound in the horizontal plane. Wrap the suture around the little finger to aid in pulling in the horizontal rather than vertical plane **(Fig. 9.123)**	 **Fig. 9.123**
Leave only a small amount of the suture on the initial drive for the tie **(Fig. 9.124)**	 **Fig. 9.124**

(continued)

Figs. 9.117–9.133 (continued)

To start the ***Instrument Surgeon's Tie*** wrap the suture around the needle holder which is held in the dominant hand **(Fig. 9.125)**

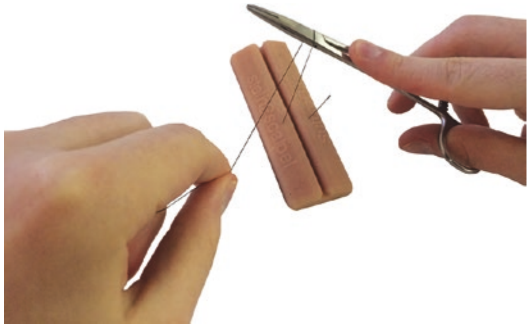


Fig. 9.125

Make sure that the suture is wrapped twice around the needle holder. Keep them slightly loose so that the needle-holder can still be opened **(Fig. 9.126)**

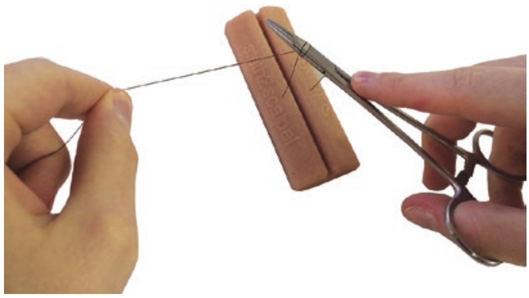


Fig. 9.126

Whilst maintaining the loops around the needle holder's grasp the short free edge of the suture **(Fig. 9.127)**

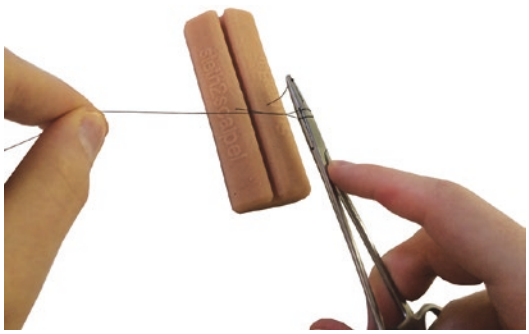
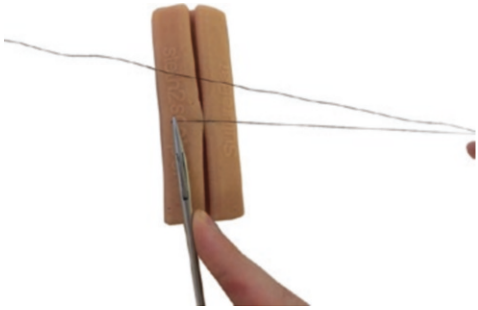
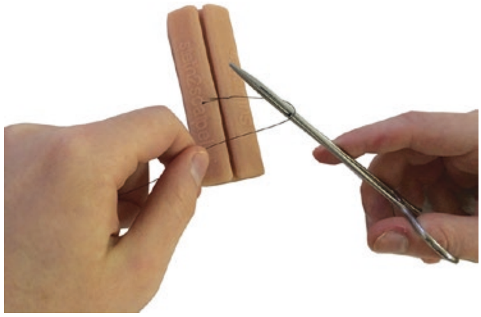
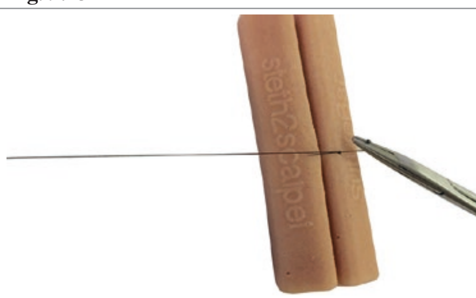


Fig. 9.127

Pull this short free edge through the loops. Try to make the tie you have created lie to one side of the wound and not over the centre **(Fig. 9.128).** All future ties should lie on the same side

Fig. 9.128

Figs. 9.117–9.133 (continued)

Pull the tie square over the wound. That is the first throw of the ***Instrument Surgeon's knot*** completed **(Fig. 9.129)**	 **Fig. 9.129**
The second throw and optional third throws are reef knots. Wrap the long end of the suture around the needle holder **once (Fig. 9.130)**	 **Fig. 9.130**
Whilst maintaining the single loop over the needle-holder grasp the short end of the suture **(Fig. 9.131)**	 **Fig. 9.131**
Pull the short end of the suture through the single loop. Ensure the tie stays on one side of the wound and not over the middle **(Fig. 9.132)** An optional third throw can be completed over this	 **Fig. 9.132**

(continued)

Figs. 9.117–9.133 (continued)

When you have completed the tie cut the long end of the suture. It should match the short end at 2–3 cm **(Fig. 9.133)**

Fig. 9.133

Surgical Equipment

Common Theatre Equipment

The standard operating theatre contains a lot of equipment designed to help the surgeon in the course of an operation. Most procedures make use of some general devices, such as suction systems. One ubiquitous piece of equipment is the electrosurgical diathermy device, which uses heat to cut and coagulate tissue. Other energy-based devices are used frequently in laparoscopic surgery.

Urinary Catheters

Catheterisation is necessary in all abdominal surgical procedures, both open and laparoscopic. This prevents the bladder from filling and obscuring the surgical field. In longer procedures, such as major trauma cases, measuring urine output can give an indication of the patient's intraoperative fluid status.

The Foley catheter is commonly used as an indwelling urinary catheter, and is held in place by an expandable water-filled balloon. Insertion can be either urethral (16 French diameter for men, 12–14 French for women) or suprapubic.

Suction and Irrigation

Various methods of suction are used to remove blood and debris from the surgical field to improve visualisation. Suction tubes come in open-ended and sump designs, and may be ceiling-mounted for ease of access mid-operation. Fluid irrigation is also used in laparoscopic surgeries to improve visual clarity, generally using saline.

Electrosurgical Diathermy

Diathermy is the induction of heat in a substance by passing high-frequency electromagnetic energy through it. Surgical diathermy is used to both cut tissue and cause coagulation, and is typically achieved by passing high frequency alternating current (AC) electricity through tissues. The frequency of this current is critical:

- **50 Hz** – low frequency AC (such as from mains electricity) will cause neuromuscular excitement, leading to tetanic contractions
- **>50 kHz** – high frequency AC avoids neuromuscular stimulation
- **400 kHz–10 MHz** – electrosurgical diathermy

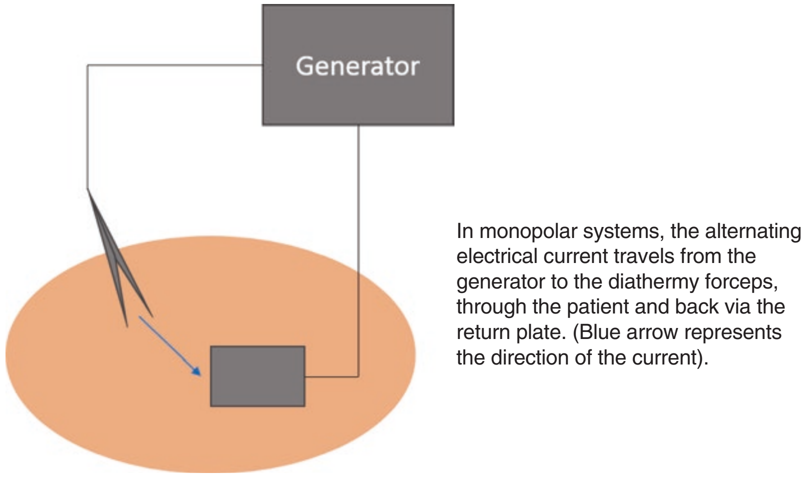


Fig. 9.134 Monopolar electrosurgical diathermy

Within the frequency range of electrosurgical diathermy, different AC waveforms can achieve different tissue effects [2]:

- **Coagulation** – Pulsed sinusoidal waveform at 10–75 W, coagulates by desiccating tissue.
- **Cutting** – Continuous sinusoidal waveform at 125–250 W, cuts by vaporising interstitial fluid and separating tissue.
- **Blend** – A pulsed wave current with a lower duty cycle, used to cut and coagulate at the same time.
- **Fulguration** – High-power current causing rapid heating of tissues to build up steam and violently burst cells. Used to ablate lesions.

Monopolar Versus Bipolar Diathermy Systems

The electrosurgical diathermy device consists of a 240 V AC generator and two electrodes: an **active** and **indifferent**. The placement of these two electrodes determines whether the diathermy system is monopolar or bipolar. In **monopolar** systems, the current passes from the generator through both limbs of the diathermy forceps, which represents the **active** electrode. The current then passes through the patient and back to the generator via the **indifferent** electrode, a metal return plate stuck to the patient (Fig. 9.134). This plate has to be a minimum of 70 cm^2 to reduce contact density and prevent burns. In **bipolar** diathermy, the current passes through one limb of the diathermy forceps (**active**), between the instrument tips, and through the other limb (**indifferent**) back to the generator (Fig. 9.135). Bipolar systems are low power and have no cutting modes.

Electrosurgery and Safety

Electrosurgical diathermy comes with hazards to everybody in the operating theatre. All theatre staff should be trained in the safe usage of electrical diathermy systems, and the final responsibility to maintain safety in the theatre lies with the surgeon.

Monopolar diathermy systems can burn patients if the indifferent electrode is too small, wet, not firmly adhered to the patient, or even absent. With some systems an alarm will sound if the return plate has been forgotten. The plate should be attached close to the surgical site on a well vascularised area but away from any ECG electrodes. As electrical currents can ignite alcohol-based antiseptic solutions, keep any skin preparations away from the plate. Some gases, such as nitrous oxide, used in laparoscopic insufflation are flammable and therefore unsuitable to use with electrical diathermy.

Electrical currents can also interact with implanted cardiac devices, such as pacemakers and defibrillators. Older cardiac pacemakers are inappropriately stimulated, while newer models may be inhibited. To avoid lethal arrhythmias, a

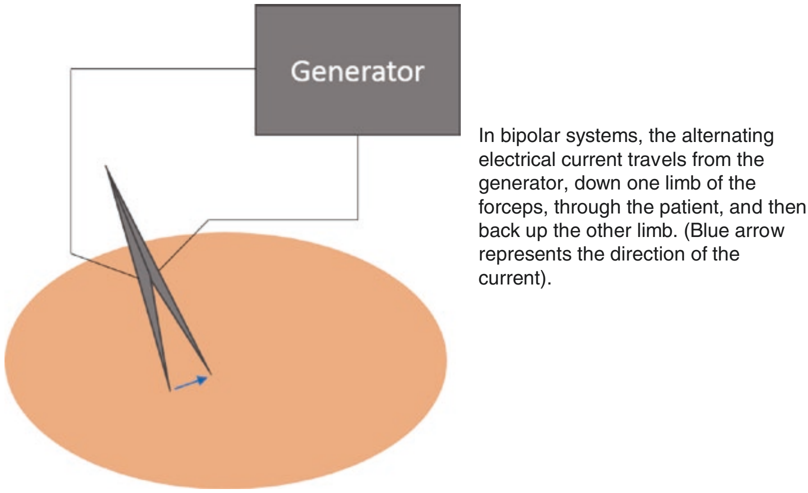


Fig. 9.135 Bipolar electrosurgical diathermy

cardiologist should be consulted regarding the particular pacemaker model.

The use of AC diathermy in appendages such as the penis, fingers, or narrow pedicles, can result in a phenomenon known as 'channelling'. The high current density can travel through the narrow structure and cause unwanted tissue coagulation. Diathermy should be avoided in these cases and, if unavoidable, **bipolar** diathermy should be employed [4].

Other Thermal Energy Sources

As well as AC electricity, a number of other energy sources are used to induce surgical diathermy. Surgical devices for cutting and coagulation can also pass ultrasound vibration or radiofrequency energy through tissue to generate heat:

- Harmonic ACE (Ethicon Endo-Surgery, USA) – Ultrasound
- THUNDERBEAT (Olympus, Japan) – Bipolar AC and ultrasound
- LigaSure (Covidien, USA) – Radio-frequency energy

Laparoscopic Equipment

Laparoscopic surgery requires specialised equipment in addition to the aforementioned surgical apparatus. The most obvious piece of equipment

Fig. 9.136 Forward viewing (0°) laparascope

Fig. 9.137 Laparoscopic camera stack

is the laparoscope, which allows the surgeon to visualise anatomical structures without direct vision. These endoscopic devices can come with an eyepiece, as in Fig. 9.136, or be connected to a camera stack (Fig. 9.137). The laparoscopic camera stack houses the optical hardware includes a video monitor which displays the image taken by the laparoscope, as well as a video processing unit and a light source. The camera stack shown in Fig. 9.137 also includes an integrated electrosurgical unit, with pedals for cutting and coagulating diathermy.

In addition to the optical equipment necessary in laparoscopic surgery, an insufflator is used to establish a pneumoperitoneum. This device pumps gas (usually CO_2) into the abdominal cavity via a trocar (or less commonly a Veress needle). Trocars comes in a range of shapes and sizes, with pyramidal, conical and even blunt tips. Simpler ones, as shown in Fig. 9.138, are simply used to puncture the abdominal wall. Other, more complex, models (Fig. 9.139) act as laparoscopic ports, with gas inlet valves and sleeves to allow the passage of laparoscopes or surgical instruments.

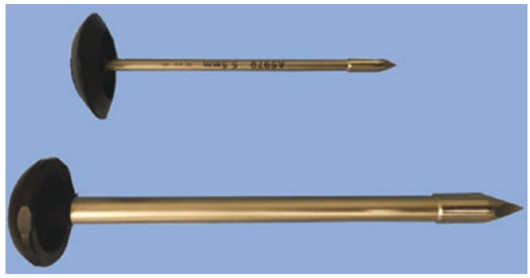


Fig. 9.138 Trocars with pyramidal tip

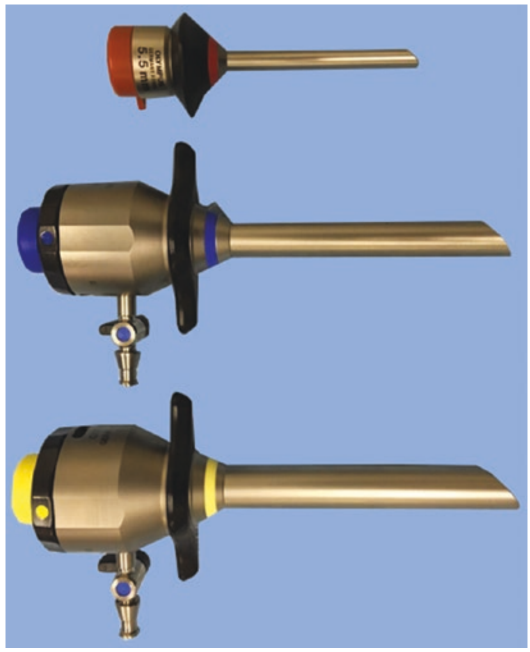


Fig. 9.139 Trocars with blunt tip, gas inlet valve and instrument sleeve

Preparing the Surgeon: Key Messages

- Pre-operative preparation for the surgeon includes the surgical scrub and the donning of the sterile surgical gown and gloves.
- Surgical incisions vary in length and placement, with some that are named and associated with particular procedures.
- Sutures are the most commonly used method of surgical closure and there are many types which vary in structure, material, and tissue reactivity.
- Surgeons use a wide variety of instruments, each with differing designs and a specific purpose in mind.
- Operating theatres contain an array of surgical equipment including several thermal energy sources for tissue cutting and coagulation, the most common of which is electrosurgical diathermy.

Surgeons' Favourite Questions for Students

1. How many minutes should the surgical scrub last for?
2. Do horizontal or vertical incisions offer better cosmetic results?
3. How is a needle holder distinguished from a haemostat?
4. Which type of suture is associated with higher rates of infection, monofilament or braided?
5. Which kind of electrical current is used in electrosurgical diathermy?

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10 Post-operative Care

Aminah N. Ahmad and Fahd Khan

Introduction

Surgery is a stressful event for patients, both physically and psychologically. Effective post-operative care should minimise these stresses, together with pain and recovery time, to produce the best possible patient outcome.

Post-operative care encompasses several aspects and this chapter aims to outline important principles, including recovery, ward care, post-operative analgesia, fluid management, nutrition, wound healing, and common complications in routine and critically-ill surgical patients.

The Recovery Room

Post-operative care begins immediately after a surgical procedure in the recovery room. Vital signs (heart rate, blood pressure, oxygen saturation, urine output) should be monitored with vigilance for any signs of immediate post-operative complications including [6]: airway obstruction, hypoxia, haemorrhage, hypo/hypertension, pain, shivering/other signs of hypothermia, and vomiting/aspiration.

Patients may be discharged from recovery when the following conditions are met [5]:

- Full consciousness and response to voice/light touch
- Clear airway and normal cough reflex
- Satisfactory respiratory rate (10–20 breaths/min) and oxygen saturation (>92 %)
- Pulse and blood pressure approximated to the pre-operative values
- No unexplained cardiac irregularity or persistent bleeding
- Pain and nausea controlled with suitable analgesia and anti-emetics
- Temperature >36 °C
- Adequate oxygen and fluid therapy when required

Once deemed fit to leave the recovery room, the patient should be discharged to the appropriate level of care (described in Table 10.1 below) with orders to control [6]: vital signs, pain, administration of IV fluid and medications, urine output, and any required laboratory investigations.

It may become necessary to move a patient to a different setting for a different level of care; ITU is considered the highest, while HDU is a step down. Care is provided by a multidisciplinary team (MDT) of ITU physicians and nurses, specialist physicians, dieticians and physiotherapists.

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Table 10.1 A summary of the levels of care available to post-operative patients [2]

Level of care	Appropriate patients
0 – Ward	Those who have undergone minor surgical procedures Those whose needs can be met through normal ward care
1 – Surgical Ward	Those who are at risk of their condition deteriorating Those whose needs can be met on a surgical ward with advice and support from a critical care team available
2 – High Dependency Unit (HDU)	Those who require a monitored bed. Nurse:patient ratio in HDU is 1:2 Those who require support for failure of a single organ system, including the need for continuous positive airway pressure (CPAP)
3 – Intensive Therapy Unit (ITU)	Those who require complex support, e.g. advanced respiratory support or support for failure of more than one organ system Those who require mechanical ventilation and advanced monitoring Those who require one to one nursing

The patient's notes should also include any surgical or anaesthetic complications that occurred, and specific instructions for any problems that may arise.

Care of the Critically Ill Surgical Patient

Critical illness is defined as injury overwhelming the physiologic reserve, to the point where life cannot be sustained without outside intervention; for example when asthma worsens, causing intubation and mechanical ventilation to become necessary. Physiological reserve may be compromised by age or prolonged illness.

The stress response to surgery causes physiological changes in patients. Figure 10.1 outlines the support methods provided in a critical care setting (HDU or ITU).

Post-operative Assessment and Monitoring [5]

A post-operative assessment should be carried out upon the patient's return to the ward. This provides a baseline which subsequent assessments can be compared against during the recovery process.

This assessment should include:

- *A review of history and peri-operative instructions*:
  - Past medical history, medication and allergies.
  - Intraoperative complications and post-operative treatment instructions.
- *Respiratory status*: oxygen saturation, respiratory rate, breath sounds, percussion notes, and tracheal position.
- *Circulatory volume*: hands (warm or cool), capillary refill, pulse rate/rhythm, blood pressure, jugular venous pressure (JVP), urine colour and rate of production, and drainage from the wound.
- *Mental state*: assess patients' consciousness and responsiveness using the AVPU scale (**A**lert – Responsive to **V**oice – Responsive to **P**ain – **U**nresponsive).
- *Any significant symptoms*: chest pain, breathlessness
- *Post-operative pain*

A monitoring regimen for the patient should be established including: temperature, pulse rate, blood pressure, respiratory rate, peripheral oxygen saturation, and urine output. Pain should also be assessed. Monitoring should be frequent in the initial period after surgery (e.g. every 15 min for the first hour), and then less frequently over time (e.g. every 30 min, dropping to once an hour after 2 h).

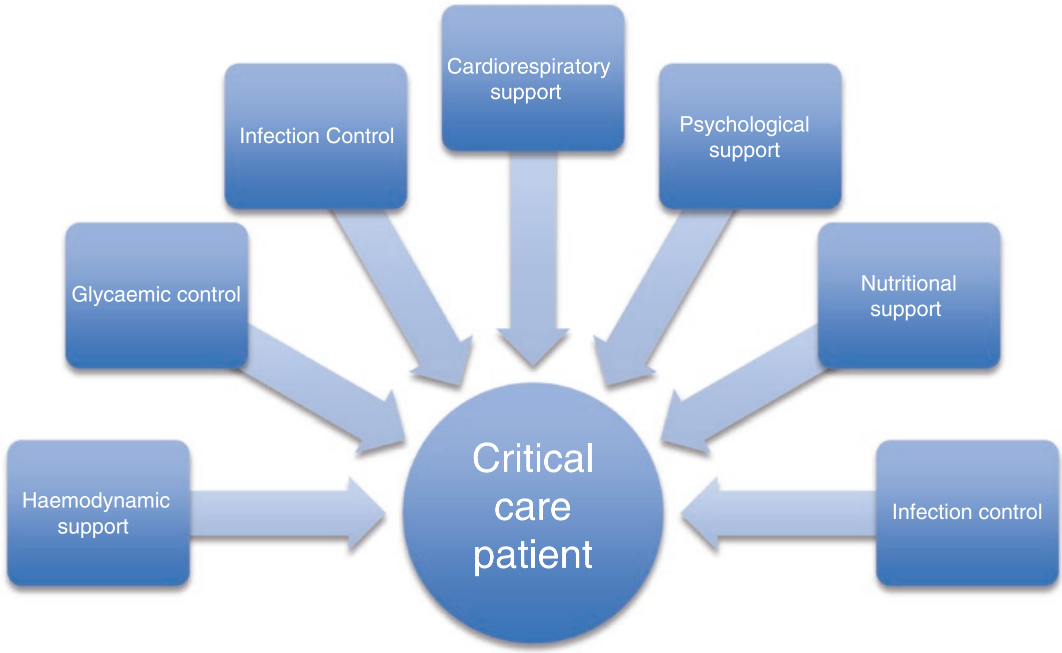

Fig. 10.1 Methods of support provided to critically ill patients in critical care settings. Cardiorespiratory support includes intubation, ventilatory and inotropic support, and a central line for monitoring central venous pressure. Fluid resuscitation is important. Ventilation strategies, including spontaneous breathing trials, allow faster weaning from mechanical ventilation

Certain patients, including those in higher levels of care, those who have undergone longer or more invasive procedures, or those with pre-existing cardiorespiratory disease, may require additional monitoring including: electrocardiogram (ECG), arterial blood pressure (ABP), central venous pressure (CVP), arterial blood gas (ABG), and haematology.

Post-operative monitoring assesses the patient's physiological state, allowing decisions regarding analgesia, nutrition, fluid management and wound care to be made.

Table 10.2 The effects of uncontrolled post-operative pain by system

Effects of uncontrolled post-operative pain	
Metabolic	Catabolism (increased cortisol, glucagon and catecholamines)
Cardiovascular	Increased myocardial oxygen demand and coagulation
Respiratory	Decreased functional residual capacity, sputum retention
Gastrointestinal (GI)/ Genitourinary (GU)	Vomiting, ileus, sodium and water retention
Psychological	Anxiety and depression

Post-operative Analgesia

Up to 75 % of surgical patients experience post-operative pain [1]. If uncontrolled, this can significantly affect recovery, increasing morbidity and mortality and decreasing quality of life. Post-operative management aims to minimise pain severity and duration.

Effects of Post-operative Pain

If unrelieved, post-operative pain can have a variety of effects (Table 10.2).

Unrelieved pain increases the likelihood of negative clinical outcomes, such as: deep vein thrombosis (DVT)/Pulmonary embolism (PE), coronary ischaemia/myocardial infarction (MI), poor wound healing, pneumonia, insomnia, and demoralisation.

There are also economic considerations – post-operative pain can extend the length of stay and increase chances of readmission [1].

The WHO analgesic ladder is reversed for surgical patients. Opioid analgesics, such as morphine, are usually administered as first line treatment intravenously or into the epidural space. These can have side effects, including nausea (an anti-emetic may be administered), urinary retention and respiratory depression. Supplementing opioids with other analgesics, such as non-steroidal anti-inflammatory drugs (NSAIDs), has been associated with reduced risk of opioid side effects.

A common management method for post-operative pain is patient-controlled analgesia (PCA), where a programmed dose of opioid is given 'on demand' – it is administered intravenously via a pump when the patient pushes a button. This is also used in labour pain and palliative care, and usually results in high patient satisfaction.

Pain Scoring

Post-operative pain can be scored using a variety of methods.

- *Qualitatively*: verbal rating score (none/mild/moderate/severe).
- *Quantitatively*: numerical rating scale (0 -no pain, 10 -worst pain imaginable).
- *Visual analogue scale*: pain indicated on line (no pain to worst pain imaginable), which is good for children.

Fluid Management

In addition to providing the normal daily fluid requirements of the patient, fluid management is used to administer drugs, correct fluid and electrolyte imbalances and for fluid resuscitation.

Normally, fluid production (metabolic processes) and intake (food and liquids) balance the fluid lost from urine, stool, lungs and the skin. If losses exceed intake, patients become dehydrated; if intake is greater, they experience fluid overload.

Symptoms of dehydration: thirst, fatigue, impaired concentration, dry skin, cool peripheries, and reduced urine output.

Symptoms of fluid overload: shortness of breath, ankle swelling, and fatigue.

Assessing fluid balance: fluid balance should be assessed by examination. The basic procedure is outlined below.

- *General inspection*: IV fluids, consciousness level (Glasgow Coma Scale)
- *Hands*: peripheral perfusion, capillary refill, pulse, skin turgor, blood pressure
- *Face*: sunken eyes, dry mucous membranes
- *Neck*: jugular venous pulse, central venous pulse
- *Chest*: pulmonary oedema, extra heart sounds
- *Abdomen*: ascites
- *Legs:* peripheral oedema
- Daily weight

The fluid challenge: fluid balance can be assessed by a fluid challenge, where 250 mL of the colloid gelofusin is given over 15 min.

- If blood pressure increases and returns to normal, the patient is euvolaemic (normal blood volume).
- If blood pressure does not increase, the patient is hypovolaemic (decreased blood volume) and fluid resuscitation is necessary.
- If blood pressure increases, the patient is hypervolaemic (increased blood volume).

Prescribing IV fluids: there are two main types of IV fluid that can be prescribed to correct fluid balance -

- *Crystalloids* (solutions of water-soluble molecules) include 0.9 % saline, dextrose saline and Hartmann's solution (contains electrolytes such as sodium, chloride, potassium, and lactate).
- *Colloids* (insoluble particles in suspension) may be natural (blood and albumin) or synthetic (gelofusin or haemacell).

Nutrition

Malnutrition in surgical patients is associated with poor outcomes and longer hospital stays. It impairs protein dependent functions in the body, leading to complications such as infection, poor wound healing and wound dehiscence (modern Latin *dehiscentem*, to gape).

Patients with weight loss of >10 % of their body weight are considered to be severely malnourished. Nutritional support for post-operative patients can be provided in three ways: oral, enteral and parenteral.

Oral support: the rise of enhanced recovery after surgery (ERAS) programmes mean that more and more patients are provided with oral support after undergoing surgery, instead of enteral or parenteral. Oral support can be polymeric (whole or undigested proteins), elemental (individual amino acids that require little digestion) or disease specific, for example in patients with liver failure, branched chain amino acids and Vitamin K are provided.

Enteral support: administering nutrition directly into the GI tract. This is usually done via a nasogastric tube. Risks include malposition of the tube and aspiration of food into the respiratory tract.

Parenteral support: providing nutrition intravenously. Both macronutrients such as amino acids, lipids and glucose, and micronutrients such as electrolytes and vitamins can be administered using this method.

Wound Healing

Types of incision closure: surgical incisions can be closed in two main ways.

- *Primary intention* – the edges of the wound are brought together and the wound is closed with sutures, staples, adhesives or tape. Epithelialisation occurs within 24–48 h.
- *Secondary intention* – the wound is left open and allowed to granulate.

The stages of wound healing: there are four main stages of wound healing.

1. *Haemostasis* – occurs immediately and Von Willebrand factor is secreted. Platelets then adhere to the damaged endothelium and aggregate, forming a platelet plug. Fibrin is added to this platelet plug, reinforcing it.
2. *Inflammation*: there are two phases.
   - *Early phase (24–48 h)* – the complement cascade is activated, and granulocytes produce free radicals and antibacterial proteases. Epithelial cell migration and proliferation then begins.
   - *Late phase* (2–3 days) – macrophages replace granulocytes, remove dead cells and aid in wound debridement, and produce growth factors that stimulate angiogenesis. Epithelisation is complete.
3. *Regeneration*: takes place 3–20 days after a wound is sustained. Fibroblasts migrate to the wound site and lay down collagen, helping to create a new extracellular matrix. Angiogenesis continues.
4. *Remodelling:* takes place weeks after a wound is sustained. Consists of the dynamic deposition and degradation of type 3 collagen. A scar with 80 % of the original strength of the wound site forms by 12 weeks.

Factors that impede wound healing can be divided into local and systemic. These are listed in Table 10.3.

Excessive wound healing: excessive wound healing occurs when the normal balance of collagen deposition and degradation during remodelling is disturbed. There are two main types.

- *Keloids*: the raised area extends beyond the wound margins and there is no wound contracture. They are treated by excision, steroids and cryotherapy, but typically recur. These are uncommon in children.
- *Hypertrophic scars*: the raised area is confined to the wound margins and there is wound contracture. They are treated by excision, steroids and cryotherapy, and typically do not recur. These can occur at any age.

Wound Dressing: there are many types of wound dressing. The most appropriate in any

Table 10.3 Factors that impede wound healing, divided into local (factors related to the wound itself) and systemic (factors that affect the entire body)

Local	Systemic
Inadequate blood supply	Advancing physiological age
Increased skin tension	Obesity
Poor surgical wound apposition	Smoking
Wound dehiscence	Diabetes mellitus
Poor venous drainage	Malnutrition
Presence of foreign bodies	Vitamin/trace elements deficiency
Haematoma Infection Excess local mobility (e.g. over a joint) Topical medicine	Systemic malignancy Shock Chemotherapy or radiotherapy Immunosuppressants Corticosteroids Anticoagulants Chronic renal/hepatic failure

given situation is governed by the properties of the wound.

- *Semipermeable film dressings*: made of a polyurethane film that adheres to intact skin. Used in dry, superficial wounds.
- *Semipermeable pad dressing:* an interface between the wound and the dressing allows exudate to pass. Indicated with wounds with low exudate.
- *Hydrocolloid dressing:* when contact with exudate is made, a gel from cellulose or gelatin is formed. Indicated in wounds with low or moderate exudate.
- *Alginate dressing:* derived from seaweed. When contact with exudate is made, a gel is formed. Indicated in wounds with low or moderate exudate.
- *Hydrofibre dressing:* a textile fibre dressing formed of carboxymethyl cellulose. Reduces risk of skin maceration. Indicated in wounds with moderate to heavy exudate.
- *Foam dressing:* formed from silicon or polyurethane. Indicated in wounds with heavy exudate.
- *Hydrogel dressing:* formed from an insoluble polymer. Aids in wound debridement and slough. Indicated in dry, necrotic wounds with minimal exudate.

Common Post-operative Complications

Surgical complications can be defined as undesirable and unintended results that affect the patient as the result of an operation. Common complications can be divided into immediate, early or late, depending on when they occur after surgery:

- *Immediate complications*: primary haemorrhage (which begins during surgery), shock, atelectasis (further described below in 'Respiratory Complications') and low urine output (due to renal injury or inadequate fluid replacement). If there appears to be no urine output, check the position of the catheter!
- *Early complications:* take place around 24 h after surgery. These include acute confusion, nausea and vomiting, fever, secondary haemorrhage, pneumonia, wound or anastomotic dehiscence and urinary tract infection.
- *Late complications:* take place a few days after surgery, including incisional hernias and neuralgic pain.

Post-operative complications can also be divided into systems: fever, infection, wound, respiratory, cardiovascular, gastrointestinal, genitourinary, and psychiatric.

1. ***Fever***
   This affects approximately 50 % of post-operative patients and is a disorder of thermoregulation. Pyrogens induce interleukin one, altering the activity of temperature sensitive neurons in the anterior hypothalamus and raising the core temperature.

   The cause of post-operative fever determines when it manifests (see Table 10.4).

Table 10.4 The infectious and non-infectious causes of post-operative fever

Causes of fever in post-operative patients	
Infectious	Non infectious
Urine tract infection	Atelectasis
Wound infection	Dehydration
Pneumonia	Myocardial infarction
Peritonitis	Pulmonary embolism
Abscess	Transfusion

- Fever that presents 0–2 days after surgery is primarily caused by atelectasis.
- Fever that presents during days 3–5 is usually caused by sepsis or wound infection.
- Fever that presents after the first week is usually caused by wound infection, other infections (e.g. UTI), DVT or PE.
- Rarely, persistent fever can be caused by malignant hyperthermia, which is a rare autosomal dominant condition caused by abnormal temperature rise in response to anaesthesia. Symptoms include metabolic acidosis, hypercalcaemia, and cardiac arrhythmia. It is treated by use of cooling blankets, ventilation, or dantrolene.

2. ***Infection***
   Surgery and post-operative infection can stimulate the systemic inflammatory response syndrome (SIRS). If untreated, this can lead to failure of multiple organ systems including the respiratory and renal systems. It is diagnosed when two or more of the following criteria are met:
   - Temperature >38 °C or <36 °C
   - Heart rate >90 beats/min
   - Respiratory rate >20 breaths/min or $PaCO_2 < 4.3$ kPa
   - White blood cell count $>12 \times 10^9$/L or $<4 \times 10^9$/L

   Sepsis: SIRS plus known infection.
   Severe sepsis: sepsis with evidence of organ dysfunction.
   Septic shock: sepsis induced hypotension with a systolic pressure of <90 mmHG that persists despite fluid resuscitation.
   Both SIRS and sepsis are generally treated by treating the underlying cause.

3. ***Wound***
   - Infection
   - Haematoma formation
   - Seroma formation
   - Wound dehiscence: occurs when there is closure failure and is treated by return to theatre for urgent wound closure. It results in approximately 30 % mortality.
   - Bleeding: can be intraoperative, immediately post-operative (in the recovery room), reactionary (within 48 h), secondary (within a week). It is treated by fluid resuscitation and blood transfusion.

4. ***Respiratory***
   - *Atelectasis*: loss of lung expansion that can occur early after surgical procedures. If ignored, it can develop into pneumonia and therefore it is treated with chest physiotherapy.
   - *Pneumonia:* an infection with symptoms including fever, shortness of breath, chest pain and oxygen desaturation. It is treated by chest physiotherapy and antibiotics.
   - *Aspiration pneumonia:* occurs when foreign bodies are inhaled into the lungs during or after anaesthesia and can cause vomiting. It is treated in the ITU by administration of IV antibiotics and ventilation.
   - *Pulmonary embolism (PE):* a blockage of the pulmonary artery or one of its branches by a blood clot that has travelled from another location in the body. 10 % of patients die within the first hour. It can be diagnosed using a CT pulmonary angiogram (CTPA).
     – Types – central, peripheral, and massive (where both pulmonary arteries are involved).
     – Risk factors – venous stasis, hypercoagulable state, immobilisation, pregnancy, the oral contraceptive pill, genetic factors, acute illness, and malignancy.

    - Symptoms – shortness of breath, chest pain, tachypnoea, tachycardia, fever, confusion, abdominal pain, desaturation, atrial fibrillation, and a patient that generally looks unwell.
    - Treated by – oxygen, anticoagulants, and percutaneous extraction of the embolus.

Cardiovascular

- *MI*: there is decreased oxygen supply due to hypoxia, hypovolaemia and hypotension. It commonly occurs on the third post-operative night.
  - Diagnosed by – ECG changes (such as ST elevation) and a raised troponin level.
  - Can be prevented by – oxygen mask, perioperative beta blockers, and continuous post-operative cardiac monitoring in HDU or ITU.
  - Treated by – oxygen, aspirin, morphine, nitrates, heparin, and stent insertion.
- *Hypovolaemia*: volume depletion occurs in most post-operative patients. It is diagnosed by low urine output and dehydration, and treated by administration of IV fluids.
- *Post-operative hypertension*: can occur a few hours post-operatively. It is treated with antihypertensive drugs.
- *DVT:*
  - Virchow's Triad includes three contributing factors to DVT – endothelial injury, venous stasis and hypercoagulability.
  - Symptoms – majority are asymptomatic but can present with leg pain, Homan's sign (pain on dorsiflexion) and leg swelling.
  - Diagnosed by – ultrasound Doppler to lower limbs, venography, and D-dimer.
  - Risk factors – immobilisation longer than 3 days, pregnancy, age, long plane or car trips in the previous 4 weeks, cancer, previous DVT, stroke, acute MI, congestive heart failure, sepsis, burns, the oral contraceptive pill, and systemic lupus erythematosus.
  - Treated by – low molecular weight heparin, warfarin, and a filter in the inferior vena cava.
  - Preventing DVT is described in more detail in the section 'DVT Prophylaxis'.

Gastrointestinal

- *Nausea and vomiting*: can occur as a reaction to anaesthesia.
- *Ileus*: can be worsened by opioids and hypokalaemia.
  - Symptoms – abdominal pain, nausea, vomiting, anorexia, bloating, abdominal distension, absent bowel sounds, lack of passage of flatus, and tympanic abdomen.
  - Treated by – NG tube, IV fluids, mobilisation, and enteral or parenteral feeding if required.
- *Diarrhoea*

Genitourinary

- *Urinary retention*: can occur as a reaction to anaesthesia. It is treated by catheter insertion and consulting urology.
- *Acute kidney injury*

Psychiatric Complications

- *Confusion and delirium*: most common in older patients.
- *Depression and anxiety*

Prevention of Complications [6]

WHO recommend the following steps be taken to minimise the risk of post-operative complications:

- Encouragement of early mobilisation – deep breathing and coughing, active daily exercise, strengthening of muscles, and use of walking aids such as canes and walkers.
- Provision of adequate nutrition
- Provision of adequate pain control
- Prevention of pressure sores and skin breakdown – the patient should be turned frequently, and urine and faeces should be kept off the skin.

DVT Prophylaxis

DVT is considered one of the most catastrophic post-operative complications. Autopsy studies have shown that up to 50 % of patients who die in hospital have a DVT. Around 10–30 % of these patients develop a secondary pulmonary embolism [4]. As a result of this, guidelines for post-operative DVT prophylaxis have been developed to reduce DVT incidence. These guidelines are summarised below [3]:

- All patients should receive a DVT risk assessment upon hospital admission.
- All patients should be encouraged to ambulate post-operatively, as early and frequently as possible.
- Patients judged to be at high risk of post-operative DVT (risk factors outlined above) should be prescribed a low molecular weight heparin to decrease the risk.

Discharge [5]

When post-operative patients are discharged, the following should be recorded in the patient notes:

- Diagnosis on admission and discharge.
- A summary of the time spent in hospital including the operative procedure.
- Instructions for future management, including all prescribed drugs.

This information must also be given to the patient, along with details of any outpatient follow-up appointments made.

The Enhanced Recovery After Surgery Programme

Given the stressful effects of surgery on patients physiologically and psychologically, the enhanced recovery after surgery (ERAS) programme exists to minimise the duration of hospital stay and number of complications encountered.

The programme begins with a referral from primary care and ends with patient follow up in the community. The multiple settings for ERAS care make the multidisciplinary team of surgeons, nurses, physiotherapists and anaesthetists essential to the programme's success.

Background of the Programme

The ERAS programme challenges the concept that the post surgical stress response is inevitable. It is a multi-modal perioperative care pathway that replaces traditional practices, with evidence-based best practice when necessary. All aspects of the patient journey are covered.

ERAS targets the key factors that keep patients in hospital after surgery, including the need for parenteral (Gr. *para* + *enteral,* beside intestine) analgesia, the need for IV fluids secondary to gut dysfunction, and lack of mobility. Primary care is an important aspect of the programme; prior to admission, general practitioners must optimise patient co-morbidities and play a role in reassuring and educating patients about their procedure. After discharge, they play an essential role in follow up.

This section summarises the measures taken at every stage of the patient journey to minimise the stress response during and after surgery and optimise a patient's experience.

Preoperative Factors

Pre-operatively, structured management of the patient can accelerate post-operative recovery. Factors to be considered can be found in Fig. 10.2.

Perioperative Factors

Perioperative care can be altered to minimise the surgical stress response. Key points include:

- Thoracic epidural anaesthesia before the initial skin incision
- High inspired oxygen concentration (80 %) during anaesthesia (and for 6 h postoperatively)
  - A face mask should be used to deliver this if necessary

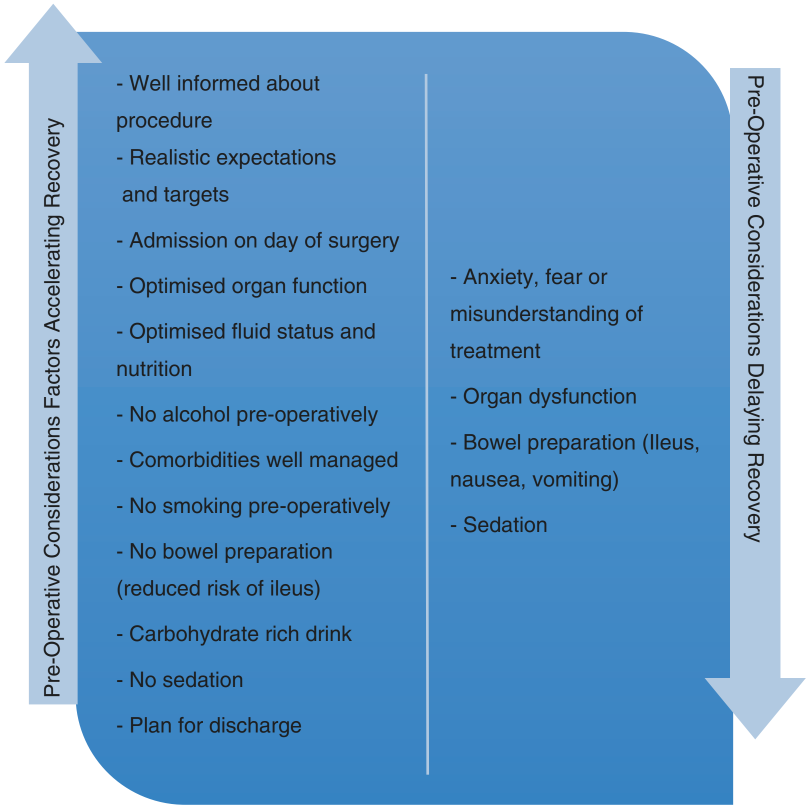

Fig. 10.2 Preoperative factors that can accelerate or delay recovery

- Use of a short acting anaesthetic agent for epidural anaesthesia and local blocks
- Warm air blankets to prevent hypothermia
- Fluid therapy and monitoring
- Short and transverse surgical incisions where possible
- Avoidance of abdominal drains and nasogastric tubes
- Minimally invasive surgery where appropriate

Postoperative Factors

Post-operative care can be optimised to shorten the recovery period and allow early discharge. Key points include:

- Avoidance of opiates
  - Paracetamol and non steroidal anti-inflammatory drugs (NSAIDS) should be used if there are no contraindications
- Early mobilisation
- Reintroduction of diet and fluids within 24 h
- Avoidance of excessive amounts of IV fluid
  - IV fluid administration should be terminated by the second postoperative day if possible
- Regular audits should take place to monitor clinical outcomes and keep readmission rates below 10 %

Figure 10.3 shows how these factors are controlled in ERAS patients during the first 2 days following a surgical procedure.

Discharge

Patients on the programme can be discharged when three conditions are met:

- Good pain control on oral analgesics
- Independent mobility at pre-operative levels
- Consumption of solid food

In addition to these, the patient must be both willing to go home and have support at home.

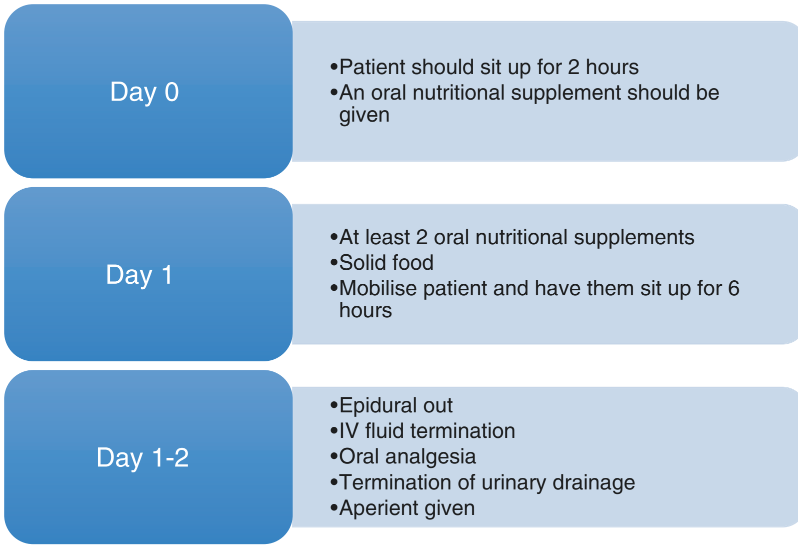

Fig. 10.3 Aims for management of ERAS patients in the first 2 days after surgery

Follow-Up

Extra support during follow up is needed for ERAS patients. There must be a clear pathway for re-admission should the patient require re-hospitalisation. Follow up at clinic should take place a week after discharge, and a daily walk-in clinic should available in case required in the interim period. A contact telephone is available in case the patient requires advice. Support from the patient's general practitioner is also vital.

Surgeons' Favourite Questions for Students

1. A patient develops fever 1 day after undergoing a surgical procedure. What is the most likely diagnosis and how would you manage this patient?
2. A post-operative patient seems to have no urine output. What is the most likely cause of this?
3. Which test would you use to diagnose PE and how would you manage a patient suffering from one?
4. Explain the fluid challenge.
5. Explain the differences between HDU and ITU.

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Minimally Invasive Surgery (MIS)

11

Mollika K. Chakravorty, Eilidh S. Bruce, Faisal I.A. Ghumman, Benjamin J. Challacombe, and Martin Sheriff

"The cleaner and gentler the act of operation, the less pain the patient suffers, the smoother and quicker the convalescence, the more exquisite his healed wound, the happier his memory of the whole incident."

—Lord Berkeley Moynihan, 1920

Introduction

This chapter aims to provide a comprehensive introduction to the fundamental principles and techniques surrounding the evolution and modern-day practice of minimally invasive surgery (MIS). New to the curriculum of undergraduate study, an appreciation of developments in this field is essential for the aspiring future surgeon in this climate of ever advancing technology.

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History of MIS

In the early days of surgery, large incisions were needed to give adequate exposure and operating space. Since then, operative techniques have been standardised and are more precise. Coupled with advances in anaesthesia and antisepsis, surgery is now much safer and less painful. As a result the goals have shifted from mere patient survival towards improving post-operative outcomes and morbidity. To achieve this, the emphasis is now on reducing the amount of tissue trauma during surgery, leading not only to better cosmetic outcomes in terms of scarring, but also a reduced hospital stay, a faster return to normal daily activity after surgery and continual improvement of aspects of the open procedures.

At first, surgeons minimised trauma caused by incisions by making smaller 'muscle-splitting' cuts, parallel to the direction of muscle fibres. However, even with small incisions, significant amounts of tissue damage were caused by the use of retractors, which pull the tissue apart to expose the operating site. Therefore, a new method was developed to allow operations to be carried out without opening the body, under indirect vision through gas or fluid mediums, termed *MIS*. Medical telescopes were developed and instruments were lengthened and adapted so that procedures could be performed via ports made through the skin, or natural orifices such as the vagina or gastrointestinal tract.

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The first medical telescope, or endoscope [Gr. *endon* + *skopein*; look into], was the 'Lichtleiter': a urethral catheter adapted by Philip Bozzini in 1805 with mirrors and a candle, to allow examination of the lower genitourinary tract. Antonin Desormeaux, widely regarded as the 'father of endoscopy', used the Lichtleiter in surgical procedures from 1853. Over the next 100 years, developments in technology, such as in video, fibre optics and television, provided increasingly detailed representations of the operating field. Combined with improvements in instrumentation, this has allowed greater precision and accuracy during procedures, making endoscopic surgery a viable alternative to open surgery. A timeline depicting the evolution of MIS can be found in Table 11.1.

Principles of MIS

Today, MIS is performed routinely across a wide range of specialities: from urology to cardiothoracic surgery. In particular, a high percentage of gastrointestinal and gynaecological procedures are carried out by MIS, especially gallbladder surgery: approximately 90 % of cholecystectomies are performed laparoscopically in the US [1].

Table 11.1 A timeline of developments in MIS

1805	**P. Bozzini** Inventor of "Lichtleiter" Composed of Mirrors, a wax candle for illumination and an urethral cannula used to visualise GU tract
1853	**A. J. Desormeaux** "Father of endoscopy" First to use Bozzini's "Lichtleiter" on a patient Genital speculum, mirror and kerosene lamp used
1877	**M. Nitze** Created first workable cystoscope
1901	**G. Kelling** Performed first experimental laparoscopy using insufflation (dog) Created pneumoperitoneum using filtered atmospheric air, to prevent intra-abdominal bleeding
1911	**B. Bernheim; H.C. Jacobaeus** Performed first laparoscopic procedures Bernheim: used a half-inch diameter protoscope and ordinary light to perform an "organoscopy" Jacobaeus: performed procedure both on thorax and abdomen, introducing trocar without pneumoperitoneum
1920	**R. Zollikofer** Determined benefits of using CO_2 for insufflation
1929	**H. Kalk** Developed 135° lens system and dual trocar Performed diagnostic laparoscopy as diagnostic method – liver and gallbladder
1938	**J. Veress** Developed spring-loaded needle Used as a treatment for pneumothorax in TB patients
1944	**R. Palmer** Performed gynaecological laparoscopic procedure Placed patients in Trendelenberg position to allow air to fill pelvis Advocated continuous intra-operative abdominal pressure monitoring
1953	**H. Hopkins** Developed rigid rod lens system and videoscopic surgery
1972	**H. C. Clarke** Developed laparoscopic suturing technique
1978	**Hasson** Alternative open trocar placement
1983	**Semm** First laparoscopic appendicectomy
1987	**P. Mouret** First laparoscopic cholecystectomy using video technique
1989	**H. Reich** Used bipolar diathermy in first laparoscopic hysterectomy Demonstrated laparoscopic staples and sutures
1989	**Reddick and Olsen** Reported that in laparoscopic cholecystectomy – CBD injury risk is 5 times higher than open procedure US government: surgeons should do 15 under supervision
1990	**Wickham and Davies** First surgical robot developed for transurethral ultrasound – "PROBOT" Automated system performed in 30 patients
1994	AESOP Robotic arm developed for holding telescope
1996	First robotic telesurgery performed
2000	FDA approves US military funded Da Vinci device
2002	**Menon** First robotic radical prostatectomy

Fundamentally, laparoscopic surgery is carried out via four sequential stages: *patient positioning, port insertion and insufflation, specimen retrieval,* and *port removal*. In the first stage, the patient is positioned appropriately on the operating table using gel pads and strapping to support the body. This ensures good weight distribution and prevents the development of pressure sores, neuropathies or rhabdomyolysis associated with poor positioning. Furthermore, patient positioning can be crucial to providing adequate intra-operative exposure. For example, in the Trendelenburg position, the patient is laid supine (flat on the back), with the table tilted in order to place the feet higher than the head. This provides better access to the pelvic organs, by allowing gravity to pull the mesentery and intestines away from the operative field. In the second stage, an initial port (trocar) is inserted into the abdomen. This trocar is used to establish pneumoperitoneum by insufflating the abdomen with CO_2 gas. This distends the peritoneal cavity and allows for optimal visualisation. Additional ports can then be inserted safely under direct vision, and subsequently used for the camera and instruments. In the third stage, the surgical procedure is performed and the specimen retrieved. Finally, the trocars are removed and the incisions are closed. The fundamental requirements for laparoscopic surgery are summarised in Box 11.1 and discussed below.

Box 11.1 Required components
- Trocar (access)
- Insufflation (retraction)
- Light source (visual input)
- Camera (visual output)
- Instruments

Trocar

Trocars act as ports, providing sealed entrances for the camera and instruments to be inserted into the abdomen in laparoscopic surgery. Modern trocars are derivatives of the '*trochartor triosequarts'* created in 1706: a three-faced instrument with a sharp, pointed perforator housed within a metal cannula. Today, modern trocars may be inserted via a closed or open technique.

Closed insertion is performed with a Veress needle, which is used to puncture the abdomen at the umbilicus. Developed by Janos Veress in 1938, the 12–15 cm long, 14 gauge needle has two elements. The first part is a cannula with a bevelled needle point, which functions to pierce the abdominal wall. Two 'pops' can be heard during insertion of the Veress needle: the first signalling perforation of the linea alba and the second, the peritoneum. Upon entering the peritoneal cavity, there is a sudden decrease in pressure against the needle. This draws forwards the second part of the instrument from within the cannula: a spring-loaded, blunt stylet, which covers the sharp needle. This is accompanied by an audible 'click'. Though use of the Veress needle is fast, preferred by many doctors and is standard practice in the USA, blind insertion of the needle is associated with higher risk of various complications. When compared to open trocar insertion, the commonest complication is failed entry, and other risks include injury to the omenta and viscera, vascular injury and extraperitoneal insufflation [2]. This technique is not advocated by any of the UK Royal Colleges of Surgeons, however it is used by the Royal College of Obstetricians and Gynaecologists.

The alternative open method of trocar insertion is termed the Hasson technique, which can be thought of as a "mini-laparotomy". In order to access the peritoneal cavity in this way, a small incision and split in the fascia is created at or near the umbilicus, approximately 1 cm in length. The abdominal wall layers are cut down, and after the peritoneum is incised, a Hasson trocar (a blunt tipped cannula with an olive shaped sleeve) is inserted through the incision. The cannula body is then securely fastened using stay sutures to the fascial edge. With regard to the comparative safety of these two access methods, currently the choice is subject to individual surgeon preference, as literature review found non-inferiority of Veress in contrast to the Hasson technique.

Insufflation

The process of inflating the abdomen, or 'insufflation', creates a domed gas-filled space within the peritoneal cavity (known as a pneumoperitoneum) that allows the surgeon to see the organs clearly. In order to create the pneumoperitoneum, a machine with an adjustable flow rate setting of between 0 and 35 L/min is used to supply a maximal pressure of 15–20 mmHg, limited to allow venous return. Working pressures of between 10 and 15 mmHg in adults, and 10 mmHg in children are generally used.

Insufflation results in an even distribution of pressure throughout the whole abdomen: as a consequence there is less local wound trauma than there would be when using retractors in open surgery. However, there are pathophysiological processes associated with the induction and maintenance of pneumoperitoneum, which must be considered. A raised intra-abdominal pressure above 20 cm H_2O can precipitate a reduction in venous return; an increase in cardiac stress related to hypotension; a reduced forced respiratory capacity; and cerebral ischaemia. The pathophysiology is summarised in Fig. 11.1.

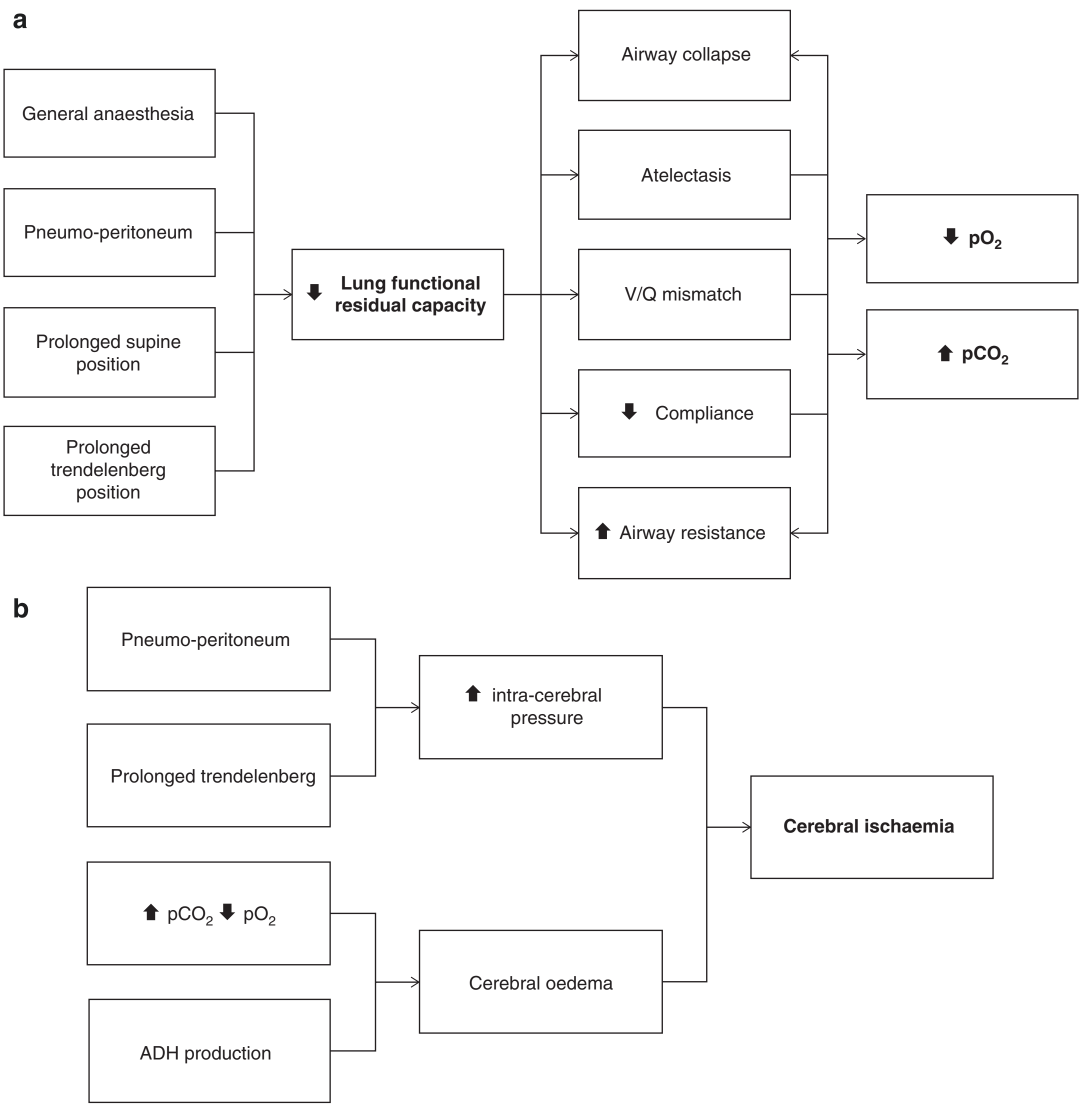
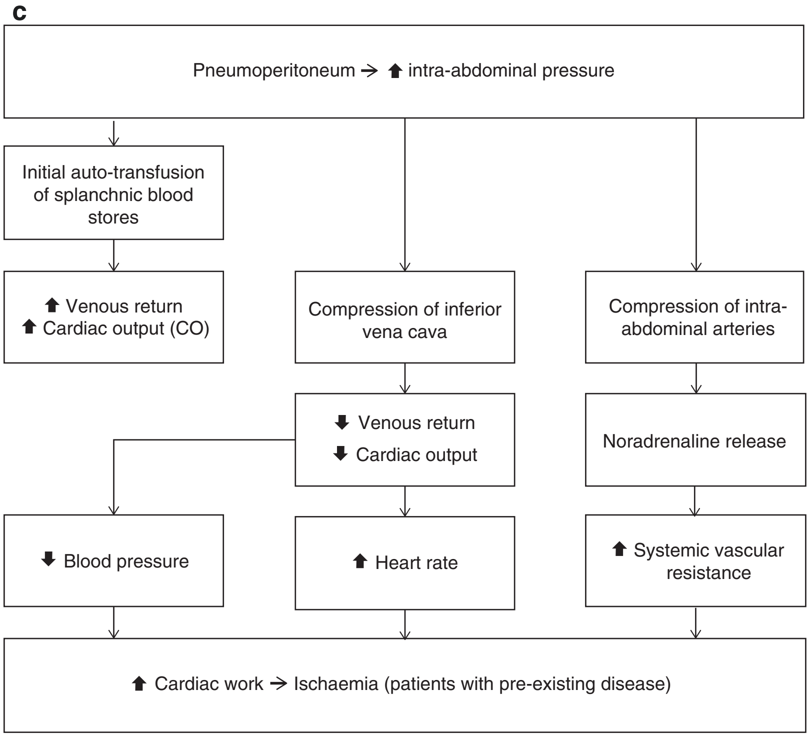


Fig. 11.1 Pathophysiological effects of pneumoperitoneum on the respiratory (**a**), cerebral (**b**) and cardiovascular (**c**) systems

Fig. 11.1 (continued)



Another important consideration in the induction of pneumoperitoneum is the insufflant used. Carbon dioxide is the gas of choice as it is readily available, cheap and non-flammable. CO_2 is extremely soluble and removed from the circulation via the lungs. However, it has a very high diffusion rate in extraperitoneal cavities, which means that establishing and maintaining sufficient CO_2 volumes in pelvic and particularly renal surgery can be difficult. Provided that oxygen levels are adequately maintained, hypercapnia is well tolerated temporarily, though high CO_2 levels in the circulation increase the risk of pulmonary hypertension and aciduria. There is also a risk of venous gas embolism, which may travel up the inferior vena cava to the right heart. This may lead to a 'gas lock effect', preventing right ventricular ejection, and lead to circulatory collapse. Though this is rare with use of CO_2 due to its high solubility, it may occur more frequently with other gases.

Alternatives to CO_2 include nitrous oxide, helium and argon. Nitrous oxide is generally not recommended as it is combustible and causes bowel expansion from cross-peritoneal diffusion. Helium and argon provide biologically and chemically inert substitutes. Though argon is relatively inexpensive, there is a risk of prolonged subcutaneous emphysema which may cause respiratory complications.

Light and Camera

The choice of light source and camera type is dependent on surgical specialty and nature of the procedure. Rigid laparoscopes are most typically used in MIS procedures. The tip may be straight (zero degree telescope) or angled, commonly at 30 degrees, to improve the visual field, allowing the surgeon to look around and behind organs. At the tip there may be a video chip connected to a rigid cable, surrounded by optic fibres, which provides a light source. Scopes adapted for use in small spaces, such as the arthroscope, may have two other channels as well as the viewing channel: one for medical instruments and manipulators (the working channel); and one for suction and irrigation. Arthroscopes may also have a camera attached to the eyepiece instead of a video chip (Fig. 11.2).

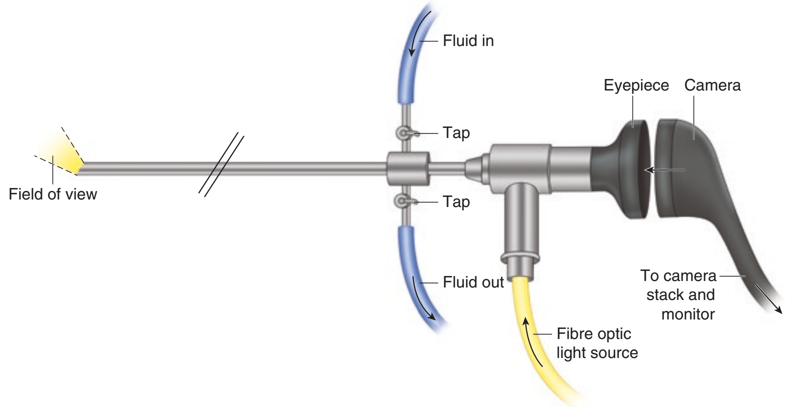


Fig. 11.2 Three channel arthroscope

Flexible endoscopes are useful in the examination of tracts, via their introduction through natural orifices, for example in colonoscopy and oesophagogastroduodenoscopy (or OGD). Their flexibility allows the user to navigate and see convoluted structures by controlling the movement of the distal end of the endoscope. However, the flexible fibres used in the lens give poorer image quality in comparison to rigid endoscopes. Capsule endoscopy may also be used to image the whole bowel [3], during which a patient swallows a capsule containing a small camera that records images of the GI tract.

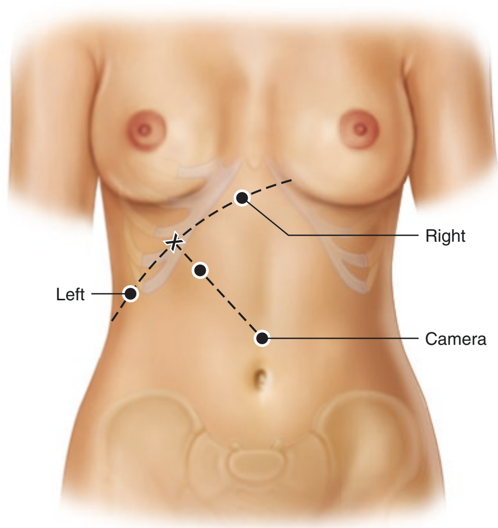


Fig. 11.3 Instrument triangulation, in relation to the viewing port and target organ (Adapted from Supe et al. [4])

Instruments

Laparoscopic instruments are most often inserted into the peritoneal cavity through separate working ports. "Triangulation" describes the method of placement of two working ports in a triangular formation either side of the camera port (Fig. 11.3), and confers a number of practical benefits to the surgeon. These include allowing the surgeon to improve the field of view, facilitate independent manoeuvrability (of instruments and of the endoscope), maintain tissue tension and improve depth perception.

Instruments used in open surgery such as scissors, graspers and needle holders have been adapted for laparoscopy to allow a maximum range of movement, despite their increase in length. Other therapeutic instruments include adapted diathermy, ultrasonic ablators and sealers using thermal coupling.

Examples of instruments used in laparoscopy and arthroscopy:

- Basket/punch biopsy forceps
- Grasping forceps
- Blades and abraders and burrs
- Electrocautery
- Surgical lasers
- Radiofrequency and cryoablation
- Staplers

- Suture anchors
- Ligament fixation material

Advantages of MIS

MIS has been shown to have a number of benefits over open surgery in the short-term. Importantly, these must be present without compromise to long-term outcomes such as tumour recurrence [5] and functional recovery. In addition to the cosmetic benefits of laparoscopic abdominal surgery, there are other factors that positively impact patient recovery and convalescence (Fig. 11.4). For example, the patient's intra-operative stress response is attenuated by reduced wound trauma, as pressure is evenly distributed throughout the peritoneal cavity. Furthermore, laparoscopy results in reduced heat and fluid loss due to reduced exposure of the abdominal organs allowing less evaporation to occur. Key advantages are summarised in Box 11.2.

Box 11.2 Key advantages

Excellent visualisation Reduced blood loss Reduced pain Less scarring	Faster recovery Shorter hospital stay Earlier return to normal activity Long-term savings

Limitations of MIS

MIS can be much more challenging than conventional open surgery, as the surgeon is working at a distance from the operating site. Instruments are longer, more complex and more cumbersome than their open surgery counterparts. Depth perception is also difficult, as the operating field is shown as a two-dimensional image, although 3D systems are in development. These elements adversely affect hand-eye coordination. Instruments used in MIS have a reduced range of motion compared to open surgery equivalents. Combined with the lack of tactile feedback (sense of touch) and the ability to palpate structures, this makes MIS technically difficult to learn and perform. Also, complications such as bleeding can be difficult to control endoscopically, as access to the body cavity is restricted and vision may be obscured. These factors can lead to prolonged operating times. Therefore, MIS can be a challenging and expensive option, especially if complications occur.

However, with increasing experience, surgeons can operate efficiently with low complication rates. A reduction in operating and recuperating time allows shorter hospital stays and means that day cases are possible: this improves the cost effectiveness of MIS.

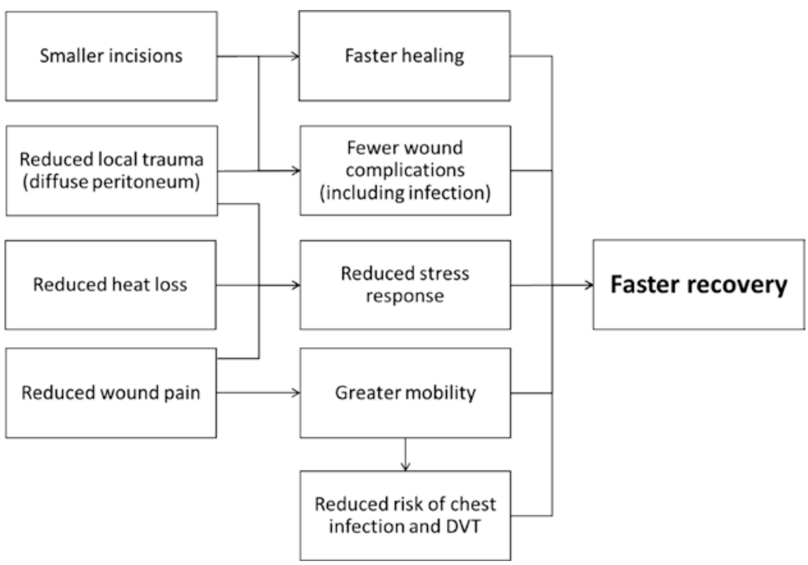


Fig. 11.4 Advantages of MIS in promoting recovery

An interesting by-product of the increasing adoption of minimally invasive techniques is the production of a new generation of trainee surgeons who have had little experience of open procedures. This can pose problems when complications occur intraoperatively, as greater access may be required to control the problem. Where more experienced surgeons are likely to convert to an open procedure in these situations, newer surgeons may not feel comfortable completing the operation using an open technique. This is also true in the case of technology malfunction. If, for example, the camera stack fails during an operation, surgeons need to be able to complete the procedure in an open format.

Box 11.3 Key limitations

- Technically demanding procedures
  - Reduced depth perception
  - 2-Dimensional vision
  - Long instruments with reduced degrees of freedom of movement.
  - Reduced tactile/haptic feedback
  - Suturing very challenging
- Higher Costs
  - Expensive instrumentation, camera stacks, disposable equipment
  - Extended operating times
- Longer learning curves
- Unfamiliarity with open conversion if required

Difficulties encountered during procedures, prolonged operating times and the use of gas to inflate the abdomen may have a number of unintended consequences (see section 'Insufflation' for more details). The boxes summarise key limitations (Box 11.3), complications which may arise (Box 11.4) and situations where MIS is not indicated (Box 11.5).

Box 11.4 Potential complications of MIS

- Cardiovascular, respiratory and cerebral complications of increased intra-abdominal pressure
- Unanticipated visceral/vascular injury
- Occult haemorrhage
- Patient positioning leading to nerve injury and pressure sores
- Increased surgical duration – and related complications (DVT, prolonged anaesthesia)
- Venous gas embolism
- CO_2 surgical emphysema

Box 11.5 Key contraindications

Absolute	Relative
Uncorrected coagulopathy Bowel obstruction Peritonitis Abdominal wall infection	Obesity COPD/significant respiratory disease Previous major open surgery Aneurysmal disease Large hernias

Robotic Surgery

Fundamentally and historically, robots have been defined as "mechanical devices that sometimes resemble human beings and are capable of performing a variety of often complex human tasks on command or by being programmed in advanced". The "Laws of Robotics" were written by American writer and biochemist Isaac Asimov (1920–1992), and an appreciation of these laws allows us to evaluate the role of robotics within modern medicine:

1. A robot may not injure a human being or through inaction allow a human being to come to harm.

2. A robot must obey the orders given it by human beings except where such orders would conflict with the first law.
3. A robot must protect its own existence as long as such protection does not conflict with the first of second law.
4. A robot may not injure humanity or through inaction allow humanity to come to harm.

In the surgical setting, robotic master–slave systems are the commonest "robots" implemented, and the first (the Puma 560) was used in 1985 to perform a brain biopsy. These systems function on the basis that the surgeon operates in real time directly controlling the movement of the robot, with no pre-programming element. Improved camera systems and computer software have meant that robots can overcome a number of the limitations of laparoscopic surgery, whilst retaining the patient benefits of MIS, thus making robotic surgery a feasible option for more complicated procedures. As a whole, surgical robots have been shown to improve both intra- and post-operative surgical outcomes. The overall benefits of robotic surgery are patient centred, reducing operating time, complication rates, blood loss, post-operative pain and length of stay, whilst improving recovery, cosmesis and time to convalescence.

A number of surgical robots were pioneered, including the PROBOT, AESOP and PAKY-RCM. The automated PROBOT was invented to assist in performing trans-urethral resection of the prostate (TURP); however it was imprecise in practice due to anatomical variation between patients. The AESOP (automated endoscopic system for optimal positioning) system was a voice activated single-arm endoscope. The PAKY-RCM, trialled in percutaneous access for nephrolithotomy, was a robotic arm controlled by the surgeon via a joystick. However, it was the arrival of the da Vinci robotic system in 2002, which prompted the evolution of robotic surgery, with over 3000 machines now in use worldwide.

The da Vinci system provides multiple benefits for the surgeon, in comparison to both laparoscopic surgical instruments and early robotic systems. Visual benefits include higher magnification of images (3–10 times), with the option for 3D stereoscopic views. Ergonomically, the console is superior as the surgeon operates in a comfortable seated posture nearby the operating table, allowing for optimum concentration and prevention of fatigue. The system filters hand tremor allowing finer control, and scales down external movements allowing for more precision in dissection. The superior ergonomics of the console system also impact on the surgeon's technical ability, by allowing optimal alignment of visual and motor axes. Of maximal importance to the success of the da Vinci is its patented "Endowrist", of which the axes of movement of the instruments provide seven degrees of freedom (Fig. 11.5), in comparison to the four degrees of freedom available with laparoscopic instruments.

The da Vinci system also provides potential benefit to surgical training programmes. Innovations such as the dual console device (where two surgeons can take turns to control the robot) and telerobotics (where the console can be elsewhere in the world) can be used in training, or to gain assistance from expert surgeons in a more convenient manner.

However, limitations exist in the implementation of robotics, on an organisational level and at the individual level of the surgeon. Organisationally, the da Vinci robot is a financially expensive venture for healthcare trusts, the surgical system itself costing between $0.6 and $2.5 million. Further cost is incurred through the annual service agreement, and the cost of the disposable instruments. Additionally, the availability of systems prevents widespread training and restricts use of robotics to high volume centres. At the level of the individual surgeon, the current da Vinci systems are limited in their ability to provide haptic feedback (i.e. a sense of touch), a key limitation of all MIS systems available today.

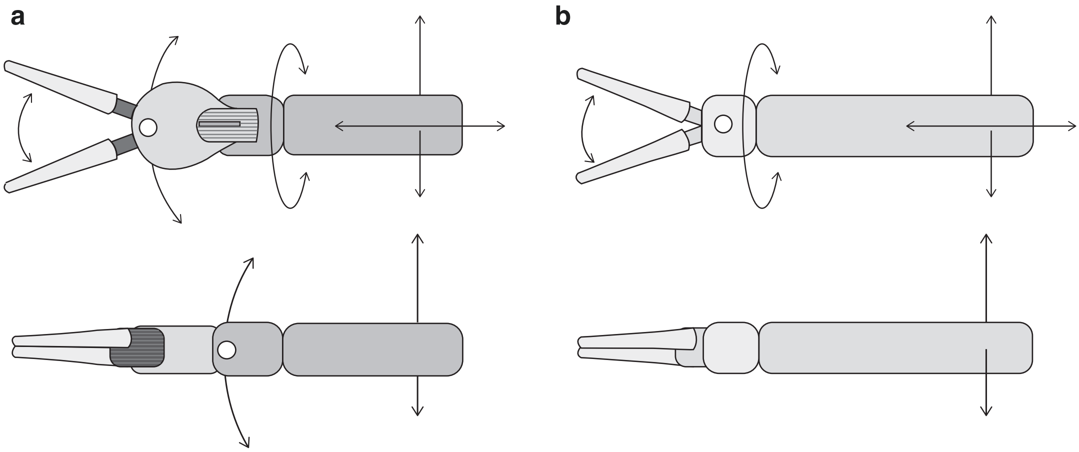


Fig. 11.5 Degrees of freedom achieved by Endowrist® instruments used by da Vinci robots (**a**) (*Source*: IntuitiveSurgical.com) [6], compared with laparoscopic instruments (**b**). *Straight arrows*: translation; *curved arrows*: orientation and grip

Further Advances in MIS

Single incision laparoscopic surgery (SILS) and natural orifice transluminal endoscopic surgery (NOTES) are new and emerging techniques within the field of MIS. In SILS, one cut is made at the umbilicus, through which adapted instruments are inserted through the same port as the endoscope. This approach to MIS provides many benefits, as well as harbouring its specific drawbacks. As only one port is used, this decreases the number of potential sites present to result in post-operative pain, bleeding and hernias. However, this approach makes manipulation of the instruments, and particularly suturing, more difficult for the surgeon. Yet, with the addition of robotics, these procedures can be made more intuitive. For instance, the robot can compensate for the left-right crossing over of instruments. Another disadvantage involves the removal of samples, especially tumours, as only a single, small incision is used. To fit through the small port, samples may need to be divided into small pieces using a morcellator. This increases the risk of spreading malignant cells along the path of the instrument ('seeding') as well as providing less information for histopathology.

NOTES is a branch of MIS in which the peritoneal cavity is accessed via puncture sites made through natural orifices, and indeed it is the only method to provide truly scar-less surgery. Initial approaches were made using a transgastric approach, however more recently NOTES has been performed via other orifices, with documented cases of transcolonic, transvaginal and transurethral surgery. Other body cavities have been approached with the use of NOTES surgery, for example in a transoesophageal approach to the mediastinum. However, due to high risks of bacterial infection and more complicated processes involving the surgical closure of puncture sites (especially in the stomach or colon) NOTES is not widely practiced by surgeons in the UK.

Although both SILS and NOTES are still rare in clinical practice, it is important to be aware of their existence. These innovative branches of MIS are evolving rapidly, exhibiting the potential for limitless advancements in developing this field of surgery.

Surgeons' Favourite Questions for Students

1. What are the five key components needed to perform MIS?
2. Which gas is used to create a pneumoperitoneum? Why? What other gases could be used?
3. Why is oxygen not used?
4. What complications can insufflation lead to?
5. What factors make MIS difficult to learn?

Key Points for the Chapter

1. MIS involves the use of a light source, camera, inflation of the abdomen with CO_2 and specially designed instruments inserted via small ports to perform procedures whilst minimising the trauma of surgery.
2. Advantages include reduced pain and scarring, faster recovery times and shorter hospital stays.
3. Disadvantages include reduced depth perception due to use of 2D images, lack of haptic feedback, longer learning curves and higher costs.
4. Use of robotic systems, such as the da Vinci robot, provide superior ergonomics, higher magnification of images, improved range of movement from the robotic wrist (with 7 degrees of freedom) and the option to scale down movements to allow more precise motions.
5. There are new techniques in development to allow surgery through natural scars such as the umbilicus (SILS) or through natural orifices such as the vagina (NOTES). These provide methods of performing surgery with truly minimal scarring.

Key Terminology

MIS	Minimally invasive surgery
-scopy	'Looking' – indicates use of instrument (endoscope) to examine the inside of a hollow organ or cavity of the body
Endo-	'Within' – relates to luminal structures within the body, often associated with upper GI tract (*endoscopy*)
Laparo-	Relating to the abdomen
Arthro-	Relating to joints
Thoraco-	Relating to the thorax
Haptic feedback	Recreation of sense of touch by using forces, vibrations or motions to the user
Trocar	Instrument used to make and maintain a tightly sealed port through the skin or wall of a natural orifice for inflation and insertion of instruments
Veress needle	Sharp instrument with retracting needle used to perforate the abdominal wall to establish pneumoperitoneum
Hasson trocar	Blunt port inserted through small incision and held in place by sutures
Insufflation	Inflation of the abdomen with CO_2
Pneumoperitoneum	Gas within the peritoneal cavity – resultant dome shaped space allowing surgeons to see and move instruments during minimally invasive surgery
Arthro-	Relating to joints
Triangulation	Triangular placement of trocars to allow ergonomic movement of instruments, which are placed either side of the camera position
SILS	Single incisional laparoscopic surgery
NOTES	Natural orifice transluminal endoscopic surgery

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12 Principles of Surgical Oncology and Pathology

Abhinav Mathur

Introduction

The *Edwin Smith papyrus* contains the earliest written record of cancer. It is an ancient Egyptian script from ~1700 BC with the collected teachings of *Imhotep* for conditions such as fractures and skin abscesses. While the script is written in a style comparable to a modern surgical textbook, the treatment offered for cancer in this manuscript is atypically short and dismal: “there is none”. Thankfully, times have changed. While surgery was the first discipline to treat cancer, these days cancer patients are taken care of by a multidisciplinary team (MDT) of specialists consisting of oncologists, surgeons, specialist nurses, physiotherapists, pathologists and palliative care specialists.

Terminology

Basic pathological terminology taught in preclinical years is often forgotten by clinical years. Being well-versed with this terminology will put you at an advantage.

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Dysplasia

Dysplasia is not a pathological process but a descriptive term used by pathologists for *disordered growth and architecture* of a tissue as seen under a microscope. Features of dysplasia are shown in Fig. 12.1. Although dysplastic tissues may already contain *neoplastic cells*, these cannot metastasise and the changes may even be reversed in early stages. The importance of recognising dysplasia is that it is a **premalignant state** and the term **intraepithelial neoplasia** is preferred instead of dysplasia in some organs such as the cervix.

Neoplasms, Tumour and Cancer

- **Neoplasm** (*new growth*): an abnormal mass of tissue, formed due to the uncontrolled proliferation of cells. Cells continue to divide after the cessation of growth signals. The word **tumour** (*swelling*) is often used synonymously.
- **Neoplasia:** the process by which a neoplasm is formed
- **Cancer:** a *malignant* neoplasm

In order to describe a neoplasm, the nature of the tumour (benign or malignant) and its histological origin must be known.

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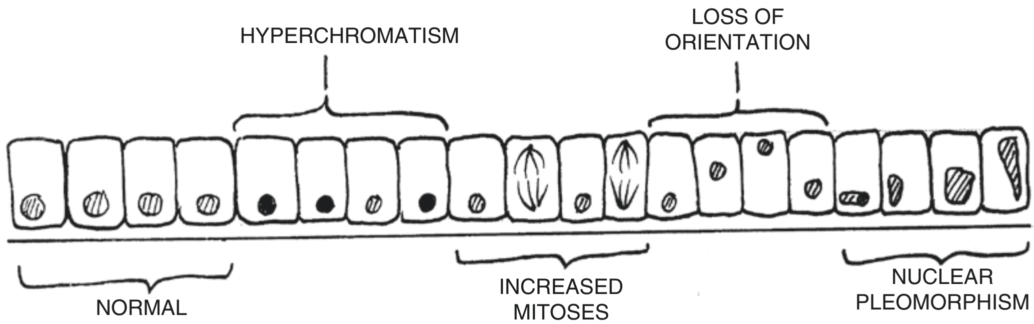

Fig. 12.1 Schematic representation of features of dysplasia as would be seen under the microscope

Table 12.1 Benign and malignant neoplasms

Benign	Malignant
No local invasion or metastasis	Local tissue invasion and metastasis
Usually slow rate of growth	Usually erratic or rapid growth
Well circumscribed	Poorly circumscribed
Good prognosis but can compress vital organs	Often poor prognosis
Histologically well-differentiated	Histologically poorly-differentiated
Often encapsulated	If encapsulated, invasion through capsule is seen

Tumour Behaviour: Benign/Malignant

All solid neoplasms are composed of *neoplastic cells*. However, neoplasms can be classified as either benign or malignant. Although there are several differences between the two (see Table 12.1), the key distinguishing criterion is the ability of malignant neoplasms to **invade and metastasise.**

Histogenesis

Microscopic examination and staining are used to assess the tissue of origin of tumours. The four main tissues from which tumours can arise are epithelial, connective, lymphoid/haematopoietic and germline tissue. The majority of tumours arise from epithelial tissue as epithelial cells line the internal and external body surfaces and are thus the most exposed to carcinogens. Epithelial tissue can be further subdivided mainly into either glandular or squamous.

Nomenclature

Some broad rules govern the naming of neoplasms. Benign tumours are usually named by adding the suffix *–oma* to the name of the tissue. For example, a lipoma is a benign tumour of adipose tissue. Malignant tumours from mesenchyme and epithelia are distinguished by the terms *carcinoma* and *sarcoma*, respectively. For example, an osteosarcoma is a malignant bone tumour. Prefixes indicate the tissue type. Commonly used nomenclature is shown in Table 12.2. Some important exceptions to the above rules are melanomas, neuroblastomas and glioblastomas, which are all malignant tumours.

Tumour Biology

A basic understanding of tumour biology helps in the management of patients with cancer.

Neoplasia: Aetiology and Mechanisms

Fundamentally, cancer is caused by DNA mutations. The overall effect is an increase the activity of oncogenes and/or a decrease the activity of tumour suppressor genes. These mutations can occur as a result of complex interactions between environmental and genetic factors. For example, inherited genetic makeup may enhance or decrease susceptibility to the DNA-damaging effects of environmental toxins, radiation, infection or hormonal imbalances. Thus, cancer is multifactorial.

Table 12.2 Nomenclature of epithelial and connective tissue tumours

Tissue of origin	Benign	Malignant
Epithelium		
Glandular epithelium	Adenoma	Adenocarcinoma
Squamous epithelium	Squamous papilloma Acanthoma	Squamous cell carcinoma
Connective tissue		
Adipose tissue	Lipoma	Liposarcoma
Smooth muscle	Leiomyoma	Leiomyosarcoma
Skeletal muscle	Rhabdomyoma	Rhabdomyosarcoma
Bone	Osteoma	Osteosarcoma
Fibrous tissue	Fibroma	Fibrosarcoma
Blood vessel	Angioma	Angiosarcoma

Hallmarks of Cancer

A widely accepted model of cancer development is the "multistep process" which suggests that multiple genetic changes need to take place in a stepwise manner for a cell to become cancerous. These mutations lead to the cells acquiring key characteristics called the **hallmarks of cancer** ([1]; see box below), which offer them a selective growth advantage over their neighbours.

Hallmarks of Cancer

1. Resisting cell death
2. Sustaining proliferative signalling
3. Evading growth suppressors
4. Limitless replicative potential
5. Inducing angiogenesis
6. Activating invasion and metastasis
7. Reprogramming of energy metabolism
8. Evasion of the immune system

Invasion and Metastasis

Metastasis of primary tumours to secondary sites, and the subsequent loss of organ function is the major cause of morbidity and mortality in cancer patients.

Metastatic Cascade Metastasis is a highly complex process involving several stages, which remain to be fully understood. Despite the complexity of the process, cancer cells regularly metastasise. While the rates and sites of metastasis may differ between cancers, there are core similarities in the mechanism of the process. Briefly, cells reduce the expression of cell-adhesion molecules allowing them to break free from their neighbours. The subsequent release of enzymes (such as matrix metalloproteinases) permits local tissue destruction and invasion by malignant cells. Intravasation into nearby blood vessels allows spread to a distant site, though cells in the blood stream must avoid detection by the immune system. A secondary focus is set up after extravasation.

Routes of Metastasis There are two main routes of metastasis:

- **Lymphatic spread** is the main route for carcinomas and typically follows the arterial supply.
- **Haematogenous spread** (especially via veins) is important for sarcomas and is often a late route for the spread of carcinomas.

Sites of Metastasis Different tumours metastasise to different organs. For example, gastrointestinal malignancies often spread to the liver via the portal vein, while breast carcinomas typically spread to the lungs and brain. The biology is not well understood. It is important to know the five main tumours which commonly metastasise to bone, as this is a common question:

Bony Metastases
(Mnemonic: **KP** crisps and a **BLT** sandwich)
1. **K**idney
2. **P**rostate
3. **B**reast
4. **L**ung
5. **T**hyroid

Clinical Features

Patients are usually asymptomatic until the tumour becomes large enough to cause signs and symptoms:

- **Local invasion and mass effects:** compression of organs or invasion into a hollow tube organ. Obstruction of the superior vena cava can be an oncological emergency if there is airway compromise.
- **Palpable mass**: often detected on clinical examination
- **Constitutional symptoms**: unexplained fever, weight loss, anaemia
- **Metastatic effects**: depend on the site of metastasis. Bony metastases can cause bone pain and even fractures.
- **Paraneoplastic syndromes**: these are "non-metastatic" effects due to ectopic hormone production or the immune response to the tumours. Ectopic ACTH production by small cell lung cancer can lead to Cushing's syndrome.
- Some patients will be picked up through screening programmes.

Assessment Before Treatment

Several investigations need to be carried out before treatment can begin. Most importantly, there must be unequivocal histological/cytological confirmation of malignancy along with an assessment of the stage. The histological assessment provides information on the tumour type and guides appropriate treatment.

Diagnostic Investigations

Simpler diagnostic tests are used before more invasive tests are carried out.

Blood Tests FBC, U&Es, LFTs and **tumour markers**.

Tumour Markers
These are serum proteins produced by tumours that are detectable at higher concentrations in the serum of patients with certain cancers. Although different proteins have been used as diagnostic or prognostic biomarkers, the relatively low sensitivities and specificities of tumour marker tests mean that they should not be used in isolation. Indeed, their main value is to monitor the course of illness and efficacy of treatment. Some frequently used tumour markers include CEA, CA 19-9, CA 15-3, and hCG.

Imaging Imaging is used not only in diagnosis but also in assessing the stage of a cancer (see below) and to monitor the response of a tumour to treatment. Various modalities are available including plain film imaging, ultrasound, CT, MRI, radioisotope imaging and PET scans. The choice will depend on the type of tumour in question and the risk of ionising radiation.

Histology and Cytology Histological analysis requires a tissue sample, which may be obtained from a biopsy sample (see below) or a resected specimen. H&E stains and light microscopy of the tumour samples are carried out to look for certain features. For example, adenocarcinomas exhibit glandular differentiation along with mucin production, whereas squamous cell carcinomas have evidence of keratinisation and the presence of desmosomes. Immunohistochemistry can also be performed such as in breast cancer for ER, PR and HER2. Differences in the staining pattern will affect the treatment offered. Pathologists will also perform **tumour grading**.

Cytology can also be used to diagnose malignancies. This involves examination of cells obtained from sputum and urine, or via fluid aspiration (from peritoneal fluid, pleural fluid or CSF, for example), fine-needle aspiration (FNA), and endoscopic brushings.

Tumour Grade

This is a measure of how closely the tumour resembles the tissue of origin i.e. the degree of differentiation. The grade is usually reported as a score from 1 to 3 which takes into account the rate of growth:

- **Grade 1:** well-differentiated and similar in appearance to the tissue of origin
- **Grade 3:** poorly differentiated with a high mitotic rate

Grade 2 tumours lie somewhere in between. The term **"anaplastic"** refers to tumours which are extremely poorly differentiated. Although tumour-specific grading systems do exist (such as the *Bloom-Richardson* grade for breast cancer), grading is subjective. However, higher-grade tumours have a **poorer prognosis**.

Staging Investigations

The stage of a cancer reflects the extent of spread of a tumour. Staging systems attempt to classify tumours into "stages" of their natural history based on uniform criteria. This is extremely important since it determines the most appropriate treatment plan and allows an assessment of prognosis. The stage of a cancer does not change after staging has been done—even after progression or regression.

Tumour Staging

The most commonly used tumour staging system is the **TNM staging system** devised by the International Union against Cancer (*Union Internationale Contre le Cancer, UICC*) and is based on the tumour size (**T**), the presence of involved lymph nodes (**N**) and whether there is any metastasis (**M**). The addition of numbers after each letter in the TNM system denotes the extent of disease (see Table 12.3). Specific staging systems exist for certain tumours such as the *Duke's staging* for colorectal cancer.

Table 12.3 Cancer staging

TNM staging system
Tumour size (T)
TX = not assessed T0 = primary unknown or no tumour Tis = carcinoma in situ T1-4 = number increases with the size of the tumour[a]
Lymph nodes (N)
NX = not assessed N0 = lymph nodes not involved N1-3 = number increases with increasing involvement[a]
Metastasis (M)
MX = not assessed M0 = no metastases M1 = metastases present

[a]Exact criteria depend on the tumour in question

A number of prefixes are often attached to the TNM stage:

- **cTNM**: **c**linical stage based on information from examination, imaging or biopsy before surgery
- **pTNM:** stage given after **p**athological examination
- **yTNM:** refers to a reassessment of stage after *neoadjuvant* therap**y**
- **rTNM:** used if a tumour is **r**e-staged if there has been a disease-free interval

Staging investigations may be performed as part of the diagnostic process and many different

Table 12.4 ECOG performance status score

Score	Description
0	Fully active, able to carry out all normal activities without restriction and without need of analgesia
1	Restricted in strenuous activity but is able carry out light work/pursue sedentary occupation
2	Ambulatory and able to self-care but unable to work. Mobile for **>50 %** of the day
3	Capable of limited self-care. Bed-bound for **>50 %** of the day
4	Completely disabled; incapable of self-care; permanently confined to bed or chair

modalities can be used. Imaging modalities like CT and MRI scans are also useful, especially for metastases. In general, surgical staging techniques have been replaced by more advanced imaging modalities such as PET/CT, which avoids unnecessary invasive procedures.

Performance Status

Assessing the **performance status** (i.e. overall fitness) of the patient is important in determining the treatment. Scoring systems like the European Cooperative Oncology Group (see Table 12.4) can be used.

Treatment and Management

There are three main treatment options:

- Surgery
- Radiotherapy
- Chemotherapy

These can aim to be either ***curative*** or ***palliative*** and this should be recorded in the notes as a legal requirement. There are four main approaches to treatment for cancer:

- **Palliative therapy** is usually the indication for patients with widespread metastasis with the goal of improving symptoms and the quality of life.
- **Adjuvant therapy:** surgical treatment can be used to reduce the bulk of the tumour. However, not all the local disease may be cleared and adjuvant *chemotherapy* or *radiotherapy* can be offered afterwards with the aim of eradicating micrometastases and improving survival.
- **Neo-adjuvant therapy:** sometimes the tumour is too large to operate and chemotherapy or radiotherapy can be administered before the surgery (neo-adjuvant). The aim is to reduce the tumour bulk to either reduce the requirement for surgery or increase the chance of successful surgery.
- **Preventive therapy:** An increased understanding of the genetics of cancer has allowed prophylactic treatments to be offered to individuals at high risk of developing cancer before the cancer develops.

Surgical Oncology

There are four main roles for surgery in oncological practice:

Prevention of Cancer

A good example is provided by *familial adenomatous polyposis*, a rare autosomal dominant disorder caused by mutations in the APC gene. It is characterised by hundreds of adenomatous polyps throughout the colon. Total proctocolectomy prevents the inevitable development of carcinoma.

Diagnosis and Staging

Although FNA and fluid aspiration can provide cytological diagnostic samples, a **biopsy** is usually preferred. This can be obtained by several procedures and the approach will depend on the type and location of tumour and the risk of contamination. Needle-track metastases can occur along the path of the surgical instrument.

Core Needle Biopsy (CNB) This uses a needle similar to a FNA needle. The needle withdraws small "cores" of tissue that are representative of the tumour. The needle is inserted into the tumour guided either by palpation or ultrasound.

Open Biopsy An open biopsy is the main surgical approach. There are two types of surgical biopsies: ***excisional biopsies*** remove the entire suspected tumour and are generally preferable to ***incisional biopsies*** where only part of the suspected tumour is removed. Excisional biopsies allow a better examination of the tissue architecture and thus can better guide further treatment. However, incisional biopsies are often required if the tumour is fixed to the local surroundings making excision too difficult.

Treatment of Cancer

Surgery often has very high cure rates at the early stage of disease for colorectal and breast cancers. Some key points include:

A surgical "cure" for cancer aims for total **excision** of the macroscopic tumour tissue. Technically, this means an ***en-block resection*** that involves the removal of the primary tumour with clear **resection margins** (grossly and microscopically), adjacent organs (if necessary), regional lymphatics and biopsy scars (as these are considered contaminated).

The length of the resection margin is usually based on the biology of the tumour and available adjuvant modalities. For example, limited resection would be acceptable in tumours that are more responsive to chemotherapy/radiotherapy as this allows a better cosmetic result.

Establishing nodal involvement is important for staging. Lymph node removal can reduce the metastatic risk but can cause secondary lymphoedema.

A **sentinel node biopsy** provides a less radical approach. The sentinel node is a theoretical group of lymph nodes to which a malignancy would be expected to spread first. The surgeon may either inject a dye or a radioactive colloid around the tumour: this drains to the lymph nodes, which can be visualised directly or using a radioactive monitor. One to three sentinel nodes are often removed at surgery and if no metastasis is involved, then no further nodal clearance is undertaken and the risk of lymphoedema is reduced.

It is believed that the systemic dissemination of cancer can occur early even in patients without evidence of regional lymph node involvement (**micrometastases**). Indeed, since the surgical manipulation of any malignant tumour causes the potential shedding and spread of cells, some surgical procedures have been designed to reduce this by initially dividing the blood supply before mobilising a tumour (**no-touch technique**).

Micrometastases

Small numbers of tumour cells can metastasise early and form "micrometastases", microscopic tumour deposits which are generally not detectable. To eradicate any possible micrometastatic disease, adjuvant chemotherapy or radiotherapy is often administered.

Palliation

Surgery can be used to improve the symptoms of patients where cure is not the main intent. There may be several occasions where this can be used. Examples include the debulking of tumours, which may be causing nerve root compression, and the fixation of pathological fractures.

Surgeons' Favourite Questions for Students

1. What are some of the common cancers that metastasise to bone?
2. What is the difference between neo-adjuvant and adjuvant therapy?
3. What is the most common staging system currently in practice? Can you think of an example where an alternative staging system is still in place?

4. How would you classify symptoms caused by malignancy?
5. What is the performance status and how is it measured?

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13 Neurosurgery

Fraser S. Brown and Andreas Demetriades

Introduction

Modern neurosurgery has its humble beginnings in the late nineteenth and early twentieth centuries. Significant breakthroughs in the scientific understanding of the nervous system and progress in technology- such as image-guided surgery, microscopy and neuroimaging- make neurosurgery one of the most technically advanced and fascinating surgical disciplines.

It encompasses the management of a diverse spectrum of cranial and spinal pathologies in both children and adults.

This chapter is by no means comprehensive. We have chosen few of the simplest procedures that medical students will be expected to recognise, understand and hopefully participate in.

Core Knowledge

Anatomy of the Central Nervous System

The central nervous system consists of the brain, brain stem and spinal cord. The brain is surrounded by the meninges and the skull. The brain's convoluted surface, the cerebral cortex, consists of gyri and sulci, protruding and receding peaks and troughs, respectively. It is composed of the frontal, temporal, parietal and occipital lobes. Various functions are ascribed to each area of the brain. Symptoms and signs can therefore provide clues as to the anatomical location of underlying pathology.

The cranium (part of the skull) is the protective cage of the brain, consisting of the frontal, parietal, temporal, occipital bones, sphenoid and ethmoid bones. These bones interface at the sutures of the skull.

The anterior, middle and posterior cranial fossae accommodate the brain. The frontal lobes lie in the anterior fossa, the temporal lobes in the middle fossa and the brainstem and cerebellum in the posterior fossa. Foramina in the skull permit passage of arteries and nerves. The brainstem becomes the spinal cord as it passes through the foramen magnum in the posterior fossa.

Intervertebral foramina are the route by which peripheral nerves connect to the spinal cord. There are 8 cervical, 12 thoracic, 5 lumbar and 5 sacral nerves. Nerves C1-7 leave the spinal cord above their corresponding pedicle; for example, cervical nerve 2 leaves by travelling superior to the pedicle of the 2nd cervical vertebra. In contrast, after cervical nerve 8 passes under the pedicle of cervical vertebra 7, the remaining nerves travel inferior to their corresponding pedicle- for example, nerve L3 travels inferior to the pedicle of the 3rd lumbar vertebra.

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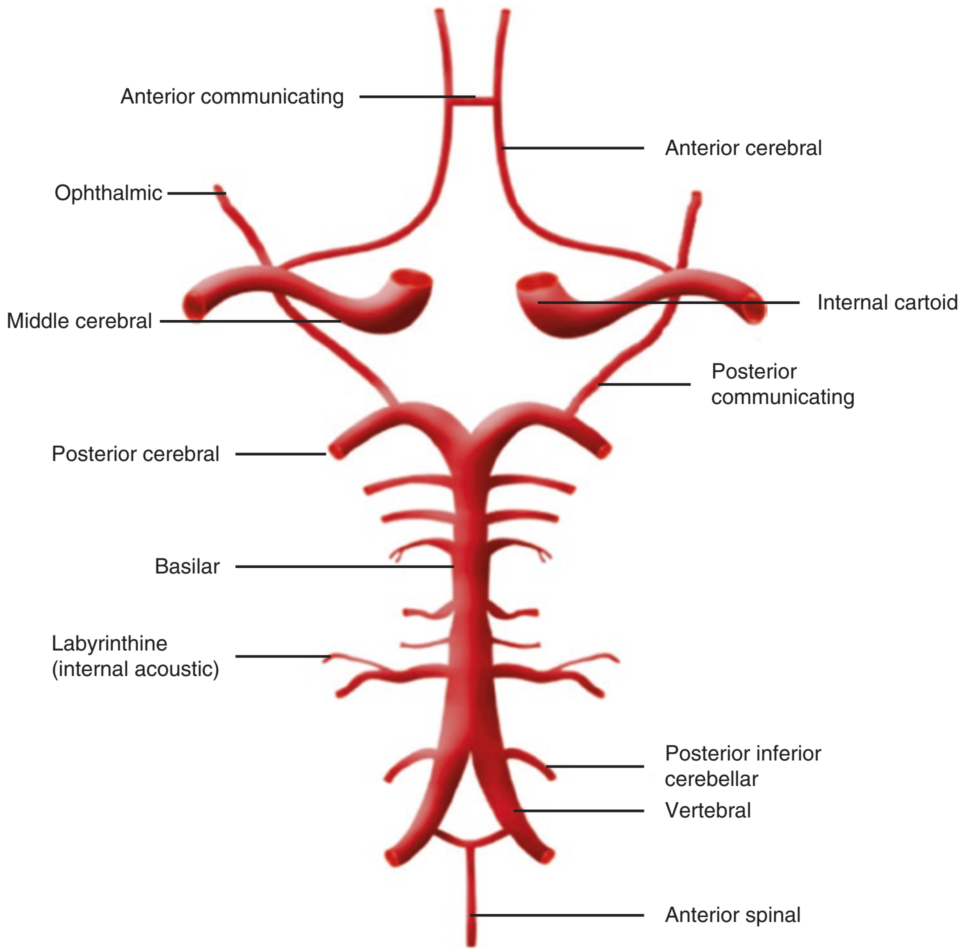


Fig. 13.1 Arterial supply of the cerebrum

The brainstem is a continuation of the brain. It consists of the midbrain, pons and medulla. Descending through the foramen magnum, the brainstem becomes the spinal cord and descends in adults to L1, inferior to which the remaining nerves descend as a bundle named the cauda equina- remembered easily as the Latin for "horse's tail".

Arterial Blood Supply

The brain is supplied by 4 main vessels: the left and right vertebral and internal carotid arteries. A thorough appreciation of the vasculature and functional anatomy of the brain is essential to understanding pathological lesions of the neurovasculature and their effects (Fig. 13.1).

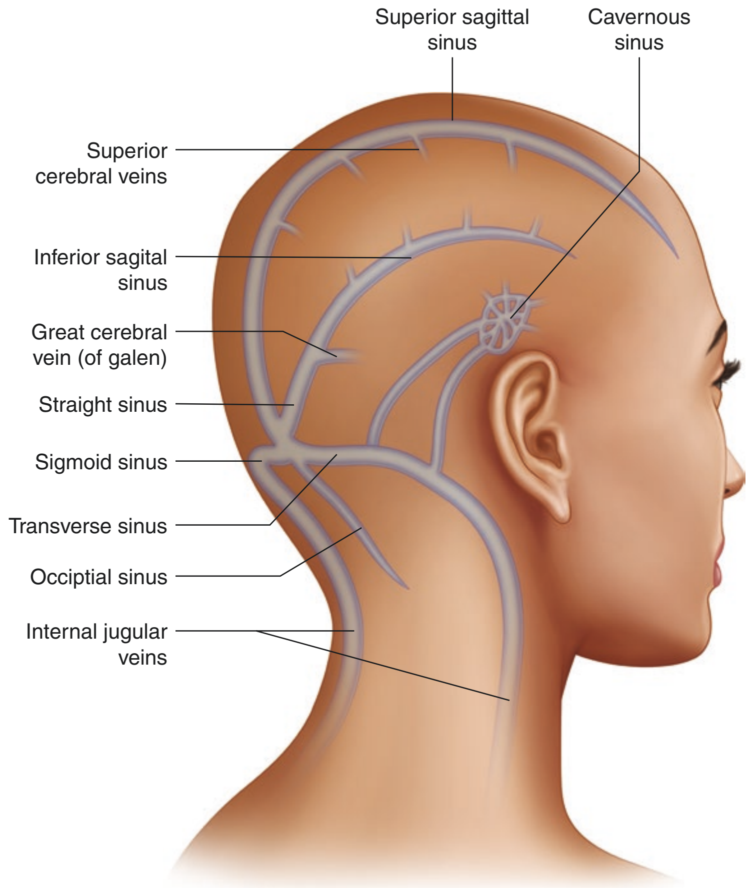
Venous Drainage

This system drains into the internal jugular vein. Notably, the bridging veins of the superior sagittal sinus are vulnerable to rupture upon impact, leading to subdural haematoma (Fig. 13.2).

Meninges

The meninges are a trio of connective tissue layers covering the central nervous system named the dura mater, arachnoid mater and pia mater. The pia mater lies the deepest, immediately sur-

Fig. 13.2 Venous drainage supply of the cerebrum



rounding the brain, whereas the dura mater is the most superficial, lying just deep to the bones of the skull. Between the dura and arachnoid mater lies the subdural space. Between the arachnoid mater and pia mater lies the cerebrospinal fluid-filled subarachnoid space. The understanding of these anatomical structures is key to the understanding of various pathological processes including subdural, subarachnoid and extradural haemorrhage.

Folds of dura mater also make up the falx cerebri and tentorium cerebelli. The falx cerebri runs between the left and right hemispheres in the longitudinal fissure. The tentorium cerebelli overlies the superior aspect of the cerebellum and separates it from the inferior aspect of the occipital lobes.

Intracranial Pressure

Intracranial pressure (ICP) is normally 7–15 mm Hg in the supine position; at 20–25 mm Hg, the upper limit of normal, treatment to reduce ICP may be needed. It varies in children from adults.

Under normal conditions, the blood flow to the brain is auto-regulated to remain within homeostatic limits. This is maintained physiologically at cerebral perfusion pressures between 50–150 mmHg (mean arterial pressure). The mean cerebral blood flow is 750 ml/min. If perfusion pressure deviates from these values, decompensation can occur with increases or decreases in cerebral blood flow (Fig. 13.3).

It is also important to appreciate the physiological relationship between intracranial pressure

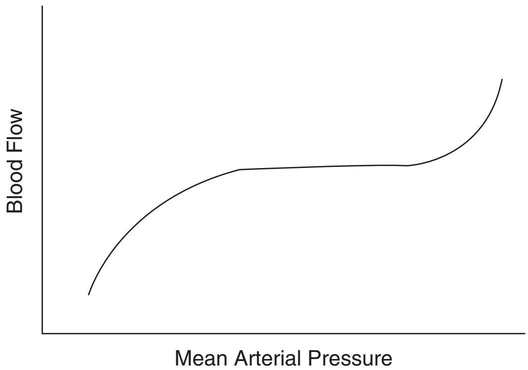


Fig. 13.3 The intracranial pressure-cerebral blood flow relationship

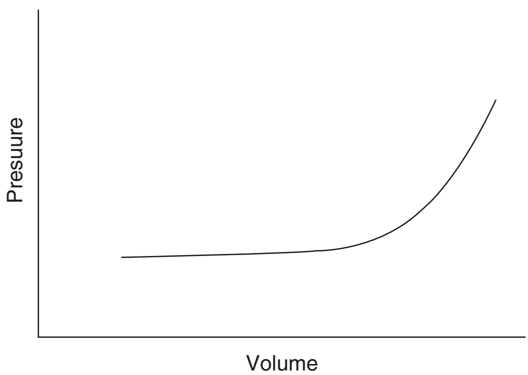


Fig. 13.4 The intracranial pressure-volume relationship

and volume. Increasing volume, for example as a result of a tumour or an expanding intracranial haematoma, can result in drastically rising ICP. An increasing ICP can eventually exceed the cerebral perfusion pressure, resulting in critically reduced brain perfusion.

Certain neurosurgical conditions require an emergent intervention to interrupt this sequence of events before catastrophic consequences to brain function; e.g. craniotomy for evacuation of a traumatic extradural or subdural haematoma; external ventricular drainage with diversion of CSF in acute hydrocephalus (Figs. 13.4 and 13.5).

The Glasgow Coma Scale

The Glasgow Coma Scale (GCS) is a tool allowing an objective assessment of the conscious state of a patient (see Table 13.1). It originated in the assessment of trauma patients but is widely used in all brain surgery conditions. The score takes into account eye opening, motor and verbal responses to various stimuli. A total score of 15 is possible. A score of 8 or below is considered to be indicative of a comatose patient and the minimum score possible, 3, indicates a totally

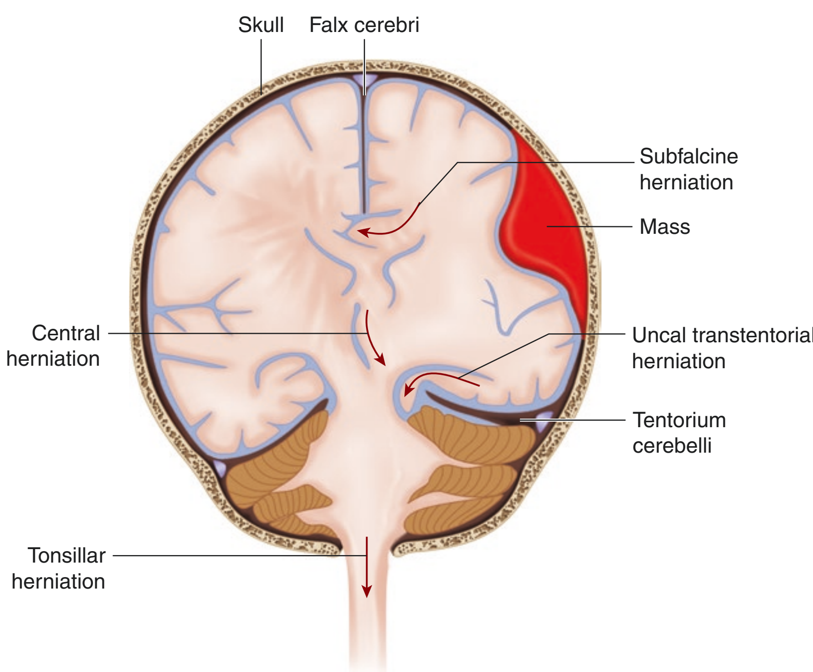


Fig. 13.5 Types of intracranial herniation

unresponsive patient. Notably, a different version of the scale is used in paediatric practice.

The paediatric scale features a modified **verbal response** scale (Table 13.2):

Hydrocephalus

This condition is characterised by dilatation of the ventricular system due to an obstruction to cerebrospinal fluid flow. This can be classified as communicating hydrocephalus (due to no obvious obstruction of the ventricular system, but presumed reabsorption deficit), or non-communicating hydrocephalus (due to an obstruction within the ventricular system). Many conditions can lead to hydrocephalus, including congenital malformations, subarachnoid haemorrhage, trauma, abscesses and tumours.

Acute Subdural Haematoma

This condition usually results from tearing and bleeding of the bridging veins of the superior sagittal sinus or other trauma to the brain or skull. A haematoma accumulates in the subdural space, raising intracranial pressure and potentially precipitating rapid neurological decline (Fig. 13.6).

Chronic Subdural Haematoma

Chronic subdural haematomas have a similar aetiological mechanism to acute subdural haematomas but develop insidiously. They are more common in the elderly and often the insulting trauma is minor and never identified.

Table 13.1 The Glasgow coma scale

Glasgow coma scale	Score
Best motor response	
None	1
Extensor response to pain	2
Abnormal flexion to pain	3
Flexes to pain	4
Localises to Pain	5
Responds to commands	6
Eye opening	
None	1
To pain	2
To speech	3
Spontaneous	4
Best verbal response	
None	1
Incomprehensible sounds	2
Words, incoherent	3
Disoriented conversation	4
Normal conversation	5

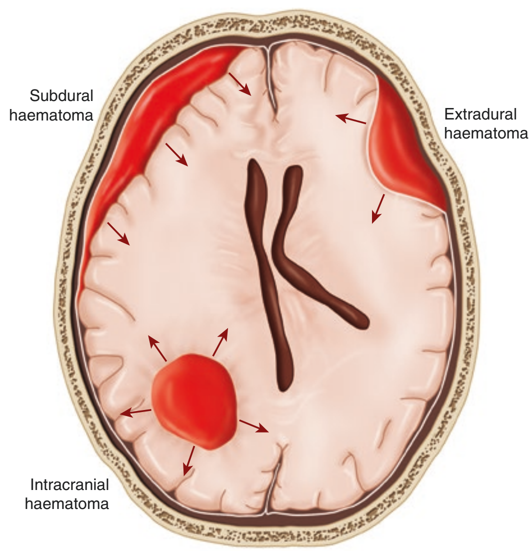


Fig. 13.6 Types of intracranial haemorrhage

Table 13.2 Modified GCS verbal score for paediatric patients

6–10 years	2–5 years	<2 years	1
None	None	None	2
Incomprehensible sounds	Grunts	Grunts	3
Inappropriate words	Cries or screams	Inappropriate crying	4
Appropriate but confused words	Monosyllabic	Cries only	5
Fully orientated	Any words	Appropriate non-verbal response	6

Traumatic Brain Injury

Traumatic brain injury describes a spectrum of clinical states categorised by GCS. They are a significant cause of mortality and morbidity in young people and range from concussion to comatose state. Pathologies requiring neurosurgical attention may result from traumatic brain injury, including subdural haematoma.

Intervertebral Disc Prolapse

Adjacent vertebrae are separated by intervertebral discs. These consist of the *annulus fibrosus*, a series of concentric fibrocartilaginous layers; and the *nucleus pulposus*, a water-based gelatinous core. Age-related changes in the annulus fibrosus allow the herniation of the nucleus pulposus through it, placing pressure on surrounding structures, including nerve roots, the cauda equina and the spinal cord above its termination point which is usually at L1/2 in adults (Fig. 13.7).

Cauda Equina Syndrome

Cauda equina syndrome is a relatively rare condition usually associated with a space-occupying lesion in the lumbosacral spine, most often a disc prolapse. It presents with pain, motor and sensory loss and bowel and bladder dysfunction. Symptoms and signs can be subtle and a high index of suspicion is necessary given the need for urgent treatment by surgical decompression of spinal canal.

Core Operations

Some of the most common neurosurgical operations are described briefly below. The aim is to provide a basic understanding and to cultivate the curiosity to delve into detailed texts.

External Ventricular Drainage

This is also called an external ventriculostomy and aims at providing a minimally invasive access to the brain's ventricular system. It allows the drain-

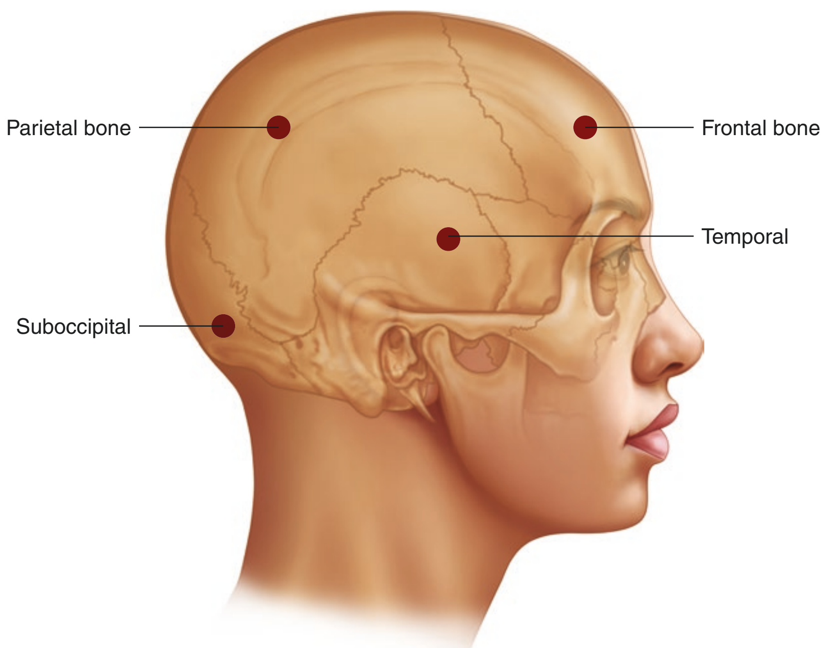


Fig. 13.7 Burr hole drainage sites

age of excess accumulated CSF and the sampling of CSF for chemical, haematological, microscopic, microbiological and other purposes.

Indications

- Raised intracranial pressure (ICP), for example due to:
  - Traumatic brain injury
  - Acute ‘communicating’ hydrocephalus e.g. secondary to subarachnoid haemorrhage
  - ‘Non-communicating’ (i.e. obstructive) hydrocephalus, e.g. secondary to an intracranial tumour
  - Intraventricular haemorrhage
- Externalisation of an infected ventriculoperitoneal shunt system

Contraindications

- Coagulopathies

Presentation of Raised ICP

- Drowsiness
- Nausea and vomiting
- Headaches (of raised intracranial pressure)
- Gait apraxia
- Cognitive disturbance
- Incontinence (urinary / faecal)
- Neurological deficit (e.g. hemiparesis; ocular palsy)
- ***Investigations*** CT: during acute presentation to exclude haemorrhage; ventricular obstruction; to monitor ventricular size
- MRI: to visualise tumour, better detail of parenchyma and ventricles.
- Lumbar puncture: only indicated if the hydrocephalus is non-obstructive, i.e. communicating (otherwise, there is a risk of ‘coning’, which is downward herniation of brainstem through foramen magnum due to a pressure gradient)

Clinical Anatomy

Kocher’s point is a common site of entry for external ventricular drains. This point is located 1 cm anterior from the coronal suture and 3–4 cm lateral to the midline. It provides access to the frontal horn of the ipsilateral lateral ventricle.

Step-by-Step Summary: Extraventricular Drainage

1. Positioning: Supine neutral head position with head of bed slightly elevated
2. Shave right frontal access point (right side is preferable as it is the non-dominant side in the vast majority of patients)
3. Longitudinal incision centred over Kocher’s point
4. Drill until the inner cranial table is breached
5. Dural opening
6. Insertion of external ventricular drain tubing to 5 cm depth, looking for release of CSF
7. Save CSF sample for analysis
8. Securing of EVD to scalp and connection to closed external drainage system
9. Scalp closure with sutures
10. Determine manometer pressure above which CSF will drain

Complications

- Drain blockage
- Infection including ventriculitis
- Drain misplacement / displacement
- Haemorrhage

Follow-Up

- Vigilant observation for infection
- If EVD is required beyond 1 week, consider EVD change to avoid colonisation
- If patient remains EVD-dependent, conversion to a Ventriculo-Peritoneal shunt may be necessary
- CT scan to assess volume changes

Surgeons’ Favourite Questions for Students

1. What are the indications for EVD?
2. What is the location of the access burr-hole?
3. Potential complications of brain injury secondary to misplacement in relation to gross brain anatomy?
4. What is a normal ICP?

Burr Hole Drainage of Chronic Subdural Haematoma

Indications
- Chronic blood is liquefied, whereas acute blood is jelly-like in viscosity. The former is more amenable to burr hole drainage.

Contraindications
- Coagulopathy

Presentation
- Hemiparesis
- Ataxia
- Confusion, variable conscious state
- Seizures
- Headache
- Nausea, vomiting
- Trauma not always described- minor repetitive injuries are commoner in the elderly, who often do not remember a specific traumatic event.

Investigations
- CT: shows age of blood (isodense or hypodense)

Step-by-Step Summary: Burr Hole
1. Positioning: Supine with head tilted so as to expose the affected side up, with shoulder support, to avoid overstretching of the neck.
2. Shave access point(s); the burr holes are positioned over the cranial convexity at location where haematoma is thickest. Either one or two burr holes are used.
3. Longitudinal incision
4. Drill until the inner cranial table is breached. Handheld or mechanical drills can be used.
5. Dural opening
6. Copious wash-out of haematoma between the burr holes until no further blood visible

Complications
- Re-accumulation of haematoma
- Seizures
- Focal brain injury
- Subdural empyema
- Tension pneumocephalus

Follow-Up
- Repeat CT if patient's neurological status does not improve or improves then regresses

Craniotomy

Brain tumours occur in 15–20 per 100,000. Secondary tumours due to metastases are the most common of these tumours- 20–30 % of patients with systemic cancer will have brain metastases. Brain tumours comprise 10 % of all malignancies and 20 % of paediatric neoplasms. Brain tumours can be classified by parenchymal location (extrinsic or intrinsic), malignancy (primary or secondary) cell of origin (neuroepithelial, meninges, blood vessel etc.) and histological grading (WHO Grades I-V).

Indications
- Acute extradural haematoma
- Acute subdural haematoma / empyema
- Intracranial tumour
- Trauma

Contraindications
- Coagulopathy
- Anaesthetic considerations

Presentation
- Hemiparesis
- Confusion, variable conscious state to coma
- Seizures
- Headache
- Nausea and vomiting
- Trauma

Investigations
- CT: better for acute haemorrhage and skull fracture
- MRI: better detail for soft tissue anatomy, including brain parenchyma, tumours and their relations

Clinical Anatomy
Students are advised to revise gross brain anatomy including lobar localisation and speech and language areas, motor and sensory cortices, basal ganglia and inter-hemispheric commissures.

Step-by-Step Summary: Craniotomy
1. Positioning: the head is often secured in Mayfield pins to eliminate intra-operative movement. Neuronavigation is used to design the position of the scalp flap.

2. Limited hair shave.
3. Prepare the skin and drape
4. Scalp incision
5. Perioesteal elevation
6. Burr holes along the outline of craniotomy window. A drill is used to run between these.
7. The bone flap is elevated.
8. Dural opening
9. Corticotomy along brain surface to gain access to target lesion.
10. Special high-tech instruments allow precise resection of tumours in eloquent areas, such as an ultrasonic aspirator and micro-instruments, under specialised microscope.
11. Small "dog bone"-shaped metallic plates are used to connect the bone flap to the surrounding skull in order to secure it back in place.

Complications
- Seizures
- Intracerebral haemorrhage
- Focal brain injury
- Subdural empyema
- Tension pneumocephalus

Follow-Up
Follow up will be tailored to the target pathology e.g. MRI for tumours, angiography for vascular abnormalities (such as aneurysms or arteriovenous malformation).

Surgeons' Favourite Questions for Students
1. How can one classify brain tumours?
2. Which is the commonest brain tumour?
3. How common are brain tumours?
4. How do intracranial malignancies compare with all tumours?
5. How is the bone flap secured back in place at the end of the operation?

Lumbar Microdiscectomy

Lumbar disc prolapse involves herniation of the nucleus pulposus through the annulus fibrosus. An L4/L5 prolapse will affect the L5 nerve root. Far lateral or extra-foraminal prolapses at this level would affect the L4 nerve root. CSF leakages may cause complications such as pseudomeningocoele, headaches and in extreme cases subdural haematoma. Conus Medullaris syndrome refers to a syndrome resulting from insult to the most inferior part of the spinal cord, the conus medullaris, which usually lies around L1-L2 before becoming the cauda equine inferiorly. An injury here will cause mixed upper and lower motor neurone symptoms and signs, usually affecting the perineum and lower extremities.

Indications
- Lumbar disc herniation: refractory to medical management, progressive symptoms
- Cauda Equina Syndrome: neurosurgical emergency affecting bladder, bowel and sexual function (see above).

Contraindications
- Anaesthetic considerations

Presentation
- Leg Pain
- Back pain
- Numbness
- Weakness
- Paraesthesia
- Cauda Equina Syndrome (urinary / faecal incontinence, saddle anaesthesia, uni- or bilateral lower limb symptoms)

Investigations
- MRI: to exclude cauda equina compression via central canal occlusion, most commonly from a central disc prolapse; to assess for nerve root compression

Step-by-Step Summary: Lumbar Microdiscectomy
1. Prone position on a frame such as the Montreal mattress or the Wilson frame

2. X-ray localisation: it is paramount that before skin incision the correct spinal level to be operated upon is identified radiographically
3. Prepping of the skin and draping the patient
4. Unilateral stripping of subperiosteal muscle off the spinous process and lamina, to expose the entry point into the canal
5. Retractor system: this helps hold the retracted muscle away, thus maintaining access
6. X-ray confirmation of level: it is good practice to confirm that the surgeon is at the correct spinal level by repeating an x-ray intraoperatively
7. Microscope: its use has revolutionised lumbar disc microsurgery with the associated magnification and illumination
8. Entry into the spinal canal via fenestration through ligamentum flavum
9. Identification and decompression of the affected nerve root
10. Identification of disc prolapse and its resection by incising the annulus and removing the loose fragment
11. Haemostasis and closure in layers

Complications

- Nerve root or cauda equina injury
- Dural tear / pseudomeningocele
- Discitis (sterile or septic)

Follow-Up

- Immediate mobilisation and physiotherapy
- In the event of a CSF leak, the patient is often kept flat on bed-rest for 24–48 h

Surgeons' Favourite Questions for Students

1. An L4/5 disc prolapse will affect which nerve?
2. When will an L4/5 disc prolapse affect the L4 nerve root?
3. What are some complications of CSF leakage?
4. What is Conus Medullaris syndrome?
5. Does any removed disc material need to be replaced?

Tips for Placement

1. Revise simple neuroanatomy and neurophysiology
2. Attend neuroradiology meetings
3. Attend multidisciplinary meetings for subspecialties (e.g. neuro-oncology, neurovascular, complex spine, skull base, paediatric, pain and functional)
4. Shadow the on-call neurosurgical trainees
5. Scrub in theatre to see up-close and personal what the procedures are all about

Careers

Within neurosurgery there is a great deal of choice of subspecialisation, including paediatric neurosurgery, neurotrauma, neurovascular surgery, surgical neuro-oncology, functional and epilepsy neurosurgery, skull base surgery and spinal surgery.

Entry is competitive with some of the highest competition ratios for ST posts. Application to training posts is through a national selection process currently hosted by Yorkshire and Humber Deanery. This training lasts for 8 years (ST1-8). This is a run-through programme. Trainees proceed through a structured curriculum including optional attachments in neuro-intensive care and neuro-rehabilitation. There is the opportunity to undertake an attachment in a sub-speciality of specific interest towards the end of training (fellowship).

Progression also depends upon completion of professional examinations and contribution to teaching, research and audit. Often candidates for consultant posts will have completed an MD or PhD.

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Ophthalmology

14

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Introduction

The primary aim of most ophthalmic procedures is to restore or preserve vision. Modern ophthalmology is divided into various sub-specialties, and some common operations from each sub-specialty, along with cataract surgery, will be considered in this chapter. Cataract surgery is one of the commonest operations performed worldwide and most ophthalmologists carry out the procedure many times during their career.

Ophthalmologists also treat several conditions medically, and perform a number of procedures outside the operating theatre, such as retinal laser treatment and intravitreal injections (injections into the posterior segment of the eye). This chapter will mainly describe those operations that are carried out in the operating theatre.

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Core Knowledge

Ocular Anatomy

Figure 14.1 shows a schematic of the eye with structures labelled. The structures are discussed in more detail in Table 14.1.

Extraocular Muscles

Each eye has six extraocular muscles responsible for eye movements. Figure 14.2 shows a schematic of the muscles responsible for each eye movement. Underaction or overaction can lead to strabismus (squint) which can be corrected with squint surgery. The six muscles include four rectus muscles and two oblique muscles.

- The rectus muscles arise from the annulus of Zinn and insert near the limbus.
  - The medial rectus pulls the eye medially (adduction)
  - The inferior rectus pulls the eye down (infraduction or depression)
  - The lateral rectus pulls the eye laterally (abduction)
  - The superior rectus pulls the eye upwards (supraduction or elevation)

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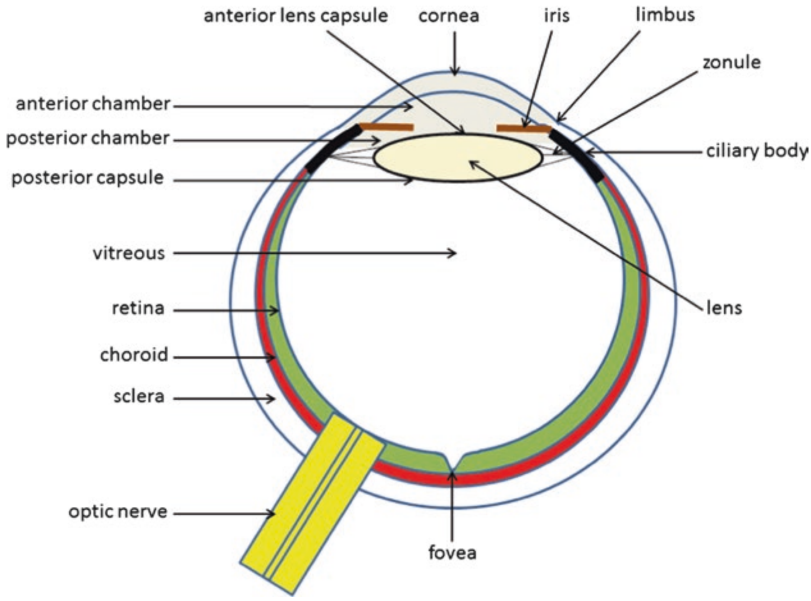

Fig. 14.1 Schematic of the eye with ocular structures labelled

Table 14.1 Description of ocular structures (anterior to posterior)

Structure	Comments
Cornea	A transparent, avascular structure that joins the sclera at the limbus. It receives its nutrients from the tear film. The outer layer is densely innervated with pain fibres, whilst the inner layer is responsible for maintaining corneal hydration and transparency
Anterior chamber	This is the space between the cornea and the iris. It is filled with aqueous humour, which is secreted by the ciliary body. Aqueous drains out of the eye via the trabecular meshwork found in the drainage angle (angle between cornea and iris). From here, it drains into the canal of Schlemm
Iris	A circular, pigmented contractile muscular diaphragm. Sympathetic innervation causes dilation and parasympathetic innervation causes constriction. It divides the anterior and posterior chambers of the eye
Lens	This is just behind the iris and is attached to the ciliary body via zonules. With the cornea, it provides refractive power to the eye. When looking at near objects (accommodation), the circular ciliary muscle contracts, reducing tension in the zonules by making the lens assume a more globular shape. This enables the focus of near rays on the retina
Vitreous	A gel-like material that fills the posterior chamber. It is attached to the retina most strongly at the annulus of Zinn posteriorly and the ora serrata anteriorly
Retina	A multi-layered neural layer, stretching from the ora serrata to the optic nerve. It contains rod and cone photoreceptors that detect light, and transmit signals, via other neurons, to the optic nerve. The macula is the central portion of retina that contains the fovea at its centre. This has a very high density of cone photoreceptors, which gives high central visual acuity
Choroid	Vascular layer that nourishes the outer retina. The inner retina is supplied by the retinal vessels
Sclera	Tough outer layer of connective tissue to which the extraocular muscles attach. Posteriorly, the sclera is encased in Tenon's layer. Anteriorly, it is covered by the conjunctiva

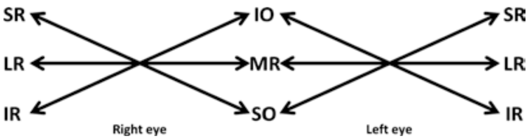

Fig. 14.2 Schematic diagram of the extraocular muscles responsible for different directions of gaze. *SR* superior rectus, *LR* lateral rectus, *IR* inferior rectus, *MR* medial rectus, *IO* inferior oblique, *SO* superior oblique. Note that this is a simplified scheme. The actions differ depending on the direction of gaze; for example the oblique muscles may act to abduct the eye in the primary position, and the superior and inferior recti adduct the eye when in the primary position

- The oblique muscles arise from the orbital walls and insert temporally on the globe.
  - The superior oblique arises from the sphenoid bone and travels through the trochlea (u-shaped cartilage) before inserting superotemporally on the globe. The trochlea is located on the superonasal part of the anterior orbit, creating a pulley-like structure.
  - The superior oblique depresses and abducts the eye.

The inferior oblique arises from the inferonasal part of the anterior orbit, and inserts posterotemporally on the globe. It elevates and abducts the eye.

The superior oblique and superior rectus also intort the eye (superior limbus rotates medially), and the inferior oblique and inferior rectus extort the eye (the superior limbus rotates temporally). The extraocular muscles are all supplied by the 3rd cranial nerve (oculomotor nerve) except for the lateral rectus (6th cranial nerve, abducens) and the superior oblique (4th cranial nerve, trochlear). The 3rd nerve also innervates levator palpebrae superioris which elevates the upper lid.

Eyelid Anatomy

The upper and lower lids are very important in protecting and lubricating the corneal surface. The structure can be simplified to four layers from anterior to posterior, listed in Table 14.2.

Table 14.2 Basic components of the eyelid (anterior to posterior)

Structure	Comments
Skin	This overlies loose connective tissue. At the lid margin, there are 2–3 rows of eye lashes with secretory glands at the follicles (glands of Moll and Zeiss)
Orbicularis oculi	This is a large muscle with different portions responsible for closure of the eyelids. It is supplied by the 7th cranial nerve (facial), and hence lid closure can be diminished in facial nerve palsy
Tarsal plate	This is a thickened plate of connective tissue and serves to maintain the lid shape. It contains Meibomian glands which secrete the lipid layer of the tear film. Blockade of this secretion leads to a chalazion
Tarsal conjunctiva	This lines the inner surface of the tarsal plate and is continuous with the bulbar conjunctiva at the conjunctival fornix

Lid opening is achieved by the upper lid retractors (a large voluntary muscle called levator palpebrae superioris, and a sympathetically-innervated smaller muscle called Muller's muscle) and the lower lid retractors (more rudimentary than the upper lid retractors).

Lacrimal System

The lacrimal gland is a bi-lobed structure located in the superolateral part of the anterior orbit. Parasympathetic innervation leads to increased tear production (Fig. 14.3).

Tears drain via the upper and lower puncta (the majority via the lower puncta) into the lacrimal sac via the upper and lower canaliculi. The lacrimal sac drains via the nasolacrimal duct into the nose. One treatment for dry eyes is to reduce tear drainage by occluding the lacrimal puncta (temporarily with punctal plugs or permanently with punctal cautery). Blockage of the lacrimal drainage system can lead to a watery eye. Treatment of this depends on the site of blockage (discussed later).

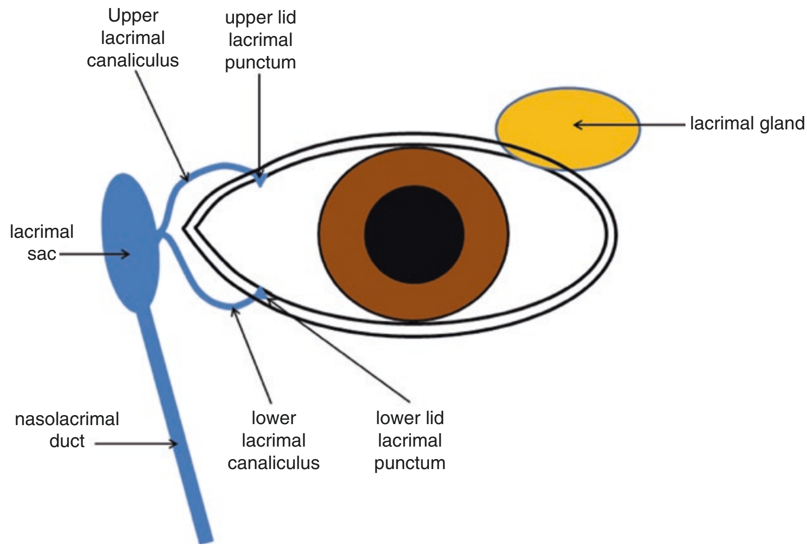

Fig. 14.3 Schematic anatomy of the lacrimal system

Core Procedures

Cataract Surgery

Cataract is opacification of the lens of the eye, and the only treatment is surgical. The lens is composed of crystalline material bounded anteriorly by the anterior lens capsule, and posteriorly by the posterior capsule. The usual symptom is the gradual onset (over years) of blurring of vision (Table 14.3).

Types of Cataract

Table 14.3 Common types of cataract

Type	Description
Nuclear sclerotic	Opacification of the central part of the lens. This may increase the refractive index of the lens, giving increased myopia (short-sightedness) as well as blurring of vision
Cortical	Radial spoke-like opacification of the lens. This often leads to increased glare, frequently impairing ability to drive at night
Posterior subcapsular	Opacity that is mainly in the posterior part of the lens, just anterior to the posterior capsule. This tends to impair reading vision particularly, and can be associated with exposure to steroids

Risk Factors

- Age (the commonest risk factor)
- Diabetes
- Intraocular inflammation (uveitis)
- Steroid exposure
- Trauma or ocular surgery

The Procedure

Cataract surgery is performed routinely and is not usually an urgent procedure. Rarely, the cataract can cause significant shallowing of the anterior chamber which can lead to secondary angle closure glaucoma. This is known as phacomorphic glaucoma and would require urgent treatment.

Modern cataract surgery is performed using an operating microscope under local anaesthesia with small (less than 3 mm) sutureless incisions. Some of the main steps are summarised below.

1. A circular tear is carefully made in the anterior capsule, giving access to the lens. This tear is called a continuous curvilinear capsulorhexis, and is frequently the most difficult stage in the operation for new trainees.

2. The main part of the lens is broken up ("phacoemulsification") into pieces using a probe that vibrates at ultrasound frequencies.
3. The lens pieces are sucked out, taking care not to rupture the posterior capsule.
4. A flexible synthetic replacement intraocular lens (IOL) is injected through the small incision and opens within the lens capsule.
5. An antibiotic is injected (commonly cefuroxime).
6. A pad and shield are placed over the eye (or just a clear shield if the operation was performed under topical anaesthesia).

The "phaco machine" is a sophisticated piece of equipment used in modern cataract surgery. The "phaco probe" is held in the surgeon's dominant hand, and is used to sculpt and emulsify the cataract using ultrasound energy, and it also aspirates the lens fragments. A second instrument, the "chopper", is held in the surgeon's non-dominant hand to manipulate the lens pieces. The phaco machine controls the ultrasound power, the rate of fluid entering the eye to maintain a deep anterior chamber, and rate of aspiration of fluid or material out of the eye. During the operation, the surgeon controls the rates of irrigation and aspiration and phacoemulsification power using a foot pedal. The other foot controls the operating microscope. Thus, during cataract surgery, both hands and feet are used simultaneously, just as in driving a car.

Post-Operative Care

The pad and shield are removed later the same day or the following morning. The patient is usually given steroid drops (dexamethasone or prednisolone) and antibiotic drops (e.g. chloramphenicol) to administer 4 times daily. The shield is usually worn at night for a week post-operatively. The antibiotic drops may be stopped after 1–2 weeks, and the steroid drops are usually continued for a month. Patients are reviewed around 2 weeks post-operatively, and can visit an optician subsequently to check whether there may be a need for glasses.

Complications

- Damage to anatomical structures surrounding the lens, particularly rupture of the posterior capsule, which occurs in 1–2 % of operations.
- Endophthalmitis is a post-operative intraocular infection, and is a devastating, often blinding complication, which is fortunately rare (around 1 in 1000 operations). Usual presentation is with pain, loss of vision, and pus in the anterior chamber (giving a hypopyon). Prompt treatment with antibiotics injected into the vitreous cavity (intravitreal antibiotics) is essential.
- Post-operative inflammation (uveitis) is common, and can usually be controlled by increasing the frequency or duration of topical steroid drops.
- Cystoid macular oedema (fluid in the central retina) may develop some weeks after cataract surgery (there is an increased risk in diabetic patients and those with pre-existing uveitis), and is usually treated with topical steroid or non-steroidal anti-inflammatory drops. Persistent cases may be treated with intravitreal steroid injections.

Oculoplastics (Lids and Adnexa)

Urgent Procedures

Trauma resulting in full-thickness lid lacerations involving the lid margin should be repaired by an ophthalmologist within 48 h. It is important to first bring the cut edges together carefully at the lid margin to avoid notching of the lid, and then close the defect in layers.

Rarely, in cases of trauma, a haemorrhage can develop behind the eye (retrobulbar haemorrhage), which causes proptosis and restriction of eye movements. This is particularly true when trauma has affected the orbit. There is a risk of optic nerve compression, and urgent decompression is needed, which is achieved by cutting through and freeing the lateral canthus (lateral canthotomy).

Other urgent lid procedures may include ocular surface protection. For example, when the ocular surface is severely exposed (e.g. in facial nerve palsy), the upper and lower lids may be sutured together (lateral tarsorrhaphy). Other more common methods including injection of Botulinum toxin, or insertion of gold weights, to drop the upper lid.

Routine Procedures

Chalazion Drainage

Lid cysts are common, in particular Meibomian cysts or chalazia (due to blockage of Meibomian gland outflow). These are usually self-limiting and frequently resolve spontaneously or with hot compresses. Persistent or symptomatic cysts may be treated with incision and drainage.

Ptosis Repair

Ptosis is drooping of the upper lid, which can be congenital or acquired. Acquired types include involutional (age-related muscle weakening), neurogenic (3rd nerve palsy), myogenic (e.g. myasthenia gravis) or mechanical (e.g. due to the weight of a mass). Ptosis can often be corrected by shortening the levator aponeurosis (continuation of levator palpebrae superioris). However, if levator function is extremely poor, other procedures such as a brow suspension may be required.

Ectropion Repair

Ectropion refers to out-turning (eversion) of the eyelid (usually the lower lid). The commonest cause is age-related lid laxity, and treatment is usually with a lid-shortening or tightening procedure. Other causes include cicatricial (due to scarring), mechanical (due to the weight of a mass) or paralytic (due to orbicularis oculi weakness in facial nerve palsy).

Entropion Repair

Entropion refers to in-turning (inversion) of the eyelid. Treatment is usually more urgent than that for ectropion, due to the possibility of corneal injury and scarring from the in-turning lashes. The commonest cause is involutional, where tissue laxity results in dysfunction of the inferior lid retractors. Often, this is corrected with a lid tightening procedure which may also include placement of everting sutures to turn the lid outwards.

Other

Other lid operations include biopsy or removal of masses (which may be urgent if malignancy is suspected). By far, the commonest lid malignancy is basal cell carcinoma. Less common are squamous cell carcinoma and sebaceous gland carcinoma.

Lacrimal drainage problems may also require surgical treatment. One cause of a watery eye may be nasolacrimal duct obstruction. This is diagnosed by syringing the lacrimal ducts: a cannula is inserted into the lacrimal punctum, and is carefully advanced as far as the lacrimal sac. Saline is then injected. The lack of flow of saline into the nasal cavity and back of throat indicates obstruction. This can be treated with a dacryocystorhinostomy (DCR) operation, in which a new connection is created between the lacrimal sac and the nasal cavity under general anaesthesia. The conventional operation is the external DCR (where the approach is external). More recently, endoscopic approaches via the nasal cavity have been used (endonasal DCR).

Corneal Surgery

Urgent Procedures

A corneal abrasion or partial thickness laceration can be treated with topical antibiotics (e.g. chloramphenicol ointment), and the eye may be padded. Full-thickness lacerations are more likely to need surgical repair. Small, self-sealing penetrating injuries can be treated with application of a bandage contact lens and observation. Small defects can sometimes be sealed with corneal glue. However, a substantial penetrating injury will usually require exploration and suturing under general anaesthesia in the operating theatre.

Sharp injuries lead to corneal or scleral penetrations. Blunt trauma may lead to anterior or posterior globe ruptures, which also require surgical repair.

Routine Procedures

Pterygium Removal

A pterygium is a triangular growth of fibrovascular tissue that encroaches onto the nasal cornea from the limbus. It is commoner in males and in dry climates with high ultraviolet light exposures. Most pterygia can be managed conservatively with topical lubricants. However, a substantial pterygium that encroaches on the visual axis may require surgical removal. This is usually combined with a conjunctival autograft, where superior conjunctiva is taken and sutured into the area corresponding to the base of the removed pterygium. Post-operatively, frequent topical steroid drops are used (as well as topical antibiotics) to reduce scarring. Post-operative complications include discomfort, infection, scarring and recurrence of the pterygium, which may necessitate further surgery.

Corneal Grafts

When the central cornea (the visual axis) is opaque (e.g. due to scarring from previous infection or from a corneal dystrophy or ectasia), the only treatment that will restore vision is a corneal transplant, in which a donor cornea is used to replace the diseased host cornea.

A full-thickness corneal graft is called a penetrating keratoplasty (PK). Steps during this procedure are as follows:

1. Drops to constrict the pupil are administered pre-operatively
2. Measure the size of host cornea to be removed and donor cornea (should be larger than area of host cornea to be excised)
3. Inject viscoelastic material into host anterior chamber
4. Excise “button” of donor cornea using trephine
5. Excise button of host cornea using trephine
6. Place donor cornea in position and secure with four cardinal sutures (10–0 nylon)
7. Place remaining sutures (interrupted or continuous)
8. Fill anterior chamber with balanced salt solution

Post-operatively, topical antibiotic and frequent topical steroid drops are given, and the patient is reviewed the next day, and regularly thereafter. Complications include wound leak, infection, graft rejection, astigmatism and recurrence of corneal disease in the graft.

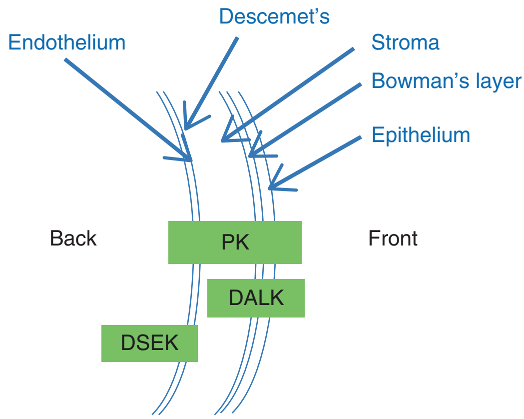

Fig. 14.4 Layers of the cornea with types of corneal graft. *PK* penetrating keratoplasty, *DALK* deep anterior lamellar keratoplasty, *DSEK* descemet stripping endothelial keratoplasty

Partial thickness keratoplasties are also performed, where only some layers are replaced. These include deep anterior lamellar keratoplasty (DALK) for diseases affecting the anterior layers, or descemet stripping endothelial keratoplasty (DSEK) for diseases affecting the posterior layers (Fig. 14.4).

Glaucoma

Glaucoma refers to a characteristic optic neuropathy usually resulting from a raised intraocular pressure. A raised intraocular pressure (greater than 20 mm Hg) is termed ocular hypertension, and if combined with glaucomatous optic nerve damage, this would be termed glaucoma. There are two main types of glaucoma: open and closed angle. Whilst open angle glaucoma can be managed routinely, closed angle can be an emergency prompting urgent treatment.

Angle Closure Glaucoma

Angle closure glaucoma occurs when the intraocular pressure is raised due to impaired drainage of aqueous through a narrow or closed drainage angle.

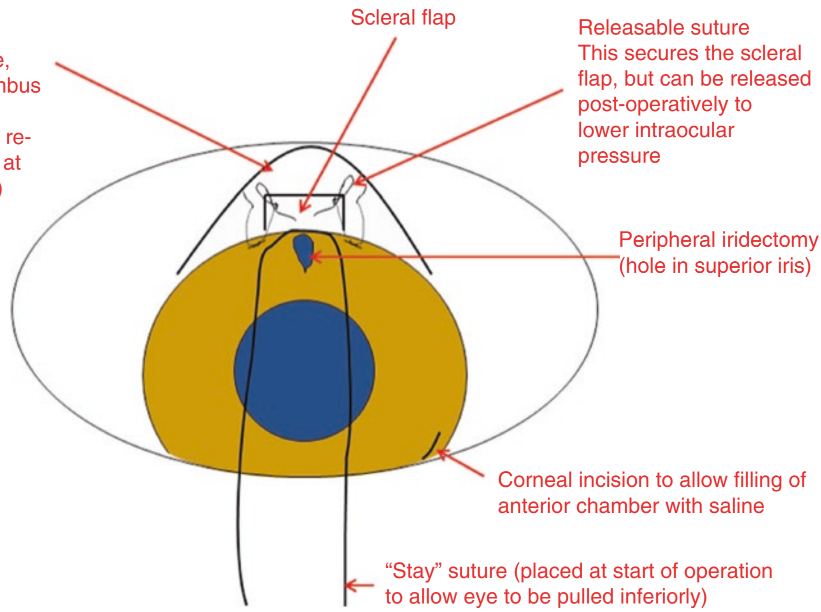

Fig. 14.5 Schematic of trabeculectomy

Acute angle closure glaucoma occurs when the drainage angle becomes acutely blocked (often in darkness, when the pupil dilates, causing the peripheral iris to thicken and block drainage). As more aqueous is produced by the ciliary body behind the iris, the iris bows forward, further blocking drainage and creating a vicious cycle. The pressure can rise markedly, making the eye intensely painful and causing clouding of vision due to corneal haze (giving the symptom of seeing haloes around lights).

Signs seen on examination are a red, painful eye with a hazy cornea, and a fixed mid-dilated pupil. Patients are at greater risk with increasing age, and if they are hypermetropic (long-sighted) as this usually indicates a smaller than average eye with a shallower anterior chamber. Urgent treatment is needed, with drops and systemic agents (such as the carbonic anhydrase inhibitor, acetazolamide) used to lower the intraocular pressure.

More definitive treatment involves making a hole in the peripheral iris (peripheral iridotomy) which gives aqueous a path to travel from behind the iris to the front. As aqueous rapidly accumulates in front of the iris, the iris is pushed back (the anterior chamber deepens) and the drainage pathway is unblocked. The peripheral iridotomy can be achieved using a slit lamp mounted YAG laser. After the procedure, the pressure is rechecked to check it is normalising, and steroid drops are given.

Primary Open Angle Glaucoma

The most common glaucoma is primary open angle glaucoma. This means that the anterior chamber drainage angle is open in the presence of raised intraocular pressure and glaucomatous optic nerve damage. Patients are usually asymptomatic, because the field loss occurs in the peripheral visual field; however, the field loss is irreversible. Most patients are referred following a routine eye test. Treatment aims at reducing the intraocular pressure, and this is usually achieved with topical medication. Eye drops can either reduce the production of aqueous or increase its outflow.

If drops are insufficient to control intraocular pressure, the next step would usually be a glaucoma drainage operation called a trabeculectomy. This increases aqueous outflow by making a direct communication between the anterior chamber, through a scleral flap, and the subconjunctival space. Figure 14.5 depicts a trabeculectomy schematically and the main steps are listed below.

Trabeculectomy Procedure

1. Incise conjunctiva with scissors superiorly at the limbus
2. Undermine the conjunctiva superiorly and diathermy area of intended trabeculectomy
3. Make horizontal partial-thickness incision in the sclera 3 mm above the limbus with two vertical incisions at either end to make a flap
4. Advance the flap towards the limbus until the anterior chamber is reached at 12 o'clock and create a sclerostomy (hole in the sclera)
5. Grasp iris through sclerostomy and create a peripheral iridotomy by cutting a small hole
6. Secure two releasable sutures from each corner of the flap to the cornea at 11 and 1 o'clock. These sutures will tighten the flap of sclera, but it can be released post-operatively if the intraocular pressure needs to be lowered.

Post-Operative Considerations

Post-operatively, patients are given topical steroid and antibiotic drops, and reviewed the next day, and at regular intervals determined by recovery and pressure readings. A functioning trabeculectomy should result in a visible drainage "bleb" (a raised area subconjunctivally in the sclera superior to the limbus indicating good drainage of aqueous).

Post-operative complications include bleeding, infection of the bleb (blebitis, which can lead to endophthalmitis), high pressure, low pressure (termed hypotony), development of cataract, and need for further procedures. Trabeculectomies can be revised if failure occurs, but there are also newer, more advanced surgical techniques that are becoming more common. These involve insertion of artificial drainage devices, such as the Baerveldt tube and the Ahmed valve.

Vitreoretinal Surgery

Retinal Detachment Repair

Retinal detachment refers to detachment of the overlying retinal layers (the "neurosensory retina") from the underlying retinal pigment epithelium. Retinal detachments can involve a break ("rhegma") in the retina, which allows fluid from the vitreous space to enter the subretinal space. These are rhegmatogenous retinal detachments, and represent the commonest ophthalmic surgical emergency.

Presenting features of a rhegmatogenous retinal detachment include acute onset of flashes of light and floaters, and a shadow in the visual field (corresponding to the area of detached retina). Symptoms will be monocular. Patients presenting with these symptoms should undergo a full retinal examination urgently by an ophthalmologist to exclude a retinal detachment.

The commonest cause of rhegmatogenous retinal detachment is a posterior vitreous detachment (PVD), which is the separation of vitreous from the retina that occurs with age. In most people PVD is uncomplicated; in some people, as the vitreous separates from the retina, it may cause a tear at an area of abnormally strong vitreoretinal adhesion, or an area of retinal degeneration. The traction from the vitreous can cause the tear to progress; if the break extends for 3 or more clock hours, it is termed a giant retinal tear.

Small tears with limited subretinal fluid can be treated with argon laser retinopexy, where laser burns are applied at the slit lamp in a confluent manner around the retinal break, creating a barrier to progression of subretinal fluid. However, if there is significant subretinal fluid, this is unlikely to work and surgical treatment is indicated. If the central part of the retina, the macula, has detached ("macula-off detachment"), the visual prognosis after surgery is very guarded. Thus, a detachment where the macula has not yet detached ("macula-on detachment") should be operated on urgently (usually within 24 h, to prevent progression to macula-off detachment) as the visual prognosis is still good.

Non-rhegmatogenous detachments can occur due to traction from fibrotic tissue ("tractional retinal detachments") or due to exudation of fluid, often in an inflammatory process ("exudative retinal detachments").

Retinal detachment operations include vitrectomy and scleral buckling procedures. The vitrectomy operation involves removing the vitreous (to remove traction on the retina which can cause progression of the detachment) and is usually combined with cryotherapy or laser to seal the retinal break, and some form of tamponade (commonly gas, but sometimes silicone oil in the case of complex detachments) to keep the retina flat.

Vitrectomy Procedure

1. Make three openings into the sclera ("sclerostomies"), each 4 mm from the limbus, to make entry points for:
    i. An infusion cannula, which is placed in the inferotemporal sclerostomy to maintain the pressure within the eye
    ii. A "vitrector" which is a device for cutting and aspirating the vitreous
    iii. A "light-pipe" to provide illumination
2. Remove vitreous (vitrectomy), first from its posterior attachments and then peripherally
3. Carefully search for all breaks by exploring completely around 360 degrees of peripheral retina
4. Treat breaks with laser or cryotherapy
5. Replace infusion fluid with tamponade agent, which is usually gas or silicone oil in more complex detachments
6. Suture sclerostomies

Post-Operative Considerations

Post-operatively, the patient may be asked to posture a certain way (e.g. face-down for a few hours a day) to optimise the position of the gas bubble depending on the location of the retinal detachment. Patients are given drops (topical steroids and antibiotics) and are reviewed the first day after surgery, then after 2 weeks, and then at regular intervals depending on recovery or complications.

Complications include infection (endophthalmitis), high intraocular pressure (particularly if there is a gas overfill), recurrence of retinal detachment, and development of cataract (up to 50 % of patients may need cataract surgery within 2 years of a vitrectomy).

Scleral Buckle

Another operation used to treat retinal detachments is a scleral buckling procedure, in which a "buckle" is sutured to the sclera in the area of the detachment (after applying cryotherapy to the retinal break). By indenting the sclera, the retinal pigment epithelium is moved closer to the retina, helping the detachment resolve and reducing traction from the vitreous. As this is not an intraocular procedure, the risks of intraocular infection are diminished.

Strabismus

The visual axes of both eyes are usually aligned so that rays from the object of regard are simultaneously focused at the fovea in both eyes. When the eyes are not aligned, a squint will result. This is also known as strabismus. Concomitant strabismus refers to a deviation that is constant in all directions of gaze, whilst incomitant strabismus varies with direction of gaze. Causes of incomitant strabismus include the following:

- Neurogenic – due to a cranial nerve palsy (III, IV or VI nerve palsies).
- Mechanical – due to restriction of movement, e.g. due to thyroid eye disease (enlarged, inflamed muscles) or an orbital wall fracture
- Myogenic – due to primary muscle weakness such as in myasthenia gravis or inherited myopathies.

A patient with strabismus should be assessed with a full history (including acuteness of onset, associated trauma, symptoms of diplopia) and examination (including measurement of visual acuity, refractive error, angle of deviation for distance, near and in each direction of gaze), and further investigations for the above causes (including possible neuroimaging in the case of an acute onset cranial nerve palsy).

Deviations may be classified as esotropia, exotropia, hypertropia or hypotropia when the deviating eye looks inward, outward, higher or lower respectively. Patients should be seen by orthoptists, who are professionals specialised in the measurement of eye movements.

Strabismus surgery involves operating on the extraocular muscles to realign the eyes. This may be done for purposes of improving vision (e.g. removing symptoms of diplopia), or for normalising the appearance of the eyes.

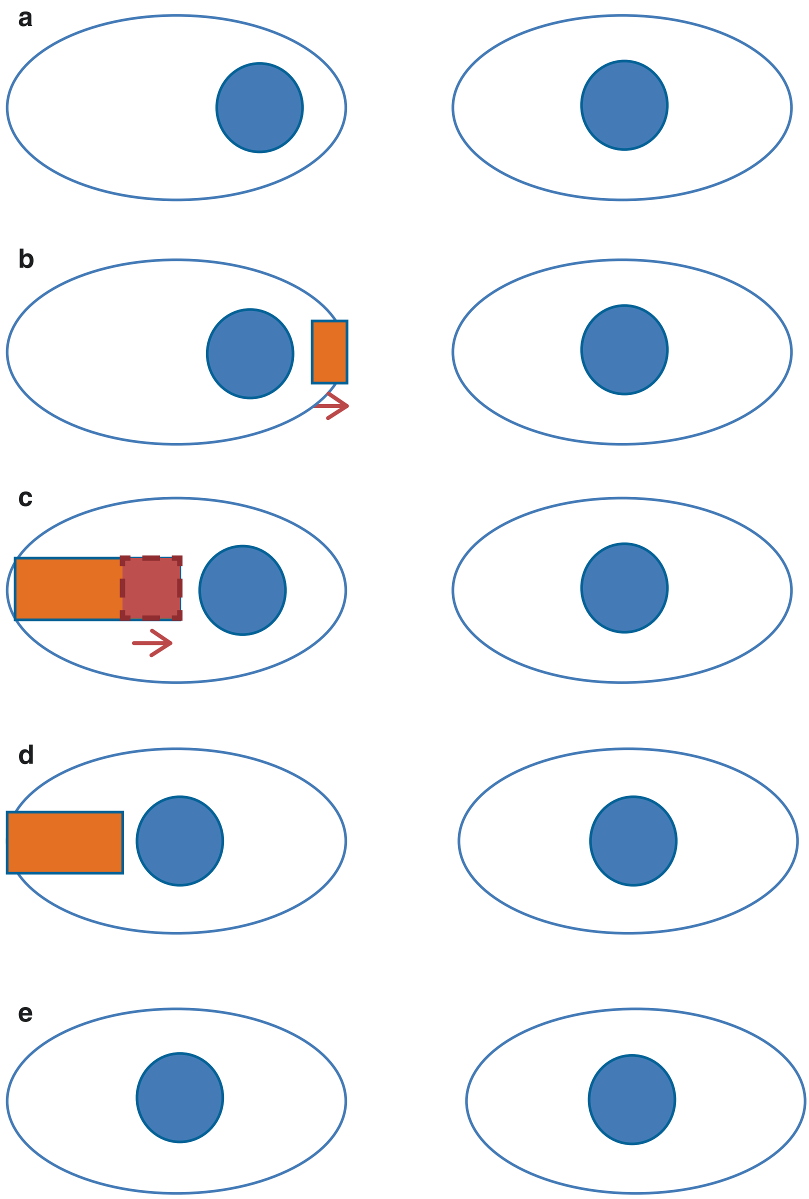

Fig. 14.6 Schematic depicting principles of correction of convergent squint. (**a**) Right convergent squint. (**b**) Recession of medical rectus (the medial rectus is identified and its insertion is moved further away from the limbus). (**c**) Resection of the lateral rectus (the muscle is shortened, strengthening it). (**d**) The new position of the muscles straightens the eye. (**e**) Position at the end of surgery

A temporary intervention involves injecting botulinum toxin into an overactive muscle (under local anaesthesia). The results of this procedure usually last for some months. This can be a useful intervention to simulate the results of surgery in a reversible way, or as an alternative to surgery in patients who are not fit for an operation.

Broadly speaking, strabismus surgery involves weakening overacting muscles and strengthening underacting muscles under general anaesthesia. For example, to correct a horizontal squint, the horizontal recti muscles would be operated on. A convergent squint can be corrected by weakening the muscle that adducts the eye (the medial rectus) by moving its insertion further away from the limbus ("recession"), and strengthening the muscle that abducts the eye (the lateral rectus) by removing some of the muscle ("resection") to shorten it. Surgical steps for such a procedure are shown in Fig. 14.6.

In adults, sutures can be tied in such a manner that they can be adjusted post-operatively once the patient has woken up from anaesthesia. This allows optimisation of the final result. The above operation describes the correction of a simple convergent horizontal squint. More complex squints require more sophisticated operative techniques on different muscles.

Intraoperative complications include bleeding, penetration of the globe, loss of the muscle and inadvertently operating on the wrong muscle. Post-operative complications include bleeding, infection, under or over-correction, discomfort, diplopia and need for further surgery.

Surgeons' Favourite Questions for Students

1. What causes cataract and how is it treated?
2. Which usually requires more urgent treatment: lower lid ectropion or entropion?
3. How are corneal penetrating injuries treated?
4. Describe features of a pterygium. How is it managed?
5. Describe the symptoms that could indicate a retinal detachment.
6. Describe the presentation and treatment of acute angle closure glaucoma.
7. What is the commonest operation for primary open angle glaucoma?
8. Name the extraocular muscles, their nerve supplies and primary actions.
9. How could a convergent squint be treated?

Tips for Placement

As with all placements, it is worth reading up prior to starting the placement. Ocular anatomy entails a host of new names not always taught during medical school anatomy sessions, so it is worth getting to grips with basic ocular anatomy early on (see section above). A more detailed, but very readable description of ocular anatomy is Clinical Anatomy of the Eye (Authors: Richard S. Snell and Michael A. Lemp).

Ophthalmology is unique in that it combines both medicine and surgery. It has its own dedicated specialist training programme, lasting 7 years. Aspiring ophthalmologists apply at Foundation Year 2 level to start specialist training after their second foundation year. As it is extremely competitive, it is worth demonstrating a commitment to the specialty, e.g. by completion of related research or audit projects. The Royal Society of Medicine has monthly ophthalmology evening meetings which are often attended by students and Foundation Year 2 doctors who are interested in ophthalmology. Training follows the ophthalmic specialist training (OST) curriculum (available at the website of the Royal College of Ophthalmologists, www.rcophth.ac.uk).

15 ENT Surgery

Deep P. Sarode, Carl R. Mulholland, Margaret Johnston, and Craig Murray

Introduction

Otorhinolaryngology, more commonly referred to as ENT (Ear, Nose and Throat), is concerned with the diagnosis and management of pathology associated with the ears, nose, throat or neck. ENT surgeons manage patients who suffer from difficulties with breathing, swallowing, speech, hearing or balance. They also act as physicians, treating patients medically in outpatient settings.

As with all surgery a detailed knowledge of the relevant anatomy is required. You should refer to a comprehensive textbook to gain a general understanding of ENT anatomy. In particular, a sound knowledge of the complex blood supply to the head and neck and its innervation is essential in understanding complications of procedures. This chapter will explain the key concepts of the most commonly performed ENT procedures.

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Core Operations: Ears

Myringotomy and Grommet Insertion

Myringotomy is the process by which an incision is made in the tympanic membrane. Grommets (also known as tympanostomy tubes or ventilation tubes) are tiny tubes designed to prevent closure of a myringotomy incision (Fig. 15.1). The aim of this procedure is to equalise the pressure within the middle ear by providing ventilation. Grommets generally remain in the tympanic membrane for around 1 year before falling out.

Indications

- Bilateral otitis media with effusion (OME) of longer than 3 months duration.
- Recurrent acute otitis media (AOM).
- Complications of AOM e.g. mastoiditis or facial nerve palsy.
- Meniere's disease: to facilitate repeated gentamicin injections.
- Prophylaxis: to reduce progression of a tympanic membrane retraction pocket and subsequent trapping of squamous cells (cholesteatoma).

Contraindications

- Vascular middle ear tumour (e.g. glomus tumour).

Investigations

- Otoscopy.

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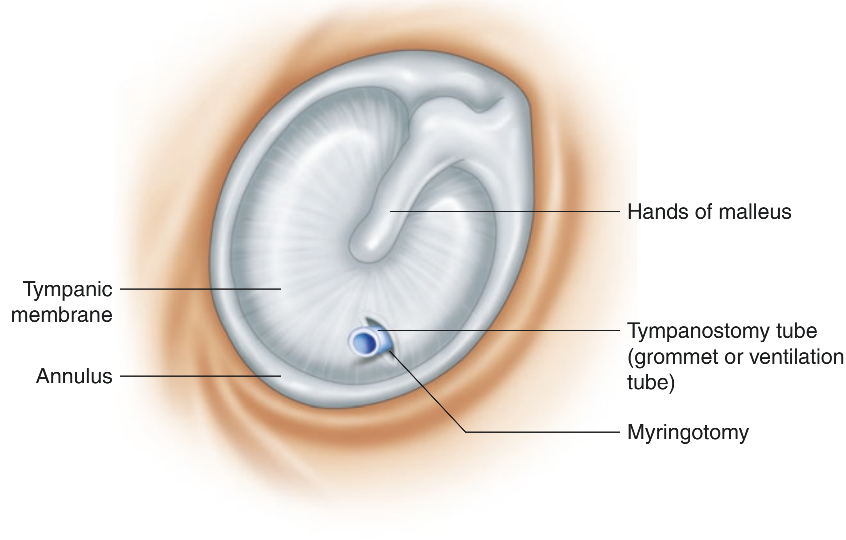
Fig. 15.1 Grommet



- Tympanometry (to confirm a diagnosis of OME).
- Audiometry.
- Flexible nasal endoscopy to visualise the nasopharynx.

Step-by-Step Summary: Grommet Insertion

1. The external auditory canal is visualised using an appropriately sized speculum.
2. Wax and debris are cleared from the canal to visualise the tympanic membrane.
3. The tympanic membrane is assessed to exclude secondary pathology, including attic defects or cholesteatoma.
4. The tympanic membrane is incised antero-inferiorly to avoid damage to the ossicular chain.
5. Excess fluid is aspirated to clear the middle ear.
6. Crocodile forceps are used to grip the grommet with the flange protrusion forwards.
7. The flange protrusion is placed through the tympanic membrane incision.
8. The grommet is gently pushed until it is stable and secure.
9. A single dose of topical antibiotic is given post-procedure.

Complications

- Infection.
- Bleeding.
- Residual tympanic membrane perforation following extrusion of the grommet.
- Tympanosclerosis (scarring of the tympanic membrane).
- Premature extrusion of the grommet.

Follow Up

- Check that the patient has not experienced excessive ear pain, otorrhoea, bleeding or fever like symptoms. These symptoms may indicate infection.
- Outpatient audiology follow up to re-test hearing.
- Ensure patency of the grommet at each follow-up appointment.

Tympanoplasty

A tympanoplasty is the reconstruction of the tympanic membrane. A graft, usually from the temporalis fascia, is taken and placed either medially (underlay) or laterally (overlay) to the tympanic membrane (Fig. 15.2). The aim of this procedure is to close off the middle ear in order to reduce infection rates. Closure may also benefit hearing in many cases. Tympanoplasty is a day case procedure.

Indications

Non-healing tympanic membrane perforation with one of the following:

- Hearing loss.
- Recurrent infections.
- Need for intact tympanic membrane (e.g. swimmers).

Contraindications

- Active infection of the ear (relative contraindication).

Investigations

- Otoscopy.
- Audiometry.

Step-by-Step Summary: Endaural Approach

There are three common surgical approaches to this procedure: endaural, postaural or transcanal. The endaural approach is particularly useful in that the attic can be easily visualized and is described below. The postaural approach may be used in anterior perforations.

1. Local anaesthetic is injected along the incision line.
2. Access to the ear canal is gained through an incision beginning at the 12 o'clock position and extending superiorly between the tragus and crus of the helix.
3. A temporalis fascia graft is harvested.
4. The edges of the tympanic membrane perforation are freshened to precipitate adhesion and healing of the graft.
5. The canal incision is completed posteriorly to create a flap which is mobilised to the level of the annulus (surrounding border of the tympanic membrane).
6. The annulus is elevated to enter the middle ear, freeing the tympanic membrane superiorly and inferiorly.
7. The chorda tympani is identified and traced to the neck of the malleus.

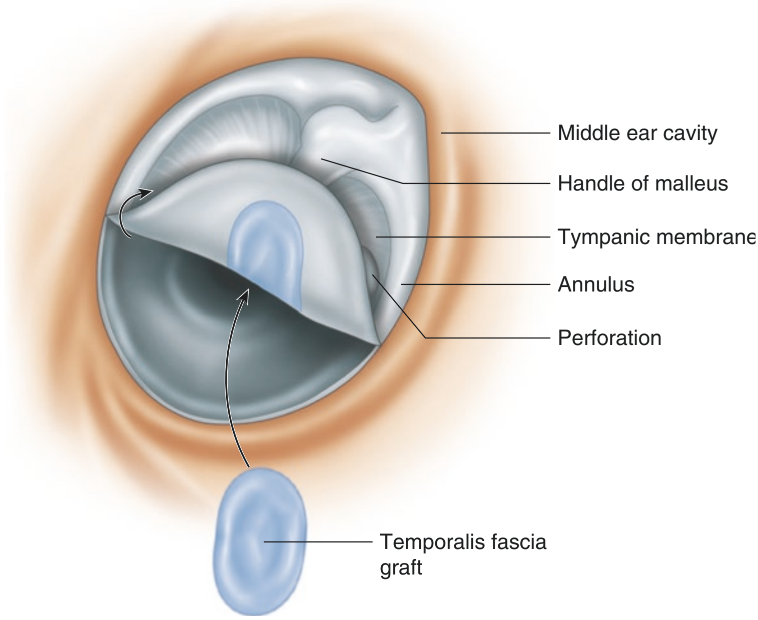


Fig. 15.2 Tympanoplasty

8. The ossicular chain is inspected for integrity and mobility to assess the need for ossiculoplasty.
9. The graft is inserted into the middle ear, under the tympanic membrane, to close the perforation.
10. Spongistan (a dissolvable material) is placed medial to the graft to aid adhesion to the perforation edge.
11. The flaps are replaced and closure of the perforation is assessed, particularly anteriorly.
12. Spongistan and a wick are placed in the ear canal.

Complications

- Failure to close the perforation or recurrence of the perforation.
- Tympanic membrane retraction.
- Bleeding.
- Infection.
- Tinnitus.
- Inner ear damage: can lead to vertigo or rarely sensorineural hearing loss.
- Taste disturbance secondary to chorda tympani damage.

Follow Up

- Follow-up appointment at 6 weeks and 6 months to make sure the perforation has healed and to check for formation of cholesteatoma (an abnormal collection of keritanised cells in the middle ear).

Core Operations: Nose

Septoplasty

The nasal septum separates the 2 nasal cavities. Patients can develop a deviated septum either as a developmental abnormality or as a result of trauma. Septoplasty involves the correction of any deviation to restore appropriate anatomy and relieve upper airway tract obstruction (Fig. 15.3).

Indications

- Nasal obstruction due to deviated nasal septum.
- Harvesting cartilage for use in rhinoplasty.
- Surgical access (e.g transseptal-transsphenoidal approach for resection of pituitary tumour).

Contraindications

- Large septal perforation.
- Active infection in nose.
- Coagulopathy.

Investigations

- Anterior rhinoscopy using a speculum.
- Nasal endoscopy.

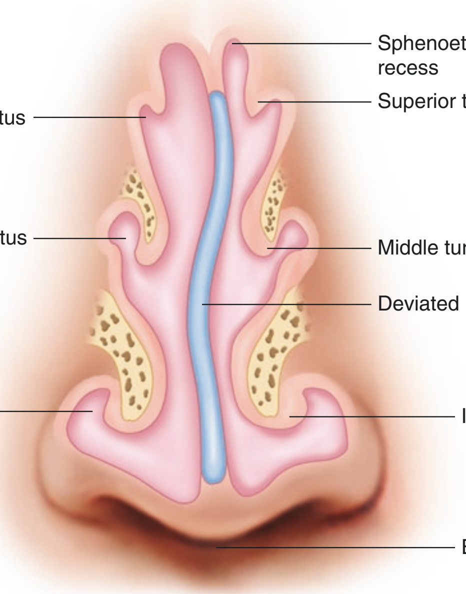
Step-by-Step Summary: Septoplasty

1. The nose is first decongested.
2. Local anaesthetic with adrenaline is injected into the septal tissues.
3. An anterior incision along the columella (external end of the nasal septum) is performed.
4. The subperichondrial and subsequently the subperiosteal planes are carefully entered anteriorly.
5. These flaps are elevated posteriorly to separate them from the septal cartilage and bone.
6. The septal cartilage is separated from bone and any obstructive or deviated bone is removed.
7. The cartilage is trimmed to fit and permit mobilisation to a more central position, avoiding reduction of the anterior height.
8. The cartilage is sutured into the new columella pocket and the flaps are sutured back together to prevent septal haematoma.

Complications

- Bleeding/septal haematoma.
- Crusting.
- Perforated septum.
- Infection.
- Damage to dental branches of the maxillary nerve: numbness of upper lip, incisors and tip of nose.
- Supratip deformity.

Fig. 15.3 Septoplasty



Follow Up

- In the rare event that packing is used, it should be removed in the first couple of days post-operatively. Prophylactic antibiotics are required if it remains in situ for longer than 24 h.
- Patients should return for the removal of a splint, if used, 7–10 days post-operatively.
- Patients are followed up at around 6 weeks to identify complications, in particular septal perforation.

Functional Endoscopic Sinus Surgery (FESS)

Functional endoscopic sinus surgery (FESS) is a minimally invasive procedure to remedy pathologies of the nasal cavity and sinuses in order to restore functional drainage of the passageways within the nose. Endoscopic surgery is aimed at the removal of bony or soft tissue obstruction of the normal drainage pathway, with minimal damage or removal of excessive tissue (Fig. 15.4). It leaves no external scars and the recovery time is short and is therefore used as an alternative to open procedures. However, open procedures do provide the advantage that they provide direct visualization of the pathology.

Indications

- Chronic sinusitis.
- Nasal polyps.
- Severe epistaxis.
- Sinonasal tumours.

Contraindications

Depending on the clinical details of each patient, it may be preferable to use an open approach instead of FESS. This is most likely when there are intraorbital complications from sinusitis.

Investigations

- CT scan.

Step-by-Step Summary: Functional Endoscopic Sinus Surgery

1. The nose is first decongested.
2. A 0° rigid endoscope is used to enter the nasal cavity.

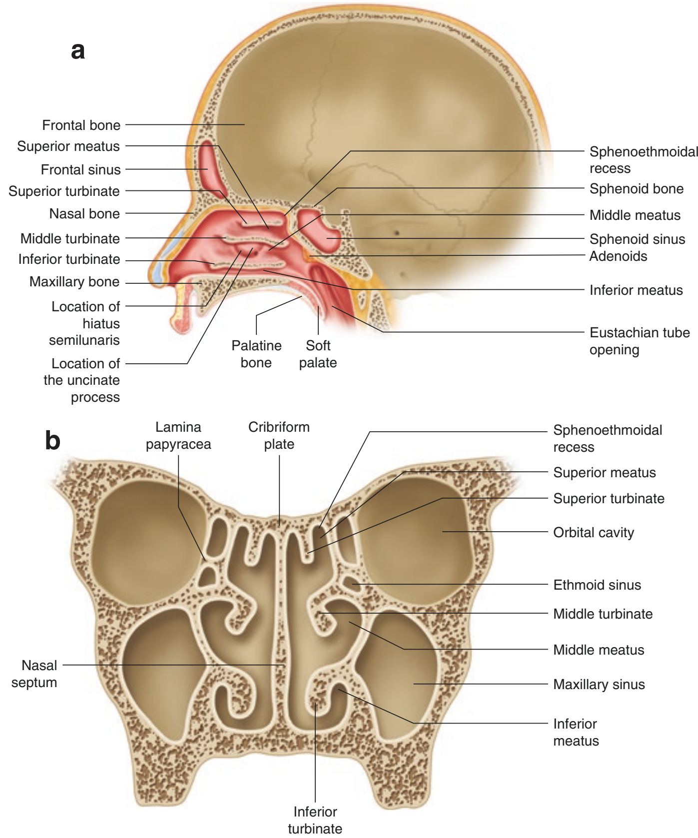


Fig. 15.4 Functional endoscopic sinus surgery (FESS) (**a**) Sagittal plane and (**b**) Coronal plane

3. Local anaesthetic with adrenaline is injected into the uncinate process (part of the ethmoid bone which lies in front of the opening of the maxillary sinus) and bulla ethmoidalis (the anterior ethmoidal air cells).
4. The uncinate process is removed with a Freer elevator or a sickle knife and forceps to allow access to the hiatus semilunaris, which marks the opening of the maxillary sinus.
5. The opening of the maxillary sinus is identified and enlarged to permit clearance of maxillary disease and to further identify orbital cavity boundaries.
6. Next, the bulla ethmoidalis is opened to expose and clear disease in the anterior ethmoid air cells.
7. If access to the posterior ethmoidal air cells is required, the basal lamella of the middle turbinate is opened inferomedially to avoid entering the orbital cavity.
8. Further bone/cell removal may be necessary to expose the openings of the frontal or sphenoid sinuses, the need for which is dependent upon the case and pathology.

Complications

- Haemorrhage.
- Orbital cavity breach: breach of the lamina papyracea (orbital plate of the ethmoid bone), which forms part of the medial orbital compartment, can result in displacement of the fat behind the eye into the nasal cavity or entrapment of the intraocular muscles, particularly the medial rectus.
- Damage of arteries or veins associated with the lamina papyracea can lead to

intraorbital haemorrhage. In particular, severance of the anterior ethmoidal artery results in the artery retracting into the orbital cavity while it continues to bleed. This is an emergency situation and can lead to loss of vision.
- CSF leak: there is a possibility of a cranial cavity breach, leading to cerebrospinal fluid (CSF) leakage. If the CSF leak is identified during the operation, a tissue graft and tissue glue can be used to patch the breach. The breach may not be noticed until post-operatively where the patient complains of a clear, watery discharge through the nose (CSF rhinorrhoea). Beta-2 transferrin levels in the nasal discharge are used to confirm it is CSF.

Follow Up
- To prevent crusting of the nasal mucosa, douching is performed using saline.
- Post-operative steroids or antibiotics may be given.

Core Operations: Throat

Tonsillectomy

The palatine tonsils (Fig. 15.5) are 1 of 3 sets of tonsils that make up Waldeyer's ring, the others being the adenoids and the lingual tonsils. Tonsillectomy mainly involves removal of the palatine tonsils and in children it is often combined with adenoidectomy. Various methods for tonsillectomy are available and the chosen method depends on surgeon preference, procedural outcomes and regional guidelines. Methods include: cold steel, electrocautery (diathermy or coblation), ultrasonic scalpel and laser.

Indications
- Recurrent episodes of acute tonsillitis which fulfil the SIGN criteria.
- Recurrent peritonsillar abscesses (quinsy).
- Enlargement of the tonsils causing obstructive sleep apnoea.
- Suspected tonsillar malignancy, particularly if tonsillar enlargement is unilateral.

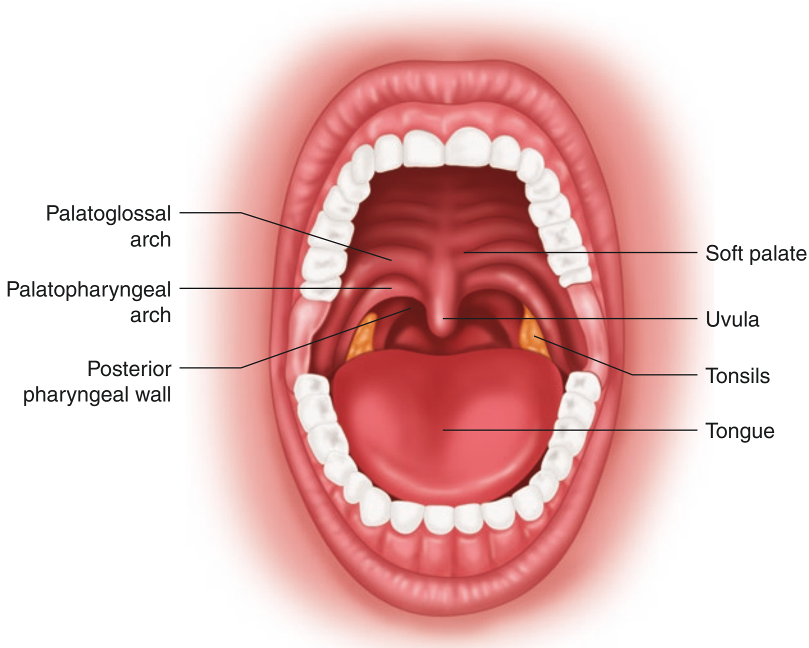


Fig. 15.5 Tonsillectomy

> The following are the SIGN recommendations for tonsillectomy when there is a history of recurrent, acute, sore throat in both children and adults:
>
> - Sore throats are due to acute tonsillitis.
> - The episodes of sore throat are disabling and prevent normal functioning.
> - 7 or more well documented, clinically significant, adequately treated sore throats in the preceding year.
> - 5 or more such episodes in each of the preceding 2 years.
> - 3 or more such episodes in each of the preceding 3 years.

Contraindications
- Current acute tonsillitis or upper respiratory tract infection: it is recommended to wait until this resolves.
- Coagulopathy.
- Cleft palate.

Investigations
- FBC.
- Coagulation screen.

Step-by-Step Summary: Tonsillectomy
1. The patient is positioned with the head extended and a shoulder roll in place.
2. A Boyle-Davis gag is inserted to open the mouth and control the position of the tongue and endotracheal tube.
3. The tonsil is gripped and pulled medially.
4. Dissection of the tonsil is started at the upper pole, at the level of the capsule, avoiding damage to the constrictor muscles when dissecting inferiorly.
5. The lower pole is either tied or snared.
6. Haemostasis is achieved with bipolar diathermy or ties.

Complications
- Primary haemorrhage (up to 24 h).
- Secondary haemorrhage (up to 3 weeks).
- Infection.
- Tooth or lip damage due to Boyle-Davis gag.
- Nasal regurgitation.

Follow-Up
- No routine follow-up is required. Patients who have post-operative bleeding are admitted for observation and/or surgical intervention.
- Patients should be given adequate analgesia and advised that their pain may increase in the week following the operation.
- If there is post-operative nausea and vomiting, antiemetics should be administered. In children, a single intraoperative dose of dexamethasone should be given instead.

Thyroidectomy

The most key aspect of a thyroidectomy is familiarity with the surrounding anatomy, notably the course of the recurrent laryngeal nerve (Fig. 15.6).

Indications
- Significant goitre with either symptoms due to local compression or for aesthetic reasons. These patients may be hypothyroid or hyperthyroid.
- Hyperthyroidism which is not adequately controlled by medication or would benefit from surgical treatment.
- Suspected thyroid malignancy.

Contraindications
Thyroidectomy should be delayed in patients with uncontrolled severe hyperthyroidism until thyroid hormone levels are stable to avoid causing an iatrogenic thyroid storm.

Investigations
- Thyroid function tests.
- Serum calcium.
- Parathyroid hormone levels.

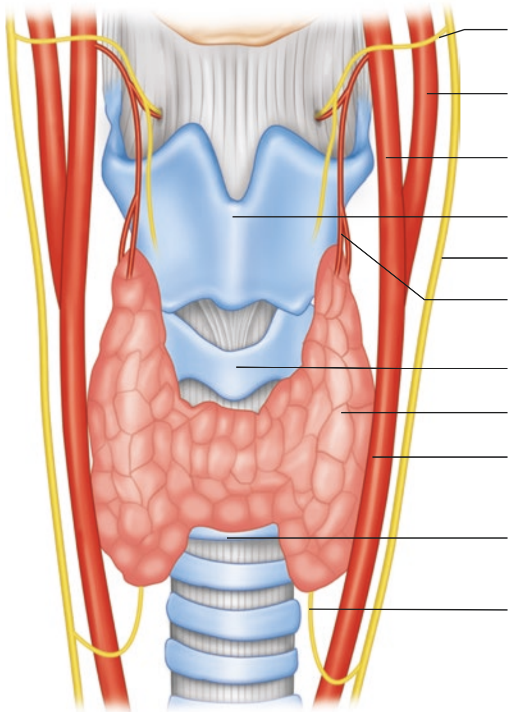


Fig. 15.6 Thyroidectomy

Radio-isotope tracer scanning is sensitive to detect thyroid cancers. USS should be performed on any patient with an enlarged thyroid on examination to determine whether thyroid nodules are present. If so, a fine needle aspiration (FNA), ideally under ultrasonic guidance, can be used to histologically assess thyroid tissue using the Thy classification. Additionally, a MRI/CT scan can be performed to assess the degree of spread. Staging is reported using the TNM classification.

Step-by-Step Summary: Thyroidectomy

1. Often a laryngeal tube with sensors for recurrent laryngeal nerve stimulation is used.
2. An incision is made in a horizontal skin crease.
3. The platysma muscle is divided and the strap muscles are separated in the midline.
4. The thyroid gland is identified.
5. The superior pole is first dissected following ligation of the superior vascular bundle near the gland to protect the superior laryngeal nerve.
6. Following ligation of the middle thyroid vein, the thyroid gland is further mobilised.
7. Dissection of the thyroid gland is continued at the inferior pole.
8. The recurrent laryngeal nerve is identified and the inferior thyroid vessels are ligated with the nerve in direct vision.
9. The dissected thyroid lobe is removed.
10. Closure is performed in 2 layers.

Complications

- Parathyroid dysfunction or inadvertent removal: leading to hypocalcaemia.
- Recurrent laryngeal nerve damage: the patient will complain of hoarseness or stridor

(bilateral damage). Temporary damage due to handling of the nerve may resolve over time. Nerve monitoring during the operation can test the nerve's integrity.
- Superior laryngeal nerve damage: susceptible to injury in this operation when tying the superior pole of the thyroid. This results in impairment of vocal cord extension and therefore difficulty in reaching high vocal pitches. In most cases, this is usually only a problem for professional voice users especially singers.

Follow Up

- Serum calcium and PTH levels are monitored post-operatively and calcium supplements ± vitamin D given if required.
- In patients who complain of changes of voice, the function of the laryngeal muscles can be assessed via laryngoscopy.
- Thyroglobulin levels are measured in thyroid cancer patients who undergo total thyroidectomy to determine whether there is any residual thyroid tissue. Radio-iodine (I-131) can be administered to destroy residual tissue. Thyroglobulin levels are monitored to detect recurrent disease. Post-operative patients are also prescribed levothyroxine or tri-iodothyronine to suppress TSH levels.

Tracheostomy

When the integrity of the upper respiratory tract is compromised, insertion of a tracheostomy tube into the trachea may be required for ventilation (Fig. 15.7). It can be carried out as an elective procedure or used in an emergency setting when immediate ventilation is required because of airway compromise.

Indications

- Obstruction:
  - Head and neck malignancy.
  - Foreign body obstruction.
  - Inflammation (e.g. epiglottitis).
  - Bilateral vocal cord paralysis (e.g. following thyroid surgery).
- Ventilatory failure:
  - Long term ventilator support.
  - Neuromuscular disease (e.g. myasthenia gravis).
- Drainage of excessive secretions from lower respiratory tract.

Contraindications

- The presence of severe anatomical deformity of the neck (e.g. short neck, unable to extend).
- Severe goitre.
- Coagulopathy.

Investigations

- FBC.
- Clotting screen.

Step-by-Step Summary: Tracheostomy

1. The patient is positioned with the head extended and a shoulder roll in place.
2. A horizontal incision is made midway between the cricoid cartilage and the sternal notch.
3. The midline plane is developed by separating the strap muscles vertically.
4. The thyroid isthmus is either displaced or, preferably, divided.
5. The rings of the trachea are identified.
6. The 2nd or 3rd tracheal ring is identified and cleaned.
7. The anaesthetist then prepares to withdraw the endotracheal tube.
8. An appropriate tracheostomy tube is chosen and the cuff is tested.
9. Only then is 2nd or 3rd tracheal ring partially excised anteriorly.
10. The endotracheal tube is withdrawn and the tracheostomy is tube inserted and attached to the anaesthetic machine to confirm a CO_2 trace.
11. To avoid subcutaneous emphysema, the wound is closed loosely.
12. The tracheostomy tube is secured with sutures in addition to tape.

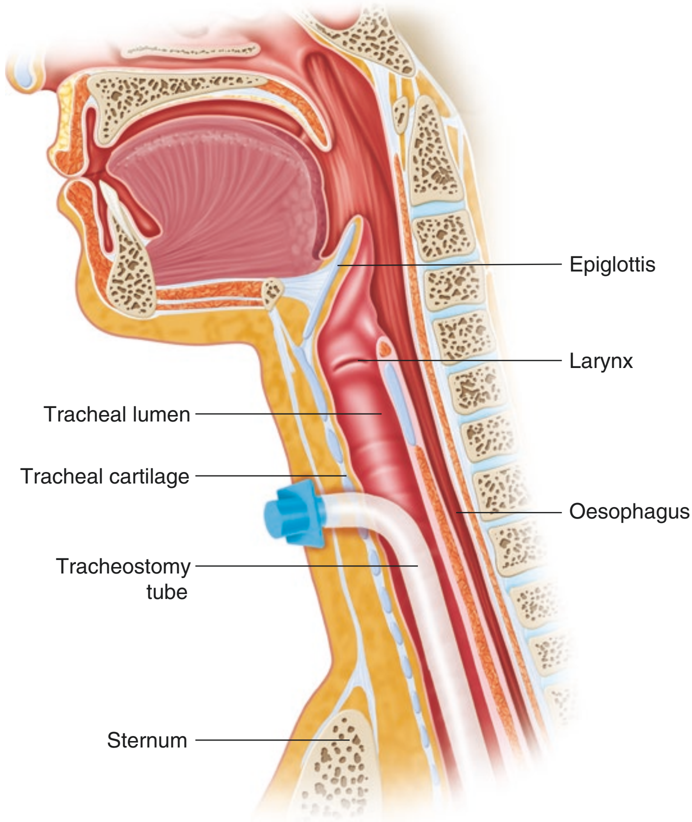


Fig. 15.7 Tracheostomy

Complications

Procedure-Related

- Bleeding
- Surgical/subcutaneous emphysema
- Recurrent laryngeal nerve damage
- Pneumothorax
- Infection
- Hypoxia

Tube-Related

- Tracheostomy tube displacement
- Tube blockage
- Tracheal stenosis: excessive pressure from the cuff of the tube can cause pressure necrosis on the adjacent cartilage leading to fibrosis and narrowing
- Tracheoesophageal fistula formation

Follow Up

- Controlling cuff pressure is important.
- Patients must be taught to perform suctioning independently.
- Removal of the tracheostomy tube should be performed in a hospital setting. Before removal of the tube mechanically block the tracheostomy tube and assess breathing independent of the tube. Once the tube has been removed, allow the stoma to close spontaneously.

Student Tips for Placement

Before beginning your ENT block, you should try to get a grasp of the commonest conditions and their presentations. At most universities, the ENT block comprises of only a few weeks of clinical teaching and so to get the most out of the block it is important to do some background reading before attending teaching sessions. As with all surgical specialties, a comprehensive knowledge of the relevant clinical anatomy is essential. After learning the basic anatomy, experience in theatre is crucial to understand the practical relevance of anatomy, such as the close proximity of cranial nerves at different stages of a dissection.

Make sure to attend all aspects of the specialty to attain a well-rounded view of it. It is especially important to attend ward rounds, in conjunction with outpatient clinics. This gives you the opportunity to see emergency patients and allows you to look in patient notes to clarify what you do and don't know. On call registrar shadowing also provides insight into emergency situations that arise in ENT. Prior to attending surgery, have a look at the theatre lists to see which operations are scheduled. Reading up on the details of the operations, revising relevant clinical anatomy and examining patient notes will help to provide a well-rounded experience in theatre.

Careers

ENT surgery encompasses the management of 3 different anatomical areas, each associated with its own pathologies. In addition, sub-specialties include: otology, rhinology, laryngology, head and neck surgery, facial plastics and paediatrics. As well as necessitating a vast depth of knowledge, this breadth also results in a diverse mix of patients. Furthermore, ENT doctors act both as physicians and surgeons. ENT-related presentations are also some of the most common presentations in general practice.

ENT surgery is a highly evolving field with many branches coupled with technological innovations. For example, the use of lasers in ENT has become a mainstay in laryngeal surgery and has largely improved post-operative outcomes. Cochlear implants and even auditory brain stem implants have also had success in the treatment of deafness. Furthermore, stem cell therapies, such as a tracheal transplant grown from autologous stem cells, have scope in this field.

This specialty affords a good balance between a workload that is not too hard pressed but which also encompasses sudden life-threatening emergencies. This allows a more flexible lifestyle as compared to some other surgical specialties but also includes the challenging aspect of working in high-pressure situations.

16 Oral & Maxillofacial Surgery

Rizwan Mahmood

Introduction

Oral & Maxillofacial Surgery (OMFS) is a unique surgical speciality which emerged from the World Wars through treatment of the facial injuries encountered by service personnel. These injuries necessitated adequate repositioning of the teeth by dental surgeons to re-establish normal form and function of the facial bones. As the speciality evolved and the spectrum of surgery broadened, medical training (as a second degree) became mandatory. Modern day OMFS focuses on eradicating infective, benign and malignant diseases of the head and neck, and restoring normal form and function of the dentition and facial bones following trauma or deformity. It requires a wide skill base, which harnesses aspects from a number of different surgical specialities in order to treat disease.

This chapter will focus on some basic anatomy and core operations that you are likely to see, along with some tips to ensure that you make the most out of your rotation.

Core Knowledge

The intricate anatomy of the head and neck is beyond the scope of this book, but the diagrams included encompass the basics in order to better understand the nature of the surgery involved (Fig. 16.1).

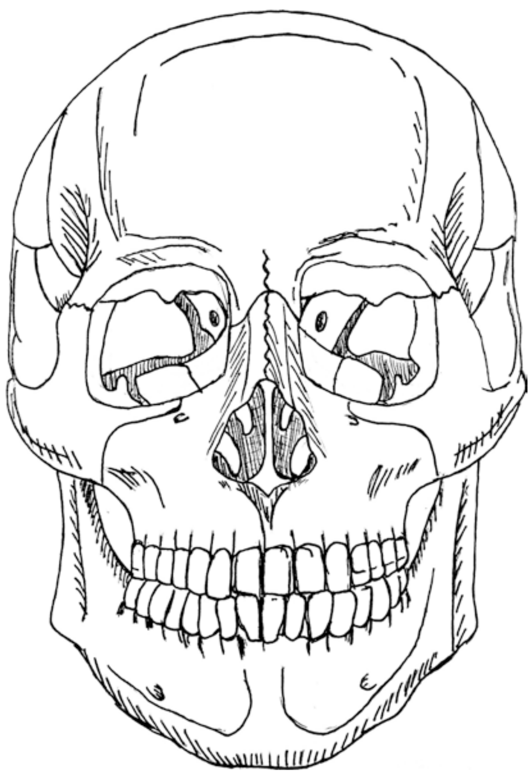


Fig. 16.1 Image of skull – frontal view

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The Le Fort Classification

One of the main classifications utilised to describe maxillofacial trauma is the Le Fort Classification. This was devised by a French surgeon who struck cadavers with a cannon ball to observe any reproducible fracture patterns and eventually describing three fracture patterns (Fig. 16.2).

Le Fort I

This is a horizontal maxillary fracture resulting in the tooth-bearing maxilla being detached from the midfacial skeleton. The fracture line passes above the teeth, but below the zygomatic processes.

Le Fort II

This is a pyramid-shaped fracture with the nasofrontal sutures at the apex and maxilla forming the base. The fracture extends through the posterior tooth-bearing segment of the maxilla, nasal bones and orbital floors.

Le Fort III

Also known as craniofacial disjunction, the fracture results in separating the middle third of the face from the cranial vault. The fracture lines extend more laterally than Le Fort II through the nasal bones, zygomaticofrontal sutures (ZF), maxilla & orbital floors.

Core Operations

There are five main sub divisions in OMFS

1. Dentoalveolar
2. Trauma
3. Deformity
4. Oncology
5. Salivary Gland

Dentoalveolar

Dentoalveolar surgery is taught and practised at dental school and often involves removal of teeth which are decayed, actively infected or impacted.

Investigations

- Intraoral radiographs
- Dental panoramic pantomogram (DPT)
- Cone beam computed tomography (CBCT)
  - CT has allowed for improved 3D visualisation of teeth and associated structures

Dental Extractions

- Indicated when a tooth is deemed unsalvageable/decayed
- If these teeth are left, they can become susceptible to infection.
- If the infection persists, it can potentially compromise the airway depending on the tissue spaces the infection is draining into (see Table 16.1 below). This usually depends on the teeth.
- In a fluctuant infection, incision and drainage (I+D) may be required to drain the pus.
- However, patients with associated sepsis and trismus (limited mouth opening) will often require a GA for the extraction, I+D of the infected tissue space and several doses of IV antibiotics.
- The attachment of the mylohyoid muscle is important, as it can dictate the course of the infection.
- Submandibular infection normally originates from posterior teeth, as the roots of the teeth lie below the mylohyoid muscle.

Signs/Symptoms

- Pain originating from region of the tooth in question
- Sepsis
- Trismus
- Difficulty swallowing
- Drooling

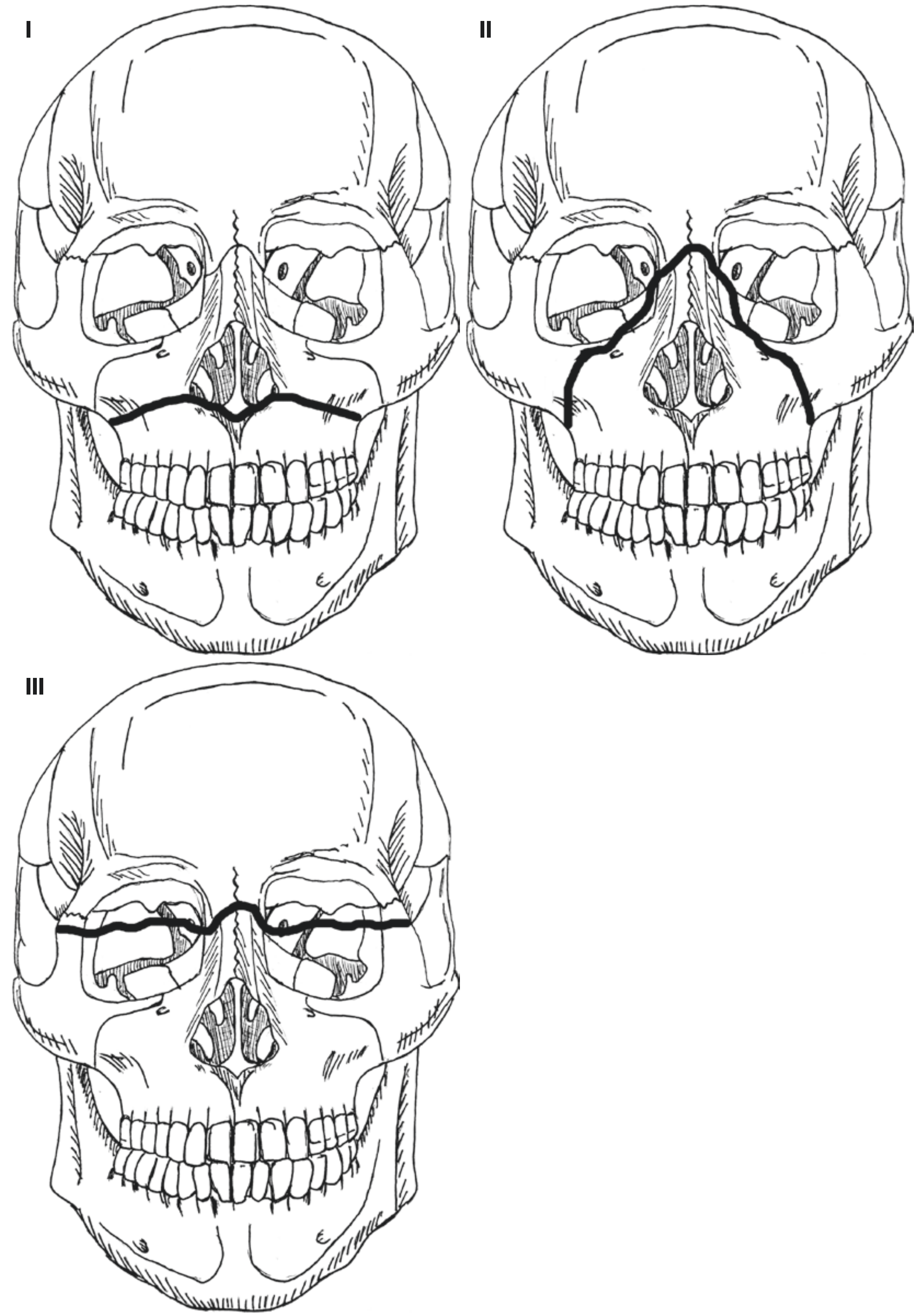

Fig. 16.2 Le Fort divisions I, II, and III

Table 16.1 Sites of swelling and the location of teeth that might be the underlying cause

Swelling	Tooth in question
Submandibular	Lower posterior
Submental	Lower anterior
Periorbital	Upper anterior
Intraoral	Adjacent tooth

- Sublingual firmness
- Altered voice
- Facial swelling

Step-by-Step Summary: Dental Extractions

1. Inject local anaesthesia
    a. Infiltration of gums around tooth
    b. Regional block
        i. Inferior dental (ID) nerve
        ii. Infraorbital nerve
2. Raising of gum flap, and bone removal
3. Use of surgical instruments to loosen and deliver tooth
4. Incision into swelling/abscess
5. Placement of drain (usually corrugated)
6. Ensure adequate haemostasis

Complications

See Table 16.2

General complications include:

- Pain
- Swelling
- Bleeding
- Infection
- Retained roots
- Damage to adjacent teeth
- Further surgery
- Weakness of lower lip
    – An extraoral submandibular incision can result in damage to the marginal mandibular branch of the facial nerve.
- Scarring
    – This can be problematic if the incision is extraoral.

Table 16.2 Potential complications of tooth extraction

Tooth	Complication	Result
Upper molars	Oroantral communication	Communication between maxillary sinus and oral cavity
Lower premolars	Mental nerve paraesthesia	Numbness of lower lip
Lower wisdoms	ID nerve paraesthesia	Numbness of lower lip, tongue, gums

Trauma

Traumatic injury to the face can result in a variety of consequences depending on the severity of the injury.

- Dental
- Mandible
- Zygomatic complex
- Orbit

Dental Trauma

Patients can present in a variety of ways to Accident and Emergency, but in essence it is better managed in dental practice.

Investigations

- DPT – to estimate damage to the teeth
- Chest X ray – to ensure that any unaccounted teeth have not been inhaled into the lungs

Signs/Symptoms

- Pain
- Bleeding
- Missing teeth
- Deranged occlusion
- Chipped teeth
- Avulsion (complete loss of tooth)

Step-by-Step Summary: Dental Trauma

1. Ensure any avulsed teeth are stored in milk/normal saline
2. Obtain good local anaesthesia

3. Attempt to manipulate the teeth/bone back to normality and check the occlusion
4. Make sure the correct teeth are in the correct socket!
5. Splint the teeth using orthodontic wire and dental composite (dental adhesive material)
6. Ensure the patient attends their dentist for follow-up care

Mandibular Trauma

- Mandibular trauma is common, and the complexity of its management can vary
- Teeth are fundamental to the success of treatment: they are used as a guide to achieve adequate reduction of the fractured mandible
- Treatment requires general anaesthetic

The following anatomical classification is useful to be able to communicate the type of fracture:

- **Condyle**
  - Part of the mandible, anchoring the mandible to the skull within a fibromuscular sling
- **Angle**
  - Distal to the last standing molar
- **Body**
  - Tooth-bearing segment from the distal molar to the canine teeth
- **Parasymphysis**
  - Tooth-bearing segment between the lower canine teeth (Fig. 16.3)

Investigations

Ensure two views are taken

- DPT
- X-Ray Mandible

Signs/Symptoms

- Pain/trismus
- Malocclusion

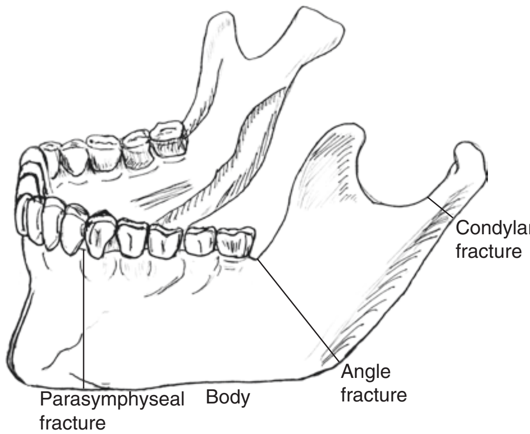

Fig. 16.3 Image of mandible and fracture areas

- Numbness of lower lip/chin
  - Paraesthesia of ID nerve or its mental nerve branch
- Gingival laceration/bleeding
- Sublingual bruising/haematoma
  - Pathognomonic of a mandible fracture

Step-by-Step Summary: Mandibular Fractures

Open Reduction Internal Fixation (ORIF)

1. Inject local anaesthesia
   a. Infiltration of the gums around tooth
   b. Regional block
      i. ID nerve
2. Expose the fracture site(s) with intraoral incisions, conscious of important adjacent structures
3. Irrigate and debride the fracture site
4. Reduce the fracture anatomically
5. Ensure normal occlusion has been achieved
6. Place titanium mini-plates and screws to fix the mandible in position
7. Close the wounds with resorbable sutures

Certain fractures may need to be accessed by an extraoral approach. These include:

- Condyle fractures
- Edentulous fractures
- Comminuted fractures

Closed Reduction

- For certain fractures, metallic bars and wires can be applied to the upper and lower teeth.
- Arch bars allow placement of wires or elastic bands to bring teeth into the correct position and restore normal occlusion.

Complications

- Infection of the miniplates
- Numbness of lower lip, chin, gingiva
  - Certain fractures in close proximity to the ID nerve and its branch (mental nerve) can be bruised and/or even damaged during the ORIF procedure.
- Damage/loss of teeth
  - If teeth in the fracture line are broken, loose or deemed of poor prognosis, they may be removed during the procedure
- Further Surgery
  - If normal occlusion has not been achieved, further surgery may be required to correct the abnormality.

Zygomatic Complex

The classic fracture pattern is known as a "tripod fracture" which results in disruption of:

- ZF suture
- Zygomatic arch
- Infraorbital rim

Classification

Clinicians will vary in their choice of classification, but a common system is the Henderson classification:

i. Undisplaced fracture
ii. Zygomatic arch only
iii. Tripod fracture & undistracted ZF suture
iv. Tripod fracture & distracted ZF suture
v. Blowout fracture of orbit
vi. Fracture of orbital rim only
vii. Comminuted fracture or other than above

Investigations

Ensure two views are taken

- X-ray facial bones
  - First line investigation for midface trauma
  - Occipitomental 10° & 30° (OM 10° & 30°)
- CT scan
  - Patients with significant head trauma usually have head and C-spine CT, which can provide more accurate 3D imaging of the facial bones

Signs/Symptoms

- Pain
- Facial deformity
- "Bony Step" deformity
- Subconjunctival haemorrhage
- Trismus
- Infraorbital nerve paraesthesia
- Epistaxis
- Eye signs (see section "orbit")
- Periorbital haematoma

Treatment

Treatment can be complex, and is normally dictated by the nature and site of the fractures. This will influence the surgical approach, which usually requires a combination of incisions. Upon adequate access to the fractures, the bones can be reduced anatomically and held in position by miniplates to restore normal form function.

Open Reduction Internal Fixation

See Table 16.3

Closed Reduction: Gillies Approach

- Allows closed reduction of zygomatic arch fractures
- Involves an incision 2 cm anterior and superior to the pinna of the ear in the temporal region
- This allows access to insert a Rowe's elevator to lift out the fractured zygomatic arch which remains stable despite no miniplate fixation.

Table 16.3 Common incisions and the regions they are used to access

Incision	Bony Access
Supraorbital	ZF suture
Transconjunctival	Infraorbital rim/orbital floor
Buccal Sulcus	Zygomatic buttress
Coronal Flap	Upper and middle facial skeleton down to zygomatic arch

Postoperative eye observations are required due to the risk of retrobulbar haemorrhage.

This is a sight-threatening condition, which results from a bleed behind the eye causing compressive ischaemia of the optic nerve. The risk of irreversible blindness, however, is small at 0.3 %.

This is a medical emergency, and will require immediate lateral cantholysis. To relieve the pressure, superior and inferior lateral canthal ligaments must be cut.

Eye Observations

- Every 15 min for the first 2 hours
- Every 30 min for the next 2 hours
- Hourly overnight

Complications

- Retrobulbar haemorrhage/blindness
- Diplopia
- Facial asymmetry
- Facial nerve injury – temporal branch
- Chronic sinusitis
- Pain, swelling, bleeding, bruising, scarring

Orbit

- Orbital trauma can result in an isolated "blow out" fracture of the orbital floor
- But it can also occur with a zygomatic complex fracture
- The orbital floor is very thin which serves to protect the globe.
- During traumatic injury, the thin orbital floor gives way as the intraorbital pressure increases, preventing the globe from being crushed within the bony eye socket.
- Trapping of the inferior rectus muscle can result in restricted eye movement, and in children, should be treated as an emergency.

Orbital trauma can result in:

- Diplopia: double vision
- Enophthalmos: displacement of the globe posteriorly
- Hypoglobus: displacement of the globe inferiorly
- Subconjunctival haemorrhage: bleeding beneath the conjunctiva

Treatment

Some of the more common approaches to access the orbital floor include:

- Transconjunctival
  - Through the conjunctival layers
- Transcutaneous
  - Through the skin of the eyelid

As with zygomatic fractures, post-operative eye observations are mandatory.

Complications

- Retrobulbar haemorrhage/blindness
- Enophthalmos
- Hypoglobus
- Diplopia
- Scarring

Deformity

Facial deformity can present in a number of ways. This can be from birth in the form of cleft lip and palate (CLP), or it can develop through a maturing facial skeleton. It can also come about following traumatic injury, or as part of a syndrome.

Orthognathic Surgery

This is an elective joint surgical-orthodontic procedure which involves creating precise bony cuts into the maxilla and mandible to create fractures at certain points to enable repositioning of the upper and lower jaws into what is deemed to be a more aesthetically and functionally acceptable position. Orthodontic braces are worn for up to 18 months prior to the surgery to position the teeth in preparation for the new position of the jaws.

Plaster study models fabricated by maxillofacial lab technicians are utilised to provide a three-dimensional model of what the position of the teeth should be pre- and post-op. In addition, an acrylic wafer is also used to act as a guide to ensure that the teeth are in the correction position in relation to the jaws.

Complications include numbness of upper lip, lower lip, chin and tongue which may occur as a result of damage to infraorbital and inferior dental nerves.

Cleft Surgery

Cleft lip and palate deformities develop in-utero. Prevalence is 1:700 in the UK, with a number of dedicated specialist cleft centres scattered across the country.

The surgery requires a number of surgical procedures throughout childhood, including soft tissue repair of the lip, iliac crest bone grafting, orthognathic surgery and rhinoplasty.

Oncology

Oncological surgery and reconstruction is complex and beyond the scope of this chapter. However, the surgery involves removing cancerous tissue with adequate margins. Such resection can be extensive, and may require soft and hard tissue reconstruction in order to optimise adequate form, function and appearance. This normally takes place in the form of a vascularised free tissue flap.

The most common surgical procedures include:

- Hemimandibulectomy: partial resection of mandible
- Hemiglossectomy: resection of tongue
- Hemimaxillectomy: resection of maxilla

It is usually combined with a neck dissection, which involves removal of lymph nodes in the neck in order to prevent or remove metastatic spread.

Common reconstructive free flaps:

- Radial forearm
- Fibula
- Anterolateral thigh
- Iliac crest
- Scapula

Salivary Gland Surgery

There are 3-paired sets of salivary glands, all of which can present with differing pathology.

- Neoplastic disease: Benign/malignant disease
- Infectious disease: Bacterial/viral
- Obstructive disease: Salivary duct stone
- Other: developmental, inflammatory, autoimmune

Parotid

The parotid gland is situated in the preauricular region, and has branches of the facial nerve running through it. Patients occasionally have some facial weakness post-operatively, which usually improves with time. The surgical approach for parotidectomy includes making an incision in the preauricular area and removing the diseased tissue. There is potential for damage to the facial nerve and the auriculotemporal branch of the trigeminal nerve, which can result in gustatory sweating, also known as Frey's syndrome.

Submandibular

It is located under the lower border of the mandible with the lingual and marginal mandibular branch in close proximity to it. Surgery involves a submandibular incision, which carries a risk of compromise to these two nerves which may result in numbness of the tongue and weakness of the lower lip, respectively. Obstructive disease is most commonly associated with this gland.

Sublingual

This gland is located between the underside of the tongue and behind the lower front teeth.

Surgery in this area can compromise the lingual nerve, which can result in numbness to the tongue. Neoplastic disease found here is malignant in most cases.

Surgeon's Favourite Questions for Students

1. What is the vascular supply to the head and neck?
2. What are the bones of the orbit?
3. What are the branches of the facial nerve?
4. What are the nerves involved during neck dissection?
5. What are the tissue spaces involved in dental infection?

Tips for Placement

Some top tips for your OMFS rotation:

1. Ensure you get to know the registrar who will be able to teach and show you around
2. Read up on the surgical procedure and relevant anatomy the night before
3. Learn the basic anatomy of the teeth and the surrounding structures
4. Midface trauma surgery is usually delayed until the facial swelling goes down to allow assessment of the full extent of the deformity
5. Oxford Handbook of OMFS is a great resource
6. Join BAOMS – it is free as a student
7. Learn the cranial nerves in particular Facial and Trigeminal and their branches
8. Be able to perform a cranial nerve exam
9. If one mandibular fracture is suspected, look out for a second one
10. Plain film X-rays are required at different angles (normally 2) to identify fractures

Careers

OMFS is a very unique speciality in that it requires qualification in both Dentistry and Medicine, with many medical and dental schools now offering an accelerated 3-year course in either specialty as a second degree.

The Table 16.4 shows the training pathway for entry through both medicine and dentistry. Both pathways take approximately 12–15 years from the primary degree depending on fellowships, higher research degrees etc.

Table 16.4 An overview of the training pathways through medicine and dentistry to become a maxillofacial surgeon

Dental School	5 years	BDS	OMFS TRAINING PATHWAY	Medical School	5 years	MBBS
↓				↓		
Dental Foundation Training	1–2 years	MFDS/MJDF		Medical Foundation Training	2 years	
↓				↓		
Medical School	3–4 years	MBBS		Core Surgical Training	2 years	MRCS
↓				↓		
Medical Foundation Training	2 years			Dental School	3–4 years	BDS
↓				↓		
Core Surgical Training	1–2 years	MRCS		Dental Foundation Training	1–2 years	MFDS/MJDF
↓				↓		
SpR	5 years			SpR	5 years	
↓				↓		
Consultant		FRCS		Consultant		FRCS

The broad spectrum of disease allows for the development of an exceptional skill and knowledge base that is harnessed from a variety of other surgical specialities. Although the career pathway appears to be extensive, it is no longer than any of the other specialities. Surgical specialites furthermore, it provides a broad spectrum of surgery which, in combination with academic pursuits, will provide for a challenging yet rewarding career.

Useful Links

www.baoms.org.uk
www.jtgonline.org.uk

17 Cardiothoracic Surgery

Aminah N. Ahmad and Michael Ibrahim

Introduction

Cardiothoracic surgery is a specialty which is concerned with surgical treatment of diseases associated with organs in the thorax, most commonly the heart and lungs. The development of cardiothoracic surgery as a specialty occurred soon after the Second World War when the first open heart procedure using the "heart-lung machine" was performed. Compared to other specialties it can therefore be regarded as relatively young. Although procedures are often complex and timely, requiring complex specialist equipment, the risk of death associated with cardiothoracic surgery has dramatically decreased since the 1950s. The mortality rate for a first time coronary artery bypass graft (CABG) has decreased to 1 % and elective cardiothoracic surgery is currently considered routine.

This chapter outlines the core concepts of cardiothoracic surgery including the core clinical anatomy and knowledge required to understand the most commonly performed procedures and techniques.

Clinical Anatomy

Having a basic knowledge of the anatomy of the thorax is essential for understanding most cardiothoracic procedures. This section summarises the clinical anatomy relevant to this chapter; however, it is not intended to be comprehensive. If you are interested and wish to know more, a dedicated anatomy textbook is recommended.

The Thoracic Cage

The thoracic cage is composed of the sternum and costal cartilages anteriorly, the 12 thoracic vertebrae dorsally and the ribs laterally. It provides support for the pectoral girdles and upper limbs, provides a source of attachment for the muscles of the neck, back, chest and shoulder, acts as a source of protection for the heart, lungs and great vessels and provides the structural apparatus for breathing.

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The sternum ("breastbone") consists of three parts:

- The manubrium.
- The body of the sternum.
- The xiphoid process.

The sternal angle (angle of Louis or manubriosternal junction) is the junction formed where the manubrium meets the body of the sternum. It is normally at the level of the intervertebral disc between vertebrae T4 and T5.

It is an important marker for a number of anatomical features:

- The bifurcation of the trachea into the left and right main bronchi (the carina).
- The beginning and end of the aortic arch.
- The left laryngeal nerve looping around the aortic arch.
- The azygos vein emptying into the superior vena cava.
- The bifurcation of the pulmonary trunk into the left and right pulmonary arteries.
- It also acts as the boundary between the superior and inferior mediastinum.

The rib cage consists of 12 pairs of ribs:

- Ribs 1–7 are considered to be '*true ribs*' as they articulate directly with the sternum.
- Ribs 8–10 are considered to be '*false ribs*' as they do not articulate with the sternum, but with the costal cartilages of the ribs above them.
- Ribs 11–12 are termed '*floating ribs*' as they articulate only with the vertebrae posteriorly – they have no anterior articulation.

The Lungs

The lungs, which occupy the pulmonary cavities, have three surfaces: costal, mediastinal, and diaphragmatic. The right lung has two fissures, the oblique and the horizontal. These fissures divide the right lung into three lobes: superior, middle and inferior. The left lung has only one fissure, the oblique fissure which divides the left lung into a superior and an inferior lobe. The anterior border of the left lung has a cardiac notch. This is an indentation where the apex of the heart is in contact with the lung. Each lung is encased in a continuous pleural sac which has two defined parts: the visceral pleura (lines the surface of the lungs) and the parietal pleura (lines the pulmonary cavities). The anterior border of the pleural reflection on both the right and left side lies between the 2nd and 4th costal cartilages. The reflections reach the midclavicular line at the level of the 8th costal cartilage, the mid axillary line at the level of the 10th rib and the scapular line at the level of the 12th rib. Posteriorly, they proceed toward the spinous processes of the 12th thoracic vertebrae.

Blood Supply

With regards to the pulmonary circulation, deoxygenated blood reaches the lungs via the pulmonary arteries, which originate from the right ventricle. Pulmonary veins carry oxygenated blood back from the lungs to the left atrium of the heart. The arterial blood supply to the lung parenchyma is via the bronchial arteries, which arise directly from the thoracic aorta.

The Azygos Venous System

The azygos venous system of veins drains the posterior surface of the thorax and abdomen. It forms a pathway between the SVC and IVC and allows blood to reach the right atrium if there is obstruction of either vena cava. The azygos vein itself drains the right side, receiving blood from the 4th–11th right intercostal veins. The left side is drained by its tributaries:

- The accessory hemiazygos vein:
  - Receives the 4th–8th left intercostal veins.
- The hemiazygos vein:
  - Receives the 9th–11th left intercostal veins.

The Heart

The heart, which lies in the middle mediastinum, is enclosed in a fibroserous membrane known as the pericardium. The right heart receives deoxygenated blood from the venae cavae. This is stored in the right atrium during atrial diastole (ventricular systole) and flows through the tricuspid valve (right atrioventricular valve) during ventricular diastole (passive flow) and atrial systole (active flow). This blood is then pumped to the lungs for oxygenation by the right ventricle via the pulmonary trunk. The left heart receives oxygenated blood from the lungs via the pulmonary veins (left and right superior and inferior veins), which fill the left atrium during atrial diastole (ventricular systole). The oxygenated blood then flows into the left ventricle via the mitral valve (left atrioventricular valve), and is pumped throughout the body through the aorta by the action of the left ventricle. The coronary sinus drains venous blood from the muscle of the heart itself into the RA.

The Heart Nodes

All cardiac muscle has the potential to spontaneously contract. However, spontaneous contraction is not useful. The rate of spontaneous contraction of cardiac muscle is therefore superseded and regulated by the higher frequency impulses of the sino-atrial node (SAN) and the atrio-ventricular node (AVN).

- The SAN is located deep to the junction between the SVC and the right atrium. It acts as the cardiac pacemaker, initiating the impulses for atrial contraction. This activity is electrically isolated from the ventricles by fibrous tissue and is only transmitted via the AVN.
- The AVN is located in the septum between the atria, close to the tricuspid valve. It receives signals from the SA node and distributes the signal through the bundle of His, which through its branches activates ventricular muscle to contract from the apex superiorly, propelling blood towards the great vessels.

The Coronary Arteries

The coronary arteries are the first branches of the aorta. They supply arterial blood to the myocardium. They are diagrammatically represented in Fig. 17.1.

The right coronary artery (RCA) arises from the right coronary sinus of Valsalva. Its branches include the SA nodal artery, the right marginal

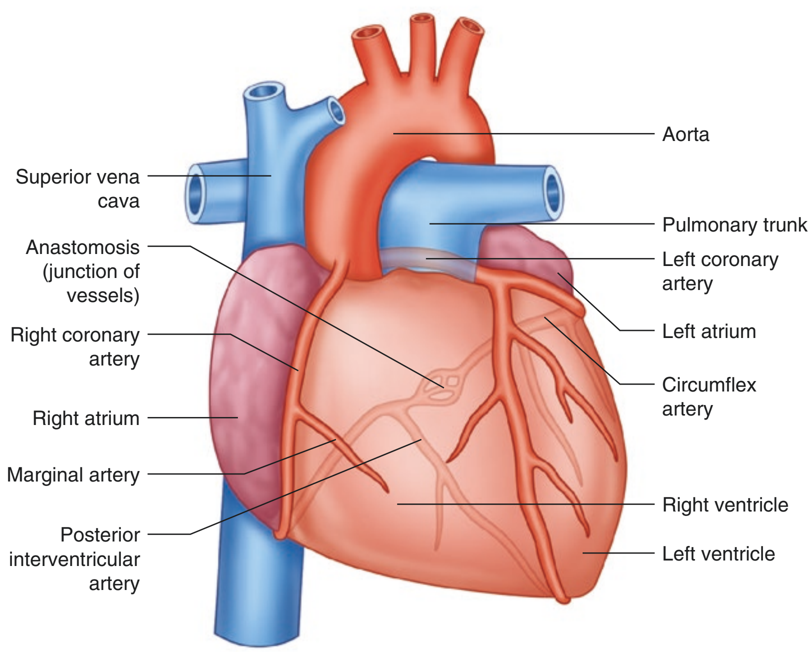

Fig. 17.1 The anatomy of the coronary arteries, showing their location in relation to the chambers of the heart and main branches

artery, the AV nodal artery and the posterior interventricular artery (usually, although anatomy can vary between individuals). The RCA usually supplies the:

- Right atrium.
- Right ventricle (most of it).
- Diaphragmatic surface of the left ventricle.
- Interventricular septum (part of it).
- SAN.
- AVN.

The left coronary artery (LCA) arises from the left aortic sinus. Its branches are the left anterior descending artery and the circumflex artery. The LCA usually supplies the:

- Left atrium.
- Left ventricle (most of it).
- Right ventricle (part of it).
- Interventricular septum (part of it).

Coronary Dominance

Coronary dominance is determined by the artery that gives rise to the posterior interventricular artery.

- In approximately 70 % of people this is the RCA.
- In approximately 15 % of people it arises from the circumflex artery.
- In the remaining 15 % of the population, both arteries contribute to the formation of the posterior interventricular artery – co-dominance.

The Heart Valves

There are two sets of heart valves:

- Atrio-ventricular valves (also known as the mitral and tricuspid valves) which are found between the atria and the ventricles.
- Ventriculo-arterial valves (also known as the aortic and pulmonary valves or the semilunar valves) which are found in the arteries leaving the heart.

The mitral and aortic valves are found in the left side of the heart and the tricuspid and pulmonary valves are found in the right side of the heart. The tricuspid valve has three cusps (anterior, posterior and septal), and prevents backflow of blood from the right ventricle into the right atrium during ventricular systole. The mitral valve, so named because of its resemblance to a bishop's mitre, has two cusps, the large anterior cusp and the smaller posterior cusp. The mitral valve prevents backflow of blood from the left ventricle into the left atrium during ventricular systole. The semilunar valves each have three cusps. They close in order to prevent backflow of blood from the aorta and pulmonary trunk back into the ventricles. The aortic cusps insert into the aortic annulus. Above each of these, the vessel walls dilate, forming a sinus. The left and right coronary arteries arise from the left and right coronary sinuses respectively (sinuses of Valsalva).

Types of Heart Valve Replacement

Aortic and mitral valve replacements are currently more common that valve repairs. Valve replacements are broadly divided into two categories: mechanical and tissue.

Mechanical Valve Replacements

Mechanical valves are usually made of carbon.

- Advantages:
  - Extremely durable.
  - Should last over 30 years in most patients.
  - Usually a lower risk of failure than tissue valve replacements.
- Disadvantages:
  - Risk of thrombosis means that lifelong anticoagulation is necessary, usually in the form of warfarin.

Tissue Valve Replacements

- Allografts:
  - From a person of the same species e.g. cadaveric homograft.

- Autografts:
  - A different valve from the same patient e.g. the Ross Procedure (the use of a pulmonary valve as an aortic valve replacement – an allograft replaces the pulmonary valve).
- Xenografts:
  - From a different species e.g. porcine.

Historically, tissue valve replacements have shown a significant risk of valve failure over time due to structural valvular deterioration. However, the latest data suggests the deterioration curve is no longer as steep. One reason for this may be due to living valve substitutes, as in the case of the Ross Procedure. Unlike mechanical valve replacements, lifelong anticoagulation is not required in patients who undergo a tissue valve replacement.

Core Knowledge

Cardiothoracic surgery is divided into two broad subspecialties: congenital (i.e. paediatric cardiothoracic surgery) and adult. Adult cardiothoracic surgery is further subspecialised into cardiac and thoracic subspecialties. Cardiothoracic surgeons also perform heart and lung transplantations.

Congenital

Congenital heart defects can be classified as either cyanotic or acyanotic.

Cyanotic cardiac lesions can be remembered using the 1–5 mnemonic:

- **1 persistent vessel**: Persistent ductus arteriosus (PDA).
- **2 vessels transposed**: Transposition of the great arteries (TGA): a group of congenital defects involving the abnormal spatial arrangement of the aorta, venae cavae, pulmonary arteries and/or pulmonary veins.
- **3 – tricuspid**: Tricuspid atresia: complete absence of the tricuspid valve.
- **4 – tetralogy**: Tetralogy of Fallot: pulmonary stenosis, overriding aorta, ventricular septal defect and right ventricular hypertrophy.
- **5 letters** – Total anomalous pulmonary venous return (TAPVR): the four pulmonary veins do not form normal attachments with the left atrium.

Cyanotic heart lesions are associated with deoxygenated blood entering the systemic circulation, therefore bypassing the lungs. Acyanotic heart lesions occur when there is "shunting" of blood from the left to the right side of the heart. The most common cause of an acyanotic heart lesion is a ventricular septal defect (VSD) or an atrial septal defect (ASD), although there are others. Often, but not always, patients benefit from early anatomical correction. It is important to consider both the anatomical and physiological consequences of repair.

Adult

Coronary Artery Bypass Grafting (CABG) is the most common adult cardiac procedure, followed by replacement of the aortic valve. Other common procedures include repair or replacement of the mitral valve, surgery to the thoracic aorta and heart failure surgery (including ventricular assist device implantation and transplantation).

Much of adult thoracic surgery is concerned with cancer.

The Heart Team

The emergence of new technologies is blurring the boundaries of expertise in cardiology, interventional radiology and surgery. The presence of competing treatment options, which may require the input of multiple specialists, has resulted in the development of the Heart Team. This team should be involved in the decision making process regarding diagnosis and management of the patient, with the aim of providing patients with a range of different options across specialties. This avoids the bias of any single specialist. A good example of this is coronary artery disease (CAD), where current guidelines recommend discussion with the heart team. The team should present all appropriate treatment options (e.g. surveillance, percutaneous coronary intervention and CABG) to the patient.

Investigations

Investigations are useful in that they can occasionally explain symptomatology (e.g. anaemia precipitating angina in CAD), direct therapy appropriately by eluding to the appropriateness of various interventions, allow assessment of the severity of disease and estimate prognosis in certain circumstances.

Blood Tests

- Full Blood Count (FBC):
  - This measures haemoglobin and therefore checks for anaemia, which can be a cause of chest pain or exacerbate heart failure.
  - Haemolytic anaemia may occur due to prosthetic heart valves – red blood cells are damaged as they pass through the valves.
- Lipids:
  - Measured in the risk factor assessment for CAD.
- Urea, Electrolytes and Creatinine:
  - Electrolyte disturbances can promote arrhythmia (especially potassium and magnesium).
  - To monitor renal function which can be affected by cardiopulmonary bypass.
- Troponin:
  - The first cardiac biomarker to rise after MI.
  - Should be tested on admission and retested 12h after the onset of maximum chest pain.
  - Important in detecting myocardial cell death.
  - Always high when myocardial tissue is damaged.
  - WARNING: Can be raised in many other conditions.

Other Investigations

- Electrocardiogram (ECG):
  - Changes to the ECG can indicate cardiac ischaemia or arrhythmias.
- Chest X-ray:
  - Can show results of previous surgery e.g. sternal wires.
  - Can also show signs of heart failure which can be remembered by **ABCDE**:
    Alveolar oedema.
    Kerley **B** lines (lines that run perpendicular to the pleura).
    Cardiomegaly (enlarged heart).
    Upper lobe **d**iversion (prominent vessels in the upper lobe).
    Pleural **e**ffusion.
- Echocardiogram:
  - Can be used to assess the structure of the heart e.g. the valves.
  - Can be used assess contractile function.
  - Can be used to assess valve regurgitation (classified as none, mild, moderate or severe).
  - Can measure ejection fraction:
    A measurement of how much blood is pumped out of the left ventricle with each contraction (as a percentage of the blood in the ventricle).
    Normal is 55–70 %.
    Below 40 % should be investigated in light of the whole scan.
- MRI scan:
  - To visualise complex anatomy.
- Stress testing:
  - Tests heart function during physical activity;
- Angiogram:
  - Visualises blood vessels.
  - Can be diagnostic in CAD and can evaluate the pattern and extent of disease.
- Angiography:
  - Visualises blood vessels.

For thoracic procedures, the following investigations should be considered:

- CT scan.
- MRI scan.
- Bone scan: May detect metastatic bone disease.
- PET scan: Can check for metastatic cancers.

- Bronchoscopy.
- Thoracotomy: Occasionally used to stage lung cancer.
- Lung function tests:
  - Spirometry:
    - Forced expiratory volume in 1 sec (FEV1).
    - Forced vital capacity (FVC).
    - Peak expiratory flow (PEF).
    - Total lung capacity (TLC).
    - Tidal volume (TV).
  - Transfer factor.

General Indications for Surgery

The New York Heart Association (NYHA) functional classification places patients into categories depending on their tolerance for physical activity. It is used to assess the severity of a range of symptoms of heart failure. A certain NYHA class is often used as an indication for a surgical procedure. The four classes are described below:

- NYHA Class I:
  - Cardiac disease, but no limitation of physical activity.
- NYHA Class II:
  - Slight limitation of physical activity. Ordinary physical activity causes symptoms such as fatigue, palpitations, angina and dyspnoea.
- NYHA Class III:
  - Significant limitation of physical activity. Less than ordinary activity e.g. getting dressed, causes symptoms such as fatigue, palpitations, angina and dyspnoea.
- NYHA Class IV:
  - Symptoms present at rest.

General Contraindications for Surgery

Some conditions or co-morbidities make patients unsuitable for surgery. General contraindications for surgery include:

- Severe renal failure.
- Extremely poor cardiac function.
- Severe sepsis (defined in Chap. 8: Post-Operative Care).
- Uncontrollable bleeding or coagulopathy.

Cardiopulmonary Bypass

The first successful open heart operation utilizing cardiopulmonary bypass (CPB) was performed by John Gibbon in 1953. CPB allowed the acceleration of research into cardiothoracic surgery. CPB takes over the function of the heart and lungs during surgery allowing the heart to be arrested and emptied of blood creating a stable field for safe surgery. CPB involves diverting venous blood to a machine, which oxygenates, filters and returns blood to the arterial circulation. Cannulas therefore need to be placed in the superior vena cava (SVC) and inferior vena cava (IVC), diverting blood away from the heart and lungs. Blood is then returned to the ascending aorta. The temperature of the blood is regulated using a heat exchanger. Whether the blood is warmed or cooled depends on the procedure being performed – during CABG, blood is often cooled to protect the brain.

Cardiopulmonary Bypass: Step by Step Summary

1. Prior to CPB full anticoagulation must be achieved, normally using heparin. This prevents clotting of blood during CPB.
2. The bypass circuit is primed with crystalloid and heparin.
3. The aorto-pulmonary window is dissected to allow access via a cannula.
4. Deoxygenated blood is drained from either the venae cava or the right atrium into a reservoir using a venous cannula.
5. Blood is filtered and oxygenated by an artificial lung.
6. Oxygenated blood is pumped back into the aorta via an arterial cannula.

7. The ascending aorta is cross-clamped below the arterial cannula, preventing back flow of blood into the left ventricle.
8. A venting cannula is commonly placed in the right superior pulmonary vein to assist in maintaining a bloodless field.
9. Anticoagulation is reversed by the administration of protamine (a heparin binding peptide) at the end of the procedure.
10. After the procedure, the patient is rewarmed.

Cardioplegia

Following institution of CPB, cardioplegia (Gr. *cardio + plegia;* heart paralysis) is used to stop the heart. Prior to administration of the cross-clamp, a solution high in potassium is perfused through the coronary arteries, arresting the heart by removing the electrochemical gradient of the sodium/potassium pump and preventing electrical depolarisation. This must be repeated at 15–20 min intervals throughout the procedure to maintain arrest. Cardiac activity is monitored using an ECG, and if significant activity is observed cardioplegia is re-administered. By preventing cardiac energy expenditure, the requirement for oxygen also diminishes, protecting the heart from ischaemic injury. Therefore, although there is no coronary blood flow, CPB is not an ischaemic state. As cardioplegia is administered through the coronary arteries, when blood flow through them is impaired (e.g. in patients with severe CAD), an alternative means of perfusing the myocardium is required. To do this cardioplegia is administered through the venous system via a cannula introduced into the coronary sinus. This is termed retrograde perfusion.

Risks of Cardiopulmonary Bypass

The risks of CPB result from:

- Exposure to the CPB circuitry.
- Cross-clamping of the aorta and cannulation of major vessels/structures.
- Ischaemia and hypoperfusion.
- Hypothermia.
- Accessing the chest.

The most serious risks associated with CPB are:

- Injury to structures during insertion of cannulae.
- Stroke – partly by embolization of disturbed atherosclerotic lesions by the catheter.
- Renal failure.
- Coagulopathy.
- Induction of a systemic inflammatory response due to exposure to bypass circuit.
- Death.

There are many more risks associated with CPB involving almost all body systems. A list of these can be found in a more comprehensive text.

Core Operations

Five of the most commonly examinable cardiothoracic procedures are outlined below. The median sternotomy incision is used for most procedures.

The Median Sternotomy Incision

- The incision extends from the midpoint between the sternal angle and the sternal notch to below the xiphoid process.
- Superficial layers of skin and tissue are dissected to allow entry of a saw to the suprasternal notch.
- A pneumatic saw is used to cut down the middle of the sternum (taking care not to injure the internal mammary arteries on either side).
- A retractor is used to reveal the pericardium.
- The pericardium is opened and sutured to the sternal borders, lifting the heart.

Coronary Artery Bypass Graft

Coronary artery bypass grafting (commonly known as CABG, pronounced "cabbage") is the most commonly performed adult cardiac procedure. Although normally carried out using a median sternotomy incision, minimally invasive and robotic approaches are becoming more common. It is also possible to carry out this procedure without the use of CPB.

Indications

- Left main stem stenosis greater than 50 %.
- Stenosis of the proximal left anterior descending and proximal circumflex arteries greater than 70 %.
- Triple rvessel disease (blockage of three coronary arteries).
- Diabetes mellitus.
- Disabling angina.

Contraindications

- Asymptomatic patients at a low risk of MI.
- A lesion obviously amenable to stenting.
- Significant microvascular disease.

Presentation

- Angina: Exertional chest pain relieved by rest or administration of glyceryl trinitrate (GTN).
- Acute coronary syndrome.

Step by Step Summary

1. Patient is positioned and draped.
2. The median sternotomy incision is used.
3. CPB is initiated.
4. The next step depends on which vessel is being used for the bypass:
   - If venous, a branch of the great saphenous vein is harvested from the calf.
   - If arterial, the left internal mammary artery (LIMA), right internal mammary artery (RIMA) or the radial artery may be used.
5. Anastomosis is performed:
   - If the left or right internal mammary artery is used, one anastomosis is performed on the target coronary artery (distal to the stenosis).
   - If any other vessel is used, an additional anastomosis on the aorta is performed. Distal anastomosis on the target vessel is performed before proximal anastomosis on the aorta.
   - The connection is made between the intima of the vessels involved.
6. Coronary probes can be used to check the patency of the distal anastomosis.
7. The chest is closed and the patient rewarmed. Figure 17.2 shows an example of what the coronary vasculature may look like after a CABG.

Complications

- General complications of cardiac surgery (listed below).

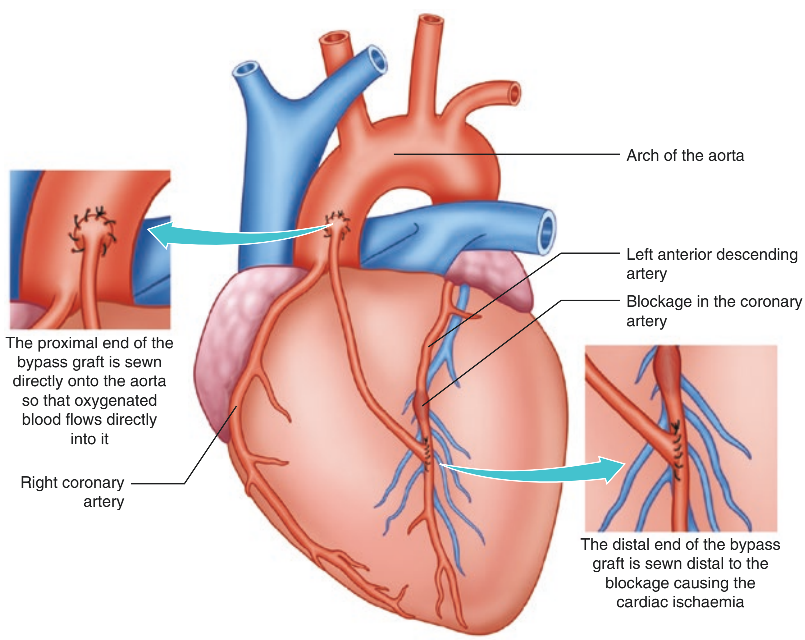

Fig. 17.2 A diagrammatic representation of CABG, showing the anastomoses created on the aorta and coronary artery to bypass the blockage. Venous or arterial grafts can be used

- Immediate:
  - MI.
  - Kinking, tension or torsion of the bypass graft.
  - Compression of the graft by another structure.
- Early:
  - Haematoma formation/bleeding.
- Late:
  - Failure of the graft to perfuse.

Follow-Up

- History.
- Examination for signs of heart failure:
  - Poor function on exercise test.
  - Poor function on echocardiogram.
  - Can be confirmed by angiogram.

Aortic Valve Replacement

Aortic valve replacements are carried out for two major reasons:

- Aortic valve stenosis (a narrowed valve).
- Aortic valve regurgitation (a valve that will not close, allowing blood to leak back through it).

Indications

- Aortic stenosis:
  - Symptomatic severe stenosis – aortic valve area <1 cm.
  - Moderate stenosis but undergoing another cardiac procedure.
  - Asymptomatic patients:
    With severe aortic stenosis and left ventricular systolic dysfunction.
    With abnormal response to exercise e.g. decreased blood pressure.
    With severe left ventricular hypertrophy (greater than 15 mm).
    With aortic valve area less than 0.6 cm^2.
  - Aortic regurgitation:
    Acute severe regurgitation.
    Severe regurgitation and New York class III symptoms.
    Severe regurgitation but undergoing another cardiac procedure.
    Valve endocarditis.

Contraindications

- Mechanical replacements:
  - When anticoagulation is contraindicated in the patient.
  - Pregnant women (higher risk of complications).
- Bioprosthetic replacements:
  - Renal failure.

Presentation

- Aortic stenosis:
  - Presents with a 'classic triad' of symptoms:
    Angina.
    Exertional Syncope.
    Dyspnoea.
  - Can be remembered using 'ASD532'
    Angina – 50 % of patients with angina due to aortic stenosis will die in **5** years.
    Exertional **S**yncope – 50 % of patients with syncope due to aortic stenosis will die in **3** years.
    Dyspnoea – 50 % of patients with dyspnoea due to aortic stenosis will die in **2** years.
- Aortic regurgitation:
  - Acute:
    Pulmonary oedema.
  - Chronic:
    Usually asymptomatic until the function of the left ventricle is severely impaired.
    Angina (at a late stage).
    Fatigue.

Step by Step Summary

1. Patient is positioned and draped.
2. The median sternotomy incision is used.
3. CPB is initiated.
4. Cardioplegia is used to stop the heart.
5. The fat pad overlying the aortic root is retracted.

6. A J-shaped incision into the proximal ascending aorta is made, exposing the aortic valve.
7. Suction is used to keep blood out of the surgical field.
8. The valve leaflets are excised, using blunt edged scissors to prevent perforation of the aortic wall (see Fig. 17.3).
9. The replacement valve is positioned and sutured into place.
10. The incisions are closed.
11. The chest is closed and the patient rewarmed.

Complications

- General complications of cardiac surgery (listed below).
- Complete heart block.
- Prosthetic endocarditis (if mechanical valve used).
- Thromboembolism.
- Prosthesis failure.
- Need for reoperation.

Follow-Up

- Yearly echocardiogram.
- Management of anti-coagulation.

Mitral Valve Repair

Repair of the mitral valve is known to be superior to replacement in mitral regurgitation. Usually, mitral stenosis (which is much rarer in the West) is treated with valve replacement. Anticoagulation is usually not required. This section describes a quadrangular resection, used to repair posterior leaflet prolapse. This procedure was devised by Alain Carpentier.

Indications

- Mitral valve area less than 1.5 cm^2 with NYHA III symptoms or risk of thromboembolism.
- Mitral valve area less than 1 cm^2 with pulmonary artery pressure greater than 60 mmHg and NYHA Class 1 symptoms.
- Acute symptomatic mitral valve regurgitation.
- A lesion amenable to repair.

Contraindications

- Severe calcification of the mitral valve annulus.
- Mitral stenosis (usually).
- Endocarditis.

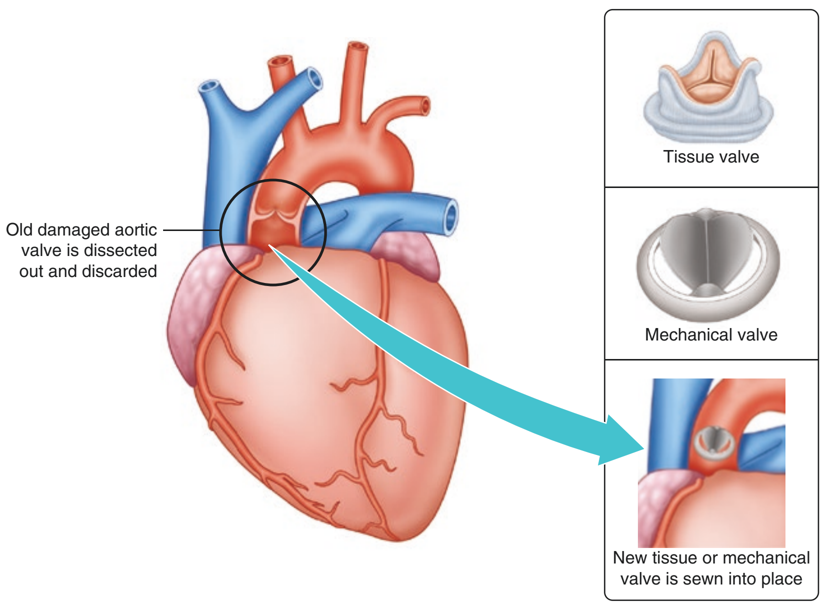

Fig. 17.3 Before and after images of aortic valve replacement surgery

Presentation

- Stenosis:
  - Many are asymptomatic.
  - Dyspnoea as a result of tachycardia caused by:
    Exercise.
    Sexual intercourse.
    Stress.
    Infection.
    Pregnancy.
    Atrial fibrillation.
  - Regurgitation:
    - Most are asymptomatic.
    - Exertional dyspnoea.
    - Fluid retention.
    - Cardiac cachexia (severe weight loss caused by heart disease).

Step by Step Summary

1. Patient is positioned and draped.
2. The median sternotomy incision is used.
3. CPB is initiated.
4. Cardioplegia is used to stop the heart.
5. Saline is injected into the left ventricle to locate the areas of leakage. This is also done pre-operatively using extensive imaging especially echocardiography.
6. The valve leaflets are examined and the degree of prolapse assessed using nerve hooks.
7. A quadrangular section of the posterior leaflet is excised from the area of maximal prolapse.
8. The resected edges are sutured together.
9. An annuloplasty ring is sutured into place to reduce the valve annulus if it is dilated.
10. An increasingly common technique is the use of artificial chordae tendinae.
11. The chest is closed and the patient rewarmed.

Complications

- General complications of cardiac surgery (listed below).
- Coronary artery injury – the circumflex artery lies very close to the mitral valve annulus.
- Valve leaflet perforation.
- Recurrent regurgitation.

Follow-Up

- Typically with serial echocardiography to assess the valve and ventricular function.
- Clinical follow up for heart failure symptoms.

Arterial Switch Operation

TGA is a rare congenital anomaly in which the aorta arises from the right ventricle and the pulmonary artery arises from the left. This results in deoxygenated blood passing through the aorta to the body, while oxygenated blood is passed back to the lungs. A PDA or septal defect to allow mixing of blood is required for the infant to survive to birth. The definitive anatomical repair is called the arterial switch, in which the vessels that are incorrectly attached to the ventricles are rearranged (see Fig. 17.4).

Indications

- TGA is incompatible with life if uncorrected.

Contraindications

- None.

Presentation

- Cyanosis.
- Signs of congestive cardiac failure.
- Most infants die within a few hours.

Step by Step Summary

1. Infant is positioned and draped.
2. The median sternotomy incision is used.
3. The ductus arteriosus, left and right pulmonary arteries and aorta are dissected out.
4. CPB is initiated.
5. Cardioplegia is carried out at the aortic root.
6. The aorta and pulmonary artery are transected.

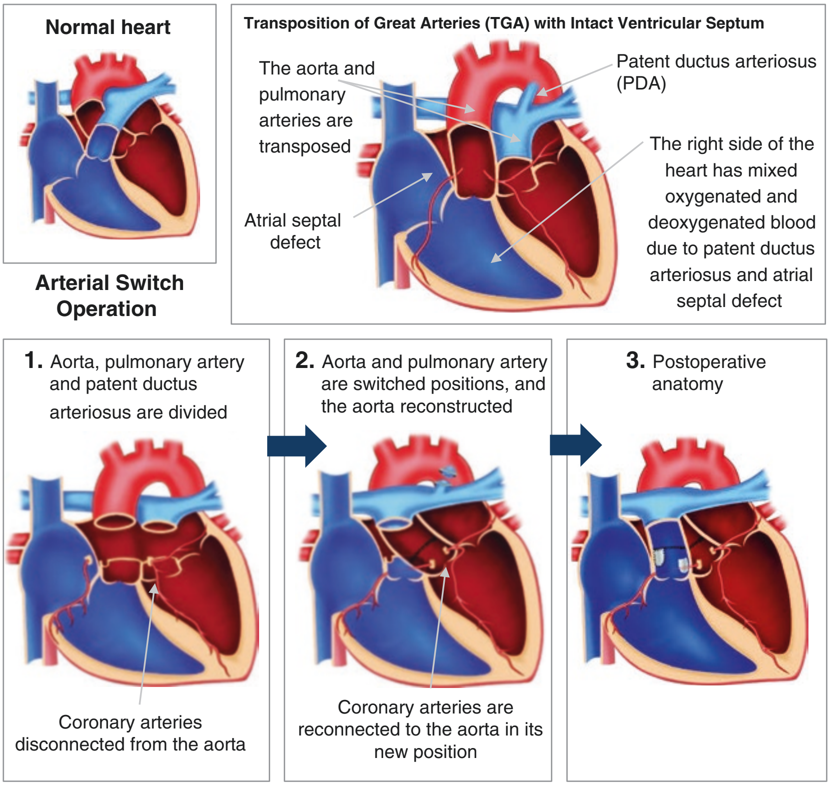

Fig. 17.4 A diagrammatic representation of TGA, showing the difference between the normal heart and TGA, and a step by step representation of the procedure, in which the aorta and pulmonary artery are transected and reconstructed

7. The distal aorta is anastomosed to the proximal pulmonary artery.
8. The distal pulmonary artery is anastomosed to the proximal aorta.
9. The chest is closed and the infant rewarmed.

Complications

- General complications of cardiac surgery (listed below).
- Coronary artery kinking or stenosis.
- Pulmonary or aortic valve insufficiency.
- Stenosis of the pulmonary artery.

Follow-Up

- Yearly echocardiogram.
- Right and left heart catheterisation.
- Exercise test.

Lobectomy

Lobectomies are often used as a first line treatment for non-small cell lung cancer. Thoracic surgical procedures, including lobectomy, can often be carried out using a technique termed video-assistedthoracoscopic surgery (VATS). This is a minimally invasive technique in which surgical instruments and a thoracoscope are inserted into the chest through small incisions. The thoracoscope transmits images to a video monitor, providing surgical guidance. This technique allows faster recovery times and reduced post-operative pain.

Indications

- Centrally located benign tumours.
- Metastatic disease.
- Infective diseases:
  - Lung abscess.
  - Bronchiectasis.

Contraindications

- A tumour that spreads across more than one lobe.

Presentation

Lung cancer may be asymptomatic. When present, symptoms include:

- Symptoms of major airway obstruction:
  – Haemoptysis.
  – Dyspnoea.
  – Cough.
  – Wheeze.
  – Stridor.
  – Hoarseness.
  – Pleural effusion.
  – Pleuritic pain.
- If there has been metastatic spread, symptoms may include:
  – Headache.
  – Nausea.
  – Blurred vision.
  – Ascites.

Step by Step Summary

This summary is for a lobectomy of the inferior lobe.

1. An incision is made at the inframammary fold.
2. Latissimus dorsi is retracted posteriorly.
3. Serratus anterior is divided.
4. The sixth rib is identified and the intercostal muscles and parietal pleura are divided just above it.
5. The pulmonary vessels are identified and divided.
6. The bronchus supplying the lobe is identified and dissected.
7. The lobe is removed.
8. The lung is re-inflated to check for air leakage.
9. The chest is closed.

Complications

- Pulmonary:
  – Atelectasis.
  – Pneumonia.
  – Empyema.
  – Prolonged air leak.
- Cardiovascular:
  – Arrhythmia.
  – MI.
  – Bleeding.
- Wound infection.
- Bronchopleural fistula.

Follow-Up

- Post-operative CT scan of the lungs.

General Complications of Surgery

Complications of cardiothoracic surgery include:

- Death:
  – The risk of death can be calculated using a scale known as the EuroSCORE.
  – Death from first time CABG is approximately 1 %.
- Stroke:
  – 2–3 % for CABG.
- Bleeding.
- Infection:
  – Deep sternal wound infection in 0.5 % of patients.
  – Superficial wound infection in 10 % of patients.
  – Chest infection in 10 % of patients.
  – UTI from catheterisation is also common.
- Air embolus.
- Ischaemia.
- Trauma to delicate structures during surgery.
- Arrhythmias:
  – 30 % of post-operative patients.
  – Can be caused by surgical damage to the nodes or conducting tissue.
  – The AVN may be damaged during surgery involving the aorta.
  – The SAN may be damaged during surgery involving the mitral or tricuspid valves.

Cardiac Tamponade

Cardiac tamponade is a rare yet potentially lethal complication that can occur after surgery.

Cardiac tamponade occurs when fluid (typically blood) accumulates around the heart, and pressure exceeds jugular venous pressure. Cardiac tamponade is usually treated by drainage.

Acute Cardiac Tamponade: Beck's Triad

Acute cardiac tamponade can be diagnosed by the presence of Beck's triad:

- Increased jugular venous pulse (JVP) (distended neck veins).
- Hypotension.
- Diminished or muffled heart sounds.

The presence of these three clinical signs can help differentiate cardiac tamponade from sepsis. The most useful indicator is the JVP, as it is usually decreased in sepsis.

In obvious cases of cardiac tamponade, the chest must be immediately re-explored in theatre.

Other indications to re-explore the chest after closure include:

- Excess bleeding despite correction of coagulopathy.
- Drainage of:
  - More than 500 ml in the first hour.
  - More than 400 ml in each of the first 2 h.
  - More than 300 ml in each of the first 3 h.
  - More than 1000 ml total in the first 4 h.
- Cardiac arrest in a patient who continues to bleed.
- Operative error discovered after closure e.g. retained needle.

Surgeons' Five Favourite Questions for Students

1. What are the main indications for CABG?
2. What are the main indications for aortic valve replacement?
3. What are the complications of CPB?
4. What are the main indications for early re-exploration of the chest?
5. How can you differentiate between cardiac tamponade and sepsis?

Student Tips for Placement

Understanding simple chest anatomy and having a basic understanding of the common procedures performed is vital for placements in cardiothoracic surgery. Knowing which procedures are specialties of the centre you are placed in is also a good idea. When in theatre, ask questions (if safe to do so). Ask a nurse or surgeon to explain the procedure itself and ask if they would be able to show you the technology used. If you know which procedure you are going to see, read up on the appropriate clinical anatomy involved and the steps involved in the procedure beforehand. You will gain far more from theatre placements by doing this. It is also important to spend time in the Intensive Therapy Unit (ITU).

Careers

Cardiothoracic surgery is a very rewarding specialty. It involves mastering technically challenging operations and looking after a variety of patients. Unlike most surgical specialties, procedures often aim to restore function, rather than excising dysfunctional tissues. The surgical workload is heavy so if you enjoy being in theatre, this may be a specialty to consider. Opportunities for research are also plentiful. However, this specialty involves a huge amount of hard work, with heavy time commitments involved. The training pathway for cardiothoracic surgery in the UK is the same as for most other surgical specialties. After medical school, you enter foundation training, and then core surgical training. Cardiothoracic training is entered at either ST1 or ST3 level. The total length of higher surgical training time is 7 years.

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18 Vascular Surgery

Aminah N. Ahmad and Rachel Bell

Introduction

Vascular surgery is a speciality in which diseases of the arteries, veins and lymphatic system are diagnosed and managed. It emerged from general surgery and has been considered a separate surgical speciality in the UK since 2013. Minimally invasive surgery now forms a large part of a vascular surgeon's workload and endovascular approaches are often used during procedures.

This chapter outlines the core concepts of vascular surgery including: core clinical anatomy, commonly treated conditions and descriptions of five commonly performed procedures.

Clinical Anatomy

This section will summarise the anatomy relevant to this chapter. It is not intended to be comprehensive, and for more information, a dedicated anatomy textbook is recommended.

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The Aorta

The aorta originates from the left ventricle of the heart and extends down into the abdomen where it bifurcates into the common iliac arteries at vertebral level L4.

It can be divided into the following sections:

- The ascending aorta:
  - Gives rise to the right and left coronary arteries.
- The aortic arch which has three major branches:
  - The brachiocephalic trunk (sometimes called the innominate artery), which divides into the right common carotid artery and the right subclavian artery.
  - The left common carotid artery.
  - The left subclavian artery.
- The descending thoracic aorta:
  - Branches include the intercostal arteries.
- The abdominal aorta:
  - Has multiple branches including the renal arteries which arise between L1 and L2.

The majority of abdominal aortic aneurysms (AAAs) originate below L1/L2 – the origin of the renal arteries – and above the bifurcation of the abdominal aorta. Although thoracic aortic aneurysms also occur, these are much less common and do not feature in exams as much as AAAs.

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The Carotid Arteries

There are two common carotid arteries which provide the majority of the blood supply to the head and neck:

- The right common carotid artery originates from the brachiocephalic trunk (a branch of the aortic arch).
- The left common carotid artery originates directly from the aortic arch.
- Both common carotid arteries divide to form internal and external carotid arteries at vertebral level C4.

The carotid arteries are contained in the carotid sheath and are positioned posterior to the sternocleidomastoid muscles in the neck. They are found in close proximity to three cranial nerves:

- Cranial nerve IX i.e. the glossopharyngeal nerve
- Cranial nerve X i.e. the vagus nerve
- Cranial nerve XII i.e. the hypoglossal nerve

During carotid endarterectomy, these nerves are at risk of damage. Damage may cause:

- Difficulty swallowing and an absent gag reflex (cranial nerve IX damage).
- Hoarseness as a result of paralysed vocal cords (cranial nerve X damage).
- Wasting of the ipsilateral side of the tongue (cranial nerve XII damage).

The Femoral Artery

The femoral artery is the main blood supply to the lower limb, and hence its occlusion can result in gangrene and the need for amputation if untreated. It is a continuation of the external iliac artery (a branch of the common iliac artery).

- It passes into the lower limb under the inguinal ligament, midway between the anterior superior iliac spine (ASIS) and the pubic symphysis.
- It descends through the thigh in the femoral sheath, lateral to the femoral vein and medial to the femoral nerve (the nerve is not in the sheath).
- It gives off several branches, the largest being profunda femoris, which supplies most of the thigh via its circumflex and perforating branches.
- It passes into the popliteal fossa through the adductor hiatus (an opening in the adductor magnus muscle), becoming the popliteal artery.

The Popliteal Artery

The popliteal artery, a continuation of the femoral artery, runs through the popliteal fossa, ending at the lower border of the popliteus muscle. It divides into the anterior and posterior tibial arteries to supply the leg.

It has five genicular branches, which anastomose with branches of the lateral femoral circumflex artery (from the profunda femoris) and the anterior tibial to supply the knee joint. If the femoral artery must be ligated due to the presence of an aneurysm, this anastomosis ensures that blood will still reach the leg. A femoropopliteal bypass operation is used to ensure limb survival in the case of a popliteal aneurysm.

The Great Saphenous Vein

The great saphenous vein is the longest vein in the body. It originates from the dorsal venous arch of the foot and passes in front of the medial malleolus of the ankle, running medially up the leg and anteriorly up the thigh before passing through the saphenous opening of the fascia lata to join the femoral vein.

The great saphenous vein is the most common vein to be used by vascular surgeons as a conduit in bypass operations.

Core Conditions

Vascular surgeons commonly manage peripheral vascular disease, aneurysms, carotid artery disease and varicose veins. These conditions may have a chronic course (e.g. varicose veins) or they may present as vascular emergencies (e.g. ruptured abdominal aortic aneurysms). Vascular repairs are usually carried out using either an open or endovascular approach.

Peripheral Vascular Disease

Peripheral vascular disease (PVD) is obstruction of the peripheral arterial blood flow. This definition therefore excludes the intracranial and coronary arteries. In some patients PVD may be mild with only asymptomatic plaques present. Others may suffer from moderate disease and present with intermittent claudication (IC). Finally, severe disease is likely to present as critical limb ischaemia (CLI), which may result in amputation. Both the presence and severity of PVD is determined by the ankle-brachial pressure index (ABPI). In health the ABPI is greater than 1 mmHg.

The main risk factors for PVD include:

- Smoking
- Hypertension
- Hyperlipidaemia
- Diabetes Mellitus
- A family history of PVD

Considering mild disease is mainly asymptomatic the majority of patients present with IC as a result of moderate lower limb ischaemia. The ABPI is typically 0.5–0.9 mmHg. Patients complain of muscular pain in the calf, although pain may also be felt in the thigh and buttocks. Pain is provoked by exercise, most commonly at a ‘claudication distance’ and relieved by rest. Symptoms often follow a cyclical pattern in which they progress then resolve as ischaemia promotes the development of collateral vessels. PVD can be managed conservatively by risk factor reduction strategies, including smoking cessation and supervised exercise programmes. If conservative measures fail vasoactive drugs can be used. Some patients ultimately require surgical treatment.

Severe Limb Ischaemia

Severe limb ischaemia (SLI) is the end stage of PVD. It presents with severe pain at rest which awakens the patient from sleep and requires opiate analgesics. Patients must have symptoms for more than 2 weeks and may also present with ulceration and/or gangrene. SLI encompasses both subcritical limb ischaemia (SCLI) and CLI. Patients with SCLI have an ABPI of greater than 0.5 mmHg with rest pain only. CLI is defined by an ABPI of less than 0.5 mmHg with the clinical features described above. While CLI is usually due to a single-segment of plaque, SCLI is due to plaques at multiple levels within the vascular tree. SCLI can lead to amputation if untreated. Management includes surgical repair by bypass graft or angioplasty.

Bypass Grafts

A huge variety of bypass grafts are carried out as part of vascular surgical procedures. They provide a better blood supply to a tissue, redirecting blood around a narrowed or blocked blood vessel. Considering the nomenclature of the grafts, the first part of the graft name originates from the artery the graft comes from, and the second part comes from the artery the graft is sewn on to. Examples include femoro-popliteal and axillo-femoral grafts.

Aneurysms

An aneurysm is a localised, abnormal, dilatation of a blood vessel (Gr. *aneurusma*; widening).

Types of Aneurysm

- True aneurysms:
  - Involve all three layers of the vessel wall (the tunica intima, tunica media and tunica adventitia).
  - Have a diameter that is greater than 150 % of the original vessel diameter.
  - Usually develop as a result of atherosclerosis.
  - Can be fusiform or saccular:

    Fusiform aneurysms involve the entire circumference of the artery – often referred to as spindle shaped aneurysms.

Saccular aneurysms involve only part of the circumference of the artery – often referred to as saclike aneurysms.

- False/pseudo aneurysms:
  - Result from a breach in the vessel allowing blood to leak through. The blood is contained by the adventitia. The haematoma surrounding the artery mimics an aneurysm.
  - A common complication of arterial catheterisation (e.g. coronary angiogram).
  - Can also be caused by trauma and infection.
  - Can be identified on ultrasound by a yin-yang sign (due to turbulent flow).

Aortic Aneurysms

- AAAs are the most common type of aortic aneurysm. The most common site is the infrarenal aorta.
- The suprarenal aorta and thoracic aorta can also be affected.
- The ascending aorta is usually spared.
- Aortic aneurysms are usually asymptomatic until they rupture.
  - Clinical features of rupture include:

    Shock: hypotension, cyanosis, mottling, tachycardia and confusion

    Sudden onset pain at the site of rupture

    A pulsatile abdominal mass
  - Rupture of an aortic aneurysm has a high mortality rate.
- Surgical repair can be attempted using both open and endovascular techniques.

AAAs with a diameter >5.5 cm have a risk of rupture of over 3 % per year. Until an AAA has reached 5.5 cm the risks of surgery outweigh the risk of rupture. A diameter of 5.5 cm is therefore an indication for surgical repair. Elective, asymptomatic AAA repair has a 30-day mortality of 5–8 %. Emergency, symptomatic AAA repair has a 30-day mortality of 10–20 % and a rupture repair has a mortality of 50 %.

At present, there is a UK National Screening programme which utilises ultrasound to identify AAAs in all men aged 65 years and over. If the scan reveals an AAA <3 cm in diameter, no further follow up is required. An AAA 3–4.4 cm requires follow up in 1 year and a diameter of 4.5–5.4 cm requires follow up every 3 months. Vascular surgery referral is required in those patients with an AAA diameter of 5.5 cm or greater.

Carotid Artery Disease

Stenosis of the carotid arteries in the neck is caused by atherosclerosis and plaque formation. The plaque(s) may be stable and asymptomatic or be the source of embolization. As the embolus travels into the intracranial vasculature it may cause temporary ischaemia resulting in a transient ischemic attack (TIA) or manifest as a thromboembolic stroke resulting in permanent damage. Carotid artery disease may present as a carotid bruit ('swooshing' noise) on auscultation. Colour flow duplex ultrasound is the diagnostic modality of choice.

The main risk factors for carotid artery disease include:

- Smoking
- Diabetes Mellitus
- Hypertension
- Hyperlipidaemia

If there is a greater than 50 % stenosis of the internal carotid artery on investigation which has resulted in a TIA or stroke, the first line treatment is urgent carotid endarterectomy. This is only indicated within 14 days of the event. The North American Symptomatic Carotid Endarterectomy Trial (NASCET) has reported that carotid endarterectomy provides significant benefit in patients with severe symptomatic stenosis [1]. If the stenosis in the internal carotid artery is found incidentally and is asymptomatic, the evidence for surgery is less clear. The asymptomatic carotid surgery trial (ACST) found that while the procedure reduces stroke risk in asymptomatic patients younger than 75 years, benefit to patients depends on a variety of factors including life expectancy and future surgical risk [2]. Current management options in asymptomatic disease also include medical alternatives.

Varicose Veins

There are both superficial and deep venous systems in the lower limb. They are connected to each other by perforating veins and at the sapheno-femoral and sapheno-popliteal junctions. Venous blood is returned to the heart via the iliac veins and inferior vena cava.

When the calf muscles in the legs contract blood is pumped towards the heart as venous blood drains from superficial to deep veins. When the calf muscles relax the 'one-way' valves in the veins close. This closure prevents backflow of venous blood into the superficial venous system.

Valve incompetency will allow blood to flow into the superficial veins, converting them into a high-pressure system and producing the enlarged, tortuous appearance of varicose veins.

The main risk factors for varicose veins include:

- Old age
- A family history
- Female gender
- Pregnancy
- Obesity
- A standing occupation

Thrombus Versus Embolus

An important concept to grasp when trying to understand vascular surgery is the difference between a thrombus and an embolus. Although both can block blood vessels and cause tissue necrosis if untreated, their underlying pathology is different.

- A thrombus is an abnormal aggregation of platelets creating a clot which is formed within a vessel. Thrombi commonly occur in the deep veins of the legs e.g. Deep vein thrombosis (DVT).
- An embolism implies movement. It may be thought of as a floating clot that lodges somewhere else in the vasculature. They commonly break off from thrombi e.g. a pulmonary embolism as a result of a DVT. Emboli are not always blood clots. Fat, air and bone marrow are other types of emboli.

Core Operations

Five of the most commonly performed (and asked about in exams!) vascular procedures are outlined below.

AAA Repair

This procedure can be carried out using both open and endovascular approaches.

Endovascular AAA Repair (EVAR)

Indications

- Aneurysm diameter of greater than 5.5 cm.
- Rapid aneurysm growth (greater than 0.5 cm in 6 months).
- Symptomatic aneurysm:
  - Tender to touch.
  - Back pain.
  - Distal embolization.
- Aneurysmal rupture.

Contraindications

- Less than 1.5 cm of normal aorta below the renal arteries (1.5 cm of normal aorta is required to allow a sufficient healing zone for the stent graft).
- Calcification or tortuosity of the femoral or iliac arteries.

Presentation

Aneurysms are often asymptomatic, and therefore are often found incidentally by ultrasound scan, CT scan or, rarely, clinical examination.

Symptomatic aneurysms occasionally occur. The patient usually presents with abdominal or back pain, and should be urgently referred to a vascular surgeon for diagnosis and consideration for treatment.

Investigations

- Ultrasound scan.
- CT angiogram of aorta.

In cases of suspected AAA, it is important to visualise the whole aorta, from the ascending aorta to the femoral arteries. Often, there is co-existent pathology present in the descending thoracic aorta and iliac arteries. A CT angiogram allows the patient's anatomy to be examined so the most appropriate stent graft can be chosen. It also allows the length of normal aorta below the renal arteries to be assessed, aiding in the decision of whether or not EVAR is the most appropriate procedure.

Step by Step Summary: EVAR

1. Bilateral access to the common femoral artery is obtained via femoral artery cut-down. Alternatively, EVAR can be performed percutaneously.
2. A stiff guidewire is inserted through the incision in the right groin to the aortic arch to allow the surgeon to track the catheters and stent graft into the body.
3. A pigtail catheter is placed at the level of the renal arteries and an aortogram of the abdominal aorta and iliac arteries used to guide the placement of the stent graft. This ensures the renal arteries are not obstructed by the graft.
4. The main body of the stent graft is inserted over the guidewire from the right groin incision and pushed into the correct position with the covered part below the renal arteries. The stent-graft is collapsed during this step.
5. The main body is deployed and the right limb is inserted to complete the procedure on the right side.
6. A guidewire and catheter are used on the left side to allow positioning and deployment of the stent graft on the left side.
7. Ballooning of the stent graft in the aortic neck is carried out to help the stent graft appose to the aortic wall.
8. Ballooning all the stent overlaps is carried out to make sure that no blood can leak between the stent grafts.
9. A "completion aortogram" is carried out to make sure the aneurysm is sealed and there is no endoleak.
10. The arteries are closed either with a percutaneous closure device or direct arterial sutures.
11. The groin incisions are also closed and bandaged.

Complications

- Bleeding:
  – Most commonly from the artery used for access.
  – Can also occur from accidental rupture of an iliac artery from pushing the device up through narrow calcified vessels.
- Distal embolization.
- Endoleak:
  – Blood flow outside the lumen of the graft.
  – Occurs if the seal is insufficient.
- Renal failure.
- Death.

Follow-Up

All patients require follow-up. Most surgeons would advise a CT scan before discharge (or at least in the first 3 months after the procedure) in order to check the position of the stent graft and make sure the aneurysm is sealed with no endoleak. If the CT scan shows no problems, most patients go into an ultrasound surveillance programme for the rest of their lives.

Open AAA Repair (OAR)

Indications

- As for EVAR.
- Often used for fit patients who are not suitable for EVAR due to not having a sufficient length of normal aorta below the renal arteries for a stent graft.

Contraindications

- If the patient is not fit for open surgery.
- Multiple previous abdominal operations.
- Presence of stoma (relative contraindication).

Presentation

- As for EVAR.

Investigations

- CT angiogram.
- Assessment of cardiorespiratory fitness:
  – Echocardiography.
  – Stress echocardiogram.
  – Cardiopulmonary exercise test (CPEX).
  – Lung function tests.

Step by Step Summary: Open AAA Repair

1. A midline or transverse abdominal incision is made for direct visualisation of the AAA.
2. Dissection of the aneurysm neck and proximal iliac arteries is carried out to allow the aorta to be clamped.
3. The aorta and iliac arteries are clamped.
4. The aneurysm sac is opened and the thrombus is removed.
5. The back bleeding lumbar arteries are oversewn.
6. The top end of the graft is stitched to the aneurysm neck.
7. The bottom end of the graft is stitched to the aortic bifurcation.
8. The graft is flushed to make sure there are no clots that could travel down the vessels supplying the legs.
9. The clamp is released after warning the anaesthetist.
10. The aneurysm sac is closed around the graft to protect the artificial graft from the bowel.
11. The abdominal incision is closed.

Complications

- Bleeding.
- Renal failure.
- Respiratory failure.
- Cardiac complications.
- Leg ischaemia:
  – May require amputation.
- Bowel ischaemia.
- Spinal cord ischaemia.
- Death.

Follow-Up

Most patients are seen in outpatients 8 weeks after undergoing an open repair, and then discharged.

Carotid Endarterectomy

This procedure can be carried out to relieve stenosis and remove blockages of the carotid arteries in carotid artery disease.

Indications

- Carotid stenosis of greater than 50 % with symptoms including:
  – TIA within the preceding 14 days affecting the appropriate cerebral hemisphere.
  – Stroke within the preceding 14 days affecting the appropriate cerebral hemisphere.
  – Amaurosis fugax (transient loss of sight in one eye) or central retinal artery occlusion.
- Asymptomatic carotid artery stenosis of greater than 70 %:
  – Controversial in the UK.
  – ACST trial supports carotid surgery for patients <75 years old [2].

Contraindications

- Previous surgery or radiotherapy to the patient’s neck.
- Patient not fit for open surgery.

Presentation

- Symptomatic patients are usually referred from stroke physicians:
  – Present with cerebrovascular accidents such as TIAs and strokes, amaurosis fugax or central retinal artery occlusion.
- Asymptomatic patients are referred from a variety of sources:
  – These patients have usually had a carotid duplex scan because of cardiovascular co-morbidities.

Investigations

- Carotid duplex ultrasound scan.
- CT angiogram.
- Magnetic resonance angiogram.
- Transcranial doppler.

Step by Step Summary: Carotid Endarterectomy

1. Local or general anaesthetic may be used.
2. An incision is made along the anterior border of sternocleidomastoid. Incision length is 5–10 cm, depending on the site of the stenosis.
3. The common, internal and external carotid arteries are dissected out. The cranial nerves must be avoided.

4. Slings are placed around the above arteries
5. The arteries are clamped and a longitudinal arteriotomy is made on the distal common carotid and proximal internal carotid artery.
6. Endarterectomy (removal of plaque) is carried out on the insides of the common and internal carotid arteries.
7. The arteriotomy incision is closed with a patch to prevent narrowing. At this point the surgeon must ensure there is no bleeding.
8. Ideally there should be intraoperative assessment of the surgical result with on table duplex or angioscopy.
9. The platysma muscle and skin are closed with dissolvable stitches.
10. Recovery takes place in a High Dependency Unit to monitor any signs of bleeding or new neurological symptoms.

Complications

- Bleeding.
- Perioperative stroke.
- Cranial nerve injury.
- Numbness of earlobe and angle of the jaw on the side of surgery.

Follow-Up

The carotid duplex ultrasound scan is repeated (as an outpatient procedure) to assess success of the endarterectomy.

Femoro-Popliteal Bypass

Indications

- Critical limb ischaemia.
- Short distance claudication.
- Popliteal artery aneurysm.

Contraindications

- Patient unfit for open surgery.
- No autologous vein available for bypass (relative contraindication).

Presentation

- Rest pain.
- Tissue loss or gangrene.
- Claudication upon walking less than 20–30 m (short distance claudication).
- Popliteal aneurysm greater than 2 cm.

Popliteal aneurysms often occlude suddenly. The patient will suffer acute limb ischaemia, which presents with the 6 P's:

1. Pain.
2. Paraesthesia.
3. Pallor.
4. Pulselessness.
5. Paralysis.
6. Perishingly cold.

Investigations

- Arterial duplex ultrasound scan.
- CT angiogram.
- Intra-arterial digital subtraction angiogram.
- Magnetic resonance angiogram.
- Vein map.

Step by Step Summary: Femoro-Popliteal Bypass

1. General anaesthetic or an epidural is administered.
2. A vertical or transverse incision is made in the groin to allow dissection of the common femoral and proximal superficial and deep femoral arteries.
3. A vertical incision is made behind the tibia to allow dissection of the popliteal artery and harvest of the great saphenous vein.
4. The great saphenous vein is harvested throughout its length.
5. The vein is turned around (reversed) and tunnelled from the femoral artery to the popliteal artery.
6. The vein is joined to the common femoral artery at the top and the popliteal artery at the bottom. The foot should pink up at this point.
7. The wound is closed and bandaged.

Complications

- Graft occlusion.
- Wound complications e.g. infection.
- Reperfusion injury.
- DVT.
- Nerve injury.

Follow-Up

Graft surveillance is carried out as an outpatient procedure.

Varicose Vein surgery

This procedure, carried out to repair varicose veins, is commonly asked about in exams!

Indications

- Absolute indications:
  - Recently healed venous ulcer.
  - Recent superficial thrombophlebitis (inflammation of a vein just under the skin).
  - Bleeding varicose vein.
  - Skin changes related to superficial venous reflux such as lipodermatosclerosis (hard, pigmented skin on the legs due to venous insufficiency).
- Relative indications:
  - Painful varicose veins.
  - To improve cosmetic appearance.

Contraindications

- Previous DVT with elements of deep venous obstruction.

Presentation

- Described in the 'Core Knowledge' section.

Investigations

- Venous duplex ultrasound scan.

Step by Step Summary: Varicose Vein Surgery

Open Approach:

1. A transverse cut is made 2 cm below and lateral to the pubic tubercle.
2. The superficial femoral vein and its tributaries are dissected. The femoral vein is identified.
3. The superficial femoral vein and its tributaries are ligated.
4. The great saphenous vein is stripped to below the knee.
5. Varicose veins of the calf and thigh are avulsed.
6. The groin wound is closed.
7. The leg is bandaged.

Endovascular ablation:

1. Local anaesthetic is administered.
2. Ultrasound is used to identify the great saphenous and superficial femoral veins.
3. The veins are cannulated using a wire and sheath.
4. A heat ablation catheter is inserted; either laser or radiofrequency ablation is used.
5. The superficial femoral and great saphenous veins are heat ablated throughout their length.
6. There is one small cut which is closed with a piece of surgical tape.
7. The leg is bandaged.

Complications

- Haematoma formation.
- Paraesthesia.
- Phlebitis (endovascular technique).
- DVT:
  - Rare but catastrophic.
  - Occurs in less than 1 % of patients when the endovascular approach is used.
  - Occurs in approximately 3 % of patients when the open approach is used.

Follow-Up

- Not required in most patients.

Embolectomy

An embolectomy is the surgical removal of a blood clot blocking an artery. It is often carried out as an emergency operation. This section describes the removal of a clot in the femoral artery.

Indications

- Acute limb ischaemia.

Contraindications

If ischaemia has been present for too long, it may be too risky to reperfuse the ischaemic limb. Amputation may be required under these circumstances.

Presentation

- The 6 P's of acute limb ischaemia (see above).
- Patients may present with atrial fibrillation.
- Patients usually present as an emergency.

Investigations

- CT Angiogram.

Step by Step Summary: Embolectomy

1. Local or general anaesthetic is administered.
2. The common femoral artery is dissected out.
3. A transverse arteriotomy is performed.
4. A Fogarty catheter is passed through the artery to retrieve the clot blocking it.
5. The artery is flushed and back bled to make sure that there is no residual clot.
6. The artery is closed.
7. The limb is reperfused and if successful the foot should at this point pink up.
8. The incision is closed.

Complications

- Compartment syndrome.
- Haematoma formation.
- Amputation may be required.

Follow-Up

- Follow-up is usually not required.

Surgeons' Five Favourite Questions for Students

1. Define what an aneurysm is.
2. What are the indications for surgical repair of an AAA?
3. Which three cranial nerves are at risk during carotid endarterectomy?
4. Name the different sources of emboli
5. What is the difference between an embolus and an in-situ thrombosis?

Student Tips for Placement

A grasp of anatomy, especially the arterial tree, is essential for full understanding of most vascular procedures. When going into theatre, try and find out what procedures you will be observing and read up on them beforehand. Endovascular approaches are common, so read up on the equipment involved. Don't be afraid to ask questions!

Careers

Vascular surgery is an incredibly varied and exciting specialty. It attracts people who are risk-takers, who like hard work and exciting surgery.

It is technically challenging and requires knowledge of full body anatomy. Vascular on call is unique because it is not possible to tuck a patient with a bleeding aneurysm or acute ischaemic leg up in bed and leave them until the next day – they require operating on as an emergency procedure, which will mean operating on them overnight.

The training pathway for vascular surgery in the UK is the same as for most other surgical specialties. After medical school, you enter foundation training, and then core surgical training before specialising at ST3 level.

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19 General and Emergency Surgery

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Introduction

General surgery encompasses upper GI, lower GI and breast surgery and the operations can be divided into emergency and elective procedures. As a medical student there are common procedures you are expected to know about, which will be described in this chapter.

Core Knowledge

Emergency Surgery

This includes:

- Laparotomy.
- Appendicectomy.
- Abscess.

Upper GI Surgery

This includes:

- Investigations – ERCP, MRCP and OGD.
- Cholecystectomy.
- Oesophagectomy.
- Anti-reflux surgery.
- Bariatric surgery.
- Liver resections.
- Pancreatectomy/Whipple's procedure.

Lower GI Surgery

This includes:

- Bowel resection – small bowel resection, colectomy: right hemi-colectomy, sigmoid colectomy, anterior resection, abdominoperineal resection.
- Stoma formation.
- Benign anorectal surgery.
- Hernia repair.

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Breast Surgery

This includes:

- Wide local excision.
- Sentinel lymph node biopsy.
- Mastectomy and axillary lymph node clearance.

Non-operative Surgical Conditions Including

- Pancreatitis.
- Diverticulitis.
- Sigmoid volvulus.

Emergency Surgery

The Acute Abdomen

Severe, sudden-onset abdominal pain, referred to as an 'Acute Abdomen', is one of the commonest emergency presentations in general surgery. Prompt assessment is necessary to determine whether surgical or non-surgical management is more appropriate. Common causes are viscus perforation, inflammation or obstruction. The pattern of the pain can help in determining the most likely cause.

- Site:
  - When the visceral peritoneum is the source, pain may localise roughly to the midline
  - Pain from foregut structures localizes to the epigastrium.
  - Pain from midgut structures localizes to the umbilicus.
  - Pain from the hindgut structures localizes to the suprapubic region.
  - When the parietal peritoneum is involved, pain will localize to the abdominal wall adjacent to the site of the pathology
  - Pain may be referred e.g. the pain of an inflamed gallbladder may refer to the tip of the shoulder blade.
- Time-course:
  - Viscus perforation – Sudden onset, unremitting pain that spreads across the abdomen
  - Inflammation – constant pain, increasing in intensity over hours
  - Obstruction – pain that waxes and wanes i.e. colicky pain

Patients with symptoms and signs of shock e.g. hypotension and tachycardia require prompt resuscitation. Further investigations will be guided by the history and clinical examination findings but are likely to include blood tests and imaging. The approach to management is also guided by the clinical picture, and may involve a wide variety of surgical and non-surgical options, many of which are described in the following sections.

Laparotomy

A laparotomy is the opening of the abdominal cavity for diagnostic and/or therapeutic purposes.

Indications

Exploratory laparotomy is carried out to investigate and/or treat any underlying pathology in patients presenting with an 'acute abdomen' or abdominal trauma. Common indications include:

- Intestinal obstruction.
- Acute mesenteric ischaemia.
- Viscus perforation.

Presentation

Intestinal obstruction may present with:

- Abdominal pain.
- Distension.
- Constipation.
- Vomiting – this is indicative of small bowel obstruction.

Mesenteric ischaemia presents with:

- Severe, unremitting pain, initially with few physical findings.
- Later, once the bowel wall has become necrotic, signs of peritonitis will be evident.

Perforation of a viscus results in the spillage of its contents into the peritoneal cavity and presents with:

- Localized or generalised peritonitis.
- Severe abdominal pain.
- Tenderness.
- Guarding.

Investigations

Pre-operative investigations may vary depending on the presenting complaint, but may include:

- Erect chest x-ray.
  - Gas under the diaphragm indicates perforation of a viscus.
- Abdominal x-ray.
  - This is indicated if intestinal obstruction is suspected.
- Abdominal CT scan.
- Blood tests e.g. Full Blood Count, CRP, amylase.
  - May indicate inflammation.

Clinical Anatomy

The abdominal wall consists of the skin, subcutaneous fat, the abdominal muscles and their associated fascia, the extraperitoneal fascia, and the parietal peritoneum.

The external oblique, internal oblique, and tranversus abdominis muscles form the muscular layer of the lateral abdominal wall.

Anteriorly, these muscles continue as their respective aponeuroses to meet in the midline as the linea alba. On either side of the linea alba, the aponeuroses are arranged to form the rectus sheath, which surrounds the rectus abdominis muscles. Deep to the muscular layer is the transversalis fascia, overlying a layer of extraperitoneal fat/fascia.

The innermost layer, lining the outer wall of the peritoneal cavity, is the parietal peritoneum.

Step-by-Step Summary: Laparotomy

1. The abdominal cavity is opened using a vertical midline incision.
2. The peritoneum is lifted up as it is opened to reduce the risk of bowel perforation.
3. Any adhesions between the visceral and parietal peritoneum, or between loops of bowel, must be separated carefully.
4. The peritoneal cavity must be thoroughly explored to determine the site and cause of the underlying pathology.
5. The subsequent procedure will depend on the indication for laparotomy i.e. repair of a perforated ulcer, resection of infarcted bowel segments.
6. At the end of the procedure the greater omentum is positioned between the viscera and the incision site as far as possible.
7. After ensuring haemostasis has been achieved, the wound is closed.

Complications

- Wound infection
- Chest infection
- Wound dehiscence
- Bowel perforation
- Anastomotic leak
- Respiratory failure
- Septicaemia
- Death

Potential complications will vary depending on which, if any, procedure is undertaken secondary to the laparotomy.

Obstruction

Common causes of obstruction, of either the small or large bowel, include:

- Adhesions
- Hernias
- Tumours
- Strictures (IBD, diverticular)

Presentation

Signs and symptoms include:

- Acute abdominal pain
- Generalised tenderness (often accompanied by rebound tenderness or guarding)
- Abdominal distension
- Nausea and vomiting
- Bowels not opening

Investigations

Blood Tests

- Full blood count (FBC)
- Urea and electrolytes (U&E)
- Liver function tests (LFTS)
  - AST, ALT, gamma GT, Alkaline phosphatase and bilirubin
- CRP
- Arterial blood gas (ABG)
  - To check the lactate level and determine if the patient is acidotic

Other Investigations

- Erect chest x-ray – exclude perforation of a viscus
- Abdominal x-ray – to check for signs of bowel dilatation suggestive of bowel obstruction
- CT scan – to identify the cause of the obstruction

A midline laparotomy is the gold standard for diagnosis and treatment. The aim of surgery is to relieve the obstruction. Segments of bowel may also need to be resected if they are found to be ischaemic.

Following a bowel resection a primary anastomosis of the two ends is often performed with or without a de-functioning stoma. In some instances when an anastomosis is not suitable, an end stoma is formed, or the two ends of the bowel are brought out to the abdominal wall as stomas to be closed at a later date.

Appendicectomy

Indication

Acute appendicitis is inflammation of the appendix secondary to the occlusion of its lumen.

Causes include:

- Faecolith
- Caecal tumour
- Parasitic worms

Presentation

Signs and symptoms include:

- 12–24 h history of central abdominal pain which often localises to the right iliac fossa (RIF).
- Rebound tenderness or guarding
- Pyrexia
- Tachycardia
- Vomiting
- Loss of appetite
- Positive Rovsing's sign – palpating the left iliac fossa causes pain in the RIF.

Investigation

Diagnosis of appendicitis is often based on the clinical presentation. Some investigations, however, are useful to support the diagnosis and to exclude other possible causes of the pain. These include:

- *Blood tests* – a raised white cell count (WCC) and CRP indicates inflammation and supports the diagnosis of appendicitis.
- *Urine dip (including HCG)* – excludes a urinary tract infection and ectopic pregnancy as the cause of the RIF pain.
- *Ultrasound scan of abdomen and pelvis* – this can be requested to exclude a gynaecological pathology.
- *CT scan* – helpful when the clinical diagnosis is unclear or in the elderly where a caecal tumour might be suspected.

Clinical Anatomy

The appendix is a blind-ended structure at the ileocaecal junction, located 2/3 of the distance from the umbilicus to the right anterior superior iliac spine. This area is known as McBurney's Point (see Fig. 19.1). The appendix

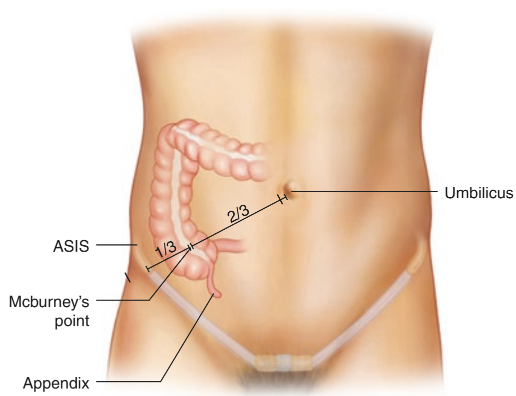

Fig. 19.1 McBurney's point can be found 2/3 of the distance from the umbilicus to the right anterior superior iliac spine

has a mesoappendix and an appendicular artery supplying it.

An appendix can be removed by an open procedure where a transverse Lanz incision is made over McBurneys point on the anterior abdominal wall or by a laparoscopic approach. Here we describe the laparoscopic approach:

Laparoscopic Appendicectomy

This involves a three-port technique – one for the camera and two for the instruments.

1. The caecum is identified and the bowel is traced proximally to the ileum where the appendix can be found at the ileocaecal junction.
2. The appendix mesentery and the appendicular artery are then divided using diathermy.
3. The appendix is ligated at the base using at least one Endoloop (up to three loops may be used).
4. The appendix is cut at the base and removed through a bag that is introduced via the camera port.
5. The area is washed with fluid and any pus collections are suctioned out.
6. The port sites are then sutured closed.

Complications

- Intra-abdominal or pelvic collections
- Wound infections

> **Surgeons' Favourite Questions for Students**
> 1. Where is McBurneys point?
> 2. What is the appendix?
> 3. Where is the appendix found and in what positions can it lie?
> 4. How can you differentiate the small from the large bowel?
> 5. What layers do you cut through to reach the appendix in an open appendicectomy?

Abscess

An abscess is a pus filled cavity anywhere on or within the body.

Common abscesses include peri-anal abscess, pilonidal abscess, gluteal abscess, abscess in the axilla and abscess on the back.

Treatment

Incision and Drainage (I + D)

1. A stab incision is made directly over the abscess and the pus filled cavity drained.
2. The incision is then extended to a cruciate and the cavity debrided with a curette.
3. The cavity is washed out thoroughly and then packed with ribbon gauze and a dressing placed over the top.

Follow-Up

- The wound is packed and the dressing changed daily by a district nurse or the GP once discharged back into the community.
- No formal outpatient hospital appointment is required.

> **Surgeons' Favourite Questions for Students**
> 1. What is an abscess?
> 2. Where would you commonly find an abscess?
> 3. How is an I + D performed?

Upper Gastrointestinal (GI) Surgery

Upper GI surgery is subdivided into three subspecialties:

- Oesophagogastric (OG).
- Hepatopancreatobiliary (HPB).
- Bariatric.

Investigations

Common investigations in upper GI surgery include:

Blood Tests

- FBC (Full blood count).
- U & E (Urea & electrolytes).
- LFTs (liver function tests).
- Amylase/ Lipase – this is important for excluding pancreatic disease. Amylase is frequently used, as it is the least expensive, however lipase is a superior test, being more specific for pancreatitis. Amylase is most commonly used in the UK, with lipase being more common worldwide, including in the USA and Australia.
- CRP/ESR (inflammatory markers) – CRP increases acutely, whereas ESR suggests a more chronic inflammatory process.

Endoscopy

- This enables direct visualisation of the upper GI tract.
  - Passage of instruments down the endoscope allows diagnostic and therapeutic procedures
- Upper GI endoscopy enables the oesophagus, stomach and first two parts of the duodenum to be visualized.
- Capsule endoscopy involves the patient swallowing a small capsule that is equipped with an imaging device. This then transmits images as it passes through the GI tract.
- Double balloon endoscopy.
  - This involves the sequential inflation and deflation of balloons along the endoscope
  - Allows for visualisation of the entire length of the small bowel

Indications

- Dyspepsia aged >55 years
- Haematemesis
- Iron-deficiency anaemia
- Dysphagia
- Investigation of malabsorption – a duodenal biopsy would be performed
- Persistent vomiting
- Therapeutic interventions
- Treatment of varices – this may involve either banding or sclerotherapy
- Palliation – stent insertion, laser therapy
- Treatment of strictures – stent insertion, balloon dilation
- Control of bleeding – diathermy, clipping, laser therapy

Complications

- Cardiorespiratory arrest resulting from sedation.
- Aspiration pneumonia.
- Perforation.

Step-by-Step Summary: Endoscopy – Oesophagogastroduodenoscopy (OGD)

Patients are required to stop all anti-acid therapy for at least 2 weeks prior to having an endoscopy and should not eat or drink for 4 h prior to the procedure.

1. The patient may be given a local anaesthetic throat spray for comfort or additional benzodiazepine sedation intravenously.
2. The endoscope is passed down the oesophagus – suction is used to prevent aspiration in to the lungs.
3. Instruments can then be passed down the scope and interventional procedures performed.

Patients must be advised not to drive for 24 h following the procedure.

Endoscopic Retrograde Cholangiopancreatography (ERCP)

This is an endoscopic technique involving cannulation of the main pancreatic duct and common bile duct to enable investigation and/or therapeutic intervention

Indications

- Investigation of biliary disease – choledocholithiasis (stones in the CBD), biliary tumours, strictures and intrahepatic biliary disease

- Investigation of pancreatic disease e.g. strictures
- Therapeutic interventions
- Removal of calculi in the CBD
- Stenting – CBD stones, strictures and tumours
- Sphincterotomy- where the sphincter of Oddi is cut to enable passage of stones

Complications

- Perforation- of the oesophagus or duodenum
- Bleeding – following therapeutic procedures e.g. sphincterotomy
- Post-ERCP pancreatitis
- Post-ERCP cholangitis
- Respiratory depression and arrest – due to sedative over-medication

Imaging

Magnetic Resonance Cholangiopancreatography (MRCP)

A non-invasive imaging technique used to investigate the pancreatic ducts and intra- and extra-hepatic biliary ducts.

It avoids the morbidity associated with ERCP; however, it cannot be used to perform therapeutic interventions.

Ultrasound

Ultrasound is an important imaging modality when investigating both intra-abdominal and biliary disease. This technique enables detailed visualisation of abdominal and biliary structures whilst remaining a non-invasive and relatively cheap imaging technique. It can also be used to guide biopsies of specific lesions.

Indications

- Gallstones and biliary tract obstruction – first line investigation
- Abdominal masses and organomegaly
- Ascites
- Imaging of the small bowel

X-rays

Abdominal x-rays are commonly used to investigate:

- Paralytic ileus
- Intestinal obstruction

They may also detect:

- Gallstones
- Calcified lymph nodes
- Renal stones

An erect chest x-ray may also be performed if perforation is suspected. This would be indicated by the presence of free air under the diaphragm.

- Contrast studies.
  - These are x-rays that are performed after ingestion of contrast medium.
  - They may be used to investigate: anatomical abnormalities (e.g. perforation or fistula) or disorders of motility (e.g. achalasia).
  - Endoscopy and more detailed imaging techniques have largely superseded the need for these studies.

Computed Tomography (CT)

Abdominal CT scanning is used for the evaluation of acute abdominal pain with a major role in the evaluation of renal calculi, acute appendicitis and complex abdominal pathology.

Indications include:

- Differentiation of causes of bowel obstruction ± signs of perforation
- Evaluation of complications of hernias, pancreatitis, biliary obstruction, acute vascular compromise and abdominal aneurysm.

It is also used in planning of surgical treatment and in the diagnosis of postoperative complications. The patient must have adequate renal function and no known history of allergy before giving IV iodinated contrast. This contrast is nephrotoxic.

Magnetic Resonance Imaging (MRI)

MRI scanning is extremely useful for providing highly detailed images of soft tissues. It does not involve any radiation, and the contrast used, gadolinium, is less allergenic than the iodine-based contrast used in CT scanning. Unfortunately, MRI scanning of the abdomen is a lengthy procedure and patients are required to lie still for extended periods of time

MRI scanning is contraindicated in the presence of foreign bodies or metallic implants such as pacemakers, aneurysm clips, intra-ocular foreign objects and some cardiac stents

Common Procedures in Upper GI Surgery

Cholecystectomy

Indications

- Symptomatic gallstones.
  - A cholecystectomy will not be performed with asymptomatic gallstones
- Acute cholecystitis.
- Gallbladder polyps and cancer (rare).

Presentation

Gallstones can be completely asymptomatic, or may present in a variety of ways from biliary colic to gallstone ileus.

Symptoms of biliary colic include:

- Right upper quadrant pain.
  - Associated with radiation through to the back typically after the ingestion of fatty foods.
  - If the stone impacts in the gallbladder neck, acute cholecystitis can ensue which may cause right upper quadrant pain which is continuous and referred to the right shoulder due to the dermatomal distribution of pain.
- Positive Murphy's sign.
  - Pain on inspiration during palpation under the subcostal margin.
- Pyrexia.
  - Suggests evidence of inflammation differentiating it from simple biliary colic.
- If the stone obstructs the common bile duct patients will also present with jaundice, pale stools and dark urine.
- Acute cholangitis occurs when an infection supersedes resulting in right upper quadrant pain, jaundice and pyrexia (Charcot's triad).

Investigations

Blood Tests

- FBC, LFTs, U&E
- CRP
- Amylase – to exclude pancreatitis

If the patient has presented with biliary colic the blood results will usually be within normal limits. If, however, the patient has acute cholecystitis there will be increased inflammatory markers, a raised bilirubin level and potentially peripheral leukocytosis evident on blood results. Obstruction of the CBD usually present with deranged LFTs – the gamma glutamyl transferase (GGT) and alkaline phosphatase (ALP) levels would be raised.

As well as the above blood tests, it is important to work out the location of the stone. If a stone is in the gallbladder or cystic duct, a laparoscopic cholecystectomy can be performed.

If the stone is in the common bile duct the patient may require an ERCP (endoscopic retrograde cholangiopancreatography) in the emergency phase or an OTC (on the table cholangiogram) with CBD exploration during the laparoscopic cholecystectomy.

To determine the location of the stone the following investigations may be performed:

USS Scan

- This is the gold standard of investigations for gallstones
- It may show thickening of the gall bladder in cholecystitis or dilation of the extra and intrahepatic ducts if the CBD is obstructed.

MRCP

- This is used for further investigation if tests indicate an obstructing gallstone in the common bile duct (CBD).

Clinical Anatomy

The gallbladder is divided into four parts: the fundus, body, neck and Hartmann's pouch. Hartmann's Pouch is an out-pouching at the junction of the neck of the gallbladder and the cystic duct where gallstones commonly get stuck. An overview of anatomy can be seen in Fig. 19.2.

The cystic artery supplies the gallbladder and most commonly originates from the right hepatic artery. A networking of branching vessels arises from the cystic artery and supplies part of the common bile duct and hepatic ducts. Venous drainage consists of multiple, small veins that empty into the portal circulation.

Calot's triangle is bound by the cystic artery, cystic duct and common hepatic duct; it is an important anatomical landmark when performing a cholecystectomy. The hepatocystic triangle is also bound by the cystic duct and common hepatic duct but its upper margin differs; formed by the inferior border of the liver.

Lund's node is a lymph node found in the triangle and can become enlarged in cholecystitis or cholangitis.

Bile leaves the gallbladder via the cystic duct, which joins the common hepatic duct to form the common bile duct distally. Bile passes through the biliary tree and empties into the 2nd part of the duodenum via the ampulla of Vater, which is surrounded by a ring of circular muscle called the sphincter of Oddi.

Laparoscopic Cholecystectomy

Step-by-Step Summary: Laparoscopic Cholecystectomy (aka 'Lap Chole')

1. This is normally a four port technique: one for the camera, one for an instrument to retract the gallbladder and two for instruments to perform the procedure.
2. The gall bladder is retracted up and over the liver to display Calot's triangle/hepatocystic triangle.
3. Careful dissection of the peritoneal fold and fascia surrounding and within the triangle is used to identify the cystic duct and cystic artery, which are clipped and then cut.
4. The gallbladder is dissected off the liver bed using diathermy.
5. Once the gallbladder has been freed a bag is placed in the abdominal cavity and the gallbladder is placed in it.
6. Haemostasis is checked and the area may be washed with fluid, particularly if there has been some bile spillage.

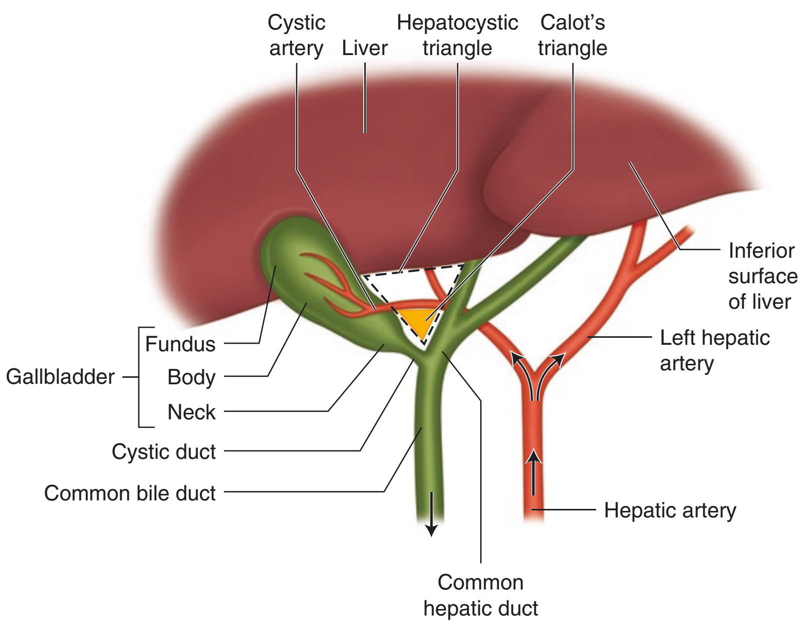

Fig. 19.2 Relevant surgical anatomy for a cholecystectomy

7. The gallbladder is removed from the abdomen in the bag and all port sites closed.

Note that there are also single port 3D laparoscopy technologies available on the market. The first 3D laparoscopic surgery was performed in London in 2013. These machines utilize the same polarized 3D technology used in 3D cinema, with the intention of reducing error and improving surgeon performance. These are becoming more commonplace in the USA and India, but are still unusual in the UK.

Complications

- Bile spillage/gallstone spillage.
- Injury to the common bile duct.
- Retention of a stone within the common bile duct.
- Injury to the bowel.

Development of these complications may necessitate conversion to an open procedure.

Surgeons' Favourite Questions for Students

1. Describe the anatomy of the gallbladder and biliary tree.
2. What is Calot's triangle or the hepatocystic triangle?
3. What are the basic steps to of a laparoscopic cholecystectomy?
4. What is an ERCP and when it is indicated?
5. Can you tell me any common anatomical variations of the cystic duct and cystic artery?

Oesophagectomy

Indications

- Cancer of the oesophagus – adenocarcinoma or squamous cell carcinoma.
- High-grade dysplasia in Barrett's oesophagus.
- Oesophageal strictures
- Rupture of the oesophagus

Presentation

- Dysphagia – usually progressive and often painless
- Hoarseness of voice
- Weight loss and loss of appetite
- Retrosternal chest pain
- Lymphadenopathy

Investigations

Blood Tests

- FBC, LFTs, U + E.

Flexible Oesophagogastroduodenoscopy (OGD)

- The gold standard investigation.
- Enables biopsy and brushings to be taken.

CT Scan

- Can detect metastatic disease and lymph node involvement, and determine the extent of oesophageal thickening.

Endoscopic Ultrasonography (EUS)

- An important staging modality.
- Used to assess the degree of invasion in to the oesophageal wall, to identify any enlargement or abnormality in the coeliac axis and to determine if there is mediastinal lymph node involvement.
- Any suspicious nodes can be sampled by fine needle aspiration.

PET Scan

- Performed to identify rapidly proliferating cells and as such can be used for diagnosis, staging and monitoring.

Laparoscopy

- This is performed for examination of any peritoneal masses and allows for tissue biopsies.

Clinical Anatomy

The oesophagus is a muscular tube, approximately 25 cm in length, which extends from the inferior border of the cricoid cartilage to the cardia of the stomach. It can be divided into cervical, thoracic and abdominal parts. The oesophageal wall includes an outer adventitia, a layer of longitudinal muscle, an inner circular muscle layer and the mucosa consisting of predominantly stratified squamous epithelium.

There are four points where surrounding structures may cause narrowing or compression of the oesophagus:

1. At the junction with the pharynx.
2. Where the arch of aorta crosses it.
3. Where it is crossed by the left main bronchus.
4. As it passes through the diaphragm at the level of T10.

Step-by-Step Summary: Oesophagectomy

Oesophageal resection is restricted to disease confined to the oesophagus in patients fit enough for surgery. It involves resection of the primary tumour and lymphadenectomy. The method used to resect the tumour depends on its location and patient factors.

Chemotherapy and/or radiotherapy may be used as a neo-adjuvant or adjuvant.

Ivor Lewis Two-Phase Oesophagectomy

- This is the method of choice for middle and lower third tumours.
- It involves mobilisation of the stomach and lower oesophagus by laparotomy.
- The oesophagus is then resected after a right thoracotomy.
- Finally, the stomach is brought up into the thoracic cavity and anastomosed with the remainder of the upper oesophagus.

Left Thoracotomy

- This is the preferred method for tumours at the oesophageal gastric junction.
- It is used particularly if further gastric resection is required.

Transhiatal Oesophagectomy

- This is used in elderly patients in order to avoid thoracotomy.
- It is also suitable for patients with early stage tumours or high grade dysplasia.
- It is a 2-surgeon technique; one surgeon approaches through the neck whilst the other approaches through the abdomen.
- The upper oesophagus is mobilised and extended down in to the chest whilst the stomach and lower oesophagus are mobilised through the hiatus, up into the neck for anastomosis to the proximal oesophagus.

Reconstruction

- The preferred route for reconstruction of the oesophagus is posterior mediastinal.
- If the stomach cannot be used, segments of the small intestine or colon can be used for reconstruction.

Post-operatively

- Patients will be managed initially in HDU/ITU.
- A feeding jejunostomy, which is inserted during surgery, is used to provide nutrition.

Complications

- Chest infections
- Anastomotic leak
- Conduit necrosis
- Gastric outlet obstruction
- Benign anastomotic stricture

Follow Up

- Patients undergoing a oesophagectomy are followed up closely in clinic.
- Unfortunately, the procedure is associated with a poor prognosis with only a 20 % survival rate after 5 years.

Surgeons' Favourite Questions for Students

1. What is the blood supply of the oesophagus?
2. What are the indications for an oesophagectomy?
3. What are the four narrowest points of the oesophagus?
4. At what level does the oesophagus pass through the diaphragm?

Anti-reflux Surgery

Gastro oesophageal reflux disease (GORD) is caused by excessive reflux of gastric acid into the oesophagus, and large hiatus hernias.

Symptoms of GORD occur as a result of a weakness of the lower oesophageal sphincter (LOS). The aim of surgery is to reconstruct an anti-reflux valve at the gastro-oesophageal junction (GOJ).

Presentation

- Epigastric pain.
- Retrosternal pain (heartburn).
- Odynophagia (pain on swallowing).
- Dysphagia (difficulty swallowing).
- Persistent vomiting – resulting in progressive weight loss.

Investigations

- Upper GI endoscopy – this is done to assess the degree of oesophagitis and to investigate for hiatus hernia.
- 24-h ambulatory pH monitoring – this is to assess reflux.
- Manometry – used to exclude primary oesophageal motility disorders.

Clinical Anatomy

The oesophagus is a muscular tube connecting the pharynx to the cardia of the stomach. It passes through the diaphragm into the abdomen at the level of T10. It has a lower oesophageal sphincter where it meets the stomach, which prevents acid and stomach contents refluxing into the oesophagus.

The oesophageal branches of the left gastric artery supply the lower third of the oesophagus. The vagus nerve, CN X, lies in close proximity to the oesophagus; the left vagus lies anteriorly and the right vagus lies posteriorly.

The stomach is divided into the fundus, cardia, body and pylorus. It has a lesser and greater curvature and connects to the duodenum at the pylorus. The lesser curvature of the stomach is supplied by the left gastric artery superiorly and the right gastric artery inferiorly. The greater curvature of the stomach is supplied by the left gastro-epiploic artery superiorly and the right gastro-epiploic artery inferiorly. The short gastric artery supplies the fundus of the stomach.

Laparoscopic Anti-reflux Surgery: Nissen's Fundoplication

Step-by-Step Summary: Nissen's Fundoplication

1. The patient is positioned in the reverse Trendelenburg position.
2. The surgeon is usually positioned between the legs, with assistants on the patient's left and right sides.
3. A five port technique is used – one for the camera, one for a fan retractor to retract the liver, two ports for the surgeon's instruments to perform the procedure and one port for the assistant's instruments to retract tissue to create views for the surgeon.
4. The oesophagus and the gastric fundus are mobilised whilst preserving the vagus nerve.
5. The fundus of the stomach is brought around the oesophagus from behind and sutured anteriorly to form a wrap around the lower part of the oesophagus. The short-gastric vessel may be divided to achieve full fundal mobilisation
6. A bougie is introduced orally into the intra-abdominal oesophagus to calibrate the size of the wrap.

Complications

- Postoperative dysphagia
- Bloating
- Hiatal stenosis/hiatus herniation
- Vagus nerve injury
- Perforation (oesophageal, gastric, duodenum, bowel)
- Pneumothorax
- Pneumomediastinum.
- Pulmonary embolism

Bariatric Surgery

Indication

Surgery is considered in patients with a BMI >40 kg/m^2 who will benefit from long-lasting weight loss and improvement in obesity-related co-morbidities such as Type 2 diabetes, hypertension, sleep apnoea, asthma, arthritic disease and depression.

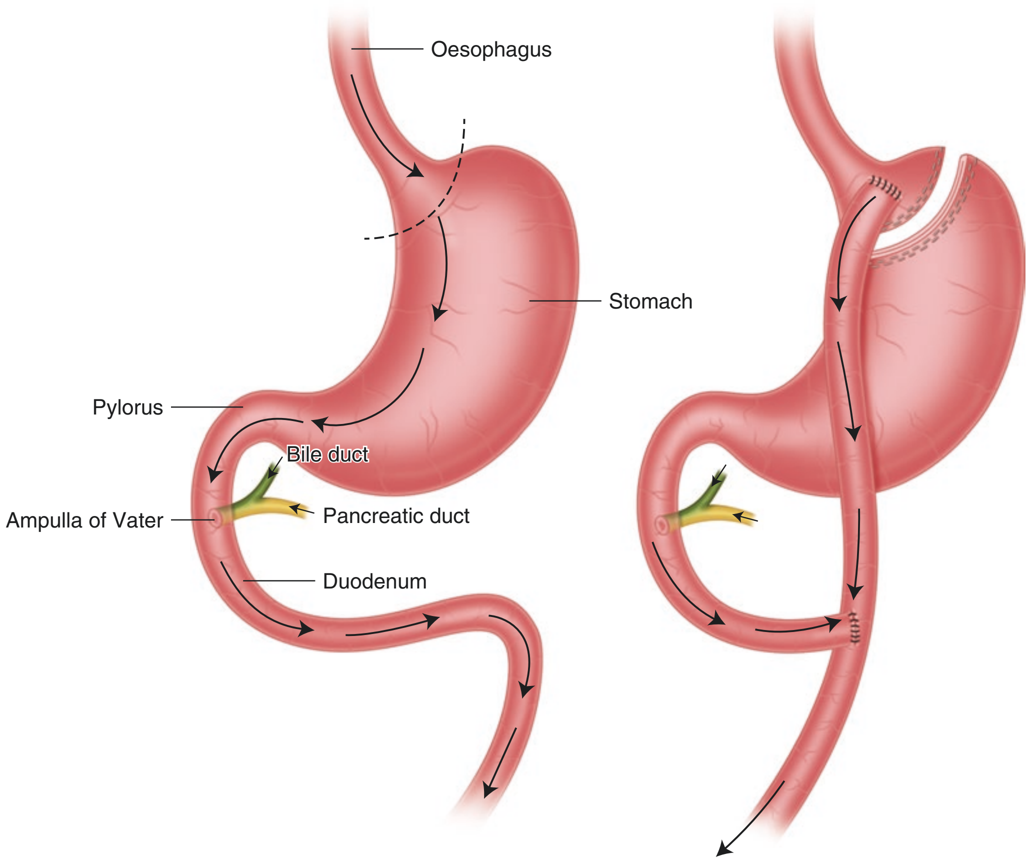

Fig. 19.3 A Roux en Y bypass, commonly used in bariatric surgery

Investigations

- BMI
- Obesity Surgery-Mortality Risk score (OS-MRS) is calculated.

Roux-en-Y Gastric Bypass Surgery

- A small proximal pouch of the stomach is created and anastomosed to a limb of jejunum to bypass the stomach and duodenum, as shown in Fig. 19.3.

Complications

- Anastomotic leaks
- Bleeding from the staple line
- Closed-loop obstruction
- Stricture at the pouch-enterostomy
- DVT and PE

Gastric Sleeve

- A gastric pouch/tube is created using a linear stapler along the greater curvature of the stomach starting close to the pylorus.
- The lesser curvature pouch/tube is formed using a bougie, which is introduced orally.
- One major complication is leakage along the staple line.

Gastric Banding

- A band is placed around the gastro-oesophageal junction with an attached port to allow for inflations and deflation of the band.

Complications

- Band slippage/erosion.
- Infection of the gastric band port.

Liver Resections

Indications

- Metastatic tumours – most commonly colorectal in origin.
- Primary hepatic malignancy e.g. hepatocellular carcinoma.
- Biliary malignancy e.g. cholangiocarcinoma.

Presentation

Liver malignancy may present with:

- Non-specific constitutional symptoms, in particular weight loss.
- Symptoms/signs of liver dysfunction.
  - Deranged liver function tests
  - Jaundice
- Right upper quadrant pain.

Metastatic tumours are often asymptomatic and detected during staging investigations for malignancy in other tissues. In this case, symptoms of the primary tumour may also dominate the clinical picture.

Tumours impinging on the biliary tree may also present with obstructive jaundice.

Investigations

Blood Tests

- Liver function tests – likely to be abnormal in patients with malignancy in the liver.
- α-fetoprotein – a raised level suggests a primary hepatocellular carcinoma.
- Carcinoembryonic antigen (CEA) – if raised, this supports the likelihood of a colorectal primary malignancy with metastatic spread to the liver.

Imaging

- Abdominal ultrasound scan – useful to determine the number and size of any hepatic lesions.
- Contrast-enhanced CT scan – to determine the number and size of hepatic lesions, as well as for the detection of any extra-hepatic metastases.

Clinical Anatomy

Anatomically, the liver is divided into the larger right lobe and smaller left lobe. This division is demarcated by the ligamentum teres – the embryological remnant of the umbilical vein. Within the larger right lobe, a further two anatomical lobes arise, the caudate and quadrate lobes.

The liver has a dual blood supply:

- The common hepatic artery arises from the coeliac trunk, and becomes the hepatic artery proper after the cystic artery is given off. This divides into left and right hepatic arteries to supply the left and right lobes respectively.
- The portal vein, draining blood from the gastrointestinal tract, is the source of 80 % of the hepatic blood supply.
- The liver is drained by left, middle and right hepatic veins into the inferior vena cava.

An important anatomical division, with respect to liver resection, is the *functional* division of the liver. This also divides the liver into two lobes, the left and the right, in a sagittal plane. This plane is known as Cantlie's line. Cantlie's line extends posteriorly from the inferior vena cava to the middle of the gallbladder fossa anteriorly.

The liver is further divided into eight segments (I to VIII) based on the distribution of the portal triad structures (hepatic artery, portal vein and bile duct). The functional right lobe consists of segments V, VI, VII and VIII, while segments II, III and IV make up the left lobe. Segment I corresponds to the caudate lobe, which is functionally distinct from the rest of the liver.

Types of Liver Resection

1. Segmentectomy – this involves the removal of a single liver segment.
2. Right hepatectomy – this is the resection of segments V-VIII.
3. Left hepatectomy – this is the resection of segments II-IV.
4. Right lobectomy/extended right hepatectomy – this involves the resection of all segments lateral to the umbilical fissure i.e.: IV-VIII ± I.
5. Left lobectomy – this is the resection of segments medial to the umbilical fissure i.e.: II and III.
6. Extended left hepatectomy – this involves the resection of segments II-IV, plus part of the right liver (segments V and VIII).

Step-by-Step Summary: Liver Resection

1. The abdominal cavity is opened using a bilateral subcostal incision.
2. A laparotomy is performed in patients with malignancy to exclude spread to other regions of the peritoneum and regional lymph nodes.
3. The position of the tumour is confirmed by palpation and using intraoperative ultrasound scanning.
4. The arterial supply and venous drainage system of the section of liver being removed must be identified and controlled using diathermy for the smaller vessels or ligation/clips for the larger vessels.
5. The appropriate portion of the liver is separated and removed.
6. The surface of the remaining liver is examined and any bleeding controlled.
7. A large tube drain is placed and the wound closed.

Complications

- Death
- Post-operative liver failure
- Wound infection
- Bleeding
- Pneumonia
- Intra-abdominal abscess
- Bile leaks

Pancreaticoduodenectomy (Whipple's Procedure)

Definition

Classical – removal of the head of the pancreas, the distal stomach and associated omentum, the duodenum and upper jejunum, the gallbladder and the distal biliary tree.

Pylorus-preserving – leaves the stomach and pyloric antrum intact (see Fig. 19.4)

Indications

The Whipple's procedure is most commonly performed to resect tumours of the pancreas, biliary tree or duodenum with curative intent. Common lesions include:

- Ductal adenocarcinoma of the head of the pancreas
- Cholangiocarcinoma
- Ampullary/periampullary tumours
- Duodenal tumours
  - Primary adenocarcinoma
  - GIST
  - Lymphoma

It may be also be used to treat chronic pancreatitis where an inflammatory mass has developed in the head of the pancreas and may be compressing the biliary tree or duodenum.

Presentation

Pancreatic Tumours

- Vague abdominal pain.
  - May radiate through to the back
- Weight loss
- Obstructive jaundice

Chronic Pancreatitis

- Recurrent attacks of acute pancreatitis
- Persistent abdominal pain
- Weight loss and malabsorption due to pancreatic insufficiency
- There may be signs of compression on surrounding structures

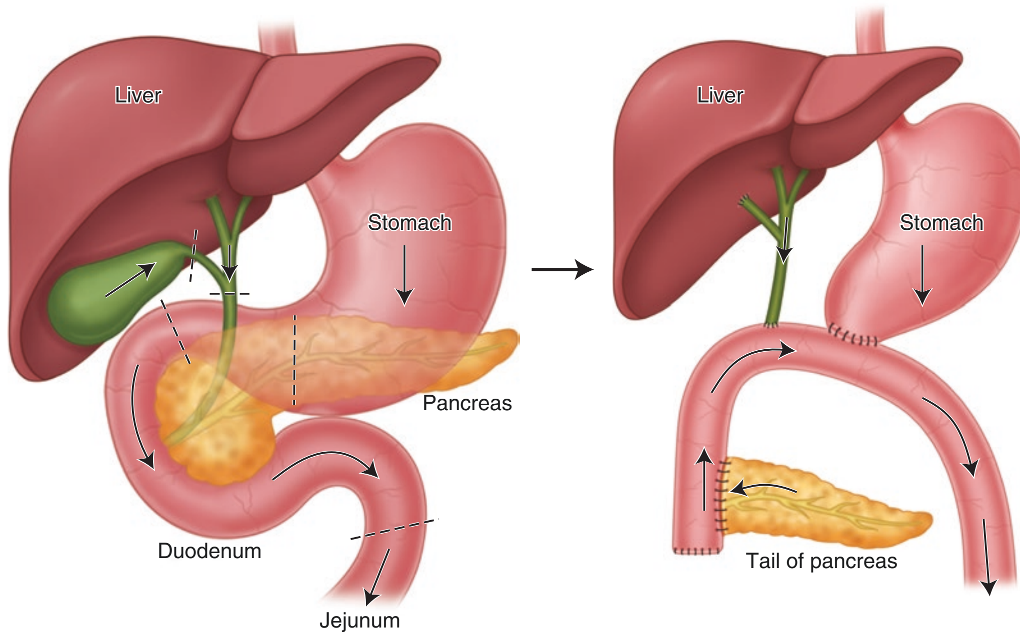

Fig. 19.4 A diagram showing the anatomy before and after a Whipple's procedure

Investigations

- LFTs – may show an obstructive picture with raised GGT and ALP if there is obstruction of the biliary tree, although this is a nonspecific finding.
- Imaging – to identify the tumour. Common modalities used are ultrasound scan and CT scan.

Tumour Staging

- CT abdomen and chest
- MRCP and/or EUS
- Laparoscopy

Accurate staging of tumours is essential as the Whipple's resection is only undertaken when there is a high chance of achieving total resection of the malignant tissue. Imaging modalities for tumour staging include CT scan (of both the abdomen and the chest), MRCP and/or EUS and laparoscopy.

Clinical Anatomy

The majority of the pancreas lies posterior to the stomach in the retroperitoneal space, except for a part of the tail that contacts the spleen.

The head of the pancreas sits in the C-shaped curve formed by the duodenum. Posterior to the neck, the superior mesenteric vein (SMV) joins with the splenic vein to form the portal vein. This is important, as the SMV will need to be separated from the pancreas during a resection.

The exocrine glands of the pancreas drain into the second (descending) part of the duodenum via the main and accessory pancreatic ducts. The accessory pancreatic duct enters the duodenum through the minor duodenal papilla, while the main duct joins with the common bile duct at the ampulla of Vater and opens into the duodenum through the major duodenal papilla (or Sphincter of Oddi). The duodenum connects to the jejunum at the duodenojejunal flexure, which is surrounded by the suspensory ligament of the duodenum, or ligament of Treitz (a fold of peritoneum).

The blood supply to the head of the pancreas is derived from the superior and inferior pancreaticoduodenal arteries, the former arising from the gastroduodenal artery (a branch of the common hepatic artery) and the latter a branch of the superior mesenteric artery. The gastroduodenal artery will need to be identified and ligated during the procedure.

Blood draining from the head of the pancreas empties into the portal system via the inferior and superior pancreaticoduodenal veins.

Step-by-Step Summary: Resection of Pancreatic Cancer

A laparotomy is carried out to confirm the accuracy of pre-operative staging and the feasibility of curative resection.

Resection

1. The abdomen is opened using a bilateral subcostal, or transverse, abdominal incision.
2. The SMV is identified and separated from the overlying neck of the pancreas.
3. The gastrohepatic ligament is divided to expose the portal triad.
4. This is followed to identify the gastroduodenal artery, which is then ligated.
5. The gallbladder is removed by ligating the cystic artery and common hepatic duct above the cystic duct.
6. The stomach is divided through the lesser curvature, the pancreas through the neck and the jejunum 15 cm distal to the ligament of Treitz.
7. The distal stomach, duodenum, pancreatic head and proximal jejunum are removed.

In the pylorus-preserving variant of the procedure, the duodenum is divided just distal to the pylorus.

Reconstruction

1. Anastomoses are created between the remaining jejunum and the remaining pancreas (pancreaticojejunostomy), the end of the hepatic duct (hepaticojejunostomy) and the stomach remnant (gastroenterostomy).
2. The abdominal cavity is washed out with saline and two drains are inserted through the anterior abdominal wall – one below the left lobe of the liver and the other into the hepatorenal space.
3. The incision is closed.

Complications

- Delayed gastric emptying
- Haemorrhage
- Haematoma
- Seroma – accumulation of serous fluid
- Ascites
- Abscess – hepatic, abdominal wall, retroperitoneal, intra-abdominal.
- Leakage from any of the anastomotic sites (may result in abscess formation)

Surgeons' Favourite Questions for Students

1. What is the blood supply to the pancreas?
2. How might a tumour of the pancreas present clinically?
3. What anastomoses will be needed to reconstruct the GI tract?

Lower Gastrointestinal (GI) Surgery

Common procedures of lower GI surgery include:

- Colostomy and ileostomy formation
- Colectomy
- Abdominal hernia repair
- Anorectal surgery

Colostomy and Ileostomy Formation

The identification of stomas is a common examination question. This section of the chapter shall therefore cover both colostomy and ileostomy formation and the indications for such surgery.

Indication

Stomas are created for both temporary and permanent defunctioning of the bowel.

They involve exteriorisation of the bowel and it's content to the abdominal wall.

Clinical Anatomy

- A colostomy is flat to the anterior abdominal wall and is typically situated on the left side of the abdomen. It is formed using the large bowel.
- An ileostomy on the other hand is a spouted stoma that is usually located on the right side of the abdomen and formed using the small bowel.
- A loop ileostomy is a temporary stoma whereby a loop of the small bowel is brought out to the abdominal wall with two limbs (proximal end which is spouted, and distal end).

- An end ileostomy or colostomy is a permanent stoma. One end of the stoma is permanently brought out to the anterior abdominal wall.

> **Surgeons' Favourite Questions for Students**
> 1. What are the differences between an ileostomy and a colostomy?
> 2. Where are the different types of stoma commonly sited?

Colectomy

Colectomy involves surgery to remove or resect all or part of the large bowel. The extent of the removal will vary depending on the site of the disease and the blood supply to the bowel.

The colon can be divided in to four sections:

1. The ascending colon
   - This is about 8 inches in length and extends from the caecum (the first portion of the large bowel) to the hepatic flexure.
2. The transverse colon
   - This is usually over 18 inches in length and extends across the upper abdomen from the hepatic to the splenic flexure.
3. The descending colon
   - This is typically less than 12 inches in length.
4. The sigmoid colon
   - This is S-shaped and measures around 18 inches. It extends from the descending colon to the rectum.

The hepatic flexure is formed where the ascending colon joins the transverse colon, and the splenic flexure where the transverse colon joins the descending colon.

For completeness, the caecum and the rectum are also part of the large bowel.

Indications

- Colorectal cancer – colectomy is the main stay of treatment for cancer. It can be curative or palliative. It may be combined with radiotherapy and chemotherapy.
- Colitis
- Complicated diverticulitis
- Intestinal obstruction
- Volvulus
- Ischaemic colon
- Hernias
- Atonic colonic segments
  – May be congenital or acquired
- Extra colonic malignancies

Presentation

This is dependent on the indication as described above. Typically, there will be a large bowel obstruction-like picture.

Other symptoms may include:

- PR bleeding
- Abdominal pain
- Change in bowel habit
- Tenesmus
- Vomiting (although this is a late sign)

Assessment of colorectal cancer involves pathological staging using the Duke's staging system. This can be summarized as follows: (see Table 19.1)

Investigations

Blood Tests

- FBC, LFTs, U+E.
- CRP
- Coagulation screen
- Group and save
- CEA

Imaging

- X-rays
  – Erect chest x-ray – to assess for air under the diaphragm and rule out perforation.
  – Abdominal x-ray.
- Colonoscopy or sigmoidoscopy.
- CT scan.
  – This is obtained to look for a mass, or other cause of the patient's symptoms.
  – It is also performed for staging of the tumour.

Table 19.1 Duke's staging for colorectal cancer

Dukes' stage	Description	5-year survival rate
A	Tumour confined to the bowel wall; no lymph node involvement	90 %
B	Tumour outside of bowel wall; no lymph node involvement	70 %
C	Lymph node involvement; C2 if the highest node is involved, otherwise C1	C1 – 60 % C2 – 35 %
D	Distant metastasis	~15 %

Clinical Anatomy

- The ascending and descending colon are retroperitoneal, while the transverse colon and sigmoid colon are intraperitoneal.
- The main blood supply to the colon is from the superior and inferior mesenteric arteries.
- The right colic artery and the ileocolic artery provide the right side of the colon.
- The marginal artery provides the blood supply to the transverse colon.
- The arterial supply to the left colon is supplied principally by the middle colic artery and the inferior mesenteric artery.
- The venous drainage of the right colon is through the superior mesenteric vein, whilst the venous drainage of the left colon is through the inferior mesenteric vein.
- The marginal artery of Drummond and the arc of Riolan provide the collateral blood supply.

Procedures

1. ***Total colectomy*** – this involves removal of the entire colon (proctocolectomy = including rectum)
2. ***Right hemicolectomy***
   - Tumours or lesions in the ascending colon are treated by removal of the distal 5cm of the terminal ileum, caecum, ascending colon, hepatic flexure and proximal to the mid-transverse colon.
   - The dissection also includes the right branch of the middle colic artery.
3. ***Left hemicolectomy***
   - This is the treatment required for a tumour or lesion in the descending colon.
   - The splenic flexure is taken down and anastomosis of the transverse colon to the upper sigmoid performed.
   - Depending on the extent of the lesion, the sigmoid colon may also be resected, in which case the transverse colon would be anastomosed to the rectum.
4. ***Sigmoid colectomy***
   - Tumours or lesions in the sigmoid colon are treated by resection of the sigmoid colon with anastomosis of the descending colon to the upper rectum.
5. ***Anterior resection***
   - Tumours in the upper part of the rectum and lower part of the sigmoid colon are treated by removal of the rectum and sigmoid colon with anastomosis of the colon to the rectal stump.
   - The dissection is below the anterior reflection of the peritoneal lining and requires a circumferential dissection of the fascial envelope around the rectum.
     – This is termed a total mesorectal excision (TME).
   - If the cancer is in the mid to lower rectum and complete TME is performed, a 2 cm distal margin above the dentate line is needed. If the tumour is too low and a margin cannot be obtained, the sphincter complex must be removed and a permanent colostomy is required – this procedure is called an Abdominoperineal resection.
   - Depending on the length of the rectal stump, a colonic pouch may be created.
     – This is also called a J-pouch.
     – It provides better continence postoperatively by acting as an additional reservoir to store stool.
     – It is created by stapling/sewing loops of colon together to create a pouch, which is then attached to the anus.
6. ***Abdominoperineal (AP) resection***
   - Tumours low in the rectum are treated through removal of the entire rectum and part of the sigmoid colon.
   - The end of the remaining colon is brought out as a colostomy.

Step-by-Step Summary: Colectomy

Before surgery, the bowel must be prepared to decrease the incidence of infection. This preparation begins a few days before surgery (in an elective setting). The patient is placed on a low residue diet for 2–3 days and is kept nil by mouth from midnight the day of the surgery.

The patient is usually admitted the day before the surgery for bowel cleansing.

1. For left and sigmoid colectomies, and for low anterior resections, the patient should be placed in the lithotomy position. For right colectomy and AP resections the patient should be placed in the supine position.
2. A vertical incision is made and continued through the abdominal wall until the bowel is exposed.
3. The small bowel is placed in the right upper quadrant, exposing the inferior mesenteric artery takeoff from the aorta. This is then dissected and the vessel clamped.
4. A midline incision is made for a right hemicolectomy and the small bowel retracted to the left side. The ileocolic vessel is then dissected at the inferior edge of the duodenum and the right branch of the middle colic artery divided.
5. The peritoneum is incised and the ureters identified.
6. The entirety of the bowel is then examined and the area for resection identified.
7. The diseased portion of the bowel is isolated by placing soft clamps at each of the healthy ends of the bowel.
8. Crushing clamps are then applied between the soft clamps and the affected bowel is transected.
9. The resected part of the bowel is sent for histology.
10. The two cut ends of the remaining healthy bowel are then joined together to form an anastomosis
11. This anastomosis is commonly secured using a stapler.
12. A circular stapler is used during a left hemicolectomy, sigmoid colectomy, anterior resection and AP resection. This involves placing a purse string suture and placing the anvil of the stapler into the colon lumen. The purse string is then tied.
13. A linear stapler is used during a right hemicolectomy to close a side-to-side functional end-to-end anastomosis.
14. In an emergency, or for protection of the anastomosis in some instances, a defunctioning stoma is formed at the same time.
15. This stoma may be a temporary stoma and reversed at a later stage or it may be permanent if reversal is not possible and an end stoma formed (Hartmann's procedure).

Surgeons' Favourite Questions for Students

1. What makes a good anastomosis?
2. Describe the blood supply to the bowel
3. How can you tell the difference between small and large bowel?
4. What is the Duke's staging system?

Abdominal Hernia Repair

A hernia is defined as an abnormal protrusion of a viscus through an opening or a weakness in the wall of its containing cavity.

Presentation

A hernia typically presents as a bulge, which if incarcerated can be acutely tender. The skin overlying it may be discoloured or erythematous.

Strangulated hernias containing bowel require emergency attention and patients present with signs of obstruction including vomiting, bowels not opening and abdominal distension.

Hernias can be described as:

- Reducible – can be reduced back into its cavity.
- Incarcerated – cannot be reduced back into its cavity.
- Strangulated – cannot be reduced back into its cavity and the vascular supply is compromised leading to ischaemia/gangrene.

There are several types of hernia, as shown in Fig. 19.5:

- Inguinal.
  – There are two types: direct and indirect.
- Umbilical.
- Femoral.
- Epigastric.
  – The result of herniation through a fascial defect in the linea alba
- Incisional.
  – Herniation through an iatrogenic defect.
- Congenital.
  – Viscera herniates in to the tissue of the umbilical cord.
  – These are particularly common in premature babies.
  – They typically resolve within a year of birth.

Investigations

- Clinical examination.
- Abdominal x-ray.
  – This is done to check for signs of bowel obstruction.
  – If obstructed, an ABG should be done to check the lactate level.
- Ultrasound scan.
- CT scan.
  – This can be requested if an incarcerated or strangulated hernia is suspected.

Clinical Anatomy

It is important for you to know about inguinal hernias in detail, as these are the most common type (see Fig. 19.6).

The inguinal canal is approximately 4 cm in length and bounded by four walls:

1. Superiorly – fibres of the internal oblique and transverse abdominal walls
2. Anteriorly – aponeuroses of the external oblique and the superficial inguinal ring
3. Inferiorly – inguinal and lacunar ligaments
4. Posteriorly – transversalis fascia, deep inguinal ring and conjoint tendon

The deep (internal) ring lies approximately 1 cm above the midpoint of the inguinal ligament (between the pubic tubercle and the anterior superior iliac spine of the pelvis) and is an opening in the transversalis fascia.

The superficial (external) ring is approximately 1 cm above the pubic tubercle and is an opening in the external oblique aponeurosis.

The inguinal canal allows for the passage of the spermatic cord and ilioinguinal nerve into the scrotum (male) and the round ligament of the uterus and ilioinguinal ligament (female).

The contents of the spermatic cord are described in threes:

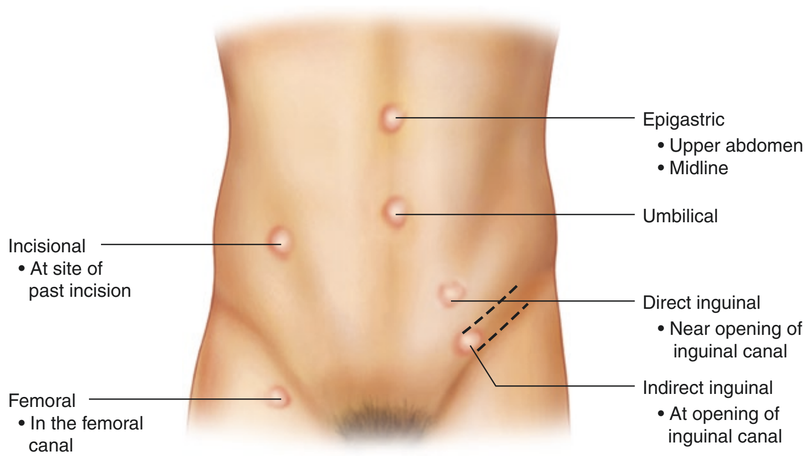

Fig. 19.5 Locations of different types of hernias

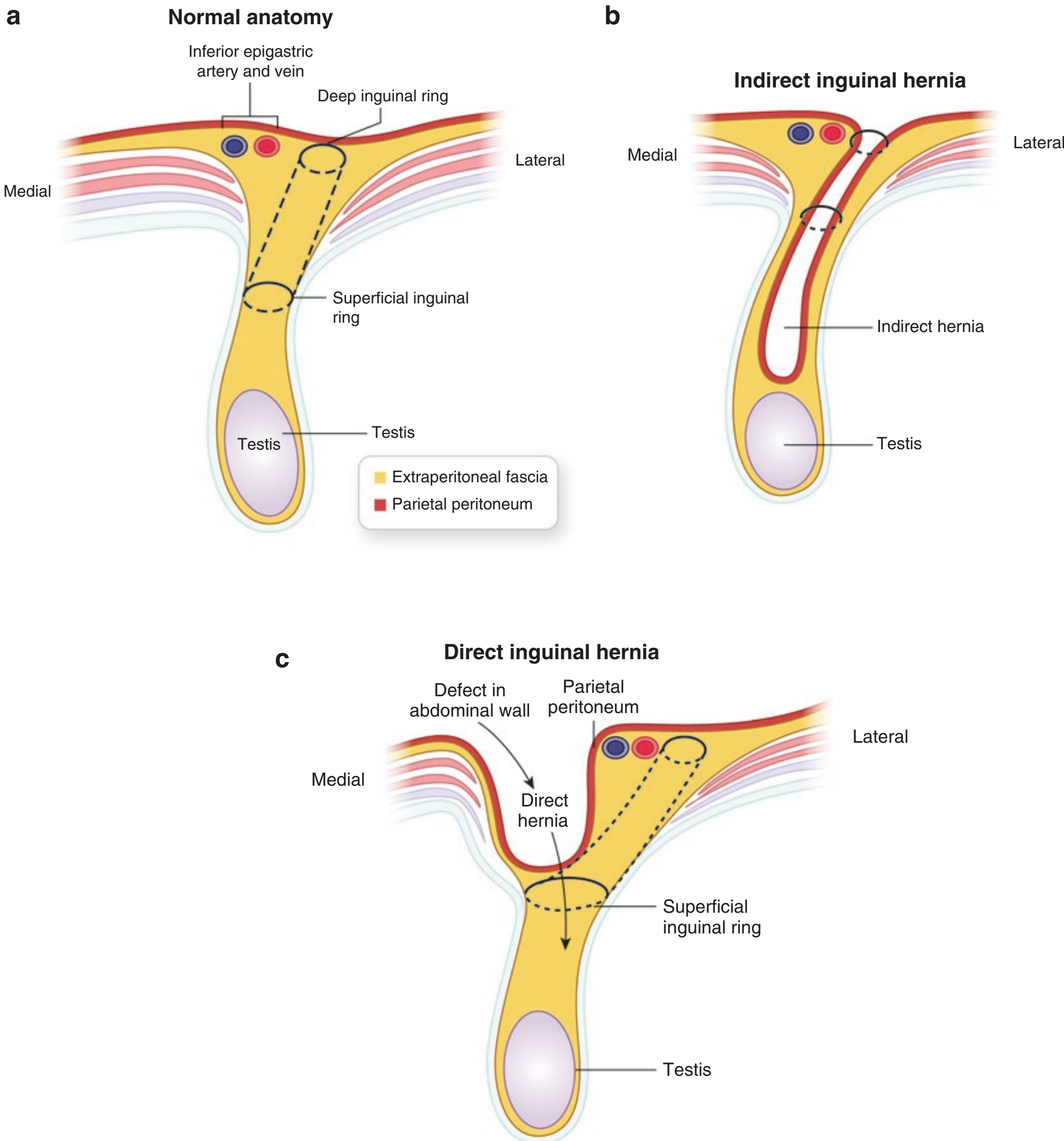

Fig. 19.6 Direct and indirect inguinal hernias

- Three layers of fascia: external spermatic fascia from the external oblique aponeurosis, cremasteric fascia from the internal oblique aponeurosis, and internal spermatic fascia from the transversalis fascia.
- Three arteries: testicular, cremasteric and the artery to the vas deferens.
- Three nerves: genital branch of the genitofemoral nerve, sympathetic nerves and the ilioinguinal nerve – although this actually lies on the cord, not within it.
- Three other structures: vas deferens, pampiniform plexus of veins and lymphatics.

In an indirect hernia the sac protrudes through the deep inguinal ring and travels in the inguinal canal. In a direct hernia the herniation occurs through a weakness in the posterior wall.

Hernias that require an operation can be repaired by an open or laparoscopic technique (TAPP – trans abdominal approach or TEPP – total extraperitoneal approach) using a synthetic mesh to reinforce the defect. Here we will describe the open technique.

Open (Lichtenstein) Tension Free Repair Inguinal Hernia

Step-by-Step Summary

1. A curvilinear incision is made approximately 2 cm above the inguinal ligament (through the skin, Camper's fascia and Scarpa's fascia) to reach the inguinal canal.
2. The inguinal canal is opened by incision of the external oblique aponeurosis (anterior wall on the inguinal canal).
3. The spermatic cord is identified from the pubic tubercle and protected in a hernia ring.
4. The hernia sac is identified, separated from the cord and reduced back through the defect.
5. The posterior wall (transversalis fascia) repaired with non-absorbable sutures and the defect is reinforced with a prosthetic mesh.

Complications

- Recurrence of hernia
- Ischaemic orchitis
- Testicular atrophy
- Numbness secondary to nerve injuries
- Mesh infection

Surgeons' Favourite Questions for Students

1. Define a hernia.
2. Can you name the common types of hernias?
3. What is the difference between a direct and indirect inguinal hernia?
4. What are the boundaries and contents of the inguinal canal?
5. Describe the management of a hernia including conservatively, medically and surgically.

Anorectal Surgery

Anal Fistulotomy

A fistula is an abnormal tract that connects two epithelial surfaces and is lined by either epithelial or granulation tissue.

An anal fistula is a persistent tract from the anal canal to the perianal skin. It commonly occurs in those with anorectal abscesses. The tract is lined with granulation tissue and connects an internal (primary) opening inside the anal canal to an external (secondary) opening in the skin.

All symptomatic anal fistulae should be treated surgically with the aim to obliterate the internal fistulous opening.

Classification

Classification is dependent on the anorectal space from which the abscess causing the fistula arises:

- **Intersphincteric**
  - These account for 70 % of anal fistulae.
  - They usually result from a perianal abscess.
  - A tract forms from the abscess via the internal sphincter to the intersphincteric space and out to the perineum.
- **Transsphincteric**
  - These account for around 25 % of fistulae.
  - They usually arise from an ischioanal abscess.
  - A tract develops from the abscess via both the internal and external sphincters and into the ischiorectal fossa. It then externalises out to the perineum.
- **Suprasphincteric**
  - These account for just 5 % and typically result from a supralevator abscess.
  - The tract develops in the intersphincteric space and forms superiorly into the ischiorectal fossa and then to the perineum.
- **Extrasphincteric**
  - These account for only 1 % of all anal fistulae.
  - Causes include:
    Iatrogenic injury from probing.
    Penetrating injury to the perineum or rectum.

Crohn's disease.
Carcinoma (and its treatment).
– A tract passes from the rectum, through the levator ani muscles and out to the perianal skin.
– The sphincter mechanism is avoided completely.

Clinical Anatomy

The anal canal is around 2–4 cm in length. It is located between the anorectal ring superiorly and the anal verge inferiorly. It is lined by columnar cells, transitional epithelium and non-hair-bearing squamous epithelium.

There are two muscular structures surrounding the anal canal. The inner muscular structure consists of the internal anal sphincter. This is a continuation of the inner, circular muscle layer of the rectum and is under involuntary control. The outer muscular structure consists of the external anal sphincter and the puborectalis. The external anal sphincter is made up of three parts:

1. Subcutaneous
2. Superficial
3. Deep

It is under voluntary control.

The dentate line is 1–2 cm proximal to the anal verge. It is the embryological fusion point of the endoderm and ectoderm and marks a separation between the innervation, blood supply and lymphatic drainage. The terminal branches of the superior rectal artery supply the anal canal above the dentate line, which is the terminal branch of the inferior mesenteric artery. The lower anal canal is supplied by the middle rectal artery, which is a branch of the internal iliac artery, and the inferior rectal artery, which is a branch of the internal pudendal artery.

The intersphincteric groove is the space between the internal and external anal sphincters and can be felt around 1 cm below the dentate line, near the level of the anal verge.

The anal margin is outside of the anal verge and is characterized by radial skin folds, thicker skin, pigmentation and skin with adnexal tissues.

Step-by-Step Summary: Anal Fistulotomy

The type of procedure used is dependent on the type of anal fistula diagnosed. As such, exploration of the external and internal openings of the fistula and the course of all tracts is the first step in surgical treatment.

Once the anatomy of the fistula has been confirmed it can be described as simple or complex and the appropriate technique used to treat the fistula.

- **Simple anal fistula**
  – Defined as a single, non-recurrent tract that crosses <30 % of the external sphincter – includes intersphincteric and low trans-sphincteric fistulae.
  – Treated using the 'lay open technique'.
  – A probe is inserted in to the tract and the overlying tissue divided.
  – The base of the wound is then curetted and left open to heal by secondary intention.
- **Complex anal fistula**
  – Include high transsphincteric fistulae, suprasphincteric fistulae, and extrasphincteric fistulae.
  – These are commonly treated with seton placement – a seton can be a non-absorbable suture, a rubber band or a silastic vessel loop
  – A seton is passed through the fistula tract and secured to itself externally
  – It is typically placed loosely to allow for drainage and then progressively tightened until it eventually cuts through the fistula tract
  – If division of the sphincter muscle is to be avoided, a secondary procedure such as an endoanal advancement flap, fibrin glue or an anal fistula plug is performed

Complications

- Post-operative incontinence

Anal Surgery for Haemorrhoids

Haemorroids result following disruption of the anal cushions. They are associated with straining and irregular bowel habits. During defecation, straining engorges the cushions and results in their displacement. Repeated displacement results in stretching and eventual prolapse of the cushions.

Anal cushions are composed of blood vessels, smooth muscle and connective tissue. They are located in the upper anal canal and are separate structures that allow dilation of the anal canal during defecation without tearing.

During defecation, the anal cushions become engorged and tense with blood and as such, cushion the lining of the anal canal.

Causes

- Constipation
- Abnormal anal pressure inc. portal hypertension, pregnancy, straining
- Inflammatory bowel disease

Classification

Broadly speaking, haemorrhoids can be classified as internal or external.

Internal haemorrhoids are located proximal to the dentate line (this area is composed of insensate columnar-glandular epithelium), whilst external haemorrhoids are located distal to the dentate line (an area covered with sensate squamous epithelium).

Further to this, internal haemorrhoids can be graded as follows:

- **Grade I (primary) –** these slide below the dentate line with strain but retract with relaxation.
- **Grade II (secondary) –** these prolapse past the anal verge but reduce spontaneously.
- **Grade III (tertiary) –** these prolapse past the anal verge and have to be reduced manually.
- **Grade IV (quaternary) –** these prolapse past the anal verge and are not reducible.

Presentation

- Internal haemorrhoids may present with sudden, painless bleeding after a bowel movement.
- External haemorrhoids typically present with:
  - Pain
  - Swelling
  - Itching
  - Bleeding

Management

- Depending on the severity of the symptoms, management is either medically or surgically
- Medical treatment is indicated as first line for grade I and II haemorrhoids
  - This consists of dietary changes, bulk-forming agents and avoidance of straining.
- Further treatment is indicated for grade I haemorrhoids that have not responded to medical treatment and for grade II haemorrhoids
  - Procedures used include:
    Rubber band ligation – performed through a proctoscope using a rubber band ligator. The haemorrhoid mass is drawn into the haemorrhoidal ligator cup with suction and a band placed at the base of the internal haemorrhoid.
- Surgery is used for haemorrhoids with significant bleeding, for large haemorrhoids and for prolapsed internal haemorrhoids
  - Procedures include:
    Open haemorrhoidectomy
    Closed haemorrhoidectomy
    Stapled haemorrhoidopexy

Haemorrhoidectomy

Step-by-Step Summary

This allows full thickness excision of the mucosa and submucosa without injury to the underlying sphincter muscle.

1. An elliptical incision is made at the perianal skin and continued to the anorectal ring in a vertical fashion. This incision should include the internal and external haemorrhoids
2. The submucosa is lifted from the underlying sphincter complex at all times to avoid injury to the muscles.
3. At the end of the procedure, the mucosa is either closed using an absorbable suture making it a closed haemorrhoidectomy, or the mucosa is left open and the procedure becomes an open haemorrhoidectomy.

Stapled Haemorrhoidopexy

Step-by-Step Summary

1. A modified circular stapler resects the excess prolapsed haemorrhoidal tissue and fixes the rest of the haemorrhoidal tissue to the distal rectal wall.
2. A circular anal dilator is inserted and anchored to the skin with a heavy suture.
3. A purse-string suture proctoscope is introduced through the dilator.
4. A purse-string suture is then placed in a circular fashion at 3–4 cm above the dentate line through the mucosa and submucosa.
5. A fully open stapler head is then inserted through the purse string. The two tails of the suture are drawn back through the head of the anvil and the purse string secured.
6. The stapler should then be aligned along the axis of the anal canal and closed while maintaining a downward tension with the lateral tails. The 4 cm mark should be at the level of the anal verge. If the patient is female, pass a finger into the vagina to ensure the posterior wall is not caught in the stapler.
7. Fire the stapler then open the head and remove the stapler

Complications

- Bleeding/haemorrhage
- Pain
- Anal incontinence
- Anovaginal fistulas
- Retroperitoneal sepsis
- Tissue necrosis

Breast Surgery

Introduction

Breast surgery in the UK remains a subspecialty of general surgery and is mainly involved with the diagnosis and management of benign and malignant diseases of the breast. Breast cancer remains the commonest malignancy in women ahead of lung cancer, representing up to 30 % of all cancers in women – with over 1 million new cases each year worldwide. However, benign breast complaints and diseases are just as important and are more commonly encountered in clinic and general practice.

This section will provide a brief insight into the common presenting complaints and diseases of the breast, as well as surgically relevant anatomy.

Core Knowledge

Diseases of the breast are broadly categorised as either benign or malignant. Common presentations of breast disease are outlined in Table 19.2. The likelihood of the diagnosis is dependent on the patient's age (e.g. breast lump in a 25 year old is likely to be a fibroadenoma, as compared to in a 75 year old where carcinoma is more likely). In the UK, the ONE-STOP clinic forms the main outpatient referral pathway for most patients with breast related complaints. It involves a triple assessment with history and examination {E}, radiological investigations (mammogram {R} or ultrasound {U}), and tissue sampling (usually in the form of core biopsy {C}, less commonly fine needle aspiration). Patients over the age of 40 will have a mammogram of both breasts and focal lesions are assessed further with ultrasonography. A score between 1 (benign) and 5 (malignant) is assigned for each assessment, e.g. E3, R4, U5,

Table 19.2 Common presenting complaints in breast surgery and possible diagnoses

Breast lump	Fibroadenoma
	Breast cysts
	Phyllodes Tumour
	Carcinoma in-situ
	Invasive breast cancer
	Overlying skin lesions e.g. sebaceous cysts
	Gynaecomastia (in men)
Nipple Discharge	Duct ectasia
	Malignant disease
	Nipple adenoma
	Ductal papilloma
Breast pain	Chest wall pain
	Other musculoskeletal pain
	True mastalgia
	Breast abscess/infections

C5. Core biopsies are taken with special biopsy guns under local anaesthetic in clinic and assessed by pathologists. The results of each assessment is then discussed at the multidisciplinary meeting which involves radiologists, oncologists, surgeons, specialist nurses, and pathologists. Finally, the breast cancer-screening programme offers 3-yearly mammograms to women between 47 and 73 years old (50–70 years old in Scotland)

Clinical Anatomy

Located on the anterior thoracic wall, the breast usually extends from the 2nd to the 6th rib and from the sternal edge medially to the mid-axillary line with an axillary tail projecting towards the axilla. The breast is composed of fat, glandular tissue, and about 20 lactiferous ducts, which extend to the nipple where each duct has an opening. There are also suspensory fibrous strands called ligaments of Cooper, which help maintain the projection of the breast – their atrophy in older women contributes to them becoming increasingly pendulous (droopy). These ligaments of Cooper are also responsible for the peau d'orange sign and skin dimpling which may be present in malignancy.

Blood supply – Lateral thoracic artery, internal mammary artery (important in free flap reconstruction of the breast – **see below**), pectoral branch of the thoracoacromial artery, and perforator vessels from the posterior intercostal arteries.

Lymphatic Drainage – Majority of lymph drains the breast to the axillary lymph nodes (of which there are three levels based on the relation to the pectoralis minor muscle). The medial breast drains to the parasternal nodes along the internal mammary artery. Less commonly, drainage occurs to the supraclavicular nodes.

Trivial Knowledge

- ***Milk line*** – imaginary line along which accessory nipples may form, runs from pubic tubercles via the nipple to the axilla when the arms are raised in the air.

Tubercles of Montgomery – multiple small elevations around the areola.

Common Diseases

Diseases of the breast can be grouped into two very broad categories: Benign and malignant. Some of the more commonly encountered benign breast diseases include fibroadenomas, breast cysts, duct ectasia, and mastitis. Invasive and in-situ carcinomas of the breast are the main malignancies of the breast.

Benign Breast Disease

Fibroadenoma

These arise as a result of an anomaly of normal development that is hormone dependent proliferation of connective tissue and proliferative epithelium and arises from the terminal duct lobular unit. They are commonly seen in younger patients between 20 and 40. They can be classified as simple fibroadenomas: they have low stromal cellularity and regular cytology, benign, discrete, mobile lumps. Other related benign tumours include:

- Phyllodes tumours (less common, and not discernible from fibroadenoma on core biopsy).
- Tubular adenomas.
- Lactating adenomas.

Management

- Establish the diagnosis on core biopsy, reassure patient it is benign, observe and repeat USS in 6 months – if increased in size, excision; if unchanged, reassure.

Breast Benign Cysts

Palpable breast cysts are very common in the western world and represent over 10 % of all discrete breast lumps seen in outpatient clinics. They may be solitary or multiple and may be unilateral or bilateral. They are involuted fluid-filled distended lobules. There are two main peaks in presentation, late teenage and early 20s, and peri-menopausal period. On mammography, they are seen as halos and are further characterised on ultrasound. Patients with cysts are at no clinically significant risk of developing malignant diseases of the breast and should be reassured.

Management

- Examination of the breast and lymph nodes, mammogram and ultrasonography. Significant cysts can be drained with ultrasound guidance under local anaesthetic.

Duct Ectasia

Terminal ducts are shortened and dilated close to the nipple resulting in nipple discharge, nipple retraction, a palpable lump, or asymptomatic. There is an increasing risk with age and presents with white cheese-like discharge.

Management

- See Nipple Discharge (common presentations).

Radial Scars

They belong to the family of sclerosing breast lesions (Radial scar, complex sclerosis lesions, and sclerosing adenoma), a result of abnormal stromal involution leading to excessive fibrosis. More often, radial scars are asymptomatic and are associated with malignancy particularly atypical ductal hyperplasia, carcinoma in-situ or low-grade invasive cancers. Mammography appearances are similar to malignant lesions making it difficult to exclude cancers at screening.

Management

- Core biopsy, and open excision to exclude underlying/associated malignancy.

Breast Infections

These are relatively common and can be largely divided into lactating, non-lactating, and post-operative breast infections. The underlying causative organisms vary in each and thus antibiotic therapy. Management strategy of all breast infections ± abscesses should include early antibiotic therapy and aspiration (under ultrasound guidance) or drainage of abscesses.

Lactating Infection

Mastitis in breast-feeding mothers mainly occurs within the first month of lactation and as the baby starts to grow teeth. Causative organism – Staphylococcus Aureus – via nipple cracks into ductal system. Management involves flucloxicillin, USS to establish presence of abscess, aspiration under USS guidance, promotion of milk drainage from affected breast.

Non-lactating Infection

These may be peri-areolar or peripheral:

- Peri-areolar is more commonly seen in younger patients who are smokers and may be due to peri-ductal mastitis. Causative organism: Mixed anaerobes causing peri-areolar inflammation ± abscess.
- Peripheral infections are more common in premenopausal women and may be associated with systemic disease including diabetes and rheumatoid arthritis. Causative organism: Staphylococcus aureus.

Trivial Knowledge

- Neonatal breast infections also occur due to staph aureus infection.

Malignant Breast Disease

Carcinoma In-Situ

A pre-malignant disease of the breast characterised by malignant cells but an intact basement membrane. They are most commonly ductal or lobular carcinoma in-situ, with ductal carcinoma in-situ (DCIS) having a higher incidence. The diagnosis of DCIS is mainly on screening mammogram, as they are classically impalpable micro-calcifications. There is an inherent risk of progression to invasive disease. Management strategy of DCIS involves prevention of local recurrence and progression to invasive breast cancer. Breast conserving surgery in the form of wire-guided wide local excisions with at least a 1 mm margin the mainstay surgical option, however, this is dependent on size and whether or not the tumour is multicentric or multifocal.

Invasive Breast Carcinoma

Breast cancers arise from the epithelial cells of the terminal duct lobular units.

Epidemiology

- Remains the commonest cancer in women.
- Over a million new cases each year worldwide.
- Annual incidence of up to 4 in 1000 in women between 65 and 70 years old.
- Increasing incidence with screening and decreasing mortality with advances in surgical techniques and medical therapies.

Risk Factors

- Age – increased risk with age.
- Family history – increased with affected first degree relatives.
- Nulliparity
- Early menarche and late menopause
- Breast density
- Current use of HRT (risk returns to baseline on cessation)

Genetics

- BRCA 1 and 2 genes – high risk of breast and ovarian cancers.
  - Most common genetic abnormality in inherited breast cancer.
  - Other identified breast cancer genes include: PTEN, TP53, CHEK2 genes.
- Genetic testing/screening is offered to patients with significant family history of breast cancer usually around the age of 35.

Presenting Features

- Breast lump
- Nipple discharge ± blood stained
- Skin dimpling
- Peau d'Orange appearance
- Incidental finding
- Screen detected

Pathology and Classification

They can be largely classified into ductal and lobular types. More recently they are categorised based on the presence or absence of specific unique features; those with these specific characteristics (morphology and growth patterns) are termed invasive carcinoma of special type, (e.g. classic lobular, cribriform, papillary, etc) while others are invasive carcinoma of no specific type (NST). This may have some impact on prognosis. Other important pathological parameters in breast cancer include

- Hormone status: Oestrogen receptor (ER), Progesterone receptor (PR), Human Epidermal growth factor Receptor (HER-2), Triple negative (ER-/PR-/HER2-)
- Tumour size (assessed in TNM staging).
- Tumour Grade – based on degree of differentiation (how similar it is to normal cells around).
- Lymphovascular invasion – any malignant cells in local blood vessels and lymphatics.
- Lymph node positivity.
- Distant spread – bone, liver, etc.

Staging: Remains TNM staging based on tumour size (T), Nodal involvement (N), and presence of distant metastases (M) {**See Box**}. This is an important determinant of survival, i.e. prognosis.

Management Strategies

The management of breast cancer requires a multidisciplinary approach, which integrates surgeons, pathologists, radiologists, oncologists, and nurse specialists. Prior to a decision on management, results of clinical examination, radiology findings, and biopsy results.

Non-surgical management: These may be neo-adjuvant or adjuvant

- Hormonal therapy.
  - Useful in patients with positive ER or HER2 cancers.
  - ER positive cancers – Largely Tamoxifen or an Aromatase Inhibitor e.g. letrozole, dependent on whether pre- or post-menopausal.
  - HER2 positive cancers – Herceptin (Trastuzumab) and other derivatives.
- Radiotherapy.
  - Also adjuvant or neo-adjuvant.
  - May be delivered to breast/chest wall or axilla.
- Chemotherapy.

Surgical Management (See below for full details)

- Breast Conserving Surgery – mainly wide local excision.
- Mastectomy.
- Immediate or delayed reconstruction.

Risk Reduction Surgery

Patients at significantly increased risk of breast cancer, such as presence of BRCA mutations, may undergo bilateral mastectomies with immediate reconstructions as part of the risk reduction strategy. This reduces risk of breast cancer in BRCA mutation carries who have not developed breast cancer by up by 90 %. These patients also attend annual screening.

Common Operations

Wide Local Excisions

Indications

Excision of invasive and non-invasive malignant diseases of the breast with the aim of conserving the breast (compare with mastectomy).

Contraindications

- Extensive, multifocal disease
- Large tumour in small breast
- BRCA mutation
- Central tumours in small breast

Presentations

Screen-detected cancers or calcifications or symptomatic breast lumps, nipple discharge

Step-by-Step Summary: Wide Local Excision

1. Tumours that are not palpable or calcifications on mammogram are localised with wires inserted under ultrasound or stereotactic guidance pre-op.
2. Position patient supine with ipsilateral arm out at 90 degrees to the patient if axillary surgery is planned.
3. Incision made along the resting skin tension lines in close proximity to the tumour.
4. Dissect and undermine skin flaps on either side of incision.
5. Vertical dissection with palpable cancer or wire guided lesion.
6. 1 cm macroscopic margin of normal tissue around tumour is taken, dissecting down to pectoral fascia.
7. Specimen is oriented with surgical clips – 1 clip anterior, 2 clips medial, 3 clips inferior.
8. Specimen is X-rayed if non-palpable to ensure adequate margins taken.
9. Further excision of margins if close.
10. Haemostasis achieved with diathermy.
11. Closure of cavity with absorbable sutures, closure of dermal layer, and subcuticular continuous sutures to skin.
12. Local anaesthetic to wound, dressing applied.
13. Specimen sent to pathology lab.

Complications

- Bleeding ± haematoma
- Seroma
- Infection
- Incomplete excision
- Poor cosmetic result

Follow-Up

- Review in clinic 2 weeks post op for wound inspection and path results.
- Consider adjuvant treatment with radiotherapy/chemotherapy/hormonal therapy.
- Annual mammograms for surveillance.

Surgeons' Favourite Questions for Students

1. What are the benefits of wide local excision over mastectomy?
2. Why do we examine the margins of the resected tissue?
3. Why might Wide Local Excision not be suitable for some patients?
4. Extra credit: We try to make incisions along the relaxed skin tension lines, or Langer's lines – why do you think this is important?

Mastectomy

Indications

- Large, multifocal, multicentric cancers
- Prophylaxis for BRCA mutations
- Patient choice
- Large cancers in small breasts

Contraindications

- Small cancers amenable to conserving surgery.

Presentations

- Screen-detected cancers or calcifications or symptomatic breast lumps, nipple discharge

Step-by-Step Summary: Mastectomy

1. Mastectomy can be performed as simple or skin-sparing mastectomy dependent on the plans for reconstruction.
2. The patient is positioned supine.
3. Incision planned and marked – Either based on the infra-mammary fold or ellipse around the nipple-areolar-complex ensuring adequate skin flaps on either side for minimal tension on closure and avoiding dog-ears (ugly fold of skin at the edge of a wound.)
4. Incision made with knife and dissection with diathermy.
5. Skin flaps undermined in the superior direction then inferiorly ensuring minimal breast tissue is left behind but the skin flaps are not too thin (important for blood supply to the overlying skin being retained.)
6. Breast tissue dissected off the pectoral fascia avoiding penetrating the fascia as this causes bleeding and pain if underlying muscle cut.
7. Orientation with surgical clip at the 12 o'clock position to help the pathologist on microscopic examination of margins.
8. Haemostasis is crucial in this operation.
9. Surgical drains inserted into wound, sutured to skin.
10. Dermal interrupted sutures to the dermal layer, subcuticular continuous suture to skin.
11. Dressing applied.
12. Mastectomy specimen sent to pathology.

Complications

- Bleeding ± haematoma
- Seroma
- Infection
- Wound breakdown
- Poor cosmesis

Follow-Up

- Outpatient clinic appointment in 2 weeks for pathology results and wound check.
- Consideration of delayed reconstruction.
- Consider adjuvant treatment with radiotherapy/chemotherapy/hormonal therapy.
- Annual mammograms for surveillance.

Axillary Node Clearance

Indications

- Axillary node positive invasive breast cancer.

Contraindication

- Significant medical co-morbidity unfit for general anaesthesia.
- Good prognosis tumours such as small tubular cancers.

Presentations

- Clinical examination, radiological or tissue diagnosis of nodal involvement.

Landmarks of the Axilla

- Apex: First rib, scapula, clavicle and subclavius muscle.
- Base: Anterior – inferior margin of pectoralis major, medial – lateral aspect of chest wall, lateral – medial aspect of arm, posterior – inferior border of latissimus dorsi.
- Anterior boundary – Pectoralis major and minor muscles.
- Medial wall – Serratus anterior and intercostal muscles.
- Lateral boundary – Tendons of coracobrachialis and biceps muscles.
- Three Levels (1–3) of axillary nodes in breast surgery based on their relation to pectoralis minor muscle.

Important Structures to be Aware of

- Axillary artery and vein
- Long thoracic nerve
- Thoracodorsal pedicle
- Intercosto-brachial nerves
- Lateral thoracic vessels
- Brachial plexus

Complications

- Seroma
- Shoulder stiffness
- Damage to surrounding nerves/thoracodorsal pedicle
- Lymphoedema
- Neuropathy

Follow-Up

- See mastectomy and WLE

Other Axillary Procedures

- Sentinel Node Biopsy – used in establishing node positivity or spread of disease. Uses radioactive Technicium 99 and "blue dye" which travel along lymphatics to hot/positive nodes.
- Axillary node sampling – Random sampling of axillary nodes usually during sentinel node biopsies, cold (non-blue, and non-radioactive) nodes are taken as axillary node samples.

Surgeons' Favourite Questions for Students

1. What important structures can be damaged in axillary clearance?
2. What are some common complications of axillary clearance?
3. What is the principle behind sentinel node biopsy?
4. What are the landmarks of the axilla?

Breast Reconstructions

- Reconstructions can be immediate or delayed.
- Autologous Reconstructions – Most commonly:
  - Latissimus Dorsi Flap – based on Thoracodorsal pedicle (see Fig. 19.7).
  - Deep Inferior Epigastic Perforator (DIEP) Flap – Free flap from lower abdomen plumbed into internal mammary vessels (see this in more detail in the Breast section of the Plastic Surgery chapter).
- Implant-based.
- Lipomodelling/Fat transfer.

Medical Treatments

- Adjuvant radiotherapy.
- Neo-adjuvant or adjuvant chemotherapy.
- Neo-adjuvant or adjuvant hormone therapy (Based on hormone positivity – Tamoxifen, Aromatase inhibitors e.g. letrozole, Herceptin, etc).

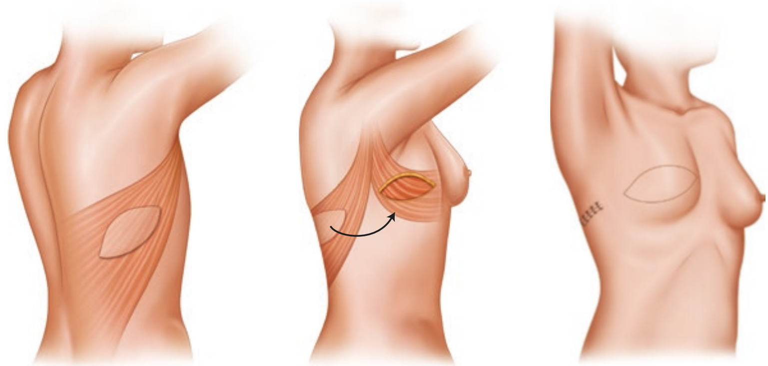

Fig. 19.7 Latissimus dorsi flap reconstruction

Non-operative Surgery

Pancreatitis

Acute pancreatitis is the inflammation of the pancreas.

Causes

Remember the mnemonic 'GET SMASHED':

Gallstones
Ethanol (alcohol)
Trauma
Steroids
Mumps/malignancy
Autoimmune
Scorpion stings
Hyperlipidaemia/hypercalcaemia
ERCP – endoscopic retrograde cholangiopancreatography
Drugs (e.g. azathioprine)

Presentation

- Epigastric pain radiating to the back
- Nausea and vomiting
- Grey-turner's sign – haemorrhagic discolouration of the flanks
- Cullen's sign – haemorrhagic discolouration of the umbilicus

Investigations

- Amylase (and/or lipase) – raised to at least three times the upper limit of normal
- A raised bilirubin and deranged LFTs may support gallstones as being the cause.
- A raised GGT may indicate there is a history of excess EtOH consumption.
- An ultrasound scan is essential to detect gallstones or alcoholic fatty liver.

The Modified Glasgow Score is used to determine the severity of pancreatitis. It is based on eight prognostic factors that should be identified in the first 24 h. A point is awarded to each of the factors, which are described in the pneumonic '**PANCREAS**':

P $pO_2 < 8$kPa or <60 mmHg
A age >55 years
N neutrophil count (WCC) >15
C calcium <2 mmol/L
R renal function (urea) >16 mmol/L
E enzymes: AST/ALT >200iu/L; LDH >600 iu/L
A albumin <32 g/L
S sugar (glucose) >10 mmol/L

A score of three or more suggests a severe attack and transfer to HDU/ICU may be appropriate.

Management

This typically involves conservative treatment with:

- Oxygen
- IV fluids
- Catheterisation (and fluid balance)
- Analgesia
- Nutritional support – NBM ± NG tube

Most patients recover in 5–10 days, however in severe pancreatitis (a Modified Glasgow Score of three or more) life-threatening complications such as multiorgan failure, pseudocysts (do not have an epithelial lining), abscesses and infective necrosis can occur. In these circumstances, a contrast enhanced CT scan at 72 h can be helpful in assessing the degree of necrosis and other complications.

Diverticulitis

Diverticula are out-pouchings of the bowel wall, the process of which is called diverticulosis. When these out-pouchings become inflamed it is known as diverticulitis.

Presentation

- Left iliac fossa pain typically
- Tenderness on palpation
- Fresh rectal bleeding

Investigations

Blood Tests

- Typically these show a raised white cell count (WCC) and CRP

Imaging

- Colonoscopy – this can be done as an outpatient to confirm the diagnosis
- CT scan – this is used to identify whether the diverticulitis is complicated or uncomplicated. This will ultimately aid the surgeon with regards to the most appropriate treatment.
  – Complicated diverticulitis is associated with abscess formation and/or perforation of the sigmoid colon

Management

- **Uncomplicated diverticulitis –** this is treated conservatively with IV fluids and bowel rest. If an infection is suspected, antibiotics are indicated.

Table 19.3 Hinchey's classification

Stage I	Diverticulitis with phlegmon or localised pericolic or mesenteric abscess
Stage II	Diverticulitis with walled-off pelvic, intra-abdominal or retroperitoneal abscess
Stage III	Perforated diverticulitis causing generalised purulent peritonitis
Stage IV	Rupture of diverticula into the peritoneal cavity with fecal contamination causing generalised fecal peritonitis

- **Complicated diverticulitis –** this is an indication for surgery. It is reserved for treatment of abscesses that require drainage and for bowel resection and anastomosis for perforations.
  – Complicated diverticulitis is staged using Hinchey's classification (see Table 19.3). It aids the surgeon in choosing the correct surgical procedure when the diverticulitis is complicated.

Sigmoid Volvulus

A loop of bowel (sigmoid) is twisted about its mesentery often causing bowel obstruction.

Presentation

- Abdominal distension.
- Nausea and vomiting.
- Bowels not opening (signs of obstruction).

Investigations

- Abdominal x-ray – 'Coffee Bean' sign: shape of the dilated twisted sigmoid colon.
- Blood tests – Lactate can be raised as a result of bowel ischaemia.

Management

- A rigid sigmoidoscopy is performed and a rectal tube inserted for decompression of the bowel.
  – This is left in situ until it falls out of its own accord.
- Any abnormal electrolytes, which can be a cause for sigmoid volvulus, are corrected.

Student Tips for Placement

To make the most out of a surgical placement, it is advisable to revise appropriate anatomy before attending theatre. Whilst in theatre try to become familiar with the laparoscopic equipment including understanding of the difference between a 0 and 30 degree laparoscopic camera.

It is important to attend clinics and clerk new patients to have a better understanding of the signs and symptoms patients present with. It is also a good place to review investigations including the histology of biopsies and imaging. Clinics will also aid your understanding of when to operate and the basic steps of the procedure as they are explained to the patient.

Endoscopy lists will allow you to visualise a range of pathology and will allow you to understand what normal looks like.

The downside for students placed in general surgery is that most of the work in theatres is undertaken deep within body cavities, which can mean students cannot see what is going on. Therefore it is useful to engage with the surgeon from the beginning of the case, and if you seem interested they will often step back to let you have a look. If possible, ask if you can scrub for the case so you can learn more, or if that's not possible try and come back on days when there are more laparoscopic cases scheduled as there will be more visible on the screens.

Orientating yourself when you're looking at the monitors during laparoscopic surgery can be difficult, as the landmarks you know from anatomy class are being approached from a completely different angle. If you're not scrubbed, try to position yourself behind the surgeon so that you can understand the angle that they are viewing from: it will help you find your bearings much more quickly.

Careers

General surgery has changed greatly in the last 20 years with the introduction of laparoscopic surgery. Most operations performed are now preferably done laparoscopically, with only more complex procedures performed open. Subspecialties include Upper GI, Lower GI, Breast, (± Endocrine surgery).

On completing Foundation Training (FY1 & FY2), doctors pursuing surgery will complete a 2 years of Core Surgical Training. In this time the MRCS exam (Part A and B) are completed, core surgical skills gained and core courses including BSS (Basic Surgical Skills), ATLS (Advanced Trauma Life Support) and CCrISP (Care of the Critically Ill Surgical Patient) are undertaken.

ST3 recruitment is competitive however achievable to those who want it. At present it is a national selection process, which occurs once a year. On obtaining a post, trainees complete 6-month rotations within general surgery during ST3, 4 and 5. At the end of ST5 the option of deciding on a sub-specialty is given during which the FRCS exam in that specialty is completed to allow for a CCT (Certificate of completion of training).

At this stage many trainees opt to undertake a fellowship as a Senior Trainee within the UK or abroad to hone in on their skills before embarking on a Consultancy post in their chosen sub-specialty.

To get ahead a mentor is most valuable as they can guide you through the stages. Often a good consultant educational supervisor is the best mentor as they do not rotate between hospitals/deaneries, which is often the case with registrars and core surgical trainees. However surgical trainees are more up-to-date with the current system and requirements and are always keen to give good advice. Keep a logbook or all your operations and register for the online elogbook for surgery so you can use it as evidence of your surgical experience when applying for core surgical training to embark on your career as a general surgeon.

Breast Surgery Careers

Breast surgery remains a part of general surgical higher training. At present, following foundation training one would progress to core surgical training and then a national training post in general surgery. The higher surgical training programme may show regional variation, but largely will consist of 3–4 years of colorectal, upper GI, hepatobiliary, and vascular surgery, with the later years spent within a local breast unit. A career in breast surgery offers a great work-life balance, quieter on-calls, minimal out-of-hours operating (as most breast surgeons are no longer on general surgical on-call teams), and more importantly interesting reconstructive surgery.

Urology

20

Catherine E. Lovegrove, Andrea Tay,
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Introduction

Urology is associated with pathology of the urogenital tract. It encompasses pathology relating to the kidneys, ureters, bladder, prostate, penis, urethra and testis. Urologists manage a wide variety of conditions ranging from cancers of each of the main organs to trauma and congenital malformations. They also manage benign conditions such as renal stone disease, bladder dysfunction or obstruction, incontinence, sexual dysfunction and problems with infertility. In addition to Core/General Urology, the speciality is sub-divided into various sub-specialities:

Oncology

This subspecialty often has further organ specific teams, covering:

- Prostate cancer (the most common cancer in males).
- Bladder cancer.
- Renal cancer.
- Testicular cancer (the most common cancer affecting males age 15–49 years).
- Penile/urethral cancer (the rarest cancer in males).

Urogenital Stones

This subspecialty uses a variety of techniques to access and remove stones from the urinary tract, including endoscopic techniques such as ureterorenoscopy (URS) or percutaneous nephrolithotomy (PCNL). Technologies such as LASER or extra-corporeal shockwave lithotripsy (ESWL) are also used to fragment stones.

Female/Functional Urology

This subspecialty is associated with the management of benign conditions of the lower urinary tract, including the female genital tract and patients with neurological conditions that have an impact on urinary system. These urologists are also specialists in the management of incontinence using a variety of techniques including slings, artificial sphincters and bladder augmentation.

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Andrology/Genito-Urethral Reconstruction

This subspecialty is associated with male sexual dysfunction including: penile conditions such as Peyronie's disease, genital trauma and genital disorders which require reconstruction using a variety of skin grafting techniques. These specialists also manage urethral stricture disease including reconstruction using oral grafts and male factor infertility using microsurgical techniques.

Paediatric Urology

This subspecialty is associated with all urogenital pathology affecting neonates to adolescents. A large part of their workload involves congenital abnormalities such as hypospadias but they also manage paediatric urogenital oncology, stones, trauma and disorders of sexual differentiation.

Clinical Anatomy

The urinary system is divided into "Upper Tract" and "Lower Tract". This subdivision is used clinically when referring to pathologies, diagnoses and treatments, and is therefore an important feature to grasp at an early stage:

- "Upper tract" refers to:
  - Left and right kidneys.
  - Ureter from the renal pelvis to the ureteric orifices into the trigone of the bladder.
- "Lower tract" refers to:
  - Bladder.
  - Urethra.

Kidneys

The left and right kidneys are located retroperitoneally within the posterior abdomen between vertebral levels T12 and L3. The left lies slightly higher than the right owing to the presence of the liver on the right hand side. The left kidney is longer and thinner than the right. In terms of gross anatomy, the superior poles are capped by the suprarenal glands while the ureter, the renal artery and a number of (usually 1–3) renal veins are found at the hilum of each kidney. The arterial supply is derived from the abdominal aorta (L1 level) and venous drainage is into the inferior vena cava. Each kidney and the associated suprarenal gland is surrounded by perinephric fat, renal fascia and paranephric fat (Fig. 20.1).

Ureters

Ureters are narrow muscular tubes that provide a route for urine from the renal pelvis to the bladder. They cross the pelvic brim at L4, anterior to the bifurcation of the common iliac arteries before blending with the muscular trigone of the bladder.

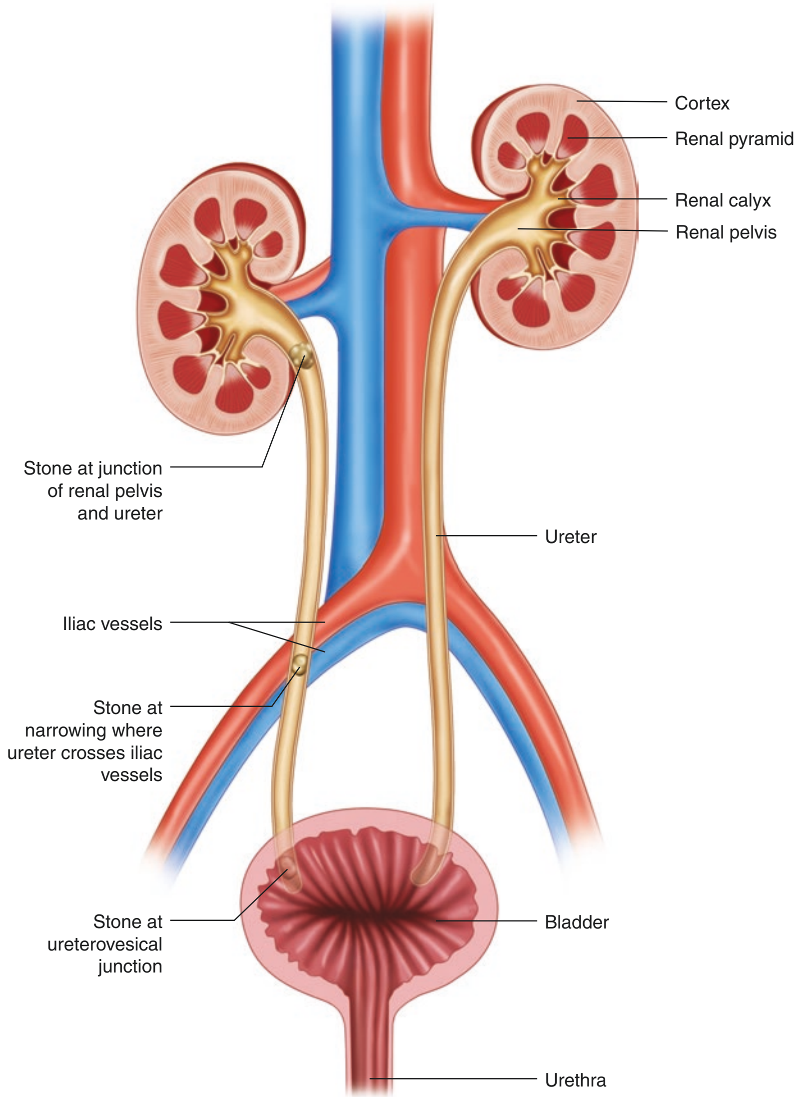
The ureters demonstrate three areas of constriction:

1. Pelvoureteric junction.
2. Crossing the pelvic brim/bifurcation of common iliac arteries.
3. Vesicoureteric junction.

Bladder

In the pelvic cavity, the urinary bladder is a distensible muscular sac (detrusor muscle), the location of which depends upon its volume. It lies posterior to the pubic symphysis and is infraperitoneal. In females it is found anterior to the vagina and in males it rests on the prostate gland. The bladder can be divided anatomically into the fundus (postero-superiorly), body, neck and apex (antero-inferiorly). The trigone constitutes a smooth region of detrusor muscle located on the posterior wall of the bladder. Here, the two ureters converge onto the bladder and at the apex the urethral orifice is formed. The trigone is important in the control of bladder emptying with autonomic and voluntary innervation. Sympathetic fibres from the hypogastric plexus and parasympathetic pelvic splanchnic nerves inhibit and promote detrusor muscle activity respectively. This autonomic innervation prevents and facilitates urination respectively through the internal urinary sphincter. These reflexes can be over-ridden with

Fig. 20.1 The urinary tract



learned voluntary control of the external urinary sphincter via the deep branch of the perineal nerve.

Urethra

The male urethra is 20 cm long compared to 4 cm in females. The urethra is lined with transitional epithelium as it exits the bladder. The main length is lined with pseudostratified columnar and stratified columnar epithelia and at the external urethral orifice stratified squamous epithelium is found.

The female urethra is a simple, uncomplicated tube running between the bladder and the external urethral orifice. The male urethra however is comprised of four parts (Fig. 20.2):

1. **Pre-prostatic urethra**: Intramural section between the bladder and prostate.
2. **Prostatic urethra:** Found within the prostate gland. It includes openings for the ejaculatory duct to convey sperm and ejaculatory fluid from the vas deferens and seminal vesicles respectively. Prostatic ducts and the utricle are also found here.

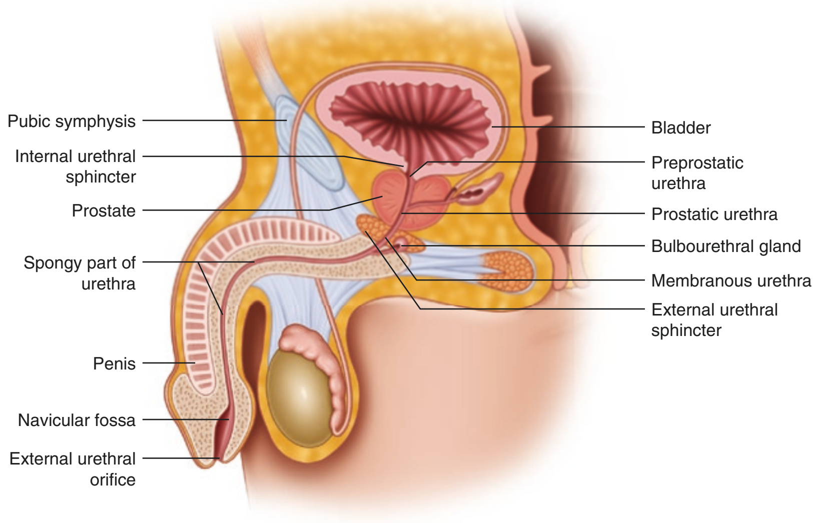


Fig. 20.2 Portions of the male urethra

3. **Membranous urethra:** This is the narrowest portion of the urethra. It lies deep to the external urethral sphincter.
4. **Spongy urethra**: The longest section of urethra, conveying urine and semen through the corpus spongiosum, with openings for the bulbourethral and urethral glands.

Core Conditions

There are some key principles and topics in urology that anyone working with a urology team must know about:

1. Urinary retention and how to catheterise (urethral and suprapubic).
2. How to assess frank haematuria.
3. How to assess renal colic.
4. How to assess acute testicular pain.
5. How to reduce a paraphimosis.

Urinary Retention

Key Points

- It can be acute (painful) or chronic (typically painless).
- It is typically caused by obstruction (prostatic in men, or pelvic mass in women), or bladder dysfunction (must exclude a neurological cause).
- It can lead to disorders of renal function due to back pressure on the kidneys.

Assessment

- Confirm retention (dull suprapubic mass/inability to pass urine).
- Check for cause – Is there a clear precipitant? (constipation/cold and flu remedies, history of progressive LUTS and known prostatic problems). Remember to check prostate (rectal exam), exclude pelvic mass in women (bimanual vaginal exam), and exclude any obvious neurology in the lower limbs if no obstructive cause or clear precipitant can be found. Clearly record the most likely cause and differentials when clerking the patient in.
- Once catheterised, the most important factors to observe are:
  – The residual urinary volume (volume of urine drained in the first 5 min).
  – Subsequent renal function.

This will form the basis for ongoing management

Catheterisation of a Male Patient

- Don't delay if in acute painful retention.
- Aseptic technique.
- Ensure correct catheter for patient (not a female short catheter for a male patient!). Typically a 14 French 2 way catheter for male patients is required.
- Clean skin with sterile solution, and insert a whole tube of lignocaine lubricant anaesthetic gel into the urethra. Milk it down the male urethra. Leave to work a few minutes before inserting the catheter. Warn the patient the gel can sting initially.
- Use your sterile hand to push the catheter through the urethra until urine flow confirms correct placement in the urinary bladder. Push slightly further to ensure that the balloon will not be inflated in the urethra. Inflate the catheter balloon with 10 ml of saline and give a gentle tug to confirm that it does not slip into the urethra.
- Tape or strap the catheter tube and bag to the patient's leg to prevent the catheter pulling, which can be painful.

Trouble-Shooting

- If the catheter won't go in, never force it. Try inserting it again (gently), using two tubes of lubricating anaesthetic jelly to distend the urethra more. Try to think how far down the urethra the catheter is sticking. If it is at the prostate level, try upsizing to a 16 French catheter – the larger catheter will buckle less going round the prostate.
- If this does not work, get help. Alternatively, include a coude (angled) tip catheter, a catheter introducer (only for senior/ expert hands only), or a suprapubic catheter (SPC).
- A suprapubic catheter is contra-indicated if there is unexplained haematuria, a history of bladder cancer, the patient is on warfarin or has a clotting abnormality (often a favourite question!). If there is any lower midline abdominal incision, additional care should be taken during insertion due to the increased risk of bowel injury. An ultrasound guided approach using a seldinger technique should be used to make the insertion.

Frank Haematuria

Key Points

- Bleeding can occur at any point throughout the urogenital tract. Think of the urological system anatomically, and this will help you think of the locations and then allow you to create a differential diagnosis.
- Haematuria can be a sign of urological cancer (there could be more than one), so approach such patients with this in mind.
- Ask where the blood comes in the stream:
  - At the start e.g. urethral pathology.
  - At the end e.g. prostatic pathology.
  - All the way throughout the stream e.g. bladder or upper renal tract pathology.
- Haematuria is easier for male patients to detect as they stand to pass urine so can see their stream. When women present with frank haematuria, it is because they see blood in the pan after passing urine. It is important to always keep an open mind to consider other sources of bleeding, including vaginal bleeds in such cases.

Key Assessment

- **Renal causes:**
  - Renal cancer arises from the renal parenchyma. It can be visualised well with a renal USS or CT Urogram (in the pre-excretion arterial phase). The classical triad of a renal cancer (favourite question) is frank haematuria, a loin mass, and loin pain, although all three are only seen in a small proportion of patients.
  - Transitional cell cancers (TCC) can arise from the urothelial lining of any part of the urinary tract. In the upper renal tract, this can occur in the calyces of the kidney, the renal pelvis or the ureters (see Fig. 20.1). Lesions are not well seen with renal USS, but demonstrated well on CT Urogram (in excretion phase). If a clear view is not seen, the upper tract can be assessed more directly with cystoscopy and ureteroscopy to look up the whole length of ureter and inside the renal pelvis (uretero-renoscope or URS).

- **Bladder causes:** TCC of the bladder urothelium is also known as bladder cancer, and is the most important bladder cause of haematuria to exclude. Risk factors for bladder cancer (favourite question) include a history of smoking (cause of 1 in 3 cases) and exposure to industrial chemicals including those in dye factories, rubber, leather, textiles, printing, gasworks, plastics and paint manufacture. Benign causes of bleeding from the bladder include infection (haemorrhagic cystitis), bladder stones or inflammation of the bladder lining (interstitial cystitis). Stones and large tumours can be picked up with USS, while infection can be diagnosed with urinalysis, microscopy and culture. Urine cytology can be useful to pick up malignant cells, which shed into the urine from higher-grade bladder cancers. Bladder pathologies can be easily assessed and directly visualised using a flexible cystoscope, which is done under a local anaesthetic (if infection excluded). If any biopsy or treatment is needed this will need to be performed with a larger scope under a general anaesthetic.
- **Prostatic/urethral causes:**
  - Prostatic: A large benign prostate gland can often develop friable blood vessels, which can pop and bleed in much the same way as a nosebleed. These can be easily assessed and diagnosed with a flexible cystoscope. Prostate cancer does not typically present with bleeding, but it is important to always check the prostate via a rectal examination
  - Urethral: Benign urethral pathologies such as a urethral stricture or inflammation or infection (urethritis) can present with bleeding. Urethral cancer is very rare, but a differential to exclude. Infection is best assessed with urinalysis, microscopy and culture, as well as with a urethral swab. Looking inside the urethra with a flexible cystoscope (in the absence of infection) will detect everything else

Investigations

- USS and CT Urogram to assess the upper tract and kidneys.
- Flexible cystoscopy to assess the lower tract (bladder, urethra, prostate).
- Urinalysis, microscopy and culture to exclude infective cause.
- Urine cytology to exclude a bladder cancer.
- Don't forget to perform a rectal exam to asses the prostate and bimanual vaginal exam to exclude other possible causes of bleeding.

Renal Colic

Key Points

- Renal Colic is often associated with kidney (or renal) stones.
- Passing a kidney stone is *very* painful – appropriate pain relief is essential.
- Patients who have had stones before or have a family history of stones are more at risk of developing stones.
- Stones are more likely to develop when dehydrated (low fluid intake, excessive sweating, hot climate).
- Stones are more common in patients with GI pathology such as inflammatory bowel disease and chronic diarrhoea.
- The ureter has three points of natural constriction where stones get stuck (a favourite question). These constrictions are described in the anatomy section.

Key Assessment

- Patients with renal colic present with acute, severe colicky abdominal pain, often with nausea and vomiting. Patients should be considered to have an 'acute surgical abdomen' until stones have been confirmed as the cause. The pain is classically loin to groin on the affected side. When the stone moves down to the lower ureter, the pain may refer to the genital region, and be associated with urinary frequency.
- Other causes of colicky abdominal pain (favourite question) include gastrointestinal

colic due to bowel obstruction, and biliary colic due to obstruction in the biliary tree (colic is pain due to obstruction in a tubular viscus which results in rhythmic smooth muscle contraction). The frequency of renal colic pain spasms is much higher than that of bowel or biliary colic (every 30 s vs every few minutes for bowel, and longer with biliary colic).

- A ruptured, retroperitoneal leaking AAA can also present with loin to groin pain (non colicky) so never forget to exclude all differentials of an acute abdomen.
- Urinalysis will show microscopic haematuria in 90 % of cases.
- It is important to always assess renal function, and ensure there are no signs of infection (check temperature, white cell count, CRP, and Us&Es).
- The investigation of choice is a CT KUB (kidneys, ureter, bladder), which will pick up stones in almost all cases, as well as excluding many of the differentials for the acute abdomen.
- Management of the stone is dependent on the site and size of the stone.

Acute Testicular Pain

Key Points

- Torsion (twisted testis) can lead to strangulation and infarction of the testicle within hours.
- The most common age for torsion is in neonates or during puberty, but can also occur in older men in their 20s and 30s.
- Testicular torsion is a surgical emergency. The testis must be untwisted as soon as possible and fixed so it does not twist again in the future. Because the cause of the twist is an anatomical defect (long cord in the fluid filled sac surrounding the testis creating a bell-clapper deformity – a favourite question), it will be bilateral so the other testis must also be fixed at the same time to prevent any future episodes.
- The main differentials are a torted testicular appendage (otherwise known as the hydatid cyst of morgagni- another favourite question), or infection of the testis and epididymis (epididimo-orchitis).

Key Assessment

- A testicular torsion may present with a high riding testis, which has a horizontal lie. However, such a classic presentation is rare. Even experienced urologists may get the diagnosis wrong in approximately 1 in 10 cases. A missed torsion will result in the need to remove the dead testis. If there is any doubt, an US Doppler in the right setting and expert hands may help with the diagnosis. However, a surgical exploration of any acute testicular pain when a torsion cannot be reliably and definitively excluded is essential both diagnostically and to manage the torsion if confirmed.
- Inflammation and swelling staring in the tail of the epididymis and going into the testis in a sexually active man, with a raised white count, raised CRP and urine dip indicative of infection if highly likely to be epididymo-orchitis.

Paraphimosis

Key Points

- Phimosis is a tight, inelastic narrowing of the foreskin preventing it from retracting.
- Paraphimosis is when the foreskin (in an uncircumcised penis) is pulled back, and cannot reduced afterwards. This can lead to swelling of the foreskin. This is more likely to occur in someone who has phimosis.
- Paraphimosis is most commonly encountered on the wards when elderly men have been catheterised, but not had their foreskin replaced after. After days of being left like this they present with a typical painful swelling of their foreskin.
- The key point to reducing the paraphimosis is to wrap a gauze around the swollen foreskin, keep the penis elevated, and apply gentle but firm pressure in your fist for at least 5 min (by

the clock!). This will help bring the swelling down. Once the swelling is reduced continue to apply gentle traction to the foreskin to pull it forward, while using your other hand to hold the glans (head) of the penis down. You will feel a sudden ‘give’, and the paraphimosis will be reduced. Check later to ensure the resolution is maintained.
- If there was a co-morbid phimosis, the patient should have an elective circumcision once the swelling is reduced.

Core Operations

Trans-Urethral Resection of the Prostate (TURP)

TURP uses electrical current to remove benign prostatic tissue in the prostate that causes lower urinary tract symptoms in men of increasing age.

Indications

- Lower urinary tract symptoms caused by benign prostatic hyperplasia (BPH) which fail to respond to medical therapy.
- Recurrent acute urinary retention.
- Bladder outlet obstruction causing renal impairment due to chronicity.
- Bladder stones as a result of prostatic obstruction.

Presentation

BPH affects more than half of all men over 50 and prevalence and symptoms increase with advancing age. Gradual onset of symptoms can include problems associated with:

- Storage: frequency of micturition, urgency of micturition, urge incontinence and nocturia
- Voiding: poor flow, hesitancy, intermittent flow and straining which may also contribute to haematuria.

In addition, BPH may contribute to the development of UTIs and result in acute episodes of urinary retention.

Investigations

The impact of BPH on an individual’s daily life is assessed using the International Prostate Symptom Score (IPSS). This questionnaire is composed of eight questions; seven are concerned with different symptoms and their severity and one assesses the impact of symptoms of on the patient’s quality of life. Each symptom may be allocated a score between 0 and 5, thus the total range of score varies between 0 and 35 (0–7 = Mild, 8–19 = Moderate, 20–35 = Severe). A flow rate test is performed to measure the speed and dynamics of voiding, while a post-void bladder scan assesses how well the bladder empties. Renal function should be assessed by checking Us&Es. Measurement of PSA (prostate specific antigen) is useful in conjunction with a rectal exam to exclude any malignant prostatic changes.

Step-by-Step Summary: Trans-Urethral Resection of the Prostate (TURP)

- General or spinal anaesthetic is administered.
- A 22 French resectoscope is passed through the urethra with a diathermy loop on the tip of the working element. Electrical energy is used to create heat in the loop to excise prostatic tissue and coagulate bleeding vessels.
- The aim is to remove benign, hypertrophic tissue, but leave the prostatic capsule intact – like removing the soft flesh of an orange and leaving the skin behind. The urethral mucosa will eventually grow back over the re-opened channel to line it once again.
- The normal anatomy is identified (bilateral ureteric orifices and verumontanum).
- Monopolar or bipolar diathermy is used to excise prostatic tissue.
- Most surgeons resect the middle lobe before resecting the lateral lobes.
- The prostate chips are washed into the bladder before removal at the end of the procedure using an Ellick evacuator. Resected tissue is sent to for histological analysis.
- Haemostasis is achieved with ‘roller-ball’ diathermy.

Complications

- Haematuria – risk of transfusion (rare). If heavy will need to go back to theatre.

- Infection.
- Retrograde or dry ejaculation (70–100%).
- Urethral stricture (approximately 10 %).
- TUR syndrome (monopolar resection only).
- Unable to void spontaneously when catheter first removed (greater than 80–90 % void spontaneously).
- Failure of storage symptoms to resolve (approximately 40 %).
- Regrowth of prostate (approximately 20 % need redo surgery at 10 years).
- Impotence (approximately 10 %).
- Incontinence (<1 %).

Follow Up

A 22 French 3 way catheter is inserted to allow continuous irrigation of the bladder in the immediate post operative period. The catheter is removed day 2 post op so long as urine has returned to normal/light rose colour. Patients are re-assessed at 3 months to assess their symptoms (IPSS) and flow again. Their histology is also followed up.

Nephrectomy

Nephrectomies can be performed to various extents (Box 20.1):

> **Box 20.1. Considerations for Nephrectomy**
> **Extent of Surgery:**
> **Radical Nephrectomy**: Removal of whole kidney including peri-renal fat and Gerota's fascia. The ureter down to the bladder (Nephro-ureterectomy) and adrenal glands may also be removed.
> **Partial Nephrectomy**: Removal of cancerous part of kidney and some adjacent healthy tissue
> **Simple Nephrectomy**: Removal of whole kidney without peri-renal fat and Gerota's fascia, usually not cancer operation.
> **Modality of Surgery:**
> - Open.
> - Laparoscopic.
> - Robot-Assisted.

Indications

- **Radical nephrectomy**: large renal cell carcinoma. It removes the kidney within its surrounding Gerota's fascia.
- **Radical nephro-ureterectomy**: upper tract transitional cell carcinoma within the renal pelvis or ureter. In this scenario, all the upper tract urothelium must be removed (kidney within its surrounding Gerota's fascia, with the entire ureter)
- **Partial nephrectomy**: Small renal cell carcinomas. This approach is even more important when there is a tumour in a solitary kidney, or if renal preservation is important (diabetic patient with poor renal function where maximal nephron preservation is important).
- **Simple nephrectomy**: performed for benign conditions and does not require removal of the peri-renal fat or Gerota's fascia. It is usually performed for infected, non-functioning kidneys, either due to large obstructing stones or chronic xanthogranulomatous pyelonephritis. As there are often multiple adhesions associated with the kidney, the procedure is often far from simple.

Investigations

- Blood tests (FBC and U&Es): to treat anaemia pre-operatively if needed and assess renal function allowing a decision to be made regarding the need for a nephron-sparing operation.
- Abdo and Pelvis CT with contrast: to define the anatomy of kidney (number of arteries and veins, important cross-overs and location of gonadal vein and ureter).
- Chest CT: part of staging.
- MSU.

Step-by-Step Summary: Nephrectomy

1. Positioning – Lateral/Siesta – patient must be well protected with gel pads to prevent pressure sores. Patient is given prophylactic antibiotics and is catheterised.
2. Transperitoneal approach chosen (can also be retroperitoneal approach,).
3. Port insertion, then diagnostic laparoscopy to assess general anatomy, position of kidney and intra-abdominal metastasis.

4. Dissection of peritoneal reflections and mobilisation of colon. Then the aim is to gain access to the hilum. This will involve varying degrees of mobilisation of both the upper and lower kidney poles.
5. The hilum is carefully dissected to reveal all arteries and veins – renal vein dissection requires extra care to prevent caval tear.
6. The renal artery then renal vein is clipped or tied.
7. The ureter is dissected and clipped.
8. The rest of the kidney is detached from surrounding tissue and placed in an Endocatch bag.
9. Low pressure check to look for venous bleed at hilum or other places.
10. Drain insertion if needed.
11. Ports removed under vision.
12. A longer incision is made at loin area to retrieve specimen.
13. Loop PDS to close sheath and muscle.
14. Different surgeons have different preferences for wound closure. The general aim is to close deeper layer to prevent hernia and dissolvable stitches for skin.

Complications

- Pneumothorax.
- Trauma to lung (rare).
- Haemorrhage.
- Infection of wound (superficial or deep).
- Trauma to spleen, tail of pancreas, large bowel (for left nephrectomy), liver, small bowel (duodenum) and/or pancreas (for right nephrectomy).
- Chest infection/ pneumonia.

Follow Up

Post-operatively it is important to closely monitor haemoglobin, blood pressure, pulse, drain output (for haemodynamic status), respiratory rate, temperature, urine output and renal function (to assess and function of remaining kidney)

Patients should be mobilised early to prevent DVT or PE and receive LMWH. A trial without a catheter (TWOC) is done when the patient is able to mobilise. Drains are usually removed when less than 50 mls is drained (usually the next day). Outpatient follow-up is at 2–3 weeks with histology and MDT outcome.

Uretero-Renoscopy (URS) for Stones

Presentation

Renal colic and microscopic haematuria.

Indications

- Symptomatic ureteric stone of any size not passing despite conservative management.
- Renal stone up to 2 cm.

Investigations

- CT KUB (CT Kidneys, Ureters, Bladder) confirms diagnosis and detects size/location of the stone).
- MSU (midstream specimen).
- Bloods including renal function, calcium and uric acid level.

Step-by-Step Summary: Uretero-Renoscopy (URS)

1. Prep and drape the patient positioning them in the lithotomy position.
2. Rigid cystoscope insertion.
3. Ureteric orifice intubated with ureteric catheter.
4. Retrograde studies with contrast and image intensifier to assess upper tract anatomy.
5. Guide-wire into ureter and up to renal pelvis.
6. Rigid cystoscope removed and rigid ureteroscope inserted via urethra and into ureteric orifice travelling up towards proximal ureter.
7. If the stone is located in the ureter it can be tackled there. If the stone is in the renal pelvis, then the rigid ureteroscope would be removed and a flexible ureteroscope inserted along the guidewire
8. Stone located and lasered to dust or small fragments for removal.
9. Stent may be placed post operatively.

Complications

- Bleeding.
- Infection.
- Pain.
- Ureteric injury – requiring longer duration of stent, open repair or nephrostomy.
- Unable to insert ureteroscope – a stent should be inserted to dilate the ureter. Can come back after 3 weeks to re-attempt URS.
- Unable to remove large renal stone in one session.

- Stent symptoms – common, can present as flank pain, haematuria, LUTS.

Follow Up

The procedure is carried out as a day case or 24 h stay procedure. If the stones are cleared and a stent is inserted for safety, remove the stent in 2 weeks with a flexible cystoscope. Follow up with an x-ray (KUB) to ensure the patient is free of stones. Ensure they are investigated for any metabolic cause of stones if they are a recurrent stone former, and advise the patient on how to prevent stones in the future

Circumcision

This is most commonly performed operation in males worldwide. It is performed for religious reasons in boys of Islamic and Jewish faith. There has recently been a WHO drive to increase circumcision given its benefit at decreasing the transmission of HIV. There has also been a resurgence of neonatal circumcision in many countries such as the USA, due to its benefit at reducing HIV and HPV transmission, in addition to reducing less common conditions including penile dermatoses, UTIs and the risk of penile cancer.

Indications

- Phimosis.
- Neonatal UTI.
- Penile dermatosis.
- Pre-malignant/malignant penile lesions.

Step-by-Step Summary: Circumcision

1. Procedure performed under local or general anaesthetic.
2. The foreskin is marked inside and out with a marker pen, then incised using a scalpel. Care is taken to excise all the diseased skin if present, but not to excise too much skin.
3. Inner cut made with scalpel circumferentially 5 mm below sulcus. The frenulum is released.
4. A dorsal slit is performed before the marked/incised skin is excised using scissors.
5. The dissected foreskin is sent for histological analysis.
6. Bipolar diathermy is used to achieve haemostasis.
7. The wound is closed using an absorbable vicryl rapide suture.

Complications

- Bleeding (1 % return to theatre).
- Infection (1–2%).
- Warn patients about the change in appearance post op. Warn them it may take 4–6 weeks to look closer to how it will in the future.
- Warn patients about post-operative changes in sensitivity (sensitivity for the first 2 weeks post op – tends to feel less sensitive during intercourse once fully healed).

Surgeons' Favourite Questions

1. What are the contraindications of a suprapubic catheter?
2. What is the classical triad of a renal cancer?
3. Can you name some risk factors for bladder cancer?
4. Where are the three points where stones commonly get stuck?
5. Name some non-urological conditions that might mimic renal colic
6. What condition might present with a bell-clapper deformity?
7. What is a hydatid cyst of morgagni?

Student Tips for Placement

Before entering theatre it is a good idea to know what operation you are going to see; familiarize yourself with the important anatomical relations and structures that surgeons will be watchful for. Where possible, research or ask a member of the theatre team what the operation will entail in order to gain an idea of the stages of the procedure.

One helpful way of confirming your understanding of the surgery and the relevant anatomy could be to apply this approach over a series of sessions in urological theatres:

1. Ask what will happen and pay attention to the pertinent anatomical structures.

2. When first watching, ask what is being done, why it is being done and why that technique has been adopted.
3. On future visits, describe what you are seeing and why it is being done to a member of the theatre team and ask for confirmation that your understanding is correct.
4. Describe the operation to a fellow student who is new to the setting. This allows you to practise your explanation skills, essential for surgeons when interacting with patients, and helps the new student who is as daunted and confused as you were when you first entered a urology theatre!

Careers

Sadly, due to poor exposure at the undergraduate level, many people do not get to experience this speciality enough to form an opinion of urology. To those who have not had the opportunity it can seem like nothing more than a catheterisation service. It has a number of different sub-specialities, which allow you to branch into a field that suits you most, ranging from oncology to reconstruction. There are not many surgical fields that have five organ-specific cancers to deal with. Each sub-speciality has its own wide array of procedures, ranging from simple open operations to complex robotic surgery and reconstruction techniques. There are a wide variety of endoscopic operations, as well as an opportunity to do laparoscopic and even microsurgical procedures. Good hand-eye co-ordination is essential. Urology is at the forefront of robotic surgery. It has embraced robotic surgery for a variety of cancer operations. Urologists also have the opportunity to branch into implant surgery and plastic surgery, using a variety of skin grafting and buccal (oral) grafting techniques for reconstruction.

In addition to the operative side, urology has great scope academically. Many of the senior trainees and consultants have completed postgraduate research degrees and doctorates, and are actively involved in academic research as part of their surgical career.

The lifestyle in urology is also a big draw. On calls are often non-resident from the speciality training years onwards, and are less intensive than other surgical specialities, allowing for a better work/life balance. Another draw is the colleagues you meet in urology. They tend to be less intense than surgeons from other specialities, but no less focussed or hard working. When you consider that you spend many hours of your life in the work environment, it's important to make sure it is spent doing something you like, with people you can get on well with.

Because of its popularity among those who have experienced it, urology can be a competitive field to get into. This should not dissuade you from pursuing it, but invigorate you to join those eager to chase such a varied and exciting speciality. For those keen for a career in urology, during your Foundation 1 and 2 years try to go to operating theatres and clinics to have a feel of what patient groups you may come across. Key skills to learn at this point are flexible cystoscopy and insertion of rigid cystoscopies as well as basic suturing techniques. You will require 2 years of core surgical training before you are eligible for ST3 national selection into Urology specialty training. 12 months of Urology is preferential with some on call experience at SpR level. Vascular, colorectal or general surgery rotations are beneficial. Time in research is useful, but by no means essential.

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21 Orthopaedic Surgery

Shibby Robati and Mark Maher

Introduction

Orthopaedic surgery (or orthopaedics) is a specialty in which conditions of the musculoskeletal system are diagnosed and managed. The musculoskeletal system is composed of the bony skeleton, musculature, soft tissues, tendons, ligaments, joints and other related structures. Most orthopaedic surgeons have a specialist interest in either a specific area of the body e.g. hip arthroplasty, a particular condition e.g. scoliosis or a specific field e.g. sports surgery. In this chapter, we aim to equip you with the core knowledge required to understand the most common orthopaedic operations. A variety of trauma and elective cases have been chosen to reflect the most commonly performed procedures as well as important orthopaedic emergencies.

Core Knowledge

A fracture is a discontinuity of bone with an associated soft tissue injury. They form a considerable proportion of injuries seen in hospital and in the community and have a significant socio-economic impact. It is therefore important that you have a solid understanding of the stages of fracture healing, their classification and description from radiographs and the principles of their management.

Fracture Healing

Fracture healing can be primary or secondary. Primary healing requires the edges of the bones to be touching exactly with no movement. This section will describe secondary fracture healing which is the commonest type of healing. Secondary healing can be divided into four stages but it should be understood as a biological continuum:

1. ***Haematoma Formation (hours)***
   The damage to blood vessels at the site of the fracture results in the formation of a haematoma which initiates the healing response. There is activation of the clotting cascade and complement system which initiates the release of cytokines and signaling molecules e.g. interleukin-6 (IL-6) and vascular endothelial growth factor (VEGF). Angiogenesis begins within 48 h. During this time the site becomes inflamed and painful.
2. ***Inflammation (days)***
   Polymorph neutorphils (PMN's) followed by macrophages migrate to the fracture site and

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phagocytose necrotic cells and tissue. Lymphocytes and other inflammatory cells also enter the fracture site. This results in the formation of granulation tissue and proliferation of vascular tissue.

3. ***Callus Formation (weeks)***
   Fibroblasts lay down collagen to help support vascular growth. As vascular growth continues osteoid is secreted by osteoblasts and is subsequently mineralised. This leads to the formation of soft callus. As the soft callus ossifies it gradually transforms into hard callus (woven bone). There is a bridge of woven bone between the fracture ends at this point.
4. ***Remodelling (months to years)***
   Remodeling completes the fracture process. There is reorientation of woven bone along stress lines forming hard dense lamellar bone. Mechanical stress placed on the bone facilitates this reorientation. Bone is restored to its original strength and structure.

A sufficient blood supply and an adequate reduction (restoration to correct alignment) of the fracture are two of the most important factors necessary for successful fracture healing. Energy transfer through the fracture and the tissue response (including infection and the presence of micromovements) can also play a part. Finally, the patient's age, co-morbidities and any other medications they may be taking can influence healing.

Fracture Classification and Description

When classifying and describing a fracture, it is important to consider the following questions (see Fig. 21.1):

- Which bone is fractured?
- Where in the bone is the fracture?
- What is the fracture pattern?

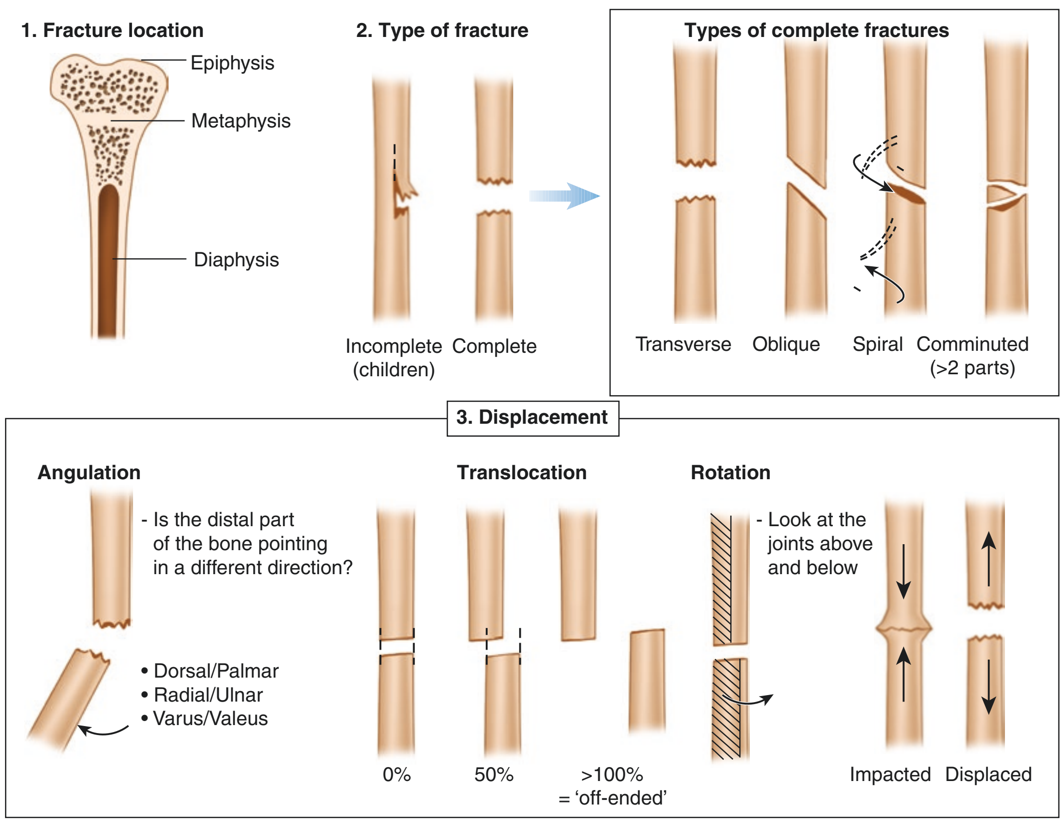

Fig. 21.1 Describing fractures

- What is the degree of comminution, angulation or displacement?
- How severe is the overlying soft tissue injury? Is it an open (wound in continuity with fracture) or closed (skin intact) fracture?
- Is there an associated neurological or vascular injury or compartment syndrome?

Fracture patterns are often described according to their appearance on a radiograph. The pattern of a fracture may indicate the nature of the causative trauma, the stability of the fracture and can guide the best method of reduction. For example, a transverse fracture is commonly a result of an angulation force, as opposed to a twisting force, which usually leads to a spiral fracture. Greenstick fractures are exclusive to children, especially in those aged 10 years or younger. The soft and relatively flexible bones characteristically bend and crack, similar to the branches of a young tree.

In terms of displacement, this commonly occurs following a complete fracture of the bone due to the force of the injury, gravity or the pull of muscles attached to it. Displacement is described in terms of shift (usually as less than 50 % and more than 50 %). It is important to remember that displacement can occur in any plane (sagittal, coronal or transverse).

Soft tissue damage is dependent on the energy involved in the fracture. Low-energy fractures usually cause only limited soft-tissue damage, such as a closed spiral fracture. High-energy fractures such as segmented or comminuted fractures can cause severe damage, whether it is an open or closed wound. The soft tissue damage has a significant effect on fracture healing and hence it is important to comment on it when describing a fracture.

Management of Fractures Can Best Be Remembered by the three R's

1. **Reduction**: manipulating the fracture into a better position or reducing a dislocated joint.
2. **Restriction**: immobillising the limb with a backslab, full cast or traction.
3. **Rehabilitation**: exercises, physiotherapy and occupational therapy if appropriate.

Core Operations

Pre-operative Management

It is important to ascertain if there has been any previous trauma to the affected joint as this may accelerate any degenerative process. Blood tests should be performed (ESR, CRP, FBC, Us & Es, LFTs, clotting, and rheumatoid factor) to exclude infection, systemic conditions e.g. rheumatoid arthritis and systemic functioning prior to surgery. A group and save should be performed. X-rays (AP and lateral) of the joint should also be performed. A chest X-ray and ECG is useful for exclusion of other co-morbidities. Further investigations may be required which are specific to the procedure.

The four cardinal signs of osteoarthritis (OA) on x-ray are:

1. Loss of joint space.
2. Bone cyst formation.
3. Subchondral sclerosis.
4. Osteophytes.

Total Hip Replacement

Total hip replacements (THR) are usually performed when there is degeneration of the joint most commonly due to OA or rheumatoid arthritis (RA). THR's are also being advocated in neck of femur (NOF) fracture patients who are active and medically stable. For elective patients requiring a THR, they commonly present with progressive pain in the groin, which is worse on movement. Night pain is also common and adoption of a waddling Trendelenberg gait is often seen. Advanced disease may cause significant degeneration of the joint leading to shortening of the leg.

Relevant Clinical Anatomy

Bryant's triangle (also known as the iliofemoral triangle) quantitatively measures supratrochanteric shortening which can be an indication of degeneration at the hip. True and apparent leg length discrepancy may also be suggestive. An understanding of the bony landmarks of the greater trochanter and the hip joint in the groin is essential for a THR procedure.

Step-by-Step Summary: Total Hip Replacement

1. A general anaesthetic or spinal anaesthesia with sedation is given along with broad spectrum prophylactic antibiotics.
2. The patient is placed in a lateral position.
3. The site is prepared and draped.
4. A posterior or antero-lateral approach may be used.
5. The incision is made through various layers until the bone is reached: skin, fat, fascia, tensa fascia lata, muscle, capsule and joint.
6. The femoral head is dislocated from the acetabulum and removed from the femoral shaft.
7. The acetabulum is reamed to create a smooth socket for the acetabular cup.
8. The inside of the femur is cleared and a prosthesis is placed into its shaft.
9. Implants are fixed into place cautiously using cement.
10. Evaluate the leg for stability, mobility and length.
11. Wash and close wound in layers.

Complications

- Peri-operative:
  - DVT, PE, MI, CVA, pneumonia.
  - Leg length discrepancy.
  - Infection.
  - Bleeding.
  - Nerve injury.
  - Aseptic loosening.
  - Death (rare).
  - Peri-prosthetic fracture.
- Prolonged pain and/or stiffness.
- Dislocation.
- Non-union and/or malunion leading to secondary OA.
- Femoral head avascular necrosis and secondary OA.

Follow Up

Routine blood tests are repeated and X-rays are performed post-operatively whilst the patient is in hospital. Physiotherapy and occupational therapy are organised and the patient is seen by their GP at 2 weeks for a wound check and then at 6 weeks in the orthopaedic clinic.

Total Knee Replacement

The majority of patients having a TKR are elective patients who suffer significant, disabling pain caused by severe arthritis. They also present with progressive pain in the associated joint which is worst on movement. Night pain, the feeling of the knee 'giving way' and an inability to fully straighten the knee (flexion deformity) are often noted. In some cases, the bone disease is restricted to one side (most commonly the medial compartment) of the knee and other devices are also commonly used e.g. unicondylar or patella-femoral knee replacement

Relevant Clinical Anatomy

The key bony landmarks around the distal femur and proximal tibia are important to know. This includes the medial and lateral condyles of the femur and tibia as well as the tibial tuberosity anteriorly. You should also appreciate the normal position of the patella. Furthermore, a clear understanding of the important ligaments and their attachments is key. This includes the anterior and posterior cruciate ligaments and the medial and lateral collateral ligaments.

Step-by-Step Summary: Total Knee Replacement

1. A general anaesthetic or spinal anaesthesia with sedation is given along with prophylactic broad spectrum antibiotics.
2. The patient is placed in a supine position with the knee in flexion.
3. A tourniquet is applied to allow for a bloodless field.
4. The site is prepared and draped.
5. Access is achieved through a medial parapatellar incision.
6. Bone cuts made to the distal femur and proximal tibia perpendicular to the mechanical axis.
7. Implants are selected and placed in situ and cemented.
8. Wash the joint.
9. Wash and close wound in layers.

Complications

- Peri-operative complications (as above).
- Particle debris.
- Injury to the popliteal vessels and nerves.

Follow-Up

Follow-up is the same as for a THR.

Fractured Neck of Femur

Fractured neck of femur (NOF) is a common presentation with over 70,000 hip fractures occurring each year in the UK. Amongst the elderly, there is a 10 % mortality rate within 1 month and 30 % within 1 year. The need for effective emergency treatment and rehabilitation into the community is vital for subsequent management of this patient group.

Fractures (often abbreviated with the symbol #) may be classified as either intra- or extracapsular:

- Intracapsular: occurring within the joint capsule, below the head of the femur but above the greater trochanter.
- Extracapsular: at the base of the neck, outside the insertion of the capsule or through the greater or lesser trochanter.

A common classification system (Garden) is used to describe the different types of intracapsular fractures as well as how best to manage them (see Table 21.1). Management varies accordingly due to the arrangement of blood vessels supplying the head of the femur (see Fig. 21.2).

Patients present similarly with either type of fracture. There is usually inability to weight bear, commonly following a fall in the elderly. Groin pain and tenderness over the greater trochanter is also typical. The affected leg will classically be shortened and externally rotated if the fracture is displaced.

Assessing the cause of the fall/trauma is vital as well as ruling out any other injuries e.g. head injury. Consider medical causes such as a stroke or MI, and risk factors for NOF fractures which include increased age, osteoporosis and post-menopause. It is also vital to ascertain other co-morbidities.

An AP pelvis and lateral X-ray of the affected hip is most commonly used to aid in diagnosis. Pre-operative assessment is required as above.

Table 21.1 The garden classification of intracapsular hip fractures and how to manage them

Garden type	Description of intracapsular fracture	Management
1	Stable, incomplete #	Cannulated screws
2	Complete #, non-displaced	Cannulated screws
3	Partially displaced #, some displacement	Hemiarthroplasty
4	Completely displaced #	Hemiarthroplasty

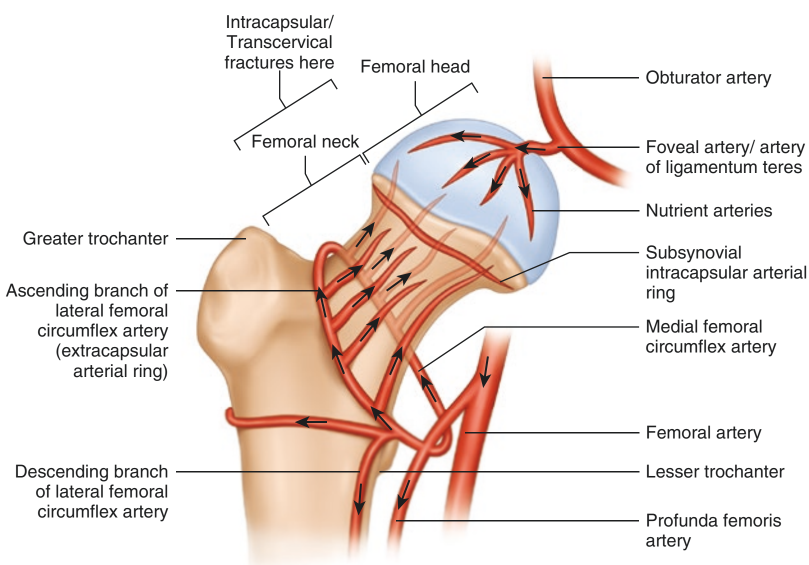

Fig. 21.2 A diagram of the blood supply to the femoral head

Dynamic Hip Screw

Relevant Clinical Anatomy

An understanding of the vascular supply to the head of the femur is key to fully understanding why certain procedures are carried out. The blood supply to the head of the femur is derived from three main sources:

1. The retinacular vessels from the medial and lateral circumflex arteries.
2. The artery to the ligamentum teres.
3. Nutrient foramina in the bone.

Indications and Contraindications

A dynamic hip screw (DHS) is used to treat an extracapsular NOF fracture where the blood supply to the head of the femur is preserved, in order to stabilise the fracture and allow early mobilisation. The use of a DHS is not recommended when there is an extracapsular fracture with subtrochanteric (beyond lesser trochanter) extension, thus a nailing implant should be used in this scenario.

Step-by-Step Summary: Dynamic Hip Screw

1. A general anaesthetic or medial (usually spinal) anaesthesia is given along with broad spectrum antibiotics. X-ray availability in the operating theatre should be ensured.
2. The patient is placed on a traction table.
3. A closed reduction of the fracture is performed.
4. The site is prepared and draped.
5. Lateral incision over the femur from lesser trochanter, proceeding distally 10–15 cm.
6. The incision is made deeper through various layers to the bone: (as above).
7. At this point the surgeon has the option of either splitting the vastus muscle or reflecting it and going underneath.
8. Insertion of the DHS metal-work.
9. Review X-ray for correct positioning.
10. Wash and close wound in layers.

Complications

- Early complications:
  - Wound breakdown.
  - Infection.
  - Pain.
- Late complications:
  - DHS cutting out through the femoral head.
  - Mal/non-union of the fracture.
  - Osteoarthritis of the joint.
  - Avascular necrosis of the femoral head.

Follow-Up

There is normally no routine follow-up. Post-operatively these patients should be seen by physiotherapy, occupational therapy and have their nutrition state reviewed. These patients usually have other co-morbidities to begin with and the focus is on providing rehabilitation within the community. Young patients should be followed-up in 6 weeks with an X-ray at an outpatient appointment.

Hip Hemi-Arthroplasty

Indications and Contraindications

A hip hemi-arthroplasty is performed in the presence of an intracapsular neck of femur (NOF) fracture as the blood supply to the head of the femur is usually so critically compromised that even reduction of the fracture will result in the death of the head due to avascular necrosis, necessitating its replacement. The acetabulum is not compromised. If the patient is not expected to survive the operation, the procedure should not be performed.

Step-by-Step Summary: Hip Hemi-Arthroplasty

1. A general anaesthetic or medial (usually spinal) anaesthesia is given along with broad spectrum antibiotics.
2. The patient is placed in a lateral position.
3. The site is prepared and draped.
4. Antero-lateral approach is most commonly used.
5. The incision is made deeper through layers to the bone: (as above).
6. The femoral neck is cut and the head is removed from the acetabulum.
7. The femur is prepared for implantation of the stem and the prosthetic femoral head is attached.
8. Finally, reduce the hip, wash and close wound in layers

Complications

- Peri-operative complications as above.
- Dislocation or loosening of the prosthesis may occur as well as acetabular wear and infection.

Follow-Up

There is normally no routine follow-up, but a wound check is organised at 2 weeks post-op.

Fracture of the Distal Radius

Usually resulting from a fall on the outstretched hand, Colles' fracture is the most common of all fractures in the elderly. This is a transverse fracture of the distal radius, typically both displaced and angulated dorsally and towards the radial side with a high force of impact. Postmenopausal osteoporosis is a significant risk factor, resulting in a high incidence in middle-aged and elderly women. A classic 'dinner fork deformity' is often seen clinically. A Smith's fracture similarly involves the distal radius, however it is associated with volar displacement and is commonly caused by a fall on the back of the hand.

Diagnosis is with AP and lateral X-rays of the wrist. You may consider X-rays of the joint above and below to exclude other injuries. Also, a DEXA (dual energy X-ray absorptiometry) scan may be appropriate at a later date to rule out osteoporosis as a contributing factor. Pre-operative management as above.

Both types of fractures can be treated conservatively or operatively. Conservative management is appropriate in an extra-articular (not involving the joint) stable fracture and in the elderly. Operative management is reserved for intra-articular (involving the joint) fractures and in young, active adults.

A fracture will require manipulation if there is an obvious deformity visible with the naked eye or if there is displacement of the ulnar styloid. Otherwise, a dorsal splint is applied for up to 48 h until there is a reduction in swelling, when the cast can then be completed. To allow for mobilisation, the cast is removed at 6 weeks.

Manipulation Under Anaesthesia and Plaster of Paris

Relevant Clinical Anatomy

A clear understanding of the bony landmarks of the hand and forearm is crucial is aiding diagnosis. The position and names of the carpal bones and the radius' association with the ulnar styloid via the triangular fibrocartilage is important.

Indications and Contraindications

Displaced or extra articular stable fractures are managed in this way. This procedure is used for the majority of Colles' fractures. It is a procedure commonly performed in the elderly.

Step-by-Step Summary: Manipulation Under Anaesthesia

1. Entonox (gas and air) given.
2. Anaesthesia given (either haematoma block, Bier's block or axillary block).
3. Traction applied in length of bone to disimpact fracture.
4. Manipulation of wrist into moderate flexion, ulnar deviation and pronation for Colles' fracture. Supination and dorsiflexion performed in Smith's fracture.
5. Position may be checked by X-ray.
6. Once position is satisfactory, wool is applied followed by a dorsal plaster slab and held in place with a crepe bandage.

Follow Up

X-rays are taken at 1 week to check the position and any displacement. At 6 weeks the fracture usually unites and the slab may be removed and exercises started.

Fixation with Percutaneous Kirschner Wires or Open Reduction and Internal Fixation

Indications and Contraindications

Displaced and unstable fractures are managed with closed reduction and the insertion of percutaneous Kirschner (K)-wires, or with open reduction and internal fixation (ORIF) with plates and screws. These procedures should not be carried out in a patient with multiple co-morbidities.

Step-by-Step Summary: ORIF or K-wires

1. Pre-operative management as above.
2. The site is prepared and draped.
3. Ensure image intensifier X-ray is available.
4. Insert metalwork as appropriate and ensure correct positioning.
5. Close wound in layers (for ORIF) or cut ends of wires and cover (K-wiring).
6. Apply plaster slab (only half a cast in order to allow for swelling).

Follow Up

Patients are seen in the fracture clinic at 2 weeks for wound check and X-ray. Plaster and wires removed at 6 weeks and exercises are started.

Complications

After applying a plaster slab, circulation in the fingers must be checked. If evidence of compromise is present, do not hesitate to loosen or remove the cast immediately. Compression or damage to the median nerve should also be considered if symptoms are present. If reduction was not complete or displacement of the fracture was overlooked, malunion may occur.

Cauda Equina Syndrome (Spinal Cord Compression)

Cauda equina (CE) is Latin for '*horses tail*' and describes the group of nerves, which commence at the termination of the spinal cord at L1.

Cauda equina syndrome (CES) describes a group of characteristic symptoms:

- Bilateral leg pain.
- Micturition disturbance: incontinence, hesitancy and urgency.
- Loss of anal sphincter tone resulting in faecal incontinence.
- Saddle anaesthesia.
- Increased motor weakness associated with gait disorder.
- Sexual disturbances.

Common causes of CES include:

- Large herniated disks
- Malignancy and trauma resulting in inflammation
- Haemorrhage or fracture.

Lesions may be complete or incomplete, sparing some or all function. It is vital that a thorough neurological, sensory and motor examination is performed upon admission in order to provide a baseline record before any treatment is initiated. To accompany a thorough neurological examination, a clear understanding of the dermatomes and myotomes of the lower limbs is important as well as the cross sectional anatomy of the spinal cord itself. An urgent MRI scan within 24 h is warranted in any suspected case of CES. Consequently if diagnosis of a lesion or compression is confirmed, immediate surgery (details of which are not important at this stage) must be performed to ensure the best possible prognosis for recovery of function.

Complications of Decompressive Surgery

- A dural tear
- Failure to relieve the symptoms and the risk of causing further neurological injury.

Follow Up

Orthopaedic follow-up is conducted in a designated spinal clinic, however rehabilitation will vary for each patient depending on the degree of loss of function incurred. This may include care and training of the bladder, aids for mobility as well as psychological therapy for patients with traumatic disability.

Compartment Syndrome

Compartment syndrome is a build up of pressure within an enclosed space which if left untreated, can prevent blood flow and nerve function to the limb, leading to muscle and tissue necrosis. It is a clinical diagnosis and definitive treatment includes an urgent fasciotomy within 6 h to prevent muscle necrosis usually via two incisions for decompression (operative detail not required).

The most common sites encountered for compartment syndrome are in the forearm and in the lower leg as there isn't much room for potential swelling to dissipate in these areas. Closed fractures are a common cause, leading to swelling.

Patients often present with significant pain. Classically, the six P's are often used to describe the main features:

- Pain
- Perishingly cold
- Pulselessnes
- Paraesthesia
- Paralysis
- Pallor

Although, the most important feature is that of pain out of proportion to clinical findings.

Intracompartmental pressures can be measured in certain cases e.g. unconscious patients.

Relevant Clinical Anatomy

Muscles groups in the compartments of the lower leg and forearm as these are the most commonly encountered sites for compartment syndrome.

Follow Up

Return to theatre in 1 week for closure of fasciotomy wound(s).

Complications

If there is prolonged muscle ischaemia as a result of compartment syndrome (usually occurs when ischaemia has lasted greater than 6 h), then muscle necrosis will occur which will need to be surgically debrided, leading to significant functional disability for the patient.

Surgeons' Favourite Questions for Students

1. What 4 X-ray features are commonly seen in OA?
2. Describe the blood supply to the femoral head?
3. What is the difference between a Colles and a Smith type wrist fracture?
4. Define cauda equina syndrome.
5. Name the six P's.

Student Tips for Placement

Most medical schools give very little exposure to students in orthopaedics so it is important to make the most of it on your placements. If assigned to a particular firm or consultant try to find out early on what their timetable involves so that you can shadow them in clinics as well as assist in theatres. Teaming up with the SHO and registrar will also give you valuable insight into the wards and oncalls. Attending the daily trauma meetings is a good way to see how different cases are presented and to learn how to use the correct lingo in interpreting X-rays (make sure you arrive at 7.58 am as latecomers are usually punished!). A nice book that we found helpful was Surgical Talk: Surgery for Finals (Authors: Andrew Gosling and Gerard Stansby). This is a well written book, notably the orthopaedics chapter which focuses on the basics, avoiding a lot of the medical jargon that can often confuse medical students. Another popular choice is Orthopaedics Trauma and Rheumatology (Authors: Andrew Duckworth, Daniel Porter and Stuart Ralston) which we think has just enough detail for clinical rotations.

Careers

Orthopaedics is of course the best specialty in the world! If you enjoy playing with lots of different toys, mending things and making them work again then this is the specialty for you. People are always going to get broken bones and musculoskeletal problems so there is always work to do and hence a job. The landscape is driving surgeons to become more sub specialized so don't be surprised if you see left and right-handed hip surgeons in the future! After 2 years of Foundation training and 2 years of Core Surgical Training, a competitive interview occurs through national selection where individuals are ranked amongst each other. Getting into theatre as an SHO can be challenging due to ward commitments, but if you show perseverance, you will usually be rewarded. Most registrar rotas in district general hospitals work on a 24 h on-call system, where a fixed half-day is given the next day. Busier tertiary centers may still adopt a rota of day and night on calls.

22 Plastic Surgery

Evelyn W.Y. Chou and Duncan Atherton

Introduction

Plastic surgery is a unique medical specialty, derived from the Greek "plastikos", meaning to remodel, reshape and mold. Its origins date back to 600BC, when Shushruta, an Indian surgeon, described the first nasal reconstruction using a forehead skin flap. During the sixteenth century, the Italian surgeon Tagliacozzi also performed a nasal reconstruction, this time using a local flap derived from the arm of his patient. However, it was during the World Wars that the specialty of plastic surgery really developed due to the high prevalence of traumatic injuries to the faces of soldiers. Hospitals were created that specialized in reconstructive techniques, setting the foundations of plastic surgery as we know it today.

Plastic surgery can be broadly divided into aesthetic and reconstructive surgery. Aesthetic surgery refers to the remodeling of normal body structures, and reconstructive surgery refers to the alteration of abnormalities, including congenital and developmental defects, disease or injury in order to restore normal function and appearances. However, a substantial amount of overlap occurs between the two.

Due to its ambiguous boundaries, no sole definition of plastic surgery exists, and in many respects, is the last true form of general surgery remaining. Unlike other specialties, plastic surgery is not based on a single organ system or specific procedures, but on certain principles and operative techniques, which form its foundation.

Core Knowledge

Skin Structure

The skin is the largest and most complex organ of the body, making up approximately 15 % of total body weight. It is subdivided into three main layers – epidermis, dermis and subcutaneous tissue. The dermis in turn, can be divided into a superficial papillary and deep reticular layer (Table 22.1).

Principles of Incisions

Since scarring always occurs after an incision, the ideal outcome is a minimally conspicuous, fine-lined scar. However, as the final appearance of a scar depends on several factors, predicting the outcome is complex and for an identical incision, two individuals may develop different severities of scarring.

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Table 22.1 Structure and composition of skin – epidermis, dermis and subcutaneous layers

	Epidermis	Dermis		Subcutaneous layer
		Papillary	Reticular	
Composition	Keratinocytes Melanocytes Langerhan cells Merkel cells	Collagen Elastic fibers Fibroblasts	Collagen Elastic fibers Reticular fibers Fibroblasts Small adipocyte clusters	Predominantly adipose tissue Collagen Elastin Lymphatic vessels
Vascular supply	None	Rich in small blood vessels	Rich blood supply	Rich blood supply
Appendages	Nerve endings	Meissner's corpuscles	Hair follicle roots Sebaceous glands Sweat glands Receptors Nails	Hair follicle roots Ruffini corpuscles Pacinian corpuscles
Description	Keratinized stratified squamous epithelium	Loose, areolar layer	Dense, irregular connective tissue	Also known as hypodermis, consisting mainly of loose connective tissue

Factors of scar formation:

- Size of incision
- Location of incision
- Incision along Langer lines (Fig. 22.1)
- Skin type
- Skin tension
- Patient systemic factors (e.g. obesity, malnutrition, diabetes)
- Patient age
- Suture technique and surgeon's own ability

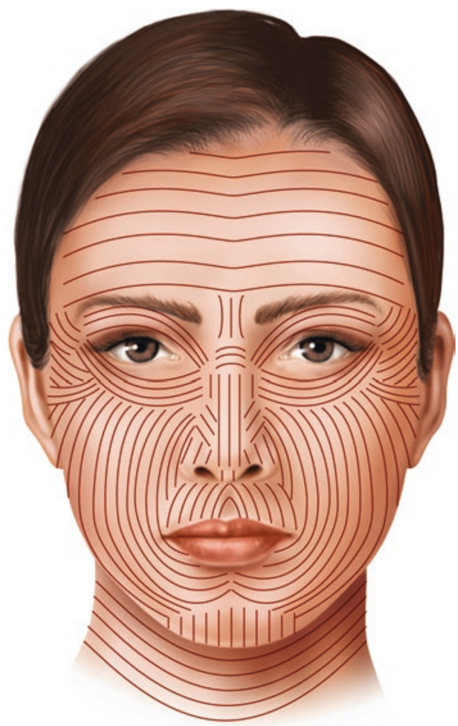


Fig. 22.1 Langer lines on the face

The Reconstructive Toolbox

A number of techniques form the basis of most plastic surgery, such as full-thickness or split-thickness skin grafts and local, regional, or free tissue transfers.

Traditionally, the reconstructive ladder (Fig. 22.2) was used when plastic surgeons were presented with various defects. The principle is that wound closure is first achieved by the simplest method, before 'climbing' to more complex methods if the former fails. It provides a basic framework, progressing from simple techniques such as wound healing by secondary intention to more complex ones such as the use of free flaps.

However, the reconstructive ladder is overly simplistic, and can be replaced by the reconstructive toolbox (Fig. 22.3). The use of this toolbox ensures that the technique chosen for the patient is the most appropriate to repair the injury or defect, with the best outcome initially.

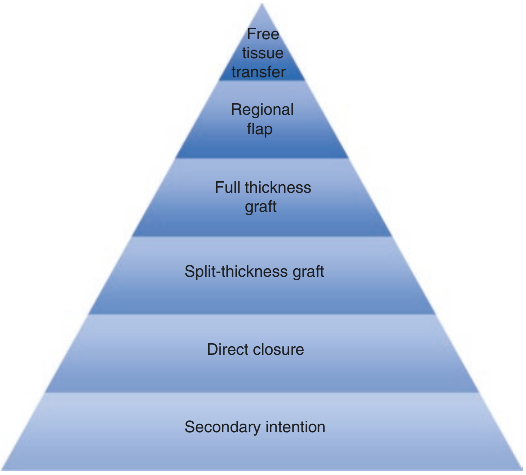


Fig. 22.2 The reconstructive ladder

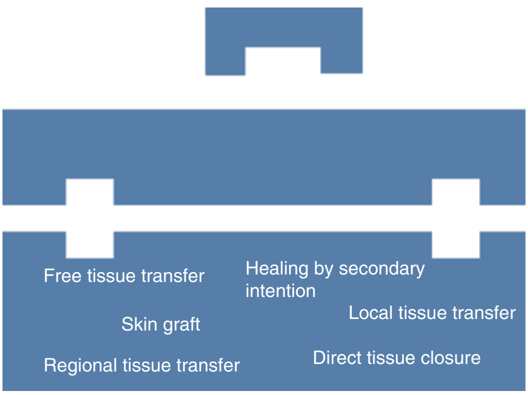


Fig. 22.3 The reconstructive toolbox

Wound Healing

Wound healing is a complex and dynamic process composed of four overlapping sequential stages: haemostasis, inflammation, proliferation and repair, and remodeling (Table 22.2).

Wound Closure

Wound closure can be achieved by primary, secondary or tertiary intention [2].

Primary Intention

Most surgical incisions heal by primary intention via use of sutures:

1. Wound edges are re-approximated
2. Epithelial regeneration occurs
3. Minimal wound contracture and scarring

Secondary Intention

1. Wound edges are not re-approximated
2. More intense inflammation compared to primary intention
3. Greater granulation of the wound occurs
4. Followed by re-epithelialization
5. More extensive wound contracture and scarring

Tertiary Intention

1. Wound edges are not re-approximated immediately, but debrided and cleaned first
2. Allowed to granulate for a few days before wound edges are re-approximated

Free Skin Grafts

Skin grafts are defined as a layer of epidermis, along with some or all of dermis, that is removed and translocated to another part of the body. They are commonly used for the treatment of burns and extensive wounds or after excision of skin cancers.

Skin grafts can be categorised as either split-thickness or full-thickness:

Split-Thickness Skin Graft

These consist of epidermis and a variable amount of dermis. They can be further classified as thin, intermediate or thick, and are harvested with a Humby knife or more commonly a power-driven dermatome. Epidermal elements (e.g. sweat glands and pilosebaceous follicles) remain at the donor site, allowing re-epithelialization and spontaneous healing. As such, larger split-thickness skin grafts can be harvested, and are selected for more extensive defects. Common donor sites include the lateral thigh and trunk. However depending on the circumstance, amount needed and type of defect, almost any part of the body could be a potential donor site; including scrotum, scalp and foot.

Full-Thickness Skin Graft

These consist of epidermis and all of the dermis, and are harvested with a scalpel. No epidermal

Table 22.2 Stages of wound healing

Stage	Description
Haemostasis	• Occurs at time of injury, completed within hours • Initial transient vasoconstriction, platelet plug and clot formation • Platelet aggregation, activation and degranulation releases platelet-derived growth factor (PDGF) and transforming-growth factor beta (TGF-b), initiating chemotaxis and proliferation of inflammatory cells
Inflammation	• Begins right after haemostasis, completed within 24-72 hours • Neutrophils infiltrate the wound, to contain foreign microorganisms, and are the predominant cell type for a few days. Other white cells present include plasma cells, monocytes and lymphocytes • In absence of infection, neutrophil infiltration diminishes, and monocytes differentiate into macrophages • Macrophages have numerous roles, including phagocytosis of dead cells and cellular debris, cytokine release to initiate repair, matrix metalloproteinase (MMP) production, and nitric oxide release
Proliferation	• Occurs 1-3 weeks after injury • Fibroblast proliferation occurs, which are responsible for collagen production • Angiogenesis and capillary growth by endothelial cells are stimulated by growth factors
Repair	• Begins 3 weeks after injury, completed within several months or years • Collagen accumulation plateaus • Random collagen fibrils are replaced with organised, cross-linked fibrils

appendages or elements are left, and the donor area has to be closed by sutures, limiting the size of the graft. Common donor sites include the supraclavicular area and postauricular regions, as well as flexural skin (e.g. antecubital fossa, groin).

While a full-thickness graft yields better cosmetic results and is more stable against trauma, they may not take as readily as split-thickness grafts.

Survival of Skin Grafts

After the free skin graft is temporarily detached, devascularised and transferred to its new site, *take* occurs; the process by which the graft is reattached and revascularised (Fig. 22.4).

The two main factors influencing graft take are graft adherence via fibrin attachment, and re-vascularisation, which are in turn determined by the characteristics of the graft bed, the graft, and conditions under which the transfer occurs [4].

Skin Flaps

Flaps differ from skin grafts in that they contain their own vascular supply – arterial, venous and capillary. The effectiveness of the blood circulation determines the flap survival. They are generally used for covering up defects with poor vascularity, reconstructing the face (eyelids, nose, cheeks) and protecting vital structures.

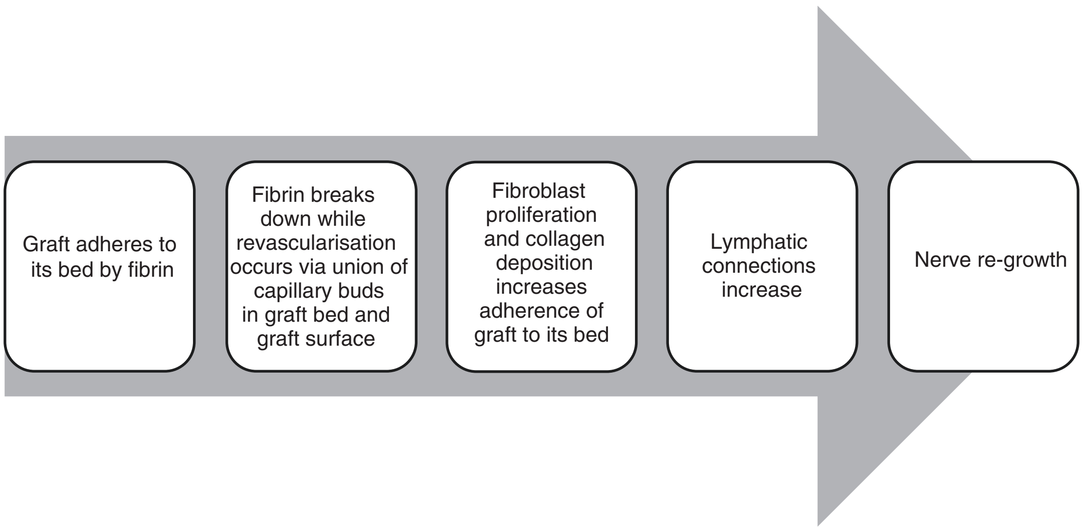


Fig. 22.4 The process of graft take

Table 22.3 Major skin flaps categorized according to composition

Flap	Composition
Cutaneous	Skin and superficial fascia
Fasciocutaneous	Skin, superficial fascia and deep fascia
Muscle	Muscle
Myocutaneous	Muscle and skin overlying muscle
Osteomyocutaneous	Muscle, skin overlying muscle and bone to which the muscle is attached

Table 22.4 Local flaps

Local flaps	
Advancement	A to T
	V to Y
	Island
	Unilateral
	Bilateral
Rotation	0 to Z
	Karapanzic
Transposition	Rhomboid Zitelli bilobe

Skin flaps can be classified in three key ways: tissue composition, donor site location or blood supply. Each of these classification systems is outlined below.

Tissue Composition (Table 22.3)

Donor Site Location

A flap may be classified based on its proximity to the site of the primary defect, and can be described as local, regional or free.

Local

Local flaps are raised from tissue in close proximity, adjacent to the primary defect, and can be further classified as advancement, rotation, or transposition flaps (Table 22.4). However, some flaps have elements of more than one technique (See Box 22.1).

Box 22.1 An Arrangement of All the Local Graft Images on One Page

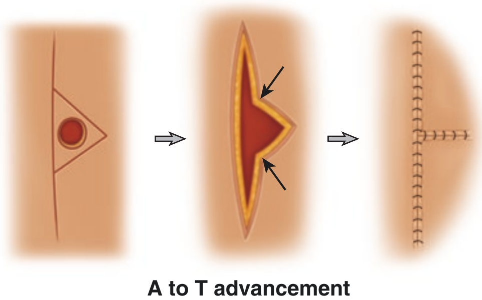


Fig. B1.1 A to T advancement

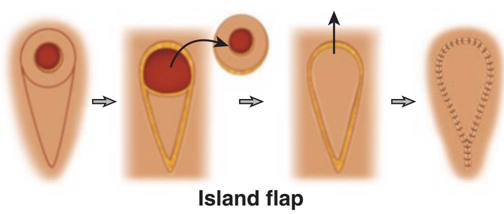


Fig. B1.2 Island flap

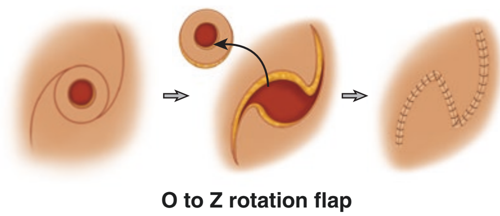


Fig. B1.4 O to z rotation flap

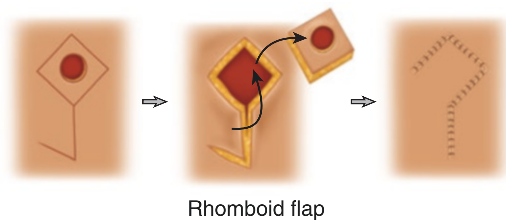


Fig. B1.5 Rhomboid flap

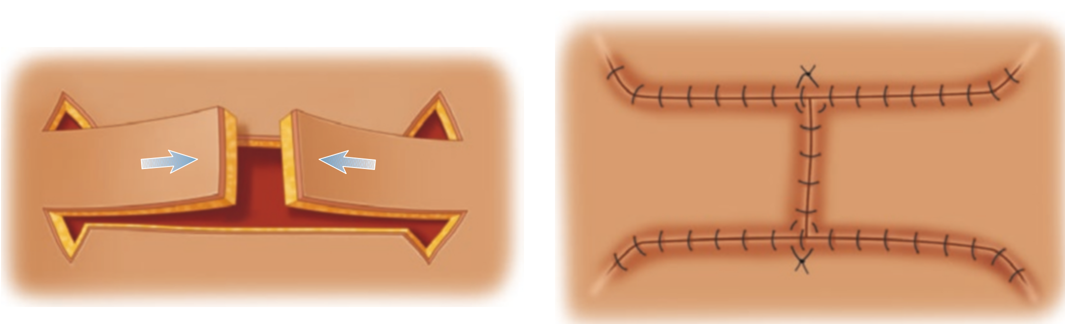


Fig. B1.3 Bilateral advancement flap

Regional

Regional flaps are raised from tissue in proximity, but not adjacent to the primary defect, and can be further classified as transposition or interpolation flaps (Table 22.5). Interpolation flaps include melolabial, nasofacial and paramedian forehead.

Table 22.5 Regional flaps

Regional flaps	
Transposition	Pectoralis major myocutaneous flap Deltopectoral flap Latissimus dorsi flap
Interpolation	Melolabial
	Nasofacial
	Paramedian forehead

Free
Free flaps are raised from tissue distant from the primary defect, and are thus non-pedicled. Thus, the vessels in the flap need to be re-anastamosed to an artery and vein in the recipient site; establishing a new blood supply and maintaining viability.

Blood Supply
Flaps can also be classified according to their blood supply. Within the dermis lies two vascular arcades – a superficial vascular plexus and a deeper subdermal plexus running between the reticular dermal layer and subcutaneous tissue. Additional vascular supply to the skin comes from perforator arteries off deep musculocutaneous arteries.

Random
Random flaps receive their blood supply from the subdermal plexus, and many local flaps are random.

Axial
Axial flaps receive blood supply from named perforator arteries off musculocutaneous arteries, and most muscle flaps are axial. They can also further be described as local, regional or free.

Axial muscle flaps can also be further classified into types I to V, based on the source, size, number, angiographic patterns, and the location and insertion of vascular pedicles supplying the muscle [7, 8] (Fig. 22.5):

- Type I – one vascular pedicle (e.g. Tensor fascia lata)
- Type II – one dominant vascular pedicle with minor pedicles (e.g. Gracilis)
- Type III – two dominant pedicles (e.g. Gluteus maximus)
- Type IV – segmental vascular pedicles (e.g. Sartorius)
- Type V – One dominant vascular pedicle with segmental vascular pedicles (e.g. Latissimus dorsi)

Z-plasty

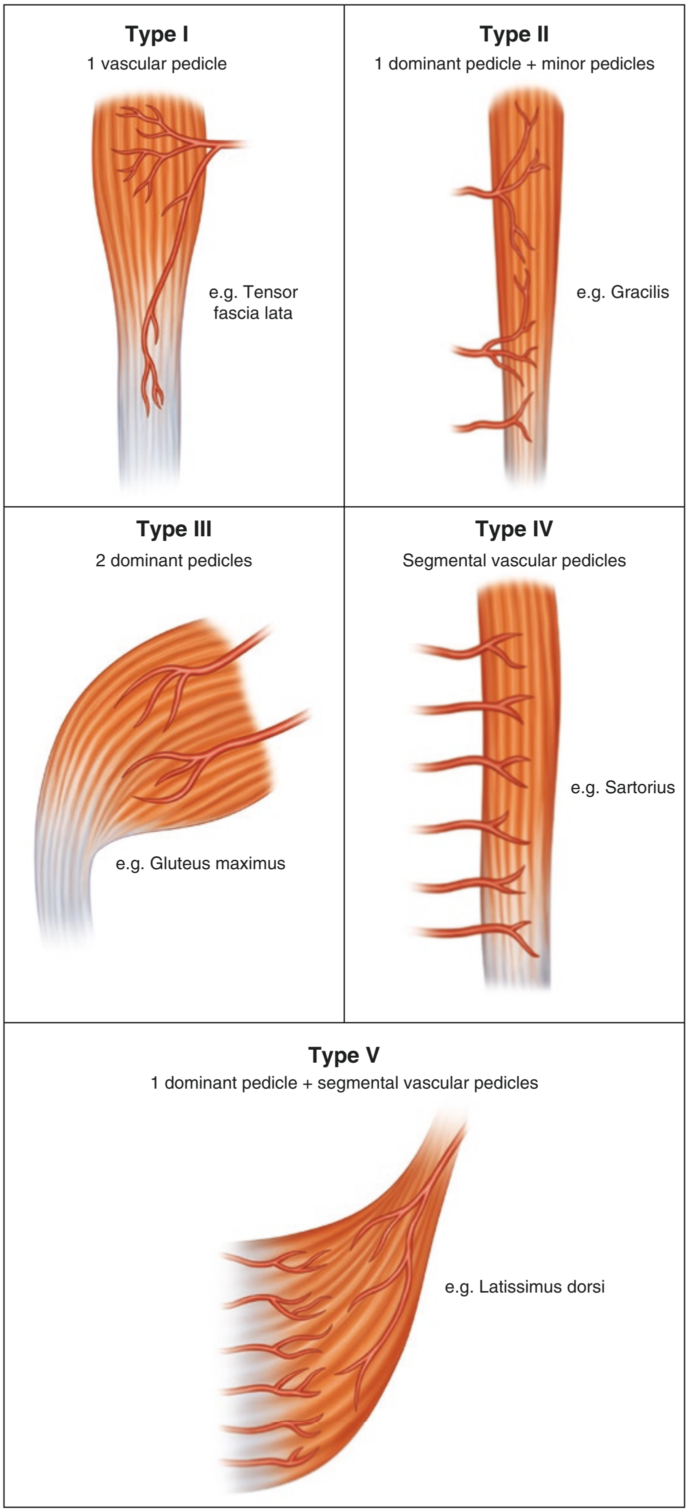
The Z-plasty is a technique that is applied in numerous areas in plastic surgery, and is named after the three limbs of the flap. This technique brings about two outcomes; a gain in length and a change in direction of the main limb of the 'Z'. It is commonly applied where a scar needs to be realigned to minimize its appearance, for the treatment of contractures, as well as in the prevention of contracture development.

Procedure (Fig. 22.6)
- The Z shaped incision is created, with the central limb lying along the contracture line.
- The limbs and angles of the 'Z' are equal in length, to ensure the two flaps fit after transposition.
- The angle size can be varied; the greater the angle, the greater the amount the scar is lengthened by:
  - 30° results in 25 % increase
  - 45° results in 50 % increase
  - 60° results in 75 % increase (most commonly used)
- The length of the limbs can be varied; a longer length allows a larger Z to be incised, accommodating a larger contracture.
- Once the 'Z' is incised, two equal flaps are created, and are transposed. They are then sutured in place [4].

Core Operations

Due to the generality of plastic surgery, almost all plastic surgeons subspecialise [6]. The common subspecialties include skin, hand and upper limb, head and neck, breast and cosmetic. An overview of some of the key procedures of each specialty is reviewed below.

Fig. 22.5 Sub classification of axial flaps – I – V



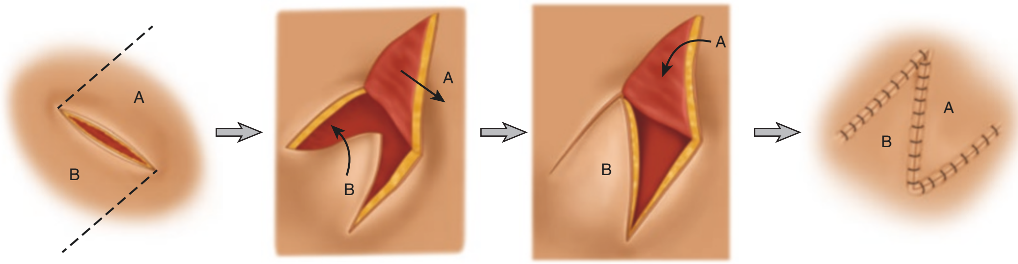


Fig. 22.6 Z-plasty

Skin

Skin surgery involves the excision of skin lesions, whether malignant or benign, as well as the removal of lymph nodes and the management of cutaneous cancer metastases. Common skin lesions removed include basal and squamous cell carcinoma and melanoma. Local flaps and grafts are often utilized in this subspecialty.

Hand and Upper Limb

This involves the correction of any congenital deformities of the hand, such as polydactyly (duplicated digits) or syndactyly (fusion of digits), treatment of degenerative hand diseases, and repairing injuries to the hand, for example by tendon grafting. One such example is flexor tendon repair.

Flexor Tendon Repair

Indications

- Tendon lacerations causing dysfunction.

Contraindications

- Extensive damage of vincula (nutrient provision to tendons).

Presentation

- Loss of flexor tendon strength.
- Limited movement of affected digits.
- Reduced range of motion.
- Deformity of digits.

Step-by-Step Summary: Flexor Tendon Repair

1. A zig-zag incision is made to avoid contracture formation.
2. Bone and joint structures are repaired first, followed by tendons and neurovasculature.
3. Tendon retraction, with minimal trauma inflicted on tendons – Intact vincula could prevent retraction of the proximal tendon.
4. The tendon is passed through the flexor sheath and secured by sutures.

Complications

- Tendon and pulley rupture.
- Infection.
- Tendon adhesions.
- Contracture of the joint.
- Trigger finger.
- Swan-neck deformity.

Follow-Up

- Rehabilitation with controlled mobilisation post-operatively is vital.
- Follow up in 4 weeks.

Breast

Breast reconstruction is carried out for several reasons, such as for patients with congenital deformities, but more commonly in patients who have undergone partial or full mastectomies for breast cancers. One common method of breast reconstruction is by using the deep inferior epigastric perforator flap, which involves free tissue transfer of skin and fat, with no involvement of the rectus abdominis.

Deep Inferior Epigastric Perforator (DIEP) Flap

Indications
- Breast reconstruction following mastectomy.
- Traumatic injury.

Contraindications
- Damaged or unsuitable deep inferior epigastric vessel.

Step-by-Step Summary: DIEP Flap
1. Main flap perforators are assessed using a handheld Doppler, and are marked. Alternatively, angiography may be used to assess blood flow.
2. Skin markings are made.
3. For the breast, the areolar complex and biopsy sites are marked. Markings are also made on the abdominal donor region.
4. The abdominal island flap is harvested by a transverse incision above the umbilicus, and a second incision similar to the Pfannenstiel incision that is used for caesarean section.
5. The flap is elevated from lateral to medial towards the main perforator(s), and this is then followed carefully through the rectus muscle to its undersurface and down to the main vessel (the deep inferior epigastric artery).
6. As the rectus abdominis is dissected, the intercostal nerves are preserved except perhaps the branch that runs with the perforator vessel.
7. Once the perforator is freed, the arterial perfusion is checked and the vessel is carefully ligated near its origin.
8. The artery (and vein which runs with it) are then anastamosed, most commonly to either the internal thoracic or thoracodorsal vessels, and the flap is inspected for adequate perfusion. The flap is then shaped, de-epithelialized and secured in position for appropriate breast reconstruction.
9. Abdominal fascia is sutured closed, as are the abdominal skin edges.

Complications
- Infection.
- Distal flap necrosis.
- Herniation of flap donor site.

Follow-Up
- Appointment with dressing clinic 1 week following discharge.
- Appointment with surgical team 4–6 weeks post-operatively.
- Routine oncology [3].

Head and Neck

An example of a procedure is mandibular reconstruction using a free fibular flap, which is useful after excision of oral cancers involving the oral mucosa and underlying mandible.

Mandible Reconstruction Using a Free Fibular Flap

Indications
- Mandibular involvement of head and neck cancer.
- Oral tumours.
- Trauma requiring reconstruction.

Contraindications
- No contraindications besides individual patient comorbidities preventing surgery.

Step-by-Step Summary: Mandibular Reconstruction
1. The lesion and tissue to be excised is marked out. The underlying mandible is exposed via a transverse incision.
2. Pre-plating is then carried out, with the plate fixed to the mandible via screws. The pre-plate is then removed.
3. The mandibular lesion is resected
4. A free fibula flap is designed with an overlying skin paddle to fill the soft tissue defect while the underlying fibula is osteotomised and using

the plate, remodeled to the shape required for reconstruction of the mandibular defect.

5. The flap is then transferred to the resected mandible and fixed to the definitive plate, vessels are anastamosed, and the skin sutured in place.

Complications

- Flap necrosis.
- Wound dehiscence.
- Wound infections.
- Wound contracture.
- Asymmetrical face.

Follow-Up

- Review of both donor and reconstructed mandible sites.
- Naso-gastric feeding 24 h post-operatively.
- Oral feeding 10 days post-operatively.
- Monitoring of flap vascularity using Doppler scans [5].

Cleft Deformities

This subspecialty involves the correction of cleft lip and cleft palates. There is debate about the exact timing of repair, although often the "rule of 10s" is applied, which suggests that the repair should occur at least 10 weeks after birth, when the infant is at least 10 pounds and a haemoglobin level of at least 10 g/dL.

Unilateral Cleft Lip Repair (Millard Rotation Advancement Closure Technique)

Indications

- Unilateral cleft lip deformity

Contraindications

- No contraindications besides individual patient comorbidities preventing surgery (anaemia, tolerability of general anaesthesia); Coexisting cardiac abnormalities.

Step-by-Step Summary: Cleft Lip Repair

1. Patient in supine position.
2. Skin markings are made with methylene blue dye (Box 22.2 Fig. B2.1 – in this example markings are simplified to red, blue and orange markers).
3. Incisions are made to create a rotation flap.
4. An additional incision is made to the contralateral side, creating the lateral philtral ridge, which is sutured to the rotation flap edge. This creates the advancement flap.
5. Closure of advancement-rotation flaps.
6. The flaps are approximated and sutured.

Box 22.2 Unilateral Cleft Lip Repair (Procedure Simplified from Flint et al. 2010)

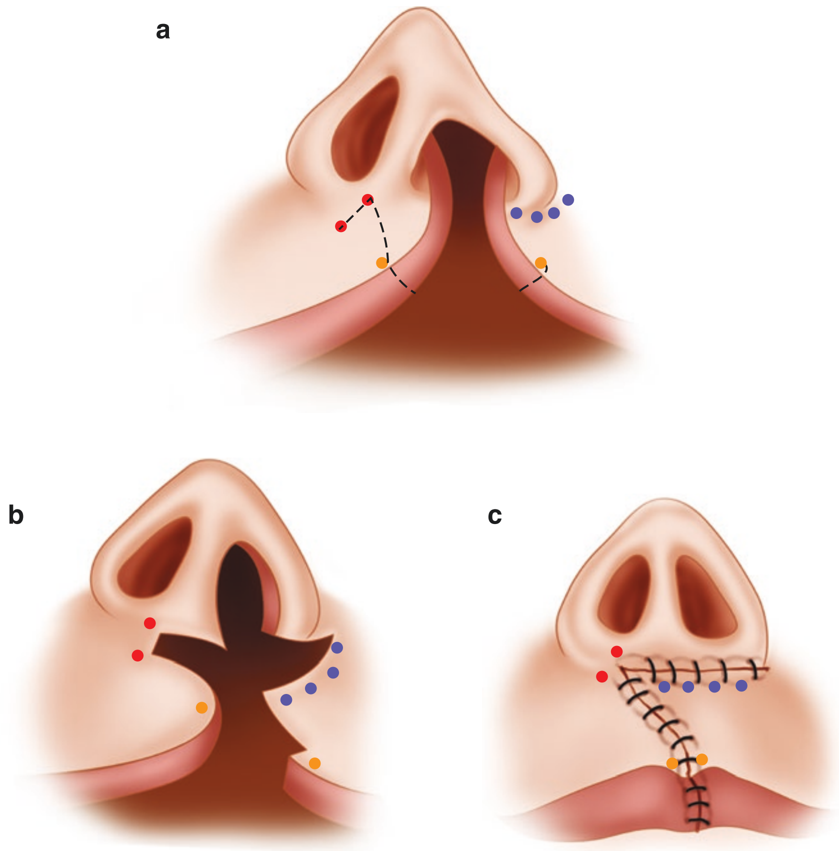


Fig. B2.1 Unilateral Cleft Lip Repair (Procedure Simplified from the Millard rotation advancement technique) (**a**) Marking the site (**b**) Incisions are made to form an advancement flap for surgical repair (**c**) Closure of advancement-rotation flaps

Complications

- Scar contracture or hypertrophy.
- Vermillion border misalignment (insufficient flap rotation).
- Wound dehiscence.

Follow-Up

- Routine wound care.
- Intraoral care of mucosal incisions.
- Revisional surgery if required.
- Assessment of hearing and speech.
- Promotion of good oral hygiene.

Burns

The goal of reconstruction of burns is the restoration of function and appearance. It involves the use of split-thickness or full-thickness skin grafts as described earlier.

Lower Limb Reconstruction

Lower limb injuries involving a fracture and skin compromise requires management by a multidisciplinary team involving orthopaedic, vascular and plastic surgeons. The multidisciplinary approach allows for extensive injuries to be treated appropriately, thus restoring the function and appearance of the limb.

Anterolateral Thigh Free Flap (Fasciocutaneous)

Branches of the lateral circumflex femoral artery supply the ALT free flap. Its descending branch supplies 3 of the 4 quadriceps muscles: rectus femoris, vastus lateralis and intermedius.

Indications

- Open wounds of the lower limb (peripheral vascular disease, trauma, tumour resection).
- Prevention of amputation.

Contraindications

- Previous surgery to upper thigh.
- Insufficient vascular supply via circumflex femoral artery.
- Peripheral vascular disease.

Step-by-Step Summary: Lower Limb Reconstruction with Anterolateral Thigh Free Flap

1. Colour doppler is used to locate the perforators of the flap.
2. Flap dissection is carried out above muscle fascia, reducing muscle herniation risk and sensory nerve damage.
3. The flap is raised, the pedicle divided at the divisions of profunda femoris artery.
4. The arterial vessels are anastomosed at the recipient site, and venous anastomosis is achieved.

Complications

- Flap necrosis.
- Wound dehiscence.
- Lateral femoral cutaneous nerve damage.

Follow-Up

- Routine wound care.
- Monitoring of flap vascularity post-operatively using Doppler scans.

Cosmetic (Aesthetic)

Cosmetic surgery is carried out to change one's appearance, and is generally not available on the NHS. Examples of procedures include rhinoplasty, breast augmentation and breast reduction.

Breast Augmentation: Inframammary Approach, Subpectoral Placement

Indications

- Patient's personal reasons.
- Breast asymmetry.
- Post-partum involution.

Contraindications

- Pregnancy.
- Existing breast malignancy or pre-malignancy.
- Concurrent infection.

Step-by-Step Summary: Breast Augmentation

1. An incision about 2.5–3 cm in length is made at the inframmamary fold.
2. The inferior pectoralis muscular attachment is freed with cautery dissection, and is then lifted off the chest wall.
3. An implant has already been chosen based partly on the patient's wishes but more importantly on her chest wall and breast dimensions. The prosthesis is placed commonly so that most of it is covered by the overlying pectoral muscle with the lower portion covered by the overlying breast parenchyma.
4. The outcome is reviewed by sitting the patient upright, before the incisions are sutured closed.

Complications

- Wound infection.
- Haematoma formation.
- Seroma (fluid build-up).
- Reduced areolar sensation due to nerve damage.
- Displacement of implant.
- Implant rupture.
- Problems with breast-feeding.

Follow-Up

- Routine wound care.
- Follow-up appointments (3 weeks, 6 weeks, 6 months, 1 year) post-operatively.

Student Tips for Placement

Whenever on a placement, it is always important to be enthusiastic and to do your research before attending. In doing so, you will be better prepared to answer the questions the doctor you are shadowing may have for you. A great and concise resource for any plastic surgery placement is 'Fundamental Techniques of Plastic Surgery', written by Alan and Ian McGregor.

A working knowledge of the reconstructive toolbox will put you in good stead for many questions. The surgeon will often be asking himself or herself: "how can I reconstruct this defect?"

Due to the very broad range of plastics subspecialties, it would be worth checking what the surgeons' interest is before attending the list or clinic and reading up around this subject.

Surgeons' Favourite Questions for Students

1. How does a graft take?
2. What is the difference between a split and full thickness graft?
3. What is the difference between and graft and a flap?
4. How do you classify flaps?
5. What makes up the reconstructive toolbox; what options are available to us?

Careers

Training follows a similar pathway to most surgical specialties. Following foundation years, core-training schemes should include a plastics rotation to gain exposure to the fundamentals of the specialty and confirm your interest. In an ideal world, trainees would then proceed directly into specialty training, which lasts for 6 years. However it is difficult to make yourself competitive for selection. Although discouraged by some, historically, many trainees have undertaken a period of time in research, which in addition to any extra degrees and publications, also develops many other skills and may provide further opportunities for surgical experience prior to formal registrar training. The number of certain procedures you have performed, such as tendon repair, and your in depth knowledge of these procedures will be assessed at your ST interview. You should be looking to maximize your surgical exposure at every opportunity and it is common to find enthusiastic and committed medical students trying to do just this at an early stage.

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23 Obstetrics and Gynaecology

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Introduction

Obstetrics and Gynaecology is often referred to as "*Women's Health*" as it is the only specialty where all the patients are female. Whilst obstetrics is the branch of medicine concerned with the complications associated with pregnancy and labour, gynaecology is the care of women's health, genitalia and reproductive organs when they are not pregnant. Midwives have now taken over basic antenatal, delivery and postnatal care for routine, uncomplicated pregnancies in the UK, and GPs are well equipped to deal with the majority of mild, uncomplicated gynaecological complaints. Many women may therefore go through their whole lives without ever coming into contact with an obstetrician or gynaecologist. In general, women will only see an obstetrician if they have a complicated pregnancy or issues during labour, and they will only see a gynaecologist if their presenting complaint is beyond the capacity of their GP to deal with or they require further, specialist investigations and/or treatments.

Obstetrics and Gynaecology is one of the few specialties that encompasses both medicine and surgery. This chapter will serve as a source of reference for the surgical aspects of the specialty, both on the wards and for exam revision. We would recommend that you supplement this book with another resource that covers the medical aspects of the specialty in more detail.

There are a number of subspecialties within Obstetrics and Gynaecology. The main ones are:

- Maternal and Foetal Medicine.
- Gynaecological Oncology.
- Reproductive Medicine.
- Urogynaecology.

As a student, aim to get a flavour of these subspecialties but try not to get hung up on rare, weird and wonderful conditions not routinely seen other than in a tertiary centre.

Obstetrics

Core Operations

Caesarean Section

A caesarean section (CS) is one of the most commonly performed procedures in obstetrics. CSs are important to know about because they are

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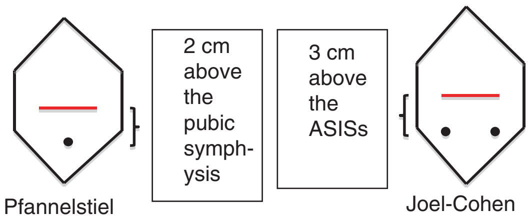

Fig. 23.1 Caesarean section incisions

rising in incidence, and emergency CSs can be life-saving.

Classification

Classification is based on the type of incision and subsequent procedure performed. The majority of CSs are performed in two different ways:

Lower Uterine Segment Caesarean Section Incision

- Almost all CSs are now performed in this way.
- There is a low risk of scar dehiscence and uterine rupture (1 in 200) [1].
- There are two different incision techniques which can be used to open the abdomen:
  1. The Pfannenstiel incision (most common) (Fig. 23.1).
  2. The Joel-Cohen incision (Fig. 23.1).

Midline Uterine Incision (Classical Caesarean Section)

- Less commonly performed.
- Higher risk of scar dehiscence and uterine rupture in subsequent pregnancies (1 in 50) [1].
- Higher incidence of adhesions.
- Greater blood loss.

Indications

Delivery by CS can be performed either as an elective procedure or as an emergency procedure. Some women request a CS but it is important that the patient makes an informed decision only once she has been counselled on all of the risks involved and the potential complications.

Elective CS Indications

- Pre-existing maternal medical conditions:
  - Maternal HIV with a high viral load.
  - Active primary genital herpes infection at the onset of labour.
  - Contracted pelvis e.g. from a previous fracture.
  - Anatomical uterine anomalies.
- Obstetric indications:
  - Previous CSs.
  - Multiple pregnancy e.g. twins/triplets.
  - Breech, transverse or oblique presentation of the baby.
  - Severe pre-eclampsia.
  - Severe intrauterine growth restriction.
  - Placenta praevia obstructing vaginal delivery.

Emergency CS Indications

- Failure to progress in first stage of labour.
- Severe foetal compromise (foetal distress).
- Intrapartum CTG abnormalities e.g. decelerations (variable or late) and/or bradycardia.
- Antepartum haemorrhage.
- Malpresentation of the foetus.
- Cord prolapse.
- Uterine scar rupture.
- Severe pre-eclampsia/Eclampsia.

Classification of Urgency of CS: A Continuum of Risk

This is an evidence-based classification system categorising the urgency of CS. It recognises four categories of urgency in contrast to the traditional classification of emergency and elective CS. Some units use the categories in a colour coded system.

1. Immediate risk to life of mother and/or foetus.
2. Urgent but no immediate risk to mother or foetus.
3. Early delivery required but no urgent risk to mother or foetus.
4. Elective CS at a time convenient for the woman and maternity services.

Anaesthesia for CS

- Most elective CSs are performed using a spinal anaesthetic block (SAB).
- Emergency CS will be performed using either a SAB or GA depending on the urgency of the CS.
- If time allows an emergency CS can be performed using a topped-up epidural if there is already one in place.

Step-by-Step Summary: Caesarean Section

1. Open the abdomen with a Pfannenstiel incision.
2. Open the rectus sheath through the linea alba.
3. Open the visceral peritoneum over the lower uterine segment and gently reflect the bladder by pushing it down.
4. Open the lower segment.
5. Put a hand under the presenting part and deliver the baby through the uterine incision.
6. Deliver the baby and clamp and cut the umbilical cord.
7. Deliver the placenta and membranes.
8. Gently check the uterine cavity manually with a large swab to ensure it is empty.
9. Repair the uterine incision in two layers, checking haemostasis.
10. Grossly check the ovaries are normal and that the uterus has contracted.
11. Check that there is no blood remaining in the paracolic gutters.
12. Close the abdomen in the usual way.

CS Complications

Complications are more common in emergency CSs.

Intraoperative Complications

- Haemorrhage greater than 1 l.
- Damage to the surrounding visceral organs (most commonly lacerations to the bladder, bowel and ureters).
- Rarely emergency hysterectomy.

Post-operative Complications

- Infection of the incision site.
- VTE.
- UTI.
- Pulmonary atelectasis.
- Scar dehiscence and rupture in future pregnancies.

Post-op Care and Follow-Up

- Keep the patient in overnight.
- Check on day 1 post CS that the uterus is contracted and lochia is normal.
- Follow-up is usually with a GP, unless the case was complex.
- Counselling on delivery options in subsequent pregnancies.
- CTG monitoring during labour in subsequent pregnancies.

Gynaecology

Core Operations

Where possible, gynaecological surgery is now performed laparoscopically (i.e. using key hole surgery), although, in some cases immediate intervention via laparotomy may be required e.g. massive haemoperitoneum in ectopic pregnancy (see Table 23.1). To perform laparoscopy, the abdomen is insufflated with carbon dioxide, and for many procedures the uterus must be externally anteverted using forceps with sponge inserted through the vagina or a Spackman cannula in the uterine cavity attached to a cervical vulsellum. Gynaecological surgery can also be performed vaginally e.g. prolapse repairs and vaginal hysterectomies. In addition, open surgery is still the method of choice in some scenarios and is performed using a midline or transverse lower abdominal laparotomy incision (Fig. 23.2). In 2005 the FDA approved the use of robotic surgery in the USA for gynaecological surgery. Although not currently in routine practice in the UK its use for gynaecological conditions is likely to grow exponentially.

Table 23.1 Advantages and disadvantages of laparotomy and laparoscopy in gynaecological surgery

Laparotomy		Laparoscopy	
Advantages	Disadvantages	Advantages	Disadvantages
Immediate access to peritoneum and pelvic organs	Increased risk of infection and haemorrhage	Decreased risk of infection and haemorrhage	Slower access
Easier to remove larger organs	Longer recovery time	Shorter recovery period	Harder to remove larger organs
	Larger scar	Smaller scars	Increased risks in patients with midline laparotomy scar

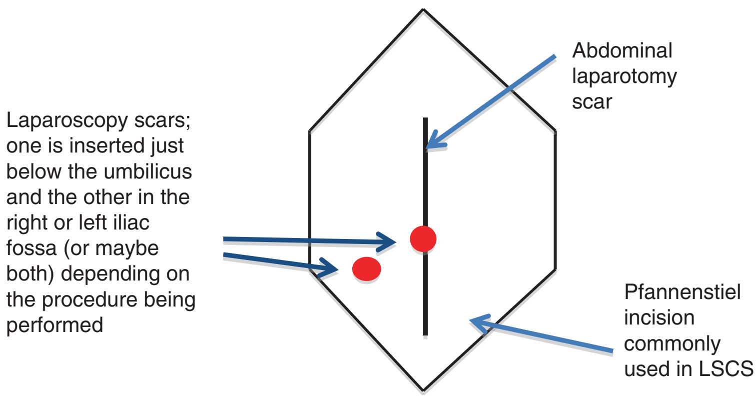

Fig. 23.2 Common gynaecological scars

> It is important to always ask if the patient has had a previous midline laparotomy. Scars can fade and are easily missed on examination: even consultants miss them occasionally. It is therefore important to always ask about previous abdominal surgeries as part of your history. You should think twice before performing a laparoscopy on someone who has had a midline laparotomy as adhesions can form between the bowel and the anterior abdominal wall. Insufflation and instrumentation may result in bowel perforation!

Hysterectomy

A hysterectomy is a surgical procedure performed to remove the uterus and other pelvic organs where applicable. Traditionally, a hysterectomy was performed via laparotomy using an abdominal incision. This technique is still widely used. Newer techniques include vaginal hysterectomy (performed using an incision in the vaginal canal) and laparoscopic vaginal hysterectomy.

Indications

- Fibroids.
- Abnormal uterine bleeding (AUB) especially heavy (and prolonged) menstrual bleeding (HMB).
- Endometriosis.
- Adenomyosis.
- Endometrial carcinoma.
- Uterine prolapse.
- Chronic PID.

Where possible, hysterectomy is avoided if medical treatment is appropriate.

Complications

- Haemorrhage.
- Infection: UTI and other postoperative infections.
- Pelvic organ prolapse and/or pelvic organ fistula.

Table 23.2 Types of hysterectomy

Procedure	Organs removed	Indications	Comments
Total abdominal hysterectomy (TAH)	Uterus, cervix	AUB, fibroids	Women with abnormal smears should opt for hysterectomy with cervix removal
Sub-total hysterectomy	Uterus only	Fibroids	Less risk of damage to urinary and GI systems. Smear tests are still required
Vaginal hysterectomy (VH)	Uterus, cervix	Uterine prolapse	Uterus accessed and removed through an incision in the upper vaginal canal Shorter recovery time than TAH
Laparoscopic assisted vaginal hysterectomy (LAVH) ± BSO	Uterus, cervix ± fallopian tubes, ovaries	AUB, prolapse, atypical endometrial hyperplasia	Quicker recovery than with open operation
TAH and BSO	Uterus, cervix, fallopian tubes, ovaries	Hysterectomy in a peri- or post-menopausal woman; early ovarian cancer	Generally (but not always) performed as an open laparotomy procedure
Wertheim's (radical) hysterectomy	Uterus, cervix, parametrium upper 1/3rd of the vagina, pelvic lymph nodes	Cervical carcinoma	Young patients who desire ovarian preservation and retention of a functional vagina are the patients most likely to have this procedure

- Urinary retention and potentially incontinence.
- Renal and ureteral injury.
- Death (rare).

Classification

There are many different types of hysterectomy which can be classified. They are defined by the anatomy removed (See Table 23.2).

Step-by-Step Summary: Total Abdominal Hysterectomy

1. Position the patient in the dorsal supine or lithotomy position.
2. Open the abdomen, usually via a Pfannenstiel incision. A midline vertical incision may also be adopted depending on a variety of factors.
3. Divide pelvic and/or intra-abdominal adhesions if present to mobilise the pelvic organs.
4. Clamp, cut and tie the round ligaments and ovarian pedicles, the uterine vessels and uterosacral ligaments
5. Open the top of the vagina to remove the uterus.
6. Ensure haemostasis within the vaginal vault.
7. Irrigate the pelvis and inspect the bladder and ureters.
8. Close the abdomen as appropriate.

Step-by-Step Summary: Subtotal Abdominal Hysterectomy

1. Position the patient and open the abdomen as above.
2. Clamp, cut and tie the round ligaments and ovarian pedicles, the uterine vessels and the uterosacral ligaments.
3. Cut the body of the uterus from the cervix at the level of the internal os.
4. Remove the uterus.
5. Oversew the cervical stump and cauterise the cervical canal.
6. Ensure haemostasis, irrigate as above and close the abdomen.

Step-by-Step Summary: Vaginal Hysterectomy

1. Position the patient in the dorsal lithotomy position to ensure optimal exposure.
2. Inject saline between the vaginal mucosa and the underlying structures.
3. Open the mucosa around the cervix and push the bladder up.
4. Open the Pouch of Douglas via the posterior vaginal fornix.
5. Clamp, cut and tie the uterosacral ligaments, uterine vessels and ovarian pedicles.
6. Remove the uterus.
7. Ensure haemostasis of the vaginal vault.
8. Close the vaginal vault and ensure elevation to prevent future prolapse

Myomectomy

Myomectomy is the removal of fibroids whilst retaining the uterus. It is performed as an alternative to hysterectomy where removal of fibroids is required and the patient wishes to preserve her uterus. It can be performed using an abdominal, laparoscopic, hysteroscopic or vaginal approach. Hysterectomy is preferred in women who do not wish to preserve their uterus as myomectomy still has a long recovery period and it is likely that fibroids with recur before the menopause. In addition, myomectomy involves more blood loss than hysterectomy.

Indications for Open Myomectomy

- Symptomatic uterine fibroids (usually intramural or subserosal, submucosal fibroids should be removed using a hysteroscopic myomectomy):
  – AUB.
  – Pelvic/abdominal pain and/or pressure and other bulk-related symptoms.
- A hysteroscopic or laparoscopic myomectomy is not appropriate.
- A laparotomy is required to treat additional intraabdominal pathology.

Complications

1. Haemorrhage resulting in conversion to hysterectomy.
2. Infection.
3. Surrounding urinary and GI system damage.
4. Adhesions.
5. Asherman's syndrome if submucosal fibroids are removed.
6. Complications in subsequent pregnancies e.g. uterine scar rupture during labour.
7. Death (rare).

Step-by-Step Summary: Open Myomectomy

1. If possible, arrange to use intra-operative cell salvage to reduce blood loss.
2. Open the abdomen via a Pfannenstiel or midline incision depending on the size of the fibroids.
3. Tie a tourniquet around the uterus at the level of the junction between the body of the uterus and the cervix, to compress the uterine vessels.
4. Identify the fibroids; incise the serosa and myometrium and remove each fibroid if possible.
5. The assistant should aspirate all the blood lost for cell salvage throughout the procedure.
6. Repair the myometrium firmly with vicryl, ensuring there is no dead-space in which a haematoma could form.
7. Repair the serosa with fine non-absorbable material (e.g. 3/0 prolene) to reduce the risk of adhesion formation.
8. Check haemostasis.
9. Put a drain in the pelvis and close the abdomen in the usual way.

Incision, Drainage, and Marsupialization

Vulvar abscesses are a common gynaecological problem that can cause severe illness. They are often mixed polymicrobial infections consisting of female genital tract anaerobes, enteric aerobes and MRSA. The main risk factors for vulvar abscesses include:

- Poor genital hygiene.
- Vulvar trauma e.g. waxing or shaving of pubic hair.
- Obesity.
- Pregnancy.
- Immunocompromised states e.g. diabetes, AIDS.

Presentation

- Painful vulvar mass.
- A feeling of vulvar "fullness".
- Vulvar pain during activities of daily living.

Bartholin's Cysts

Bartholin's cysts form on the vulva when the narrow duct of Bartholin's gland is blocked. They are most commonly found at the 4 and 8 o'clock positions when viewing the vulva in the lithotomy position. If a Bartholin's cyst becomes infected it may develop into a Bartholin's abscess. These abscesses are confined to the gland and tend not to spread. If a Bartholin's cysts becomes infected but does not develop into an abscess; the causative organism is often a sexually transmitted infection e.g. chlamydia or gonorrhoea. Therefore, an additional risk factor for Bartholin's cysts is unsafe sexual intercourse. Bartholin's cysts present in a similar way to a vulvar abscess.

Conservative Management

Abscesses and Bartholin's cysts less than 2 cm in diameter can be managed conservatively using sitz baths or a warm compress in a primary care setting in otherwise well patients. Antibiotic therapy is recommended if the patient is immunocompromised or if the abscess does not improve after 2 days of conservative therapy. If after a week the abscess remains or the lesions points, incision and drainage may be required.

Incision and Drainage

Abscesses larger than 2 cm in diameter need to be managed surgically by incision and drainage. The procedure is performed on an outpatient basis using local anaesthetic unless the abscess is larger than 5 cm in diameter. The procedure for incision and drainage is the same as for incision and drainage of a cyst anywhere else in the body. This procedure is described elsewhere in the book.

Complications

- Infection.
- Recurrence of the abscess.
- Sepsis (rare).
- Necrotising fasciitis (extremely rare).

Step-by-Step Summary: Marsupialization

The surgical management for a Bartholin's cyst is marsupialization. This ensures that the patient retains a patent functioning gland.

1. Open the cyst via the vaginal mucosa with a cruciate incision.
2. Stitch each point of the incision to the surrounding skin so that a pouch is created.
3. Pack the pouch with ribbon gauze, to be removed the following day.
4. The pouch will heal by secondary intention.

Bartholin's cysts may recur following marsupialization, especially if the incision was not sufficiently large. Haematoma formation and dyspareunia may also occur as well as the complications stated above. Patients with recurrent Bartholin's cysts are managed with excision.

Ectopic Pregnancy

Ectopic pregnancy is a subject that you need to know inside out both for written and practical medical school exams. It is a common and serious gynaecological emergency and if it is not recognized and managed appropriately women can and will die.

Definition

An ectopic pregnancy occurs when a zygote or developing blastocyst implants outside the endometrium of the uterus (most commonly in one of the fallopian tubes – 98 % of cases). An ectopic pregnancy is NOT a viable pregnancy (Fig. 23.3).

The main risk factors for an ectopic pregnancy include:

- High risk factors:
  - Previous ectopic pregnancy or pregnancy of unknown location.
  - History of tubal or pelvic surgery.
  - History of pelvic inflammatory disease/chlamydia infection and/or other tubal pathology.
- Additional risk factors:
  - Age.
  - Smoking.

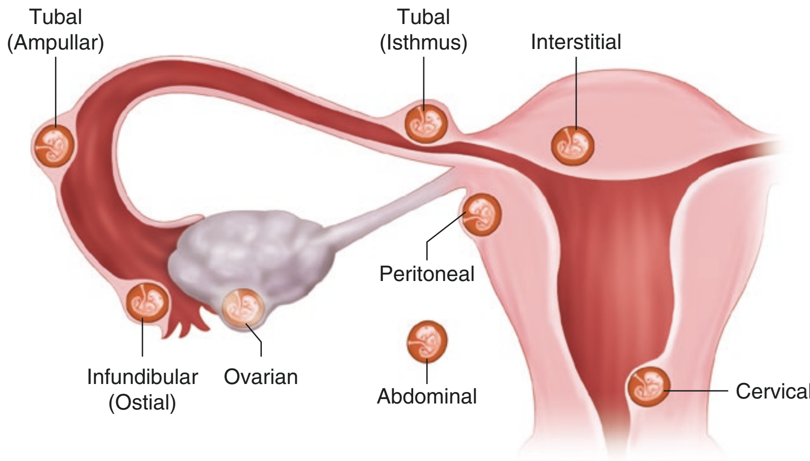

Fig. 23.3 Sites of ectopic implantation. Tubal pregnancies are the most common

- Current intrauterine contraceptive device (IUCD): patients with an IUCD have a lower incidence of ectopic pregnancy than women using no contraception as they are less likely to get pregnant, however, if pregnancy does occur IUCD users are at higher risk of having an ectopic pregnancy.
- Infertility.
- Endometriosis.
- History of IVF.

Presentation

Classic Presentation

- Sudden onset, unilateral (it can be diffuse), severe pelvic or abdominal pain.
- Per vaginal (PV) bleeding (most commonly in first trimester). It is important to know the differential diagnosis of bleeding in early pregnancy.
- Referred shoulder tip pain (due to fallopian tube rupture and blood released into the peritoneum irritating the diaphragm).
- Amenorrhoea.

Other Signs and Symptoms to Be Aware of

- Cervical motion tenderness.
- Adnexal tenderness or mass.
- Blood in vagina.
- Collapse (if ruptured).
- Normal pregnancy discomforts may be present but are less likely than in a normal pregnancy because hormone levels are likely to be abnormal.

Any woman of reproductive age with pelvic pain and/or PV bleeding has an ectopic pregnancy until proven otherwise.

Investigation and Immediate Management

Haemodynamically Unstable

- Urine hCG level.
- History and physical examination.
- Presume ectopic pregnancy rupture or haemorrhage.
- Immediate surgery.

Haemodynamically Stable

To Confirm Ectopic Pregnancy

- Urine hCG level.
- History and physical examination.
- Transvaginal ultrasound (TVU) to visualize an empty uterus and the pregnancy in one of the adnexa (detects roughly 90 % of ectopic pregnancies).
- Ectopic pregnancy visualised as a yolk sac, foetal pole and cardiac activity at TVU.
- If the TVU is non-diagnostic quantitative serum β-hCG levels are required.
- Some patients are described as having a pregnancy of unknown location (PUL) –when

hCG is <1000 iu/L and the pregnancy cannot be visualized on TVU.
  - 45–70 % of PULs resolve spontaneously [2], and this may avoid unnecessary surgery or the use of methotrexate (medical therapy).
  - Expectant management should be offered.

Once Confirmed

- Immediately alert the gynaecology registrar on call.
- Admit the patient and explain that surgery is highly likely although not definite.
- Insert two large bore (grey) cannulae.
- Ensure the patient is kept nil by mouth.
- Take blood and order; cross-match, group and save, FBC, U&Es, β-HCG.

> **Why Is an Ectopic Pregnancy Such a Big Deal?**
> Women with an ectopic pregnancy are notorious for appearing haemodynamically stable and then crashing suddenly. This is because women with ectopic pregnancy are almost always young, otherwise fit and healthy, and their bodies compensate well for the haemorrhage sustained in tubal rupture. If in doubt, always investigate further

Medical Management

Pharmacological therapy (methotrexate) is the preferred management option for ectopic pregnancy. However, it can only be used when patients fit specific criteria:

- Patients must be clinically stable (no signs of hypovolaemic shock).
- Serum hCG <3000 iu/L [2].

Single dose IM methotrexate is the treatment of choice.

- Over 10 % of women will require a second dose of methotrexate [2].
- Women will need surgical intervention should medical management fail.

Surgical Management

Surgical management is indicated when there are contra-indications to methotrexate, when the patient is haemodynamically unstable, when there is a suspicion of risk factors for rupture and/or medical therapy has failed. Salpingectomy (surgical removal of the fallopian tube) is the procedure of choice when surgically managing a ruptured tubal pregnancy. Salpingotomy (opening the tube and removing the ectopic pregnancy) may be considered when the contralateral tube is diseased or missing. A laparoscopic approach is preferred to open laparotomy in general, as laparoscopy is associated with shorter recovery times, less post-op analgesia and lower levels of intraoperative blood loss. Before a decision is made the patient should be informed of the risks and benefits of each. In haemodynamically unstable patients an open approach may be the only option.

Step-by-Step Summary: Laparoscopic Salpingectomy

1. Prepare for a laparoscopy in the usual way.
2. Insert a pair of graspers via one port and an 'endoloop' via the other.
3. Place the endoloop round the tube and pull it through with the graspers.
4. Tighten the endoloop and remove the tube.
5. Deflate the abdomen, remove the instruments and close the incisions.

Complications

- Haemorrhage and conversion to an open procedure.
- Infection.
- GI and urinary system damage.
- Port-site hernia.

Post-op Care and Follow-up

- Typically a laparoscopic salpingectomy patient will spend one day in hospital post-op, and a laparotomy patient will spend 2–3 days in hospital.

- The patient needs a follow-up appointment to discuss the operative findings, the state of the remaining tube, and the need for early attendance in any future pregnancies for a scan to determine the pregnancy site.

Answering the Difficult Questions in Ectopic Pregnancy

Question "*Can you save the pregnancy?*"

Answer Gently explain to the patient that the pregnancy is only viable within the womb, and unfortunately it is not possible to move it there (some patients/OSCE actors will ask you if this is possible). An ectopic pregnancy is essentially a miscarriage that requires more complex management.

Question *"Can you save my fallopian tube?"*

Answer Studies have shown that salpingotomy is associated with a higher rate of recurrence of ectopic than salpingectomy, and does not necessarily increase the chances of having a further successful intrauterine pregnancy [2]. There is also a chance that a salpingectomy will be required following salpingotomy, for persistence of the tubal pregnancy.

Question *"Can I still get pregnant if I'm missing one fallopian tube?"*

Answer In the immediate aftermath of the ectopic pregnancy, remind the patient that their other tube is still (hopefully) intact and functional. Later down the line, the anatomy of the female reproductive organs can be further explained; explain that the ovaries and fallopian tubes are two separate structures that lie extremely close to one another, and therefore ovulation from one ovary could still result in an intrauterine pregnancy due to migration of the ovum across to the other fallopian tube.

Termination of Pregnancy

According the 1967 UK Abortion Act [3], there are five circumstances under which termination of pregnancy (TOP) may be performed. These are:

A. Continuation of the pregnancy would involve risk to the life of the pregnant woman greater than if the pregnancy were terminated.
B. The termination is necessary to prevent grave permanent injury to the physical or mental health of the pregnant woman.
C. The pregnancy has not exceeded its 24th week, and that the continuation of the pregnancy would involve risk, greater than if the pregnancy were terminated, of injury to the physical or mental health of the pregnant woman.
D. The pregnancy has not exceeded its 24th week and that the continuation of the pregnancy would involve risk, greater than if the pregnancy were terminated, of injury to the physical or mental health of any existing child(ren) of the family of the pregnant woman.
E. There is a substantial risk that if the child were born it would suffer from such physical or mental abnormalities as to be seriously handicapped.

It is legal to perform TOP for categories C and D up until 24 weeks of gestation only, and there is no limit on the gestational age at which the remaining categories can be performed. Most TOPs in the UK are performed under category C.

There are various methods employed for TOP. The procedure used is dependent on the gestation of the pregnancy and to a lesser extent the choice of the patient.

Medical Termination

There are two drugs used for medical TOP:

1. Mifepristone – an antiprogesterone which is given first.
2. Misoprostol – a prostaglandin E1 analogue, given 36–48 h later.

What the patient needs to know when having a medical TOP:

- Complications include bleeding, retained products of conception and infection.

- They will experience cramping similar to period pains and heavy bleeding during the TOP.
- They cannot be given the misoprostol to be taken at home, therefore they must be available to come back for this drug within 36–48 h of taking the mifepristone.

Surgical Termination

There are two main methods of surgical termination, and both can be performed as a day surgery procedure provided there are no complications.

Step-by-Step Summary: Suction Termination

In early pregnancy (up to 13 weeks) a simple suction technique can be used:

1. The cervix is softened and primed using Misoprostol PV 3 h before surgery/Gemeprost PV 3 h before surgery/Mifepristone PO 36–48 h before surgery.
2. The pregnancy is visualized by transabdominal ultrasound prior to beginning the procedure.
3. Women can choose their method of sedation: general anaesthesia, conscious sedation or none.
4. The cervix is gently dilated, usually to the same number of millimetres as weeks' gestation.
5. The tip of the suction device is passed through the cervix and into the uterus to clear the uterus of all products of conception.
6. Once the procedure is complete, complete termination is confirmed by transabdominal ultrasound.

Step-by-Step Summary: Dilatation and Evacuation

More appropriate for pregnancies of greater gestation (up to about 16 weeks):

1. The cervix is softened and primed as above.
2. The cervix is gradually dilated with Hegar dilators.
3. Under transabdominal ultrasound guidance a curette and special forceps are inserted and used to remove the products of conception.

Complications

The rate of complications is dependent on the method adopted for TOP, the gestational age, patient characteristics and clinician experience.

- Uterine perforation and cervical laceration.
- Postabortal haemorrhage as a result of injury (as above), perforation, retained products of conception or uterine atony.
- Infection – once common, hence the routine use of prophylactic antibiotics.
- Asherman's syndrome – rarely uterine adhesions can form post-surgical termination.
- Need for ERPC if the process is incomplete – see ERPC section.
- Maternal mortality.
- Ongoing pregnancy (more common in early rather than late abortions)

TOP Option Depending on Gestation Reached

Up to 9 weeks: Medical TOP only.

9–13 weeks: Suction termination.

13–24 weeks:

Medical TOP.

Dilatation and evacuation.

From 20 weeks feticide by stopping the fetal heart is recommended prior to termination.

Why Do so Many Women Opt for a Surgical Rather than Medical TOP?

For most women it is a case of personal opinion and choice – however many are of the opinion that a one day procedure where they can be sedated and have the termination processed quickly is less emotionally draining to 2–3 days of cramping and bleeding with two visits to the hospital or clinic required. In reality, as the cervix is primed prior to surgical termination many experience some bleeding before sedation, and some bleeding and cramping after the procedure. These features are normal, though upsetting.

Post-op Care and Follow Up

- Observe to ensure no excessive bleeding.
- Make sure antibiotics and analgesics have been prescribed.
- Advise patient to return if she has excessive bleeding or cramping.
- No follow up required unless there are complications.

Evacuation of Retained Products of Conception (ERPC)

ERPC is carried out in the following circumstances:

- During surgical management of miscarriage.
- When expectant or incomplete medical management of miscarriage fails.
- Missed miscarriage.
- Incomplete medical or surgical TOP.

The procedure is very similar to surgical termination. The cervix is dilated with Hegar dilators and a combination of suction and curettage are used to clear the retained products of conception. The complications associated with ERPC are identical to those of surgical TOP; the need for a further ERPC is rare but does happen, especially when there is a uterine abnormality.

Step-by-Step Summary: Evacuation of Retained Products of Conception

1. Empty the bladder if necessary.
2. Do a bimanual examination to determine whether the uterus is anteverted or retroverted and to assess the uterine size.
3. Hold the anterior lip of the cervix with a vulsellum and gently dilate the cervix with graduated dilators – the os should be roughly equivalent to the number of weeks e.g. 9 mm at 9 weeks' gestation.
4. Empty the uterus using a curved suction curette.
5. Ask the anaesthetist to give an IV bolus of 5 units of syntocinon as the products are removed.
6. Check the uterine cavity is empty using a blunt curette.
7. Do a bimanual examination to check the uterus is well contracted.

Surgeons' Favourite Questions for Students

1. Why is history of previous midline laparotomy a contraindication for laparoscopic procedures?
2. Why is a hysterectomy preferable to a myomectomy where fertility is no longer desired in women with fibroids?
3. What are the risk factors for pre-eclampsia?
4. List the indications for elective and emergency CS?
5. Why do women need a CTG when they opt to have an epidural as pain relief in labour?

Student Tips for Placement

- Aim to get a good balance in experience across both O&G.
- Spend time shadowing the midwives to gain a full understanding of their role both in antenatal care and on the labour ward. They may even let you assist in the delivery of a baby or two!
- Clerk in patients presenting with symptoms on the labour ward.
- Aim to observe all the surgical procedures described in this chapter.
- Spend time shadowing and assisting the O&G registrar on call.
- Practice vaginal examinations as much as possible (with fully informed consent and a chaperone); get used to feeling a normal cervix and you will have no trouble with detecting abnormalities later on.
- Ask to examine patients in antenatal clinics to become proficient in estimating foetal lie, presentation and measuring symphysis-fundal height and locating the foetal heartbeat with both a Pinard and sonicaid.

Careers

O&G is a mixture of medicine and surgery and is appealing because of its variety. To do it you need to communicate well, be sensitive and kind, and be part of a team, whilst, at the same time being energetic, decisive and able to cope with pressure. Most juniors become interested in O&G as students: this is a good time to do a "Special Study Module" or to shadow a consultant team to get an idea of how it feels to do the job. You do not have to do O&G as part of your foundation training, but it would be wise to do the women's health module on the RCOG website, some life support training and basic surgical skills training at this stage. You should be enthusiastic about the subject when interviewed and your specialty application will look better if you pass MRCOG part 1 as soon as possible. Specialty training in O&G is a run-through scheme and you currently need to apply through the RCOG ObsJobs website. In ST1–2 jobs you will do basic training including ultrasound skills. From ST3 to ST7 your competencies will be regularly assessed so that you can progress from one stage to the next. An ST3 would be expected to be able to do a straightforward CS under supervision: an ST6 would do more surgical complex procedures, manage a busy labour ward and supervise junior colleagues. You must pass MRCOG part 2 before progressing to ST6. ST6–7 posts will include the completion of advanced training skills modules (ATSMs) in at least two subspecialty areas. The life of an O&G consultant is busy, and you learn to manage on less sleep than other people, but you become part of your patients' lives in a very privileged way, and although your work is demanding it is also exciting and hugely rewarding.

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24 Paediatric Surgery

Mollika K. Chakravorty, Caroline M. Smith, and Richard M. Lindley

Introduction

Paediatric surgery concerns the care of a specific population group, rather than concentrating on a body region or condition. The workload spans from antenatal care right through to transitioning teenagers into adults services, and therefore requires a specialised skillset to adapt to the anatomical, physiological and neurodevelopmental differences between each period of childhood (Table 24.1). This is why paediatric surgery is often described as the last remaining 'general' surgical specialty.

In addition to caring for the child, surgeons have a role in supporting the rest of the family. This ranges from helping new parents deal with surgery for their newborn, to conflicts in decision-making as patients reach adolescence.

This chapter will concentrate on the essentials for medical student survival whilst on a paediatric surgical rotation. It also covers most of the knowledge a general practitioner or trainee paediatrician would need to know about paediatric surgery.

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Common operations will be discussed as well as some conditions which are rarer but important to know.

Core Knowledge

History

Diagnosis in paediatric surgery relies heavily on history and examination. This ensures the number of distressing or harmful investigations performed, such as venepuncture and radiation, are kept to a minimum. A history is usually taken in combination from the child and family members; proportions depend on the level of speech and language comprehension of the child. As well as a change in approach, the history components are modified according to the age of the child:

Table 24.1 Common terms in paediatrics [11]

Preterm	Born at < 37 weeks gestation
Full term	Born between 37 and 42 weeks of gestation
Neonates	<4 weeks of age
Infant	<1 year of age
Toddler	1–2 years of age (first starts to walk)
Child	Up to 16 years, often between preschool and adolescent
Adolescent	Puberty – 16 years (WHO definition – 10–19 years)

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- **Antenatal history:** antenatal ultrasound findings, any complications (infections, bleeding), maternal health (infection, diabetes), medications taken during pregnancy, smoking/alcohol consumption
- **Birth:** gestational age at birth, birth weight, delivery details (vaginal – induced/instrumental, caesarean – emergency/elective), infection risks (prolonged rupture of membranes, maternal fever)
- **Neonatal:** admission to special care, vitamin K given, feeding patterns, stooling patterns, other significant illness or surgery (such as cardiac repair)
- **Development:** weight and height as plotted on an appropriate growth chart, achieving key milestones (in four domains: gross motor; fine motor and vision; speech, language and hearing; and social, emotional and behavioural. For more, see any paediatrics textbook (e.g. Illustrated Handbook of Paediatrics)
- **Family history and social history:** genetic disorders, health of siblings/parents, parental smoking, clues of any child safeguarding concerns

Tip

Paediatric patients can present differently to adults, so you have to think 'outside the box'. For example, a child with abdominal pain may present with a limp!

Examination

Completing an examination of a child can be difficult, and it is important to develop a good rapport with both parent and child. This means tailoring the examination according to their age, developmental stage and temperament. For instance, while asking an adolescent directly for consent is important, the same request made to a three year old may often yield a resounding 'no'. Sometimes you may need to adapt your examination to the position in which the child is most comfortable, such as sat in their parent's lap. In general, the examination relies heavily on observation, especially with younger children and babies: a lot of information about the state of the child can be obtained from appearance, behaviour and vital signs.

Examination Tips

- Approach the child at their level to seem less intimidating
- Make examination fun – use toys and interactive play to make auscultation and other procedures appear less frightening
- Make use of the parents to keep the child comfortable – dressing/undressing, holding the child
- Leave the most unpleasant tasks until the end – palpation in abdominal pain, using a tongue depressor for the back of the throat

Abdominal Pain in Children

Abdominal pain is one of the most common reasons for children to be admitted under paediatric surgery. There are over 2000 diagnoses which may lead to abdominal signs and symptoms: you can narrow these down by knowing which have peak frequencies at particular ages (Table 24.2). Instead of a history of abdominal pain in neonates and infants, parents will often report repeated episodes of excessive crying, not responding to comforting as normal. Babies may not want to feed, and may pull up their knees. This is known as "colic" and is a non-specific sign that the baby is in discomfort. Other features such as reduced weight gain, poor feeding, vomiting (especially bilious), abdominal distension and other associated symptoms may indicate a more serious pathology.

Table 24.2 Acute abdominal pain and possible differential diagnoses, according to age

	Birth to two years	Two to five years	>5 years	Peripubertal girls
Presenting feature	"Colic"	Abdominal Pain	Abdominal Pain	Abdominal Pain
Surgical	Intussusception Trauma/NAI Incarcerated hernia Necrotising enterocolitis Volvulus Hirschsprung's disease Intra-peritoneal adhesions	Non-specific abdominal pain Appendicitis Trauma/NAI Intussusception Foreign body ingestion Tumour Meckel's diverticulum	Non-specific abdominal pain Appendicitis Trauma Ovarian torsion Testicular torsion Cholecystitis Pancreatitis Urolithiasis Gastritis, peptic ulcer disease	Non-specific abdominal pain Ectopic pregnancy Ovarian cyst
Medical	Viral illness Gastroenteritis Dietary protein allergy Constipation Urinary tract infection Sickle cell syndrome Henoch-Schönlein purpura	Gastroenteritis Pneumonia Urinary tract infection Viral illness/Pharyngitis Henoch-Schönlein purpura	Gastroenteritis Diabetic ketoacidosis Constipation Pneumonia Urinary tract infection Inflammatory bowel disease Haemolytic uremic syndrome	Dysmenorrhoea Pelvic inflammatory disease Pregnancy

NAI Non-accidental injury

Tip
Examining an infant who is abnormally immobile, refusing to be cuddled, wants to be left untouched? Think peritonitis, as any movement may be aggravating pain.

Abdominal Exam of Child with Acute Abdominal Pain

The child should be lying straight and on their back, arms by their side. Analgesics should be given to children in pain, to put the child at ease and allow accurate assessment.

- **Vital signs**
  - Temperature, pulse and respiratory rate will give an indication of the state of the child. Central and peripheral capillary refill must be measured.
- **Inspection**
  - Look for any asymmetry, rashes (such as for herpes zoster), abdominal distension, visible intestinal peristalsis
  - Ask the patient to cough or puff up their tummy – demonstrates abdominal pain on movement, indicating peritoneal irritation and inflammation
- **Auscultation**
  - Listen for bowel sounds
  - The weight of the stethoscope may elicit tenderness
- **Percussion**
  - Check for enlarged liver or spleen
    Spleen is not normally palpable
    Liver is palpable in neonates and infants
  - Percussion tenderness can be used as a sensitive test of localised peritoneal irritation, in place of rebound tenderness
- **Palpation**
  - Look for lymph nodes in the neck and groin, suggestive of viral illness

Table 24.3 Method for calculating maintenance fluids in children according to weight

Fluids in children > 4 weeks	<10 kg	10–20 kg	>20 kg
	100 mL/kg/day	1000 mL + 50 mL/kg over 10 kg/day	1500 mL + 20 mL/kg over 20 kg/day

- Palpate the nine divisions of the abdomen systematically, using distraction techniques as necessary, noting the location of tenderness
- *Guarding*
  Assess for voluntary and involuntary guarding. Distraction helps here.
- *Palpable masses:*
  Acute appendicitis may present late as an appendiceal abscess (see below)
  Kidney problems may present as a mass in the flank
  A mass in the left iliac fossa is usually constipation
  A pyloric tumour will be found in the epigastrium

- A rectal examination should be avoided where possible: if necessary it should only be performed by the most senior doctor (i.e. by the consultant) to minimise discomfort to the child
- In females over the age of 13 years or who have started their period, pregnancy test should be performed with consent.

> **Tip**
> All males with acute abdominal pain MUST have an examination of the testes.

Dehydration in Children

Children behave differently to adults in the face of shock. They have much greater reserves and therefore compensate better to loss of volume. This means that signs of an ill child are often masked until the child is at least 10 % dehydrated. A child will often be shocked beyond the point of recovery when they drop their blood pressure and exhibit severe acidosis.

The lesson to be learnt is to be aggressive with fluids in children. Children have a higher body composition of water than adults. In addition, the overall fluid, calorie and mineral needs of children vary to adults; neonates need specialist fluids which you can ask about on your placement. Under normal circumstances, maintenance fluids for infants and children are shown below (Table 24.3). The child's maintenance fluids are supplemented depending on the level of dehydration (expressed as a percentage of their weight). Deficits are corrected over 48 h to prevent complications such as cerebral oedema.

> **Tip**
> If you are interested in the care of acutely ill children, the Department of Health has produced a free online course: 'Spotting the Sick Child'. Details are available at the end of the chapter.

Some Common Surgical Emergencies

Acute Appendicitis

- Presents similarly to appendicitis in adults. However, children may present with complicated appendicitis (perforated; with an abscess), especially if:
  - unable to communicate their symptoms (under 5 years or developmental delay)
  - the appendix is not in the right iliac fossa

Testicular Torsion

- Spermatic cord twists, occluding the spermatic blood vessels
- Risk of infarction and loss of testis
- Peak ages:
  - Puberty (13–16 years)
  - At birth

- Presentation:
  - Symptoms
    - Sudden onset unilateral scrotal +/− iliac fossa pain
    - Nausea and vomiting
    - More gradual onset presentation possible
  - Signs
    - Testis is hard, swollen, high in scrotum
- Management:
  - Surgery within 6 h of pain onset to:
    - Untwist the testis and epididymis
    - Anchor both testes to prevent further episodes

Strangulated Inguinal Hernia

- Consequence of bowel or ovary becoming stuck in uncorrected hernia
- For detailed operative correction see section 'Inguinal Herniotomy'

Intussusception

- Bowel telescopes into itself
- 90 % are ileocolic, usually due to inflamed Peyer's patches (post-viral gastroenteritis)
- Peak age: usually 6 months – 1 year of age
- Presentation:
  - colicky abdominal pain, drawing up leg
  - right upper quadrant ("sausage") mass
  - "redcurrant jelly" stools (blood mixed with mucus)
- Management: air enema for reduction (10 % fail – need surgical correction)

Core Operations

Appendicectomy

For physiology and procedure see general surgery chapter; note minimal access instruments in children may be of smaller calibre then their adult counterparts.

Oesophageal Atresia Repair

It is said that there is no greater test of a paediatric surgeon's ability than the repair of an oesophageal atresia: a congenital abnormality of the oesophagus affecting 1 in 3500 newborn babies [9]. Delayed diagnosis and treatment can lead to inflammation and poor lung function. Therefore, repair is typically performed within the first day or two of life.

Indications and Contraindications

Indications for emergency surgery: infant failing to ventilate

Contraindications:

- Bilateral renal agenesis – incompatible with life
- Some genetic syndromes (e.g. Edwards syndrome – although this is the subject of much debate).
- Surgery may be delayed if the baby is of very low birth weight and is in poor condition.

Presentation

All symptoms and signs are related to an inability to swallow.

Antenatal: unable to swallow amniotic fluid

- Polyhydramnios
- Absence of stomach bubble on ultrasound

Postnatal: unable to swallow saliva

- Frothing or excessive mucus from nostrils or lips
- Resuscitation at birth due to mucus aspiration
- Rattling breaths
- Excessive drooling
- Life threatening events with apnoea and cyanosis

Aspiration following first feed:

- Coughing and spluttering
- Cyanosis

In 50 % of cases, oesophageal atresia is associated with a number of other abnormalities such as [5]:

- Duodenal atresia
- VACTERL association

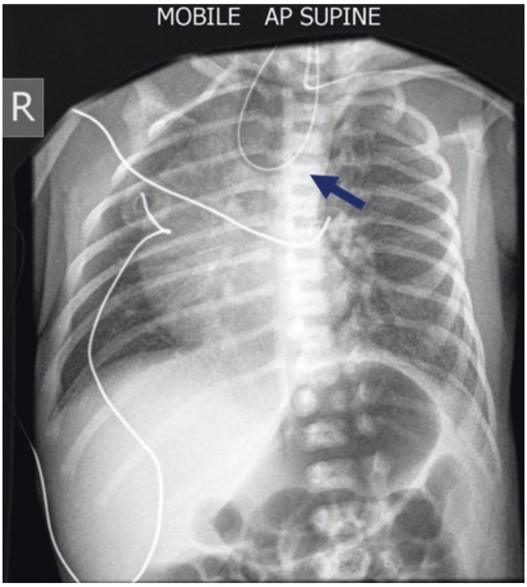

Fig. 24.1 AP chest X-ray of infant showing the curled end of NG tube at body of T5 vertebra (*arrow*) and presence of gas in stomach and bowel – suggestive of OA with TOF

  - Vertebral abnormalities (hemivertebrae, fused vertebra)
  - Anorectal abnormalities (imperforate anus)
  - Cardiac abnormalities
  - Tracheo-oesophageal fistula (TOF)
  - Renal abnormalities
  - Limb abnormalities (especially of hypoplasia of radius and/or thumbs)
- Chromosomal defects (trisomy 21 (Down's syndrome), trisomy 18 (Edwards syndrome))

Investigations

- Attempt passage of 10 Fg nasogastric tube
- X-Ray:
  - In the chest, the curled end of the NG tube stops at T3–T5 (Fig. 24.1)
  - If TOF is present: air in stomach and small bowel (Fig. 24.1)
  - May also show vertebral or rib anomalies
  - Lung fields may show evidence of aspiration events
- For related abnormalities
  - Echocardiogram
  - Renal ultrasound

Clinical Anatomy

The respiratory diverticulum develops from the ventral aspect of the foregut, and should later separate, becoming the trachea and oesophagus [8]. When this fails, the upper oesophagus is disconnected from the rest of the system, leaving a blind ending pouch, while a communication remains between the trachea and the lower oesophagus – a tracheo-oesophageal fistula (Fig. 24.2). From the distal end, contents from the stomach may be aspirated into the bronchial tree via the fistula.

Step-by-Step Summary: Repair of Oesophageal Atresia and TOF

1. Bronchoscopy may be performed to identify the distal fistula and look for a possible proximal TOF
2. Incision: left posterolateral thoracotomy (either 4th/5th rib depending on location and size of upper pouch)
3. Intercostal muscles are divided, pleura stripped off posterior structures
4. Azygos vein – identified and ligated or left intact navigated around
5. Vagus nerve – identified and preserved
6. Tracheo-oesophageal fistula is identified and ligated
7. Upper pouch is identified, at times by manipulation of the NG tube from above, and mobilised,
8. Upper pouch is then anastomosed with the distal oesophagus – with a single-layer monofilament (5/0, 6/0)
9. A transanastomotic tube is placed – allows early feeding

The procedure may also be performed by thoracoscopic techniques; however this is not common.

Complications

- Anastomotic leak
- Recurrent Fistula
- Stricture (may lead to choking)
- Gastro-oesophageal reflux
- Tracheomalacia (floppy trachea) leading to a loud barking cough ('TOF cough')

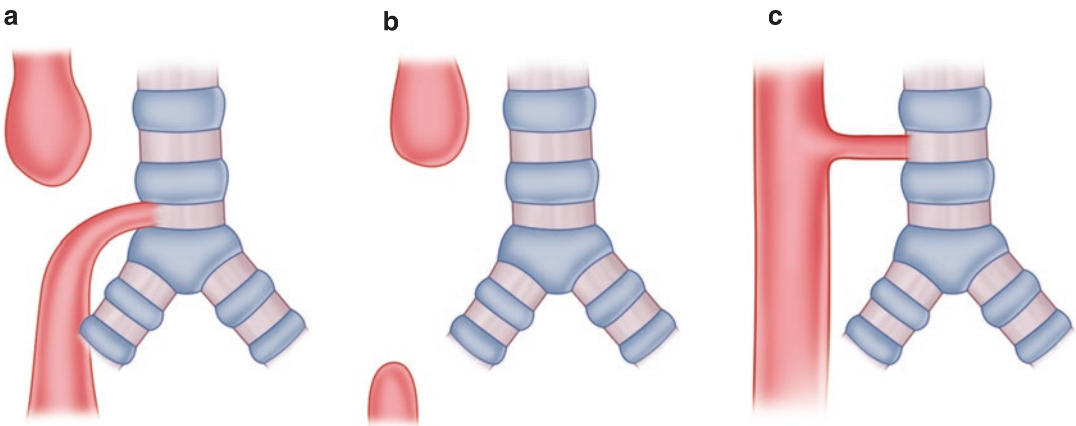

Fig. 24.2 Diagram of most common forms of oesophageal atresia. (**a**) oesophageal atresia with distal tracheo-oesophageal fistula (86 %). (**b**) Isolated oesophageal atresia (7 %). (**c**) H-type tracheo-oesophageal fistula (4 %) (Adapted from [10]))

Follow-Up

Intensive involvement is needed from surgical and respiratory team to ensure they thrive. Strictures can be dilated by performing oesophageal stretches; respiratory physiotherapy will help prevent chest infections.

Pyloromyotomy

Approximately 3/1000 newborn babies are affected by hypertrophic pyloric stenosis: a narrowing of the pylorus of the stomach due to enlargement of the muscular wall, causing persistent vomiting. It commonly affects boys more than girls (ratio 4–5:1) [6] with a high prevalence in white Caucasian populations. It can be treated by an operation to split the pyloric muscle – a *pyloromyotomy*.

Indications and Contraindications

Indications: confirmation of pyloric stenosis by clinical features (see below) or ultrasound scan.

Contraindications: prior to electrolyte correction of the infant, or if the infant is unfit for surgery. In these cases, parenteral or continuous gastric feeding should be continued and atropine can be used to relax the pylorus.

Presentation

Infants with pyloric stenosis typically present between 3 and 6 weeks of age with projectile vomiting after every feed.

Symptoms:

- Forceful vomits (may cross a room)
  - Contains milk +/− mucus
  - May contain 'coffee-ground' flecks or fresh blood (bleeding from secondary gastritis or oesophagitis)
- Initially, ready to feed again immediately after vomiting
- May become lethargic and less active with progressive dehydration and malnutrition

Signs:

- Abdominal palpation
  - Peristaltic waves during feeding (strong contractions of the pylorus against the obstructed end)
  - Firm 'olive-shaped' relatively mobile mass above umbilicus or to the right of the rectus abdominus muscle, below liver
- Look for signs of dehydration

Investigations

- Real time ultrasound, with one-sided muscle thickness > 4 mm and pyloric canal length > 16 mm
- Serum biochemistry – hypochloraemic metabolic alkalosis due to vomiting
  - High pH (↓H^+)
  - ↓Cl^-
  - ↓K^+ (bicarbonate excretion; ↑ aldosterone due to volume depletion)
  - ↓Na^+

Clinical Anatomy

The pylorus normally has a thicker muscle layer to act as a sphincter, preventing food exiting while mechanical digestion is carried out, but relaxing later to allow liquid chyme to pass into the duodenum. In infants with pyloric stenosis, the pyloric muscle is overgrown and elongated, narrowing the pyloric canal to prevent gastric emptying.

When the patient is supine or prone, the pylorus sits midway between the pubic symphysis and manubrium (approximately at the L1 vertebral body).

Step-by-Step Summary: Ramstedt's Pyloromyotomy

1. Correct electrolyte imbalances and dehydration before surgery
2. Incision: Right upper quadrant muscle-cutting or supra-umbilical
3. Peritoneal cavity opened and pylorus delivered
4. A longitudinal split is made in the pyloric muscle and this is stretched to expose the gastric mucosa

A pyloromyotomy is now normally performed at the umbilicus (better cosmesis) or laparoscopically.

Complications

- Perforation of gastric mucosa and incomplete pyloromyotomy
- Wound infection
- Persistent vomiting is common but short lived

Follow-Up

None required.

Inguinal Herniotomy

Inguinal herniae occur in children due to the presence of an embryological sac, the processus vaginalis, which fails to close *in utero* (see section 'Clinical Anatomy' below). This is called an indirect inguinal hernia, and is 20 times more common in males than females [5]. Contents of the abdomen, such as bowel or ovaries can enter the sac, and may become trapped if the hernia cannot be reduced.

Indications and Contraindications

Indications for immediate repair:

- Irreducible hernia

Indications for urgent repair:

- Infants < 6 months of age
- Symptoms suggestive of ovarian prolapse

Contraindications:

- <48 h since traumatic reduction for 'irreducible' hernia due to bruising and oedema (although now this is a relative contraindication and laparoscopic repair could be done sooner)

Presentation

The parents will report intermittent swelling above the pubic crest, more prominent when crying or straining.

On scrotal examination:

- Swelling extends into the groin
- Cannot "get above" swelling
- Swelling separate to testes
- Features of bowel may be seen, such as ripples through the scrotal skin when crying or straining
- 'Silken sleeve' – a 'rustle' can be felt of loose layers of peritoneum when rolling the index finger over the spermatic cord at the pubic crest.

> **Note**
> Bilateral hernia in an infant with female external genitalia may indicate a disorder of sexual differentiation

Investigations

Not required.

Clinical Anatomy

The inguinal canal is an oblique passage, running between the deep inguinal ring and superficial ring, lateral to the epigastric vessels and anterior to the inguinal ligament, sandwiched between the tranversalis fascia posteriorly and external oblique aponeurosis anteriorly. The canals connect the abdomen to the scrotum in males, and may reach the labia majora in females; they normally contain the spermatic cord (males) or round ligament of the uterus (females) [5].

In males during the 7th month *in utero*, the gonads descend through the inguinal canal, each taking a pocket of peritoneum that forms the processus vaginalis. Proximally, the processus vaginalis should close within the first year of life, leaving behind a serous layer surrounding each testis and scrotal ligament: the tunica vaginalis. If the processus is not obliterated, a number of problems can occur such as herniae, or a hydrocele – a build-up of peritoneal fluid. Note that as the right testis descends later than the left, the right processus is more likely to remain patent for longer after birth.

Direct inguinal herniae, which protrude through defects in the abdominal wall, medial to the epigastric vessels, are very rare in children.

Step-by-Step Summary: Inguinal Hernia Repair

1. Make an incision in skin crease immediately above midpoint of inguinal ligament
2. Divide subcutaneous tissue and Scarpa's fascia to expose external oblique aponeurosis and inguinal ligament
3. Split the external oblique fibres to enter the canal, avoiding ilioinguinal nerve
4. Split the cremasteric fibres to expose the hernial sac. Gently separate the sac from the vas deferens and vessels on the posterior aspect
5. Open the sac, reduce any contents and transfix the sac at the deep ring
6. Close in layers, with absorbable sutures

Complications

- Damage/Division of testicular vessels (1 %)
- Division/damage of vas deferens (0.5 %)
- Recurrence (1 %): risk of hernia on the other side may be up to 5 % in neonates; risk reduces with age
- Late ascent of testis (1 %)

Follow-Up

Once they have recovered from anaesthesia, children are usually discharged. Simple analgesia (paracetamol) relieves pain; parents should see GP or call ward if there are any signs of wound infection.

Orchidopexy

An orchidopexy involves fixation of the testis and is performed for undescended testes (UDT): testes that are not at the bottom of the scrotum by the age of 3 months. Up to 5 % of boys at birth have cryptorchidism (from Greek: 'hidden testicle'), but this falls to 1–2 % by the age of 3 months as the testes often descend postnatally.

There are two management plans, depending on whether the testes are palpable within the upper scrotum or groin (the majority) or impalpable. For a palpable testis, a standard orchidopexy is performed in one stage.

The causes of an undescended testis are not fully understood.

Indications and Contraindications

Indications:

Orchidopexy for a UDT is performed between 6 and 12 months of age:

- To prevent reduction in size of testis
- To increase sperm quality (but this may not affect paternity if UDT is unilateral)
- To decrease the risk of torsion (which is higher in UDT)
- For cosmetic reasons

- To make examination of the testes easier.
  - Intra-abdominal testes have a higher risk of malignant change.

Contraindications:

- Ambiguous genitalia: need further investigation prior to orchidopexy
- Age < 6 months
- Retractile testis (see section 'Clinical Anatomy' below)

Presentation

On examination of the scrotum, the testis cannot be palpated or cannot be manipulated into the scrotum.

- 70 % – palpable in the groin – within the 'superficial inguinal pouch'
- 20 % – not palpable
- In rare cases – may be ectopic (perineum, base of penis, thigh, opposite side)

In older children, a persisting processus vaginalis (PPV) may tether the testis, preventing the normal elongation of the spermatic cord over time. Therefore, it is important to check whether the testis can be brought all the way to the bottom of the scrotum before declaring it normal.

Investigations

- None for a palpable testicle
- Examination under anaesthetic and laparoscopy for an impalpable testicle to distinguish between absence and intra-abdominal testes
- (NOT ultrasound! It is unnecessary and can miss intra-abdominal testes altogether)

Clinical Anatomy

The testes develop from the urogenital ridge in the lumbar region of posterior abdominal wall, either side of the aorta. They are tethered to the anterior wall by the gubernaculum, which connect the primordial testes to the future deep inguinal ring. As the embryo increases in length and the gubernaculum thickens, it pulls the testes from the abdomen, reaching the entrance of the inguinal canal at the deep ring by the 7th month *in utero*. It then takes a further 4 weeks for the testes, the vas deferens, vessels and nerves to enter the scrotum. As this process occurs, they become ensheathed by muscle and fascia from the abdominal wall.

> **Tip**
> A mnemonic for remembering the layers of tissue around the testes: "*Some Dashing Englishman Called It The Testis*" – Skin, Dartos muscle, External spermatic fascia, Cremaster muscle, Internal spermatic fascia, Tunica vaginalis, Testis.

Between the ages of 2–8 years, the testes may not be palpable. However, if the testes are intermittently present, such as during a warm bath, this may simply be a case of the child having 'shy' testes! To keep the testis at the right temperature and out of harm's way, a reflex contraction of the cremaster muscle retracts the testis into the superficial inguinal pouch (a pocket of tunica vaginalis between the external oblique aponeurosis and superficial abdominal fascia). This reflex may be excessive between the ages of 2–8 years, and requires no treatment.

> **Tip**
> Testes have a dual supply: from the testicular artery directly, and from a branch of the artery to the vas deferens. This is useful to know when bringing down intra-abdominal testes in the two stage Fowler-Stephens technique.

Step-by-Step Summary: Orchidopexy

Prior to choice of surgical technique an examination under anaesthetic is performed for all boys with an UDT. For palpable testes, an inguinal approach is the commonest.
Inguinal incision:

1. Divide through layers as per open herniotomy
2. Open inguinal canal and deliver spermatic cord into the wound. Separate the PPV from vas deferens and blood vessels

3. Ligation of processus vaginalis (at deep inguinal ring)
4. The testis is brought into the scrotum and fixed into a pouch below the dartos muscle using absorbable or non-absorbable sutures depending on surgeon's preference

Complications

- Infection
- Scrotal bleeding or bruising
- Damage to blood supply or vas deferens with testicular atrophy
- Return of the testis to original position

Follow-Up

All boys are followed up to check for testicular atrophy, and given advice on self-examination.

Circumcision

Surgical removal of the foreskin, circumcision, is one of the commonest operations performed worldwide. The procedure has been carried out for thousands of years, as a tradition in both religious groups, and smaller tribes and ethnic groups worldwide. Though the procedure is common in countries such as the USA, there is a lack of evidence to support routine circumcision for medical reasons.

Indications and Contraindications

Indications:

- Balanitis xerotica obliterans (BXO)
- Paraphimosis
- Recurrent balanitis
- Serious urinary tract anomalies (to prevent recurrent urinary tract infections [4]).

Contraindications: when foreskin is needed for corrective surgery – such as in hypospadias (see section 'Paediatric Urology')

Presentation

- Balanitis xerotica obliterans (BXO, or lichen sclerosis)
  - A scarring dermatitis of the foreskin, with white patches on glans or prepuce
  - Causes pathological phimosis (stenosis of the foreskin)
  - Uncommon in childhood, rarer before the age of 5
  - Symptoms: soreness, itching, poor urinary stream, dysuria
  - Note: *phimosis* means a non-retractile foreskin. This is normal in young boys, as is a "ballooning" foreskin on micturition. It is NOT an indication for circumcision unless caused by BXO as above.
- Paraphimosis
  - Foreskin retracts and becomes stuck behind the glans.
    - Causes painful swelling of the glans
    - May lead to ischaemia of the glans
  - If attempted reduction under local in the emergency department fails then the paraphimosis is reduced under general anaesthetic and a circumcision may be performed at the time or in the future
- Recurrent balanitis: individual episodes of inflammation of the glans and foreskin (with discharge – balanoposthitis) occur in 4 % of boys, commonly between ages 2 and 5 years. Recurrent episodes, unresponsive to medical and conservative treatment, require surgical preventative treatment, but are rare.

Investigations

BXO and other conditions of the foreskin can be identified from examination of the genitalia.

Clinical Anatomy

The foreskin is an extension of epidermis from the shaft of the penis: *in utero* it grows over and adheres to the glans. In adults, the foreskin covers the glans and urethral meatus when the penis is flaccid. Boys are born with adhesions between the foreskin and the glans, which separate over time spontaneously. This frees the foreskin, eventually allowing it to be retracted. Amongst 1 year olds, 50 % have retractile foreskin: this goes up to 90 % of 4 year olds, and 99 % of 16 year olds. In early childhood, the adherent foreskin may balloon during micturition, and chemical irritation from urine may lead to discomfort and intermittent redness. These are self-limiting symptoms. Hormonally mediated secretions begin after puberty, which require regular cleaning. In young children, the foreskin should not be retracted and cleaned.

Step-by-Step Summary: Circumcision

There are many ways to perform a circumcision, from an 'open' technique where each cut is performed under direct vision with a blade to quicker variations. The method described below is just one technique and some surgeons may not agree this is the best procedure.

1. The foreskin is retracted and adhesions between glans and foreskin are divided.
2. The foreskin is lifted above the glans and the outer prepuce is divided using bipolar scissors, protecting the glans of the penis at all times. This is sent for histology.
3. The inner prepuce is trimmed ensuring sufficient lip to 'anastomose' the outer prepuce onto.
4. The outer and inner prepucal layers are 'closed' with an absorbable fine suture or superglue.

Complications

- Wound Infection
- Urethral meatal stenosis
- Dehiscence
- Child objection to cosmetic effects
- Recurrence of BXO

Follow-Up

In the event of histologically confirmed BXO, the child will need following up to ensure there is no glanular disease spread which might cause urinary outflow problems.

Paediatric Urology

A large proportion of paediatric surgery is comprised of urological procedures. In addition to the three operations explored above (circumcision, inguinal herniotomy and orchidopexy), correction of two other conditions may be helpful to know about.

- **Vesicoureteric reflux**, occurring due to malformation of the bladder-ureter junction, affects 1–2 % of children. It leads to recurrent urinary tract infections and can lead to renal scarring, and failure in later life. In low-to-moderate grade reflux, biodegradable materials can be injected to the ureteric orifice via endoscopy, to help block refluxing urine. In more severe cases, surgical reimplantions are performed. The most common operations are Cohen or Politano-Leadbetter. For further information on surgical options see Sung and Skoog (2012) [12].
- **Hypospadias** occurs in 1 in 300 males and is due to a failure of fusion of the urethral folds on the ventral aspect of the shaft of the penis. The urethral meatus may be placed anywhere from the glans to the scrotum, leading to a downwards curving penis with hooded foreskin. In untreated mid-to-proximal disease, boys are unable to direct their urinary stream. There are over 300 methods of correction described in the literature. To find out more, see Baskin and Ebbers [2].

Surgeons' Favourite Questions for Students

1. What other problems may an infant with oesophageal atresia have?
2. What is the typical biochemical picture seen in pyloric stenosis?
3. Are inguinal hernias in children direct or indirect, and why?
4. Why are undescended testes moved to the scrotum?
5. What are the indications for circumcision?

Tips for Placements

Paediatric surgery is a specialty that you are unlikely to come across outside of teaching hospitals. However, if you are interested, make contact! Consultants are very friendly and happy to help eager students with elective or student selected placements. Be aware that specialists in ENT, orthopaedics and general surgery at district hospitals may also perform operations on children in certain cases.

On the wards, there will be fewer clinical skills you will be able to perform as a medical student. However, you can perfect the art of taking a history and examining a child, as well as taking collateral histories from parents. Building a good rapport with the nurses and auxiliary staff will also help, as often they will often direct you to appropriate patients.

To make the most of your time in theatre, find out about the list in advance and read about the operations. Speak to the patients while they are on the surgical admissions unit to further your understanding of the disease processes and related management plans. In theatre, arrive on time (remember to allow time to change into scrubs), introduce yourself and, especially if the surgeon is operating alone, you may be asked to assist. If you arrive while the theatre nurses are setting up, they are normally happy to help you to “scrub in”.

Finally, don’t be afraid to ask questions (at opportune moments) and enjoy your time on your placement!

Careers

Paediatric surgery is a specialty of great breadth, of pathology and patient encounters, and therefore draws different surgeons for different reasons. Ask most paediatric surgeons and they will be able to describe a cathartic moment when they realised that no other specialty would challenge or captivate them career-long.

Some surgeons are drawn by the varied pathologies; with training in upper and lower gastrointestinal, urological, thoracic, oncological, trauma and hepatobiliary surgery. Others will be absorbed by the mastery of a broad range of surgical techniques, including open, minimal access, robotic and endoscopic, to high level of finesse; with an attention to aesthetics to minimise the impact of surgery on the child’s life.

Paediatric surgeons are paediatricians who operate, and as such understand antenatal, neonatal, infant, child and adolescent physiology. They work within large multi-disciplinary teams with child and family focused practise, and communication is at the core of the care we provide. Providing a single operation to correct a congenital malformation in a neonate, which allows a child to live a normal life, is an immensely fulfilling experience.

Research in paediatric surgery is led by internationally collaborative projects and conferences; and therefore you are likely to make many colleagues across the globe. Our speciality is an area of exciting research potential at present with work being done in tissue engineering, genetic manipulation, minimal access and robotic surgery and foetal surgery. Research opportunities are plentiful.

Specialty training in paediatric surgery begins after completion of core surgical training, with application via a national recruitment process. Trainees are employed by one of five consortia in the country and are expected to move within these regions. Specialty training is 5 years long, but many trainees take fellowship years to fine tune skills for consultant practise. Currently training numbers are limited and competition is fierce, in addition there is uncertainty of consultant numbers in the future.

Providing care for the surgical needs of children is a great privilege and responsibility. The job brings great joy working with children, but also can be tough emotionally. Paediatric surgery is an incredibly rewarding career.

For further information please see the specialty websites: http://www.baps.org.uk, http://www.traineesinpaediatricsurgery.org

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Transplantation and Immunology 25

Samuel P. Williams and James Richards

Introduction

Transplantation involves the transfer of cells, tissues or organs from the *donor* to the *recipient* and has revolutionised the management of patients with end-stage organ failure.

Major obstacles to organ transplantation include:

1. The availability of suitable donor tissues
2. Maintenance of long-term patient and graft function (preventing graft rejection, minimising the systemic effects of immunosuppression, etc.)

Despite these obstacles, transplant recipient survival is continually rising. One- and five-year survival rates are shown in Table 25.1. Kidney, liver, heart, lung and pancreas transplants are commonly performed and will be discussed in greater detail.

Table 25.1 One- and five-year survival rates of organ transplant recipients [1]

Organ	One-year survival (%)	Five-year survival (%)
Kidney (DBD)	96	89
Kidney (DCD)	95	88
Kidney (living)	99	95
Liver	93	80
SPK	96	90
Lung	82	55
Heart	81	78

Table 25.2 Transplant terminology

Transplant terminology	Definition
Autologous transplant	A transplanted graft occurring on the same individual (e.g. autologous skin graft)
Syngeneic transplant	A graft transplanted from one genetically identical individual to another (i.e. identical twins)
Allogeneic transplant	An allograft is transplanted from one genetically dissimilar individual to another (i.e. different HLA genes)
Xenogeneic transplant	A xenograft is transplanted between individuals of a different species
Orthotopic transplant	Graft inserted into normal anatomical location
Heterotopic transplant	Graft inserted into a different anatomical site
Antigen	Any substances that stimulates antibody production by the immune system

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Table 25.3 Pros and cons of working in transplant surgery

Pros	Cons
Technically challenging	On-call commitments and unsociable hours
Intellectually stimulating	Long surgeries
Life-saving operations	Little or no private practice
Practice of critical care	Emotionally demanding

Patient Fitness

Assessing patient suitability for transplantation is a multi-disciplinary process, involving the whole transplantation team (surgeons, physicians, transplant coordinators, pathologists, anaesthetists, specialist nurses, psychologists, etc). This review process aims to balance the risks and potential benefits for the individual patient, as well as ensuring optimal utilisation of a limited resource. Deciding who needs a transplant is difficult. Key questions for the transplant unit include:

1. Is the patient in definite need of transplantation?
2. Is the patient physically and mentally fit enough to undergo the procedure?
3. Is transplantation likely to be of overall benefit of the patient?

Donor Organs

One major challenge to organ transplantation is the availability of suitable donor organs. Despite donor numbers increasing, there remains a shortage and 456 people died in the UK waiting for an organ in 2013/14 [9].

Donor organs can be cadaveric or from living donors.

- **Donation after brainstem death (DBD)**: patients have suffered irretrievable neurological injury and have been certified dead following formal brainstem death testing. Cardio-respiratory function and end-organ perfusion is maintained after death through ventilation on a critical care unit.
- **Donation after circulatory death (DCD)**: retrieval commences shortly after cessation of cardio-respiratory function, following withdrawal of treatment from patients for whom ongoing treatment is discussed and agreed to be futile. DCD is also known as 'Non-heart beating donation.'
- **Living donation**: this is becoming an increasingly common donating option, particularly for kidney transplants but also in liver transplantation. In the former one of the donor's two kidneys is retrieved and implanted into the recipient, whereas in the latter only a portion of healthy liver is removed from a living donor.

Transplant Immunology and Organ Rejection

Donated organs are often 'matched' with the recipient before transplantation occurs. But what does this mean?

Allogeneic tissues are recognised as 'foreign' by the recipient immune system: **antigens** of the Major Histocompatibility Complex (**MHC**)/ Human Leukocyte Antigen (**HLA**) which are present on donor cell surfaces will differ (i.e. be foreign) to the recipient's.

Class I HLA antigens are found on all nucleated cells and are divided into HLA-A, HLA-B and HLA-C. Class II HLA antigens are only present on antigen presenting cells, such as macrophages and dendritic cells, and are divided into HLA-DP, HLA-DQ and HLA-DR.

HLA expression is extremely **polymorphic** throughout the population. Whilst this increases the chances of eradicating infectious agents, tissue matching becomes problematic in the context of organ transplantation.

As a result, various investigations are performed to ensure that the most appropriate organs are transplanted into the most suitable patients.

- **HLA screening**
  - Potential recipients are screened for anti-HLA **antibodies** against donor HLA antigens
- **Cross-matching**
  - Serum from the recipient (which could contain anti-donor antibodies) is mixed with serum from the donor

– If recipient antibodies bind/kill donor lymphocytes a positive cross-match is present, which is a contraindication to transplantation due to an increased risk of hyperacute rejection

Ischaemia Reperfusion Injury (IRI)

The action of transplanting an organ initiates an inflammatory response, a process which can lead to organ rejection. Once the donor blood supply is cut off from the organ, tissue ischaemia ensues: hypoxic conditions deplete cells of ATP which leads to cell death and inflammatory mediator release. Although revascularisation is crucial for salvaging the organ, reperfusion itself can cause tissue damage both locally and systemically. So-called 'marginal' organs are at a higher risk of IRI, as they are sourced from an extended donor pool. For example, the donor may be elderly or have significant co-morbidities.

Hyperacute Rejection

Hyperacute rejection occurs almost immediately following transplantation resulting in swelling and discoloration of the donor organ, which is catastrophic for the patient. It is due to preformed cytotoxic antibodies present in the host, specific for donor antigens. Fortunately, hyperacute rejection is rare owing to careful cross-matching.

Acute Rejection

Acute rejection arises in as many as 50 % of grafts less than six months post-transplant and is characterised by a T-cell response, accompanied by a number of inflammatory mediators such as tumour necrosis factor-alpha (TNFα), interferon-gamma (IFNγ) and interleukin-2 (IL-2).

A T-cell-mediated response can only take place if the T-cell has received two signals: signal one occurs at the T-cell receptor interaction with antigen, which is presented by MHC on antigen-presenting cells (APC) (Fig. 25.1). Signal two is provided by co-stimulatory molecules on the APC, which bind to various complimentary molecules on the T-cell surface. If signal one occurs in the absence of signal two T-cell anergy, or unresponsiveness, ensues (i.e. no immune response). However, if co-stimulatory cell-cell interactions occur between the T-cell and the

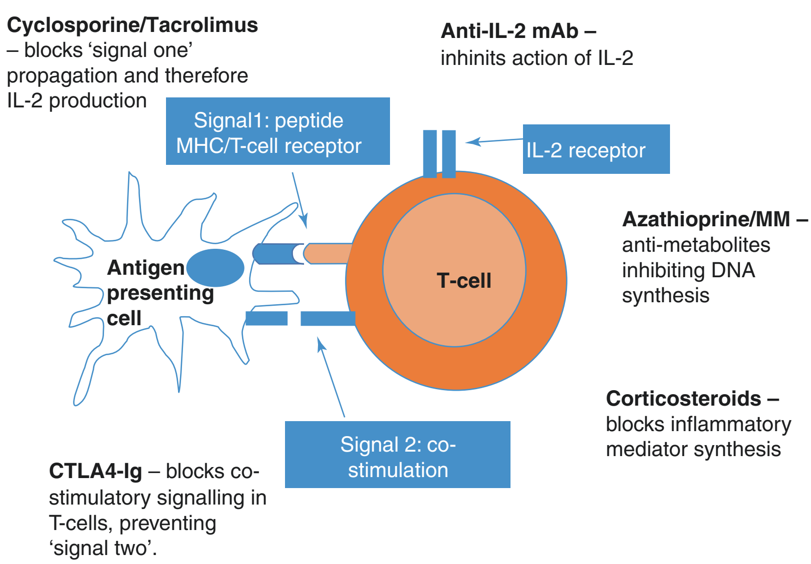

Fig. 25.1 Two-signal activation of the adaptive immune system. Antigen presenting cells present antigen via MHC molecules, recognised by the T-cell receptor. A co-stimulatory signal is also transmitted, to ensure full activation of the immune system. Several immunosuppressive drugs inhibit the actions of this pathway

APC (signal two), then a full T-cell response is initiated. This two signal model is significant in the development of new anti-rejection medications (see below).

Chronic Rejection

Chronic rejection occurs more than six months post-transplant. Contributing features include antibody release by plasma cells that ultimately destroy the graft, and as such is an irreversible process. Usually the result of vascular occlusion, chronic rejection is characterised by antibody responses to vascular endothelial cells and the subsequent response of these cells, such as smooth muscle proliferation and interstitial scarring.

Immunosuppression

To prevent organ rejection, transplant recipients are placed on anti-rejection medication, or immunosuppression. Unfortunately, there are no specific methods to prevent an immune response which is directed only to the grafted organ, meaning a non-specific dampening of the entire immune system is required.

Corticosteroids

Steroids prevent the synthesis of numerous pro-inflammatory mediators in cells of the immune system. Targeting such a generic component brings with it multiple complications including delayed wound healing, increased risk of infection, diabetes mellitus and Cushingoid symptoms. Consequently, steroid therapy is rarely used long-term and as such, steroid-sparing therapy is used.

Calcineurin Inhibitors

T-cells require two signals to become fully activated. Calcineurin inhibitors, such as ciclosporin and tacrolimus, block the propagation of 'signal one', preventing IL-2 production, which is the major stimulus for T-cell proliferation.

Anti-metabolites

Anti-metabolites such as azathioprine and mycophenolate mofetil (MMF) block DNA synthesis and therefore prevent T-cell proliferation, avoiding anti-graft immune responses. However, these drugs can cause severe adverse effects due to the non-specific killing of other rapidly dividing cells such as erythrocytes.

Cell Depletion

CAMPATH-1, or alemtuzumab, is a humanised monoclonal antibody specific for the cell surface marker CD52, which is present on all lymphocytes. As such, this is an effective lymphocyte-depleting therapy which prevents organ rejection. This drug is usually administered prior to transplantation, ensuring T-cell depletion.

Co-stimulation Blockade

Cytotoxic T-lymphocyte antigen 4 (CTLA4) is a co-inhibitory molecule that reduces T-cell activation by blocking 'signal two'. Drugs such as belatacept and abatacept, which boost the activity of CTLA4, have shown clinical efficacy in transplantation (as they prevent overt T-cell activation). The BENEFIT study showed that belatacept was associated with improved GFR and renal graft survival compared with cyclosporine treatment post-transplant [12].

Risks of Immunosuppression

As non-specific immunosuppression compromises the immune system, opportunistic pathogens take advantage. Prophylactic antibiotics can be administered accordingly, depending on the likelihood of the microbe species.

The ten-year incidence of *de novo* malignancy in transplant recipients is twice that of the general population [5]. Moreover, the risk of non-melanoma skin cancer is thirteen times greater. This phenomenon is due to defective cancer immune-surveillance, which also facilitates oncogenic viruses. Cancers including lymphoma (EBV-associated), melanoma (papillovirus) and Kaposi's sarcoma (human herpesvirus-8) are common. As such, cancer surveillance is an important aspect of follow-up care.

Kidney Transplantation

Epidemiology

In 2013/14, 3032 kidney transplants took place in the UK while 5881 patients were on the waiting list [9].

Aetiology

Kidney transplants are usually indicated in end-stage renal disease (eGFR < 15 mL/min), with common causes including:

- Diabetic kidney disease
- Hypertensive kidney disease
- Glomerulonephritis
- Polycystic kidney disease

Dialysis is offered at this stage but is only a short-term, non-curative solution. Ultimately, patients will require a transplant, which offers the best chance of long-term survival. Most studies demonstrate significantly lower mortality in kidney transplant recipients, compared with haemodialysis patients [11]. In addition, the quality of life of kidney transplant recipients is significantly superior. Absolute contraindications include active infection and malignancy, whereas relative contraindications include patient age and other significant co-morbidities.

Step-by-Step Summary

1. Preparation of donor kidney (dissection of donor renal artery and vein, removal of perinephric fat, careful inspection to ensure an intact renal capsule and ureter)
2. A small incision (Rutherford-Morrison incision) is made above the pubic symphysis to the anterior superior iliac spine
3. The iliac vessels are isolated by retroperitoneal dissection
4. The donated kidney is placed below the diseased kidney which is typically left *in situ*
5. An anastomosis is made between the donor renal vein and recipient external iliac vein and the donor renal artery and recipient internal *or* external iliac artery
6. The donor ureter is anastomosed to the recipient bladder

Complications and Outcomes

Careful management of fluid balance is crucial in kidney transplant recipients. Continual assessment and maintenance of blood pressure and serum electrolytes is required to ensure optimal graft function.

Definitions of delayed graft function (DGF) vary but, for the purposes of this text, can be defined as the need for dialysis within the first 7 days post-transplant, with the exception of dialysis necessary to treat hyperkalaemia or fluid overload [4]. It is a common occurrence in kidney transplant recipients with reported rates ranging from 5–50 % in deceased-donor transplants [14]. Patients with DGF have a 41 % increased risk of developing graft loss at 3 years, compared with non-DGF patients [14]. DGF is treated by careful fluid management and if this fails a renal biopsy is performed to exclude rejection. Complications are shown below.

- ***Immediate complications***
  - Haemorrhage
  - Hyperacute rejection
- ***Early complications***
  - Delayed graft function (DGF)
  - Acute rejection
  - Renal artery/vein thrombosis
  - Urinary leak/obstruction
- ***Late complications***
  - Renal artery stenosis
  - Fluid collections (lymphoceles)
  - Complications of immunosuppression
  - Chronic rejection

Liver Transplantation

Epidemiology

The majority of chronic liver disease is irreversible and transplantation remains the only curative option for end-stage liver disease; currently there is no reliable liver support strategy such as haemodialysis. During 2013/14, 1186 patients joined the liver transplant waiting list [9].

Aetiology

Patients requiring liver transplant suffer from multiple hepatobiliary conditions including:

Acute Liver Failure

- Paracetamol-induced
- Drug reaction (e.g. halothane, antituberculous drugs)
- Viral infection (e.g. Hepatitis A, B or E)

Chronic Liver Failure

- Alcoholic liver disease
- Non-alcoholic fatty liver disease
- Hepatitis C
- Hepatocellular carcinoma
- Primary sclerosing cholangitis
- Primary biliary cirrhosis

The severity of patients' chronic liver disease is assessed using the model for end-stage liver disease (MELD; UKELD in the UK) score which includes bilirubin, International Normalised Ratio (INR), and serum creatinine (Box 25.1). Both MELD and UKELD are useful prognostic indicators of mortality and are used for patient prioritisation on the transplant list [2, 7].

Step-by-Step Summary

A number of different techniques may be used, but typically liver transplantation involves [8]:

1. Preparation of donor liver
2. A 'Mercedes Benz' incision or midline incision following the right costal margin is made in recipient
3. Recipient hepatectomy ensuring that the recipient vessels and bile ducts are preserved
4. Donor and recipient inferior vena cavae are attached in the so-called 'piggy back' procedure
5. The portal vein and hepatic artery are anastomosed to their respective recipient vessels
6. The donor gallbladder is removed and an end-to-end anastomoses is performed between donor and recipient common bile duct

Box 25.1 MELD and UKELD scores

$$MELD = [\left(3.8 \times \ln\left(bilirubin\,mg/dL\right)\right) + \left(11.2 \times \ln\left(INR\right)\right) + \left(9.6 \times \ln\left(creatinine\,mg/dL\right)\right) \\ + \left(6.4 \times \left(aetiology: 0\; if\; cholestatic\; or\; alcoholic, 1\; if\; otherwise\right)\right)$$

$$UKELD = [\left(5.395 \times \ln\left(INR\right)\right) + \left(1.485 \times \ln\left(creatinine\right)\right) + \left(3.130 \times \ln\left(bilirubin\right)\right) \\ \left(81.565 \times \ln\left(sodium\right)\right)] + 435$$

Outcome and Complications

Primary non-function occurs if the transplanted liver fails to function within fourteen days, resulting in either death or re-transplantation [8].

Liver rejection is much less common than for other transplanted organs, as it is a relatively immune-tolerant site. However, diagnosis of rejection is usually made seven days post-transplant with increased transaminase levels. Liver biopsy may be performed to confirm the diagnosis and rejection can be treated with daily methylprednisolone. Complications are shown below.

- ***Immediate complications***
  - Haemorrhage
  - Primary non-function
  - Hepatic artery/portal venous thrombosis
- ***Early complications***
  - Hepatic artery/portal venous thrombosis
  - Sepsis
  - Acute rejection
  - Biliary leakage
- ***Late complications***
  - Complications of immunosuppression
  - Disease recurrence

Pancreas/Islet Transplantation

Epidemiology

The number of patients waiting for either pancreas only, simultaneous pancreas/kidney or islet cell transplant was 270 in 2014, up from 98 in 2003. Similarly, the number of pancreas transplants has increased from 86 in 2004/5 to 246 in 2013/14 [9].

Aetiology

Pancreas transplantation is indicated for patients with diabetes in end-stage renal failure, patients with disabling or life-threatening hypoglycaemic unawareness, and for those who are at an increased risk of developing secondary complications [13]. Although it is not a life-saving procedure, pancreas transplantation removes the burden of daily insulin injection and ultimately provides an improved quality of life. However, this comes at a cost: a high-risk operative procedure and life-long immunosuppression. Less invasive forms of the procedure are currently in use, such as pancreatic islet transplantation (discussed below).

Step-by-Step Summary

Pancreas grafts can be transplanted as simultaneous pancreas/kidney (SPK), pancreas after kidney (PAK) and pancreas transplant alone (PTA). SPK is the most common procedure performed.

1. The donor pancreas is inspected and the vessels are prepared
2. The recipient pancreas remains *in-situ* and the donor pancreas is usually implanted into the pelvis (similar to kidney transplantation)
3. An anastomosis is made with the recipient's common iliac artery
4. Venous anastomosis is made between the recipient common iliac vein, portal vein or IVC
5. Exocrine secretions can be drained into bowel or bladder

Outcomes and Complications

Close monitoring in an intensive care setting is important to detect early signs of complications. Pancreas recipients often need higher doses of immunosuppression, which has several consequences for the diabetic population: even poorer wound healing, higher risk of infection and other co-morbidities. Rejection is a particular risk, with 50 % of recipients having at least one rejection episode in the first three years and 20 % losing the graft [6]. Complications are shown below.

- ***Immediate complications***
  - Haemorrhage
  - Thrombosis
- ***Early complications***
  - Pancreatitis
  - Thrombosis

  - Anastomotic leak
  - Sepsis
  - Acute rejection
- ***Late complications***
  - Complications of immunosuppression
  - Chronic rejection

Islet Transplantation

Islet cells can be isolated from a donor pancreas and introduced into the recipient liver. The transplanted β-islet cells then produce insulin in the liver. This is much less invasive than pancreas transplantation and therefore may be suitable for those considered unfit for surgery. However, two-to-three donor organs are required per patient. In addition, it is often difficult to detect rejection in cell transplantation as it is technically challenging to biopsy the correct cells.

Lung Transplantation

Epidemiology

During 2013/2014, 218 lung transplants were performed in the UK [9]. However, with 263 lung patients added to the waiting list in the same time period, organ shortage remains a real problem.

Aetiology

The main indications for lung transplantation include:

- Cystic fibrosis
- Chronic obstructive pulmonary disease (COPD)
- Pulmonary hypertension
- Idiopathic pulmonary fibrosis
- Lung malignancy

Lung transplants may be single or bilateral, or transplanted with a heart. A huge challenge in lung transplantation is organ availability: for every five lungs donated, only one is accepted [1]. This high rejection rate is likely due to the damaging systemic effects of brainstem death, which includes a surge in sympathetic nervous activity and a so-called 'cytokine storm' which cause significant alveolar damage [1]. The maximum ischaemic time for lungs is 6–8 h: to ensure adequate preservation during this time a prostacyclin infusion is commenced (preventing pulmonary vasoconstriction) and the lungs are flushed with a cold pneumoplegia solution [3]]. The lungs are then stored at 4–10 °C.

Step-by-Step Summary

1. A lateral thoracotomy is performed and the recipient lung is identified
2. The inferior and superior pulmonary veins and pulmonary artery are ligated
3. The main bronchus is then transected and the lung is removed
4. An incision is made into the pericardium, and pulmonary veins and artery are identified and prepared for anastomoses
5. The donor lungs are placed into the chest cavity and the bronchial anastomosis is performed, followed by that of the pulmonary veins and artery

Outcomes and Complications

Recipients are closely observed in the intensive care unit in the post-operative period. Ventilatory pressures are closely monitored to minimise lung injury. Immunosuppression is commenced early in the postoperative period and regular lung biopsies are performed to detect rejection. Complications are shown below.

- ***Immediate complications***
  - Haemorrhage
- ***Early complications***
  - Infection
  - Acute rejection
  - Primary graft dysfunction
- ***Late complications***
  - Chronic rejection (characterised by obliterative bronchiolitis)
  - Complications of immunosuppression

Heart Transplantation

Epidemiology

During 2013/2014, 198 heart transplants were performed in the UK [9]. However, with 218 heart patients added to the waiting list in that time frame, organ shortage remains challenging.

Aetiology

Patients requiring a heart transplant are in advanced heart failure. Common causes include:

- Cardiomyopathies
- Coronary artery-related heart disease
- Congenital abnormalities
- Valvular heart disease

Contraindications to heart transplant include factors which increase the likelihood of perioperative mortality, such as sepsis, severe obesity and pulmonary hypertension. In addition, the patient's age and co-morbidities (e.g. malignancy, renal impairment) are likely to influence the decision whether to transplant.

Step-by-Step Summary [10]

1. The donor heart is removed and rapidly cooled with ice-cold saline
2. A midline sternotomy is performed on the recipient to expose the diseased heart
3. Following heparinisation cardiopulmonary bypass is initiated and the patient is cooled
4. The aorta is clamped and a cardiectomy is performed
5. The right atrium is removed to leave cut ends of the superior- and inferior-vena cavae.
6. The left atrium is removed to leave the posterior cuff containing the pulmonary vein orifices
7. The donor heart is inserted into the mediastinum of the recipient where atrial, aortic, pulmonary and vena caval anastomoses can take place
8. The patient is re-warmed and the heart is re-perfused

Outcomes and Complications

Post-operative monitoring of ventricular function, renal function and infection status is crucial to avoid early complications. Supportive inotropes can be administered if myocardial dysfunction occurs. Graft rejection is diagnosed by regular myocardial biopsies and is treated by altering the immunosuppression regimen. Rejection can also cause accelerated coronary artery disease, characterised by vascular wall thickening. Complications are shown below.

- ***Immediate complications***
  - Haemorrhage
  - Cardiac arrhythmia
- ***Early complications***
  - Infection
  - Acute rejection
  - Multi-organ failure
  - Ventricular dysfunction
- ***Late complications***
  - Complications of immunosuppression
  - Chronic rejection
  - Cardiac allograft vasculopathy

Surgeons' Favourite Questions for Students

1. Describe the mechanism of action of ciclosporin. What side effects might this drug cause?
2. List the four main indications for renal transplantation.
3. Why is liver rejection much less common than rejection in other organs?
4. Describe the process of islet cell transplantation.
5. A 68-year-old man received a renal transplant 3 months previously for diabetic nephropathy. The graft functioned well initially but his creatinine clearance is deteriorating. What type of rejection is present?

Careers

A career in transplant surgery is exciting and challenging. Not only does it demand a high level of technical skill, but a huge commitment is required, owing to the long hours and often unpredictable nature of the job. Following foundation years one and two, trainees must enter the general surgical training programme at ST3 level. ST7/8 provides two years to pursue special areas of interest.

Transplant surgeons tend to have a strong academic background with broad interests in immunology, pharmacology and medical ethics. A formal period of research (MD or PhD) would normally be undertaken at some point between ST3 and ST8. Transplant surgery is highly competitive and, as a result, pursuing this training programme does not guarantee a consultant post at the end. However, it is an incredibly rewarding career which offers the ability to treat patients with life-threatening disease at, what is often, the most difficult times of their lives.

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26 I Want to Be a Surgeon: What Next?

Angela E. Fanshawe and Michael E. Ibrahim

Introduction

A surgical career combines technical prowess, tough decision-making, the care of acutely unwell patients and the rewards of repairing and restoring function. For this reason, surgery is a fantastic career. It is also demanding, competitive and requires great stamina. As medical students, there is so much you can do to set your career off on the right footing.

In this chapter, we discuss the things you can do in medical school to give you the best shot at getting the career that you want. The first specific hurdle in becoming a surgeon in the UK is securing a core surgical training post (CST1-2) after your two-year foundation training. So that you know what you're aiming for (right from the basics), it is worth looking at the person specification outlined on the Core Surgery National Recruitment for the NHS page whilst still at medical school. The extent to which you match the person specification determines how likely you are to get into surgical training (http://www.surgeryrecruitment.nhs.uk/downloads).

Although it may seem too soon to be considering postgraduate applications in medical school, bear in mind that surgery is competitive and things that will stand out on your application form (audits, research, presentations) often take a very long time to see to completion. Starting early also allows you to make mistakes but still ultimately succeed. In this chapter, we discuss the key features of a surgical career, alternative similar careers and discuss what can be done at medical school to help one succeed.

A Surgical Career

Many different sorts of people have become excellent surgeons. However, in "the little red book" published by the American College of Surgeons, Drs Johansen and Heimbach discuss surgical "traits" (https://www.facs.org/education/resources/residency-search). These are certain personality traits that are worthwhile reflecting upon when deciding whether you could make a productive and happy surgeon. Such traits include a propensity to lead, good organisational skills, decisiveness, a thirst for excellence, and clarity of thought and communication. Attention to detail is particularly important in surgery because the finer

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points can have life-changing consequences. Note that many of these traits are only developed over time and with practice, but having a natural inclination towards them is a good starting point.

Whilst surgery is sometimes reduced to the technical act of operating, it is much more than this. It is the privilege of gaining the confidence of a patient who is fearful, seeing them through an operation using meticulous surgical technique and post-operative care, and having the reward of following them up afterwards. Having said this, it is essential that you do like the technical act of operating! So much can be learnt from scrubbing up and simply watching operations. How does the surgeon approach decisions? How do they hold their instruments? How do they handle particular tissues? If you do not enjoy this, then you are unlikely to find surgery a rewarding experience.

If not all of the above sounds appealing, it might be worth considering alternative careers. Technical challenge is intrinsic to both anaesthetics and interventional radiology. Tough decision-making and looking after acutely unwell patients is the day-to-day work of the intensive care physician. Those who prefer more career stability and quicker rewards might consider obstetrics and gynaecology. If having a lifestyle free of on-calls is important to you, consider being a general practitioner with a specialist interest in minor surgery.

Building a Surgical Career

Medical School Examinations

Performing well in your medical school examinations is important. Good performance helps you get your chosen foundation jobs as the higher you rank within your medical school, the more FPAS (Foundation Programme Application System) points you are awarded. A better performance also means it is more likely you will be awarded a prize (most medical schools have prizes for both subject-specific performance and overall performance). More fundamentally, the safe and effective practice of surgery is underpinned by the basic sciences and core clinical knowledge.

The postgraduate examinations in surgery are MRCS (Member of the Royal College of Surgery) Part A (multiple-choice written examination) and Part B (a clinical examination). Whilst Part B is better taken once you have a at least a few years of postgraduate clinical experience, Part A is best sat soon after medical school as the knowledge required leads on well from final year examination requirements.

BSc/Intercalation

If you are convinced you want to pursue a career in surgery from an early point in medical school, it may be worth choosing to do a BSc (and doing well in it) in a surgical topic. Not only will it give you insight into a surgical career, but will demonstrate commitment to surgery from a very early point (which looks impressive for core surgical application). A BSc with a strong research component is an excellent choice as evidence of publications and presentations plays an important part in the application process. This research component may take the form of original laboratory or clinical research, or it may be a literature review for a dissertation. Both are valid and every opportunity should be pursued to publish the research you have produced. A dissertation, for example, can be modified into a review article for a journal.

Student-Selected Modules and Electives

Almost all medical schools now offer ‘student-selected’ components as part of their curricula. Take every opportunity to choose modules that will give you a better insight into a surgical career and enhance your application to core surgical training. Don’t worry if there are no modules in the specialty that you think you might want to do, or even in any surgical specialty itself – anything allied to surgery will be of use in informing your career and contributing to your application. For example, anaesthetics and intensive care, obstetrics and gynaecology and accident and emergency may all be useful.

Similarly, choose an elective that will give you an opportunity to demonstrate your commitment to surgery at interview. There are a number of travel bursaries available from the various colleges, including the Royal College of Surgeons of Edinburgh (http://www.rcsed.ac.uk/fellows-members/awards-and-grants/bursaries.aspx).

Foundation Jobs

Whilst it currently remains essential for foundation doctors to have had experience of both medical and surgical specialties, you can tailor your two years appropriately. Choose programs from which you will learn skills relevant to surgery, such as critical care (anaesthesia and intensive care), or which may have topical overlap with surgery (such as oncology). When it comes to success in the interview for core surgery, it certainly helps to have had some experience of a general surgical or trauma and orthopaedic surgical on-call.

Prizes

Prizes make an applicant stand out from their competition. This is important to remember when applying to a competitive specialty like surgery, especially in a competitive location like London. Prizes are not reserved to performing well in examinations at medical school. The Royal College of Surgeons of England (http://surgicalcareers.rcseng.ac.uk/students/medical-students/prizes), the Royal Society of Medicine (https://www.rsm.ac.uk/prizes-awards/students.aspx) and the Women in Surgery network (http://surgicalcareers.rcseng.ac.uk/wins/women-in-surgery-prizes-1) all provide opportunities to win prizes in a variety of competitive formats. Even if you prepare a project that does not win a prize, it will most likely be suitable for submission elsewhere (for example, to a conference or journal).

Audit

An audit is a process by which healthcare professionals aim to improve the quality of the service they provide by measuring the current provision against a standard. The standard is an ideal set either locally by a hospital trust or more generally, by governing bodies such as NICE.

Audits are an essential part of the application system to core surgical training, as participation in an audit demonstrates an understanding of the NHS and a desire to improve the current service provision. Medical students are perfectly suited to getting involved right from the beginning of any audit process. On your surgical attachment, take note if you see any aspect of patient management that could be improved, or ask the team (ideally SHOs, registrars or consultants) whether they have any ideas. You could then be responsible for anything from data collection to analysis and write-up. If you discover widely applicable learning outcomes, the results and recommendations of the audit could be suitable for presentation at a local or national meeting. Extra points are awarded at application time for audits in which the 'cycle has been completed'. This means that an element of healthcare provision has been re-audited after the recommendations of the first audit have been implemented.

Research and Publications

As a medical student, the prospect of research may seem daunting. Involvement in research is, however, an important part of any medical career, since lifelong learning is essential. It also helps in any application processes. Doing a BSc (as above) may provide one route into research, which should ideally be published and listed on PubMed (http://www.ncbi.nlm.nih.gov/pubmed/).

However, you do not need to have a formal BSc project to be engaged in research. Approach a productive senior colleague in your specialty of choice as they are certain to have projects with which you could help. While simple projects like case reports are a good start and make a useful contribution, you should aim to be involved in the highest quality research available: for example, this research may involve a significant number of patients in a well-run trial or series, and address an important question. Getting anything published in a journal takes a long time. This could be in the order of months to years once submission, revision, re-submission, re-revision and proofing takes place. Therefore you need to be prepared and start a long time ahead of any deadline or job application.

It is important to understand that engaging in research is not simply about gaining publications. Research will develop your understanding of your specialty, your critical sense and your passion for medicine. Do not believe that surgical research involves only patients. There are many surgeon scientists whose discoveries in the laboratory are influencing patient care.

Presentations

Oral or poster presentations at regional, national and international conferences are excellent experience. Often an audit or research project that is not suitable for publication may be appropriate for poster presentation instead. Find a conference based on the topic of your audit or research (through a relevant society for example) and submit an abstract for presentation.

You will gain much from attending these conferences, by learning about what is new in your specialty. After all, building a passion for science and surgery is ultimately more important than building your CV. Note that if your work is accepted for oral presentation, it helps to have had some experience of public speaking. One way of achieving this is to volunteer to present at local meetings e.g. trauma meetings, morbidity and mortality gatherings and grand rounds.

Portfolio of Cases

All surgical trainees now keep a logbook of the cases they have been involved in. The vast majority of trainees use a resource called E Logbook (https://www.elogbook.org), which allows you to list cases by specialty. Information required varies depending on specialty but usually involves patient ID number (NHS or hospital), date of birth, ASA (American Society of Anaesthesiologists) grade, date of operation, nature of operation, hospital, and your personal involvement in the operation (observing, assisting or performing, for example). Medical students can sign up to E Logbook, and although signing up is non-essential for a successful application into surgical training, it gives you an organized framework for discussing your surgical experiences to date (and it is free).

Teaching and Leadership

Teaching is a common topic for discussion on application forms and at interview. It is never too early to start teaching. It may take a variety of formats including teaching elementary clinical skills to groups of early-year medical students or one-to-one basic science mentorship for students taking anatomy or physiology examinations. If you can find a way of setting up your own teaching programme, this carries more core surgical application points than participating in an already-established programme. Although some may find it intimidating, remember that teaching is an excellent way to consolidate your own learning and build confidence. Experience of leadership is also commonly assessed and this does not necessarily need to have taken place in a clinical context. Captaining a sports team, balancing a budget for a committee or providing pastoral support in your medical school all count as valid examples of leadership.

Courses

Participating in courses helps demonstrate your interest in, and commitment to, surgery. The Royal College of Surgeons of England run a number of courses geared towards medical students (https://www.rcseng.ac.uk/courses), including those in anatomy and basic practical surgical skills. Some hospitals now run courses in laparoscopic surgical simulation, which will certainly improve your practical skills and confidence in the operating theatre. At a postgraduate level, a number of courses are recommended prior to core surgical application, including Basic Surgical Skills (BSS, RCS) and Advanced Trauma Life Support (ATLS®). Once qualified, remember to apply early for these as places tend to get filled up very quickly. Note that all courses can be quite financially draining and since many hospitals will offer a reasonable study budget in your foundation years, it may be worth postponing course participation until this time.

An International Perspective

Many surgical trainees now supplement their learning with time spent abroad, or even start their surgical training abroad. The USA is a particularly popular choice, either for residency (5–6 years to completion, depending upon subspecialty) or fellowship (1–2 years post-completion of specialist registrar training). Remember that a residency in the USA can be pursued at any time after graduation, but being a 'foreign medical graduate' (graduating from a university outside the USA) can be a significant disadvantage on your application. An excellent CV (see above), together with outstanding USMLE (United States Medical Licensing Examination) results is essential to pursue a residency in a renowned institution. Consider also the possibility of training in Europe, as many countries (such as Germany) have the option of pursuing a residency in your desired specialty straight out of medical school. There are advantages and disadvantages to any healthcare system, so the most important factor to consider is where you ultimately want to end up practicing as a consultant. Working with charitable organisations that enhance the provision of surgery in the developing world may provide a unique opportunity to enhance your surgical experience, exchange knowledge and seek out career development in the context of helping to serve underprivileged populations.

Summary

Despite being tiring, competitive, risky, demanding and punishing, surgery remains one of the most sought-after careers in medicine. This is because it remains beautiful, challenging and requires perhaps the maximal development of our humanity and of our clinical knowledge and skill. We hope that the tips in this chapter help in your preparation for a career in surgery.

Surgical Research

27

Angela E. Fanshawe and Michael E. Ibrahim

Introduction

Research is fundamental to surgery. In an era of evidence-based medicine, the therapeutic choices we advise need to be grounded in high quality evidence. It is imperative that surgical trainees at every level are comfortable with the language of research so that they can evaluate the data on different interventions. It is also expected that some surgeons will be fully trained academics who actively contribute to the development of new ideas. The accumulation of a sufficient number of papers (especially case reports, letters and "best evidence topics") to pass selection panels should not be confused with the rigorous pursuit of fundamental new knowledge that underpins true academic surgery. This chapter will provide the tools to understand the basics of surgical research.

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Critical Appraisal

Critical appraisal is the assessment of the quality, role, importance and impact of research articles. This is predicated on an understanding of scientific thought, methodology and statistics.

When critiquing a manuscript or abstract, begin by assessing the research question. Has it been clearly defined? Is it a worthwhile question? A worthwhile question is one to which the answer will change our knowledge base or practice. It must be specific enough such that acquiring empirical data through an experiment will answer it.

The next step is to evaluate whether the study design is appropriate to answer the research question. Do the inclusion and exclusion criteria successfully delineate study groups of interest? Are the groups well matched (see section 'Study Design')? Is the study powered adequately? Is the design subject to bias?

In evaluating the results of a study, one should identify the significant and non-significant results and assess whether they directly answer the research question posed. Have the outcomes of the study been achieved? Statistically significant results should be evaluated in the context of the study's methodology and should not be elevated to a pedestal; statistically non-significant results should not be ignored. For example, is a statistically significant result clinically or scientifically meaningless? Or is a statistically non-significant result important? For example, the recent finding

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that permissive anaemia does not affect outcomes in sepsis (NEJM DOI: 10.1056/NEJMoa1406617) is a negative, statistically non-significant result of great clinical significance.

The final step is to evaluate the conclusions of the study. Do the conclusions match the data? Do they err beyond the confines of the data? Do the limitations of the study negate any proposed conclusions? Overall, consider what the study adds to the existing literature.

Literature Search Techniques

A literature search is performed for a number of different reasons including to help formulate and focus a research question or when writing a literature review. With the wealth of information contained in books and journals, performing an effective literature search necessitates a systematic approach.

Relevant and specific search terms should be selected and noted. The use of MEDLINE (pubmed.com) is standard. The best way to search MEDLINE is to use the advanced function, rather than the generic homepage. In this way, one can select articles of interest more specifically (for example, by searching for only original research articles, or articles within a specific publication period). Further articles can be found using the "related articles" panel, which appears alongside abstracts. Once you are satisfied that you have found all the relevant articles, you should examine the reference lists of these articles to search for any missed papers. Recent review articles often refer to useful sources of information, which may have been missed in an initial literature search.

Levels of Evidence

Not all pieces of evidence are of equal scientific worth. Evidence is sorted into scientific "strength" using a system of levels (defined, in the UK, by the Oxford Centre for Evidence-based Medicine). It is generally accepted that there are four levels of evidence (I-IV). Level IV evidence is of limited use: it may consist of the opinions of a panel of experts on a particular topic. Level III evidence is one rung higher in strength and includes non-interventional published material such as case reports, case series and retrospective comparisons. More robust evidence is from experimental studies, which should be well designed (IIb). The presence of a control group, even if non-randomized, enhances the strength of the research (IIa). Level I evidence consists of randomized control trials (RCT), which are often mistakenly described as providing the highest level of evidence. However, a single good RCT is rated as level Ib, which is below a meta-analysis of multiple RCTs (Ia). Inherent in this rating scale is an assessment of quality. A poorly designed or conducted RCT is worth less than an excellent non-randomised controlled trial. It is now routine to be asked about levels of evidence at academic interviews. These ratings are also commonly seen in clinical guidelines to show the level of evidence supporting a certain recommendation.

Ethics in Medical Research

The principles of medical ethics may be summarised as respect for autonomy (allowing people to do as they please with their own bodies and make their own choices), beneficence (doing good), non-maleficence (not harming patients) and justice (fair treatment including in resource allocation).

Medical research has a tainted history with respect to medical ethics, from the illegal harvesting of dead bodies for the study of anatomy to the intentional withholding of available treatment for patients with syphilis. While a full discussion of medical ethics is beyond the scope of this chapter, it is pertinent to summarise the major ethical and legal components of medical research.

First, we consider the use of animals in medical research. Research on animals is fundamental to the science that informs human and veterinary medicine. Much of our understanding of anatomy, physiology, pharmacology and genetics comes from work in animals. As animals are vulnerable and experimentation may cause pain or suffering, we have a duty to carefully consider their use in research. In the UK, the Home Office governs the use of animals for experimentation. All projects using animals must be approved by the Home Office and granted a licence to go ahead. The Home Office also performs random inspections to ensure that animals are being treated humanely. The UK research community adheres to the principles of "the three Rs" – replacement of animals with non-animal research models, refinement of techniques to reduce suffering, and reduction of numbers needed. In the UK, the vast majority of animal research uses species such as mice, rats and flies. Research on primates is very strictly controlled and research on great apes is essentially banned.

The ethical foundations of human research are based on the Declaration of Helsinki, originally adopted in 1964. This document emerged from the Nuremberg Code, and dealt with the medical research atrocities committed by the Nazis.

A fundamental component of modern ethical research is informed consent. This means that a subject should be informed of the risks of participation, so far as they can be estimated, and consent to an experimental intervention which may be of no benefit. This must be given freely.

Applications for human subject research are conducted via the Integrated Research Application System (IRAS) online, and are supplied by the NHS Health Research Authority. The complexity of the application and the level of detail and defence required are commensurate with the invasiveness and risk of the research, and with the vulnerability of the subjects. The type of study is also important: a retrospective study, for example, is more easily approved than an invasive, interventional one.

Study Design

General features of study design are more important in determining the quality of the results than the overall type of study (such as whether it is retrospective or prospective). As discussed in the level of evidence section, a high quality, well-controlled, adequately powered interventional study is of more value than a poorly designed RCT.

These general features are:

- *Matching:* Patients making up the different groups in the study should be as similar as possible in age, sex, other medical history, and more. Ideally, the only difference between the groups ought to be the risk factor or intervention being investigated.
- *Power:* Describes the number of patients required to detect a statistically significant effect. If the effect of an intervention is small, you will need more patients to detect an effect that is statistically significant. Note that the accuracy of measuring the effect size will also affect power. In general, the larger the number of patients, the more highly powered the experiment.
- *Confounding:* A confounding factor is an unknown which may have a hidden effect associated with the risk factor or intervention being studied. For example, consider the association of smoking with liver cirrhosis. In this relationship, alcohol consumption is a confounding factor: smokers are more likely to be heavy drinkers, and it is the alcohol consumption that causes cirrhosis.
- *Numbers and Centres:* In general, the larger the number of patients the better. Similarly, involving a number of different centres (a multi-centred trial) reduces the likelihood that the results depend on one particular centre. Thus, the results are more likely to be generalizable. However, the larger the number of patients, the more the inclusion criteria of the study may have to be expanded. Likewise, compromise is also necessary when including many centres, since the practices of different centres differ and adjustments must be made so that all centres work to an agreed protocol.

There are many different study designs, each of which should be matched to the question at hand. Note that no particular study design is "better" than another, but the study design should be appropriate for the question. The main types of study are:

- *Case reports and case series:* Novel, instructive or rare cases are written up and discussed in the setting of the wider literature available.
- *Cohort study:* A group of individuals with and without a **risk factor** is followed up prospectively (usually) and outcomes are compared. Cohort studies yield **relative risks** – for example, the relative risk of lung cancer in a group of smokers is higher than in a group of non-smokers.
- *Case-control studies*: A group of individuals with and without a **disease** is followed up retrospectively and a risk factor for that disease is identified. Case control studies give **odds ratios –** for example, patients with lung carcinoma have higher odds of having been smokers than those without lung carcinoma.
  – Both cohort and case control studies are observational, which means the investigator watches what happens but doesn't intervene. It is important that the two groups (with and without disease (case-control) and with and without risk factor (cohort)) are well matched in aspects other than the risk factor or disease.
- *Cross-sectional study*: A study of a large group of people looking at the prevalence of a disease. A cross-sectional study may give some clues as to risk factors but does not prove causation.
- *Twin concordance study:* A study that looks at the rates of disease in monozygotic versus dizygotic twins to evaluate the heritability of disease.
- *Adoption studies*: A study that compares twins adopted by different families to evaluate the effect of genetic versus environmental factors.

Interventional clinical trials are used to evaluate new therapies in humans. Assuming the general characteristics of the study are good, the highest quality data concerning the effect of one intervention compared to another are obtained from a double blinded, randomised control trial.

Interventional clinical trials are conducted in multiple phases:

- *Phase 1* (Is it safe?)
- A small study to assess the safety of a new agent, usually using healthy volunteers.
- *Phase 2* (Does it work?)
- A study to assess whether the drug is useful in patients with a specific disease.
- *Phase 3* (Is it better than current best practice?)
- A larger study to compare the efficacy of the drug with the current gold-standard.
- *Phase 4* (Have any side effects or complications been missed?)
- Ongoing study after a drug is approved and marketed, in which surveillance is undertaken to detect rare or late side effects.

Audit

Audit is not the same as research. The purpose of research is to find new information and answer a new question. The purpose of audit is to compare current practice to a defined standard and to evaluate how current practice may need to change.

The main steps in an audit are:

- *Define a standard:* This may be a set of outcomes for a centre of excellence, or a national gold-standard guideline.
- *Assess current practices or outcomes against this standard*
- *Make recommendations for change* if there is a gap between the standard and current practice.
- *Implement those recommendations*
- *"Close the audit cycle":* Re-audit to assess whether the recommended changes have now improved outcomes to the level required by the standard.

To illustrate this, let us consider a hypothetical example concerning the administration of antibiotics for sepsis. A UK guideline states that antibiotics should be given within 1 h of the identification of sepsis. You search the hospital records and find that, on average, it takes 3 h for septic patients to receive antibiotics. You identify this falls short of the guideline and recommend that this needs to change. You identify that the delay is due to the time required to obtain IV access and get antibiotics from the pharmacy. You recommend that this could be improved by making a "sepsis bundle" tool available to doctors and nurses, which reminds them to give early antibiotics and facilitates this by giving a direct access number to the pharmacy and the IV access team. After 6 months, you re-audit and find that all septic patients now receive antibiotics within an hour. You have closed the audit cycle, but you should re-audit in the future to ensure this change has been maintained.

Statistics

An understanding of basic statistical concepts is fundamental to the evidence-based practice of medicine and surgery. At the outset, you should understand that there is a big difference between statistical and clinical (or scientific) significance. For example, you might assess the length of the great toe in patients undergoing bowel resection (for various reasons) and find a statistically significant difference between patients who survive the operation and patients who do not survive the operation. In this example, the statistical significance is of no clinical or scientific significance. Therefore, it is always important to *think* about statistically significant results – what do they mean, if anything at all? Nevertheless, within this framework, statistics provide a level playing field for assessing whether a difference is likely to be large enough to be ascribed to something other than chance.

There is some basic language that you should be familiar with:

- *Average*
  There are three statistical measures of average. The **mean** is the sum divided by the number of subjects. It describes the average value if the variable was equally distributed among all subjects. The **median** is the middle value if all the values were lined up according to size. Occasionally, the **mode** (the commonest value) is appropriate to use.

- *P-value*
  Using statistical tests, you can ask whether the finding of a study is likely to be due to chance alone, or to an underlying mechanism. The p-value represents the statistical chance of obtaining your results when no such underlying mechanism exists. Therefore, a p-value of 0.05 means that, in the absence of any other influencing factor, the same result would be obtained by chance in 5 % (1 in 20) of cases. A p-value of 0.01 means that in 1 % (1 in 100) cases the same result would be obtained by chance. A p-value of less than 0.05 is normally considered to be statistically significant.

- *Errors*
  A Type I error occurs when a "statistically significant" finding (such as when $p<0.05$ for a set of data) is obtained when there is actually no underlying correlation between the set of variables being examined; the "significant" result is purely due to chance. A Type II error describes finding a "non-significant" p-value despite there being a real-world correlation between the variables. This may happen when the correlation effect is too small to be detected by a small sample size.

The following are some key statistical tests and various situations in which you might encounter or use them:

- *To compare a variable across two groups:*
  If the variable is continuous (such as the height of male and female medical school students) and normally distributed (meaning that most data points will be around the mean value, with progressively fewer at both very high and very low values) a ***t*-test** can be performed. If it is unclear as to whether the variable is normally distributed, further tests can be performed to assess this.
  If the variables are categorical, then a **Chi-squared test** is appropriate. For example, this would be appropriate in researching the types of suture used to close a wound in two patient groups.

- *To compare a variable across more than two groups*
  A *t*-test cannot be used in this situation, as the risk of a Type I error increases with each additional group involved. Therefore an **ANOVA** (analysis of variance) test is used, in conjunction with a **post-hoc test** to identify statistically significant differences between the groups.

- *To examine a correlation between two variables*
  To test the correlation between two normally distributed variables (like height and weight), **Pearson's test** is used. To test the correlation between two variables that are not normally distributed, **Spearman's test** is used.

Fundamentals of Grant Writing and Looking for Funding Opportunities

Gaining research funding is essential to provide sustainable financing for research opportunities. It also represents a core part of the scientific process of having scientific peers criticise your thinking. There is limited research funding available and it is extremely competitive.

There are many types of grant available, and these come from a wide range of organisations including the government, research charities and academic institutions. A grant might be very specific or personal (funding a specific person to complete a research degree), or might support a wide programme of research, including consumables and students. It is worth considering what support comes with a grant, including funding for travel to conferences and consumables for example.

The essence of an application for any type of grant follows some consistent patterns. The application should include a background to the research subject in the introduction: this should provide a focused literature review and define a specific, important and answerable research question. Often, to show that the hypothesis is likely to yield results of interest, preliminary results are included. An experimental plan should be included, supported by a sensible timetable and budget. Ultimately, the selection panel needs to assess the relative importance and likely success of the project. A number of factors contribute to this, including the student and supervisor's track record.

How to Write a Good Paper

A scientific paper is a tool to describe novel knowledge, the methods by which that knowledge was obtained and the means to contextualise it. Here, we give some brief tips on how to construct a good scientific paper.

- *Figures*: Start any paper with the figures. The figures (with their legends) should tell the scientific story, which should be elaborated upon in the text. Information should not be replicated.
- *Introduction:* The introduction should lay out the background to the problem being addressed and end with a clearly defined question of importance. The introduction should be sufficiently broad to allow a non-specialist scientist to understand the purpose of the paper, while being focused and detailed enough to clearly identify the aims of the paper.
- *Methods:* The methods are an essential, but often neglected part of the paper. A cornerstone of the scientific method is the ability of fellow scientists to replicate your results. The aim of the methods section is therefore to be clear and specific enough that other scientists, using the information given, may repeat your study. It is also essential to describe the statistical methods used so that they can be critiqued.
- *Results:* The results section should take the reader through a logical sequence of experimental milestones. Discursive comments should be avoided.
- *Discussion:* The discussion should begin with a summary of the paper's findings. This is followed by a logical discussion of the major

themes of the paper and the relevance of the results to the field. Controversies or differences from the published literature should be highlighted. Occasionally it is useful to outline future experiments.
- *Conclusion:* A conclusion section is helpful in summarising the main points of the paper and how it has contributed to the field. In both the discussion and conclusion, it is essential not to make subjective comments that are insupportable.

The manuscript submitted for peer review will likely be revised at least once before its publication, as reviewers generally raise queries and ask for modifications. Sometimes, this will necessitate further experiments or data analysis.

How to Present a Good Poster

The general structure of a scientific poster is similar to a paper in that it has the same subheadings, but consists largely of figures and tables. It is designed to be presented at a scientific meeting in an informal manner and result in a stimulating discussion. Typically, the results are more preliminary in a poster than in a paper and the discussions had with other students and academics can be useful in tailoring future work.

The keys to attracting people to your poster are the title and visual layout of your work, so time should be spent in refining both of these. Of course, you should be present throughout your poster session and ready to talk someone through your project. Take a notepad to make notes of things arising from your discussion.

Presentation Skills

In either oral or poster presentations, there are a few points that are worth remembering. Verbally (rather than visually) communicating most of your information is important, and therefore having an uncluttered visual presentation with a clear message is paramount. You must grab the attention of your audience with a clear statement of the problem your work is addressing.

One strategy for a slide-based presentation is to have headings that are questions with visual non-text answers (e.g. graphical data). Don't try to relay every detail, but rather focus on clearly communicating the essential points and developing the scientific story. Whilst it is important to practise your talk, try not to sound rehearsed and, finally, be ready for questions!

Summary

Surgical research is a diverse activity, involving patients and laboratory research. This chapter has hopefully given you some basic concepts to help you engage with research at an early stage. The best way to get comfortable with these concepts is to try them out.

28 Surgical Training, Simulation and Assessment

Abdullatif Aydin, Cameron Kuronen-Stewart, Rebecca A. Fisher, and Kamran Ahmed

Introduction

As a student or surgical trainee, it is important to be aware of the current ways that surgeons are trained, and why these methods are used. Exploring the best ways to train surgeons is an academic field in itself, as every method has to be thoroughly planned and validated before use. Many students stumble into this field at some point in their training, whether it is to audit the use of training programmes in their centre or just out of personal interest. Like any field of research, surgical education is full of specific terminology that is often meaningless to undergraduate students. In this chapter we will provide an overview of the different training methods currently in use, and provide an explanation of key concepts.

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The Changing Face of Training

Effective training is a crucial component of every profession, and surgery is no exception. Traditionally, surgical training was largely opportunity-based, often described as the "see one, do one, teach one" approach, ascribed to Sir William Halsted [12]. However, with the modernisation of surgical training and efforts worldwide to reduce the length of training, trainees now have less time to spend shadowing their seniors and learning in a traditional 'apprenticeship' style. One of the biggest factors in this has also been the introduction of the European Working Time Directive, which has greatly reduced the time available for operative training [13].

In order to assure competence in this modern clinical environment, surgical training has shifted to a competency-based model, where trainees must demonstrate competence in specific areas to complete their training [17]. This style of assessment will be familiar to all clinical medical students, as the Objective Structured Clinical Exam (OSCE), is universally used by UK medical schools to assess clinical competence.

Just as in undergraduate training, competency-based surgical training is focused around two broad areas: [5]

- Competence in non-technical skills – using knowledge and communication skills to make decisions in a team.

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- Competence in technical skills – physical examination skills, manipulation of tools and psychomotor skills.

The Learning Curve

The concept of the learning curve is a very important principle for both educators and trainees to understand. A learning curve is a graphical representation of an individual's improvement in performance of a task over multiple attempts. An initial improvement phase in the curve will occur for a certain number of attempts until a plateau phase is reached where competency is achieved and improvement halts. The simpler the task is to learn, the fewer attempts are required to reach the plateau phase. A common pitfall for novices (and the general public) is to incorrectly describe difficult-to-learn tasks as having a steep learning curve. Technically, this implies large improvements over a small number of cases. Difficult tasks actually have a so-called "flattened" learning curves, where small improvements take place over many attempts before proficiency is reached [20].

> *Student Tip* Never describe something that's difficult in a surgical context as having a 'steep learning curve'…things that are difficult to learn have a flat learning curve!

Evaluating a trainee's learning curve is a very useful way of assessing proficiency, and ensuring trainees achieve competence at a procedure. However, it does have its limitations. By nature, learning curves can only be plotted with quantitative data through objective assessment of one variable, and so it is harder to assess proficiency at some skills (e.g. non-technical skills) with a learning curve, and also harder to assess competency across the whole procedure. Assessing learning curves in the operating theatre also implies that patient safety will be at least partially compromised during a trainee's initial attempts. This means that this style of assessment cannot be used where complete success from the first attempt is necessary due to the nature of unacceptable complications in certain procedures.

Theatre-based Training

- Observership: The trainee, whether scrubbed in or not, is involved in an observer role only, and does not participate in the procedure itself. This is especially useful for students to learn the basic principles of surgery, and ask questions where possible and appropriate.
  - In recent years, more surgical procedures are recorded using high-definition (HD) cameras that are either built-in to the theatre lights or are wearable. This has been useful as it allows for a greater number of observers, and can potentially expand audiences over the internet to lay people. It also allows scope for training courses and educational meetings based upon live surgical demonstration.
- Hands-on training: After gaining experience through observership, the trainee is recommended to begin their operative experience by assisting in procedures and gradually completing increasingly difficult partial tasks until a full procedure can be attempted. This allows a trainee to revise their skills and knowledge before performing cases independently. This requires available mentors.
- Mentorship: A trainee is allocated a fully qualified surgical "mentor" who is responsible for teaching both technical and non-technical skills. Although as a medical student you may have a formal mentor or 'tutor' on rotations and later on in training, you may find that informal mentoring is equally important, which usually occurs on a one-to-one basis and is complemented by the trainee's own efforts.
  - One challenge to mentorship is in minimally invasive surgery: it is sometimes more difficult for tutors to be as involved in a trainee's first cases compared to an open approach. This is because mentors may have a different viewpoint and cannot intervene as quickly if something doesn't go to plan. Therefore, trainees currently undertake hands-on training courses away from the patient using various simulation methods, and then are supervised by their mentor for the first few cases before working independently.

  – Proctorship is a more thorough method of mentorship, whereby the supervisor is involved both as an assessor in examinations and other assessment methods, which involves objective assessment of the trainee's progress through analysis of live surgical experience or of videos of trainee performance. However, this is infeasible for many centres as it is time consuming and relatively expensive.
- Telementoring: This is a growing field in which surgeons can be trained or advised by surgeons in a different location. It is particularly relevant to minimally invasive surgery, as the distant mentor can have the live video from the main camera streamed to their location. It is also useful for training amongst consultants, who may not otherwise have many people in their local area able to give them advice [31]. It has also been shown to significantly improve surgical performance [16], although until recently it was limited due to poor internet connections preventing streaming of live HD videos.

Simulation in Surgery

With the advance of technology, classical surgical training has seen the development of supplementary methods of acquiring proficiency, most notably including simulation. The modern surgical trainee will come into contact with a wide variety of simulation methods at all stages of their training as centres worldwide shift to validated and evidence-based curricula [29]. Over the past two decades, surgical simulation has developed at a rapid pace and is now an established method of training and assessment.

While simulators are effective training tools, they cannot be used exclusively for training, and operative experience is key. Simulation curricula should be combined with mentorship or proctorship, as this combination has been shown to improve trainee performance in the operating room to an even greater degree than simulation alone [34]. A trainee may encounter a wide variety of different simulation methods during their training, each of which is suitable for different training needs (see Table 28.2).

Physical simulators use models to simulate operative experiences. They usually require a trained observer/mentor to assess the trainee's performance. Various types of physical simulator exist, including synthetic "bench" model simulators, usually made of latex or plastic to represent the operative anatomy. Biological models such as animals, both ex-vivo and in-vivo, and human cadavers are often used for complex training. Virtual reality simulators use computers to generate a representation of the procedure and are becoming increasingly popular as technology improves. As they can provide in-built feedback

Table 28.1 Formal mentoring vs. informal mentoring

Informal mentoring	Formal mentoring
Simpler to execute due to lower expectations	Greater workforce, monitoring, communication & administration
May be less successful despite high satisfaction levels	
Training is not necessary	Support and expert training is mandatory
Social exclusion – more confident and dominating individuals attain the successful mentors	Understanding roles and responsibilities of each individual simpler, with assistance from organization
Trusting and respectful relationship	Once the mentor-mentee relationship has been created, support is then given
Empathy and friendship are of greater importance	
Aims and objectives are not pre-determined	Clear rationale which allows both the mentor and mentee to have specific aims for the relationship
Both the mentors and mentees are personally chosen resulting in more effective cooperation in the pairing	Mentor-mentee relationship pre-planned
	May be difficult due to low availability of mentors
For task-based learning in the short term, this type may prove to have greater benefits	Clearly outlined mentoring programme

Table 28.2 Types of available simulators [29]

Modality	Advantages	Disadvantages	Best suited uses
Virtual reality simulation	Reusable, data capture, objective performance evaluation, minimal setup time	Cost, maintenance, down-time, lack of real instruments, poor 3-D view, poor face validity	Basic skills and familiarisation, cognitive training
Bench-top/ Synthetic models	Portable, reusable, minimal risks, use of real instruments	Low-fidelity: acceptance by trainees, poor face validity High-fidelity: cost	Dependent upon fidelity: low-fidelity best for part-task training, high-fidelity best for procedural simulation
Animal tissue	Cost-effective, minimal set-up time	Special facilities for storage, single use, anatomical differences	Basic surgical skills and Part-task training
Live animals	High fidelity, higher face validity, full procedures	Cost, special facilities and personnel needed, ethical concerns, single use, anatomical differences	Advanced procedural knowledge, procedures in which blood flow is important, dissection skills
Human cadavers	High fidelity, highest face validity, full procedures	Cost, availability, single use, compliance of tissue, infection risk	Advanced procedural knowledge, dissection, continuing medical education
Full immersion simulation	Cost-effective, reusable, minimal setup time, portability	Limited realism	Team training, crisis management
High-fidelity simulation	Reusable, high fidelity, data capture, interactivity	Cost, maintenance, and down-time; limited "technical" applications	Team training, crisis management

Table 28.3 Contemporary assessment tools for technical and non-technical skills

Technical skills
Observational tools
OSCE – based (Objective structured clinical examination)
Objective Structural Assessment of Technical Skills (OSATS),
Global assessment of operative skills,
Generic and procedure specific checklists,
End-product analysis.
Error – analysis based
Human Reliability Assessment – HRA
Non-observational tools
Virtual reality simulators
Motion analysis systems
Imperial College Surgical Assessment Device (ICSAD)
McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS)
Non-technical skills
Non-technical skills for surgeons (NOTSS)
Situation Awareness
Decision Making
Task Management
Communication & Teamwork
Leadership

(continued)

Table 28.3 (continued)

Observational teamwork assessment for surgery (OTAS)
Communication
Co-operation
Co-ordination
Shared-leadership and monitoring
Non-technical skills (NOTECHS)
Cooperation
Leadership and Managerial Skills
Situation Awareness and Vigilance
Decision Making
Communication

on performance, trainees can use them in their own time without the need for an expert mentor to provide feedback [33].

Non-Technical Skills Training

Non-technical skills training is becoming increasingly emphasised in training curricula [8, 32], as appropriate use of these skills has been recognised as a key factor in the prevention of surgical errors [30]. Non-technical skills include social skills (communication, teamwork and leadership) as well as cognitive skills (decision-making and situational awareness). Other skills include personal resource factors such as ability to cope with stress and fatigue. Training for these skills is particularly hard in the real operative environment for several reasons. For example, teaching skills that are more abstract in nature than technical skills is even harder for mentors and proctors to teach while focusing on the procedure itself. Non-technical skills training can also utilise simulation to increase competence outside the operating theatre while preserving patient safety. This can be achieved by human performance simulation.

Human performance simulation may take place in real operating theatres with the whole surgical team. This can provide to be very useful for team training but is associated with significant costs and is dependent on availability of such facilities [2]. A cheaper and more feasible alternative is full immersion simulation (see Fig. 28.3), which is a blow-up simulated environment with theatre staff and equipment to replicate the operating theatre as a whole [11]. Simulated procedures can be carried out under specific scenarios to help trainees develop their non-technical skills in an observed and safe environment, where detailed feedback can be given afterwards. Full immersion simulation has been shown to be a feasible, valid and cost-effective means of training for non-technical skills [21, 22, 23].

Assessment

Assessment is a very important principle in ensuring a trainee is competent and that they can practice safely and effectively. It may be defined as "the process of documenting, usually in measurable terms, knowledge, skills, attitudes and beliefs to aid decision-making" [28]. The purpose of assessment in an educational context is to:

- Make a judgement about mastery of **knowledge or skills**;
- Measure **improvement** over time;
- Arrive at some definitions of **strengths and weaknesses**;
- Rank people for **selection or exclusion**, or perhaps to **motivate** them [28].

Assessment Tools

A good way of conceptualising the assessment of clinical competence was proposed in 1990 by a psychologist named George Miller [26].

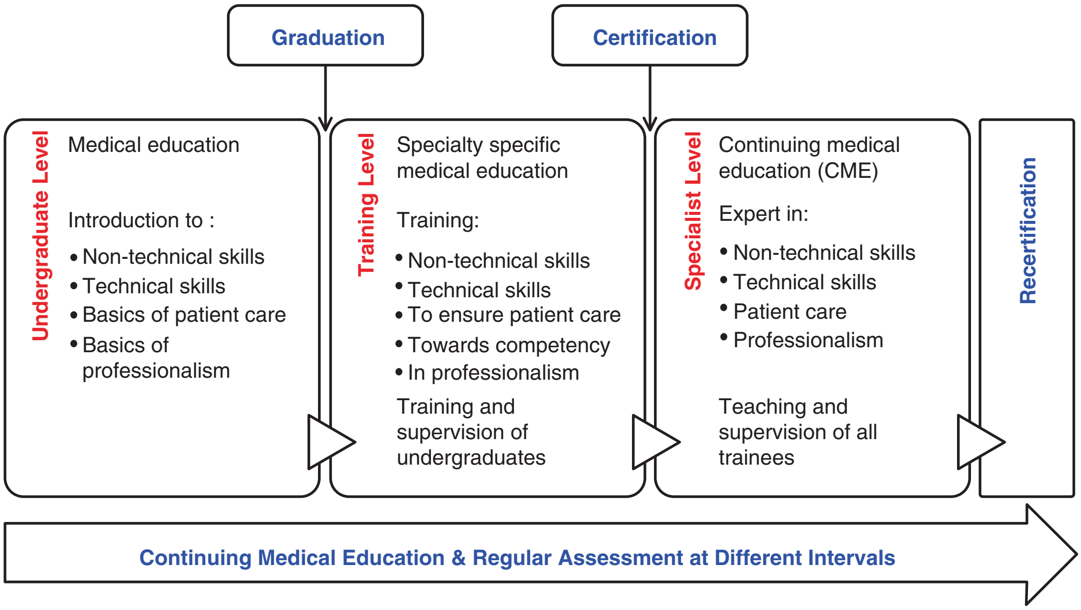

Fig. 28.1 An overview of lifelong learning and regular assessment

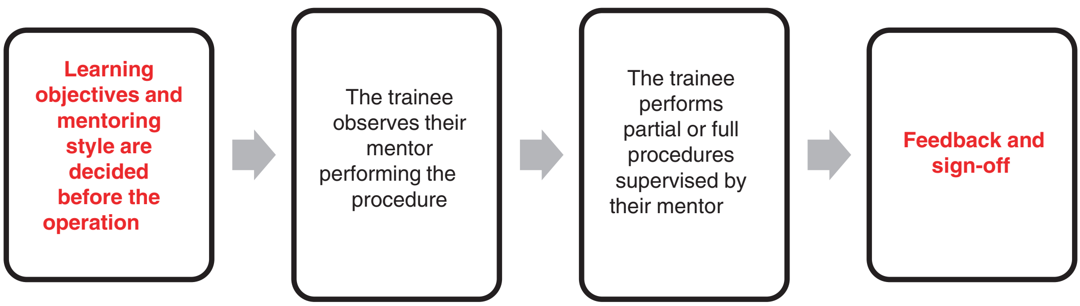

Fig. 28.2 Structure of a mentorship programme ([1], with permission)

Assessment starts at the bottom of a pyramid and works up to the top, starting with knowledge, then demonstrating understanding, or 'knows how'. This then progresses to 'shows how' or demonstration of learning, and then finally 'does', which is integrating performance into practice. Different assessment tools can be used at each stage of the trainee's journey through this framework, with varying levels of appropriateness and effectiveness. Assessment of the lower steps of the pyramid may take place in simulation laboratories, but assessment at the "Action" step of the pyramid must be focused on what occurs in practice and in the workplace, rather than what happens in an artificial testing situation [27]. This can be carried out for both technical and non-technical skills using Work-based assessments (WBAs), which are widely used in UK surgical training from foundation level onwards.

Technical skills can be assessed using objective and validated criteria/checklists completed by an expert observer of a trainee's simulated or real operative surgical performance. Common examples of these tools that speciality trainees encounter are the Surgical Direct Observation of Procedural Skills (S-DOPS), Objective Structured Assessment of Technical Skills (OSATS), and Procedure-Based Assessment (PBA) tools.

Fig. 28.3 Full immersion simulation (Photo with kind permission from Abdullatif Aydin and Oliver Brunckhorst)

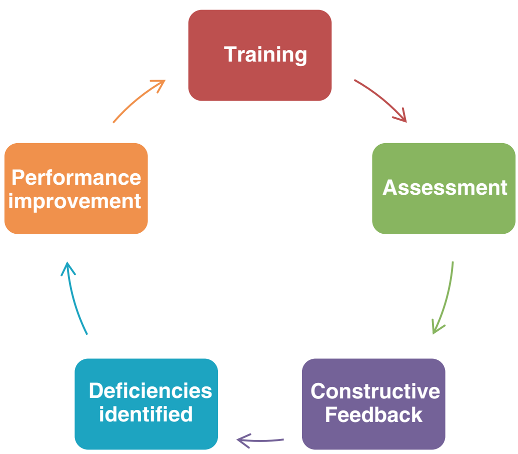

Fig. 28.4 Training, assessment and constructive feedback cycle

Trainees will also encounter many methods of assessing non-technical skills, which may constitute continuous subjective assessment by a mentor, assessment using review of patient case notes and operative outcomes, or structured multi-source feedback from the multi-disciplinary team.

Requirements for Training and Assessment Tools

We know that tools such as simulators and observational assessment criteria are necessary to assess and train future surgeons, but how do we make sure the tools are effective and fit for purpose? Before assessment tools and surgical simulation models can be used for effective training and assessment, they must undergo an initial internal assessment. This is done using a wide array of different parameters, all assessing different aspects of the training or assessment tool. This can be a confusing world full of similar yet differing terms that can disorientate the novice, but the definitions of these have been laid out clearly in Box 28.1 [25, 35]. A 3-step method encompassing the design, validation and implementation of new training and assessment tools has been suggested (Fig. 28.5) [6].

Validity of a tool can be assessed using subjective parameters such as face validity and content validity, and also through objective parameters such as construct validity, concurrent validity, and predictive validity (see Box 28.1). This allows evaluation of the degree of transfer of skills from the simulator into the real operating environment. Predictive validity is the best evaluation of this skill transfer, but is logistically very hard to demonstrate.

Evaluation of a tool's validity should be accompanied by investigating its reliability, in order to assess the level of consistency at which the tool operates. Reliability may be established in many ways. These include thorough assessment of performance by two independent and blinded assessors (inter-rater reliability), or by comparing results from different test items (inter-item reliability), and assessment of performance at two different occasions (test-retest reliability).

Before implementation or integration into a curriculum, other factors should also be evaluated, including the tool's feasibility, acceptability, educational impact, and cost effectiveness. Quantitative and qualitative methods such as surveys or interviews may be used to evaluate feasibility and acceptability. Providing participants with constructive feedback followed by re-assessment may be useful in determining educational impact, but randomised controlled studies are the ideal method. Cost analysis is dependent upon the geographical area and type of assessment environment [6].

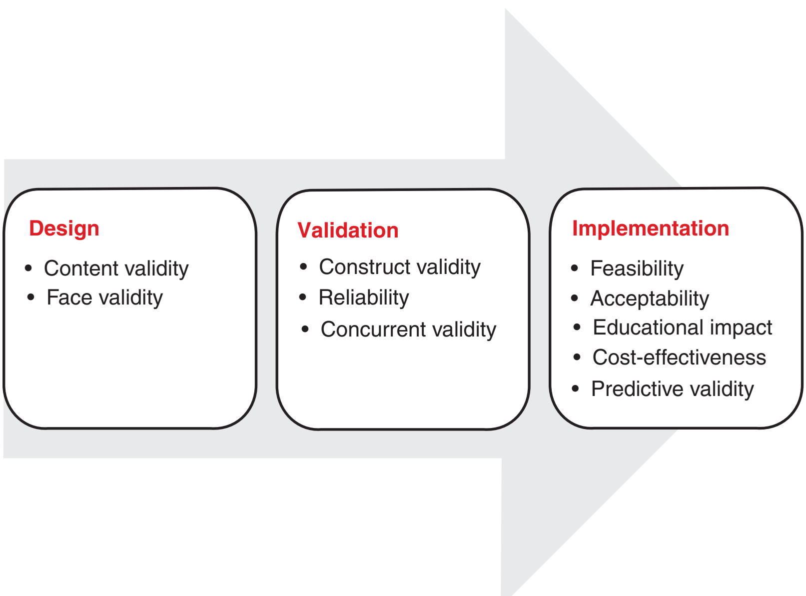

Fig. 28.5 Recommended design for validation of training and assessment tools ([6], with permission)

Box 28.1 Definitions of terms related to training and assessment [5, 6]

Validity

- Face validity – Extent to which the examination resembles the situation in the real world
- Content validity – Extent to which the intended content domain is being measured by the assessment exercise
- Construct validity – Extent to which a test is able to differentiate between a good and bad performer or ≥2 groups of performers (eg, experienced vs inexperienced)
- Concurrent validity – Extent to which the results of the test correlate with gold standard tests known to measure the same domain
- Predictive validity – Extent to which this assessment will predict future performance

Reliability

- Inter-rater reliability – Extent of agreement between ≥2 assessors/observers through correlation between 2 blinded/nonblinded assessors
- Inter-item reliability – Extent to which different components of a test correlate (internal consistency) through correlation of test items
- Inter-test reliability – Ability of a test to generate similar results when applied at two different time points through correlations between test and retest

Acceptability – Extent to which an assessment procedure is accepted by the subjects involved in the assessment

Feasibility – Extent to which a training and assessment process is capable of being carried out

Educational impact – Extent to which test results and feedback contribute to improve the learning strategy on behalf of the trainer and the trainee

Cost effectiveness – Does the assessment tool provide maximum value for money

Accreditation

At the end of successful training, trainees are awarded a certificate demonstrating their ability to practice safely and competently. Certification represents the culmination of successful training, and the recognition that a clinician is competent and safe to practice their particular specialty [5].

Recertification

Recertification is the process whereby "specialists demonstrate that they continue to meet the standards demanded by their specialty or area of practice" [5]. The formal on-going assessment of medical professionals ensures a continuing process of improvement and that patients receive medical care that is safe, consistent and of high quality.

In the UK, recertification is one of the two components of specialist revalidation. Revalidation is formed of relicensing and recertification and was introduced in 2010 (Fig. 28.6) [18]. During relicensing, the surgeon must demonstrate adherence to the "Good Medical Practice" guidelines as outlined by the GMC [19]. For recertification, consultants must demonstrate that they are consistently meeting the standards demanded by their speciality. Communication, knowledge, partnership and teamwork, skills and performance, and also safety and quality are the main assessed components. Recertification is awarded by the Royal College of Surgeons, in collaboration with the General Medical Council (GMC) and the Academy of Medical Royal Colleges.

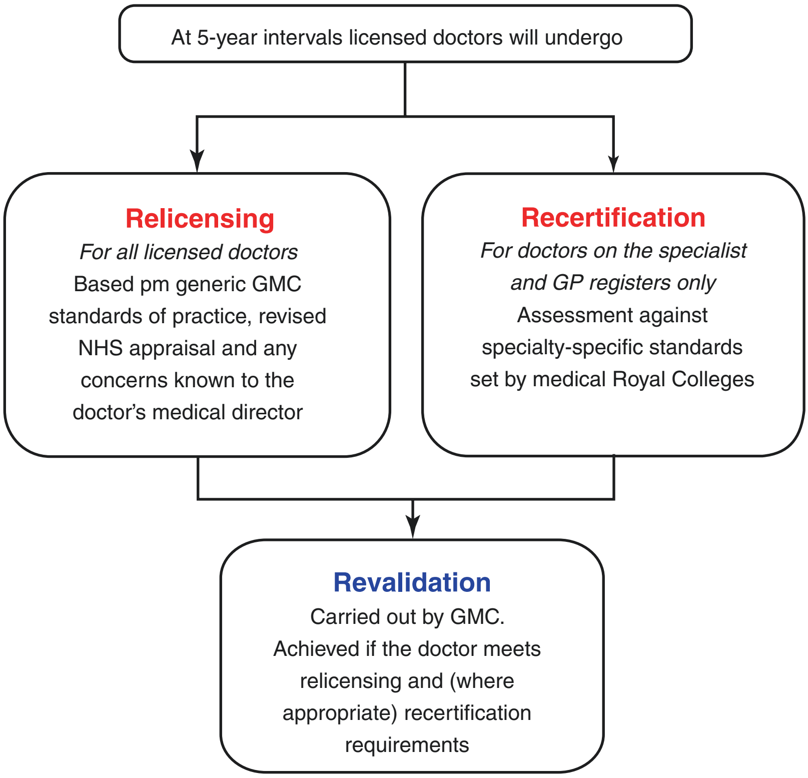

Fig. 28.6 The UK revalidation process

Lifelong Learning

Lifelong learning, often referred to as 'continuing medical education' (CME), aims to maintain and improve knowledge, skills and relationships that are essential for safe clinical practice at the specialist level [9, 15]. Since the introduction of Maintenance of Certification (MoC) in the USA and Canada, and revalidation in the UK, CME has been highlighted as a core component of this maintenance and improvement of safe specialist practice [3, 7].

Recommended learning or teaching methods for CME include case-based discussion, live or recorded demonstrations, group discussions, lectures, simulation and mentorship [24]. Points are awarded per hour of educational experience attended, where clinicians must obtain a minimum CME score during a 1–5 year assessment period. Most of these methods have been shown to improve clinical knowledge, performance and overall attitudes [10, 14].

It is not just achieving excellence that is important but also maintaining it, as surgeons must ensure and maintain public trust in both their technical and non-technical abilities, through developing proven and structured lifelong learning programmes (Fig. 28.7).

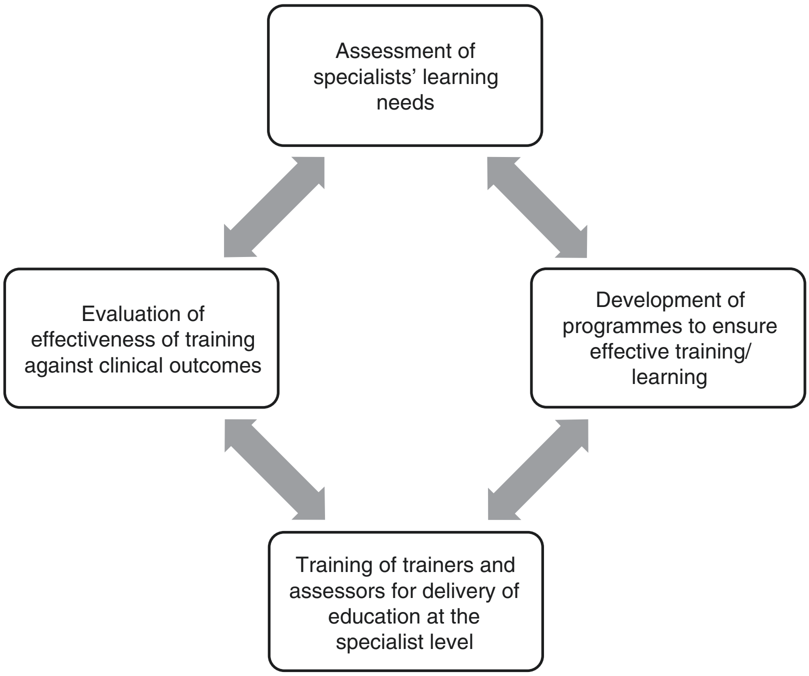

Fig. 28.7 Recommendations for the development of a specialist CME system ([4], with permission)

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29 Careers

Fahd Khan and Noman Saghir

Introduction

Surgery offers a wide range of choices and can be a highly rewarding career. This chapter reviews in detail the steps required to enter a surgical career.

Finding the right surgical specialty requires careful thought and planning, and you may need to make some difficult choices along the way. Establish your options, alternatives and a plan B. Then gather information, network and keep thinking about whether your chosen path is viable and realistically something you want to achieve. If you are interested in a specific subspecialty and have not experienced it yet, then organise a taster; be proactive!

There are no right or wrong paths in medicine. Be prepared for change and remember that your experiences (whether good or bad) are never a waste of time, as they all contribute to your development as a doctor. It is important to think about what your skills, strengths and weaknesses are, and compare these to the skills and attributes of people you meet in specific roles. Think also about the type of environment you would like to work in. A career dream is great to have, but it may only be attainable in the context of the job market and your personal circumstances. Above all, be flexible and never be without a plan B!

Choosing a Specialty

Choosing a specialty in medicine is an important decision and should not be rushed. Only around 50 % of foundation doctors have a good idea of the specialty they want to pursue [5]. A decision is not required until the first half of FY2 training. It is recommended that students and young doctors use the opportunities and resources available throughout training to explore potential areas of interest.

Undergraduate opportunities and resources:

- Student-selected modules/components (SSM/SSC) and electives
- University careers services
- Foundation programme applications advice

Postgraduate opportunities and resources:

- Foundation school experiences
- Careers advisors available in most deaneries
- Career development sessions for foundation trainees
- Taster weeks in foundation years

Studies have shown that experience at foundation level is a major influence to the specialty chosen [3]. When considering a specialty it is also

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important to consider who you are, your aptitude, what motivates you, work-life balance, previous experiences, and financial reward. Can you work under pressure, in a team or as an individual? It is important to have an idea of the minimum competencies/requirements of any given specialty. It can be useful to explore the career progression pathways, competition ratios, number and type of posts available locally and across the UK, and the qualifications and training needed by applicants. Ensure you have up to date information. This can be gathered from medical tutors, the BMJ, and the Royal College of Surgeons website for information on particular surgical specialties [7]. Any career in medicine can involve uncertainty and not all those that apply get their first choice: having a backup plan is wise.

Based on the above, career decision-making can be split into four fundamental stages:

- Self assessment
- Career exploration
- Decision-making
- Plan implementation

Career Structure

Surgery was once considered a 'calling' but, in reality, surgeons are 'made' not 'born'. The essential training required for any modern surgeon includes a medical degree, and 2 years as a foundation doctor. Of the three rotations completed per foundation year, two can be surgical, and one medical to maximise exposure to surgery early on. At the end of the first foundation year (FY1), junior doctors are assessed by their senior clinicians and awarded a GMC number to allow progression to foundation year two (FY2). Though not compulsory, it is becoming increasingly popular amongst junior doctors interested in surgery to complete the first part of the MRCS (Member of the Royal College of Surgeons) examination within these foundation years.

Depending on the surgical specialty you hope to enter, there are two main options for training after FY2. Most specialties have an 'uncoupled' approach: this involves a core surgical training programme of two or three years, after which you apply to specialty training. Other specialties have a 'run-through' programme, which starts at ST1 and continues all the way to consultancy level (See Fig. 29.1). Run-through programmes are only used in a few specialties now. Figure 29.2 shows lists of the specialties that currently have uncoupled or run-through training programmes [6].

The main exams taken by trainee surgeons are the Member of the Royal College of Surgeons (MRCS) and Fellow of the Royal College of Surgeons (FRCS) exams. These exams take place in two parts. Part A is usually comprised of multiple choice or extended matching questions (MCQ/EMQ) which test whether the candidate has adequate basic science knowledge. Part B involves vivas and objective structured clinical examinations (OSCEs) and tests the application of knowledge in a clinical context. The MRCS is taken at the beginning of registrar training (FY2-ST2) and the FRCS is taken at the end of registrar training.

To enter uncoupled specialty training after core training year two (CT2), the trainee must have also passed both parts of the MRCS exam (or the equivalent for their chosen specialty), either during foundation years or core surgical years. Once they have completed their specialist training and exams they are placed on the specialist register, and may apply for consultant posts.

This is the 'essential' training required, however competition for any post beyond foundation years is fierce. Many doctors spend a lot more time 'out of training', gaining either clinical or research experience, or obtaining a degree to make themselves 'more suited for the post'. This means that in reality, many don't reach consultancy until several years after the 'essential' training timescale.

> *Student Tip* The sooner you decide on the specialty you are interested in, the sooner you can begin gaining vital experience. Tailoring your portfolio will increase your success rate when applying for senior clinician posts.

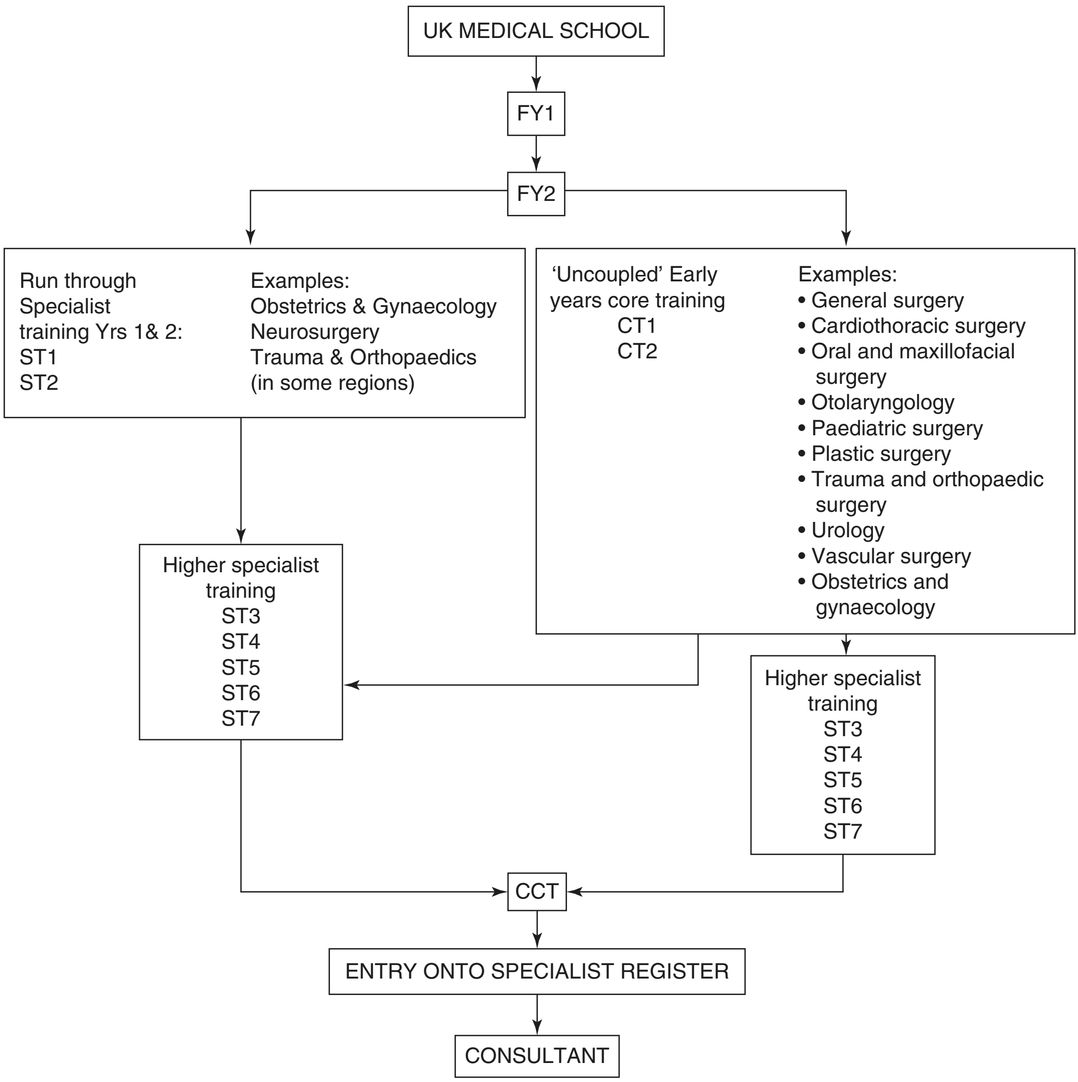

Fig. 29.1 Diagram depicting the two main routes of training to reach consultancy in a given specialty. Table of specialties separated by route of training

A Week in the Life of a Surgeon

The great number of different surgical specialties translates into huge differences between the 'day-to-day' timetables of different surgeons. However, every surgeon attends theatre, outpatient clinics and Multi-Disciplinary Team (MDT) meetings, and has administration responsibilities. Research and private practice commitments are also taken on to different extents by many surgeons. Figure 29.2 shows the typical timetable for a consultant urologist.

Academic Surgery

Recently there has been an increase in the number of applicants applying for the academic foundation programme (AFP). The AFP allows the applicant to engage in teaching, research or management during FY2. Doctors can choose to pursue their chosen option either within a single rotation during FY2, or by taking one day off each week throughout the year of FY2 training. The AFP is particularly popular as both teaching and being involved in research give useful

Fig. 29.2 A typical weekly timetable of a consultant urologist

	09:00-13:00	13:30-17:00
Monday	Outpatient clinic	Private practice
Tuesday	Haematuria clinic (Flexible cystoscopy)	Outpatient clinic
Wednesday	Day case theatre	Admin
Thursday	Main theatres	MDT
Friday	Main theatres	Main theatres

additional skills for the progression of any medical practitioner. The AFP experience also gains doctors points when applying for future registrar posts (see below for more detail.)

Time to carry out research work (while getting paid for it!) may seem like a win-win situation, but is not without downfalls. AFP doctors need to obtain an equivalent level of competency to their non-AFP counterparts in less time. Time management can be difficult, but if handled correctly, AFP doctors may gain a poster presentation or publication from their year. It is useful and important to ask the foundation doctors encountered on placements to find out what AFP has been like for them. In addition, do some research on the foundation programme website, which also has a list of all the current academic posts on offer (www.foundationprogramme.nhs.uk).

Beyond foundation years there are further opportunities that combine both clinical and academic responsibilities. These include academic clinical fellowships, which are essentially registrar posts that can last a maximum of 3 years. You can apply for these at any point after completion of your foundation years. These fellowships provide clinical responsibilities, but 25 % of working hours are allocated to research and teaching. Alternatively, you may propose a project on a particularly interesting aspect of your specialty of choice and source some external funding for it. Finally, if you find a certain area

Why choose academic surgery? (8)	
Advantages	Disadvantages
• **Best of both worlds - opportunity to carry out clinical work as well as long term research**	
• **Contributes to society clinically and academically**	• Extra effort needed to acquire and maintain operating skills through periods of research. Possibly longer hours needed.
• **Good platform to influence peers and allied research fields**	• Stiff competition in the field, i.e. funding and papers, and for posts to advance your career
• **Potentially large amount of national / international travel developing rewarding collaborations**	• Limited scope for personal private work
• **Ability to supervise and train at all levels and contribute to medical education**	• May be a difficult transition when returning to full-time clinical work.
• **Substantial personal and public reward**	

Fig. 29.3 A table outlining the advantages and disadvantages of a career in academic surgery

of medical science particularly fascinating, or if you find it difficult to get a registrar training post, doing a PhD would certainly give you a boost when re-applying.

Of course, it is not necessary to do a PhD, and there are many other postgraduate courses available. There is an array of masters degrees that can be attained part time too. These can be found on the postgraduate search website [4]. If academic surgery appeals, you may want to consider a senior lecturer or professor position in the future. Figure 29.3 outlines broadly the advantages and disadvantages of academic surgery.

Applying for Surgical Training

The application system for surgical training involves two main stages: the application form, and the interview process (for which you need your portfolio).

Application Form

The essential requirements for the application form to enter core training year 1 include a medical degree and full general medical council (GMC) registration for license to practice independently in the UK.

Other desirable criteria include [1]:

- Any additional qualifications such as BSc, BA, BMedSci, or higher degree.
- Evidence of research and audit skills including relevant academic and research achievements such as prizes, awards, distinctions, publications and presentations.
- Evidence of attendance at clinical courses, or of teaching experience with accompanying feedback.
- Participation in extracurricular activities and achievements relevant to surgical career progression and development.

- Personal skills in management and leadership with evidence of effective multi-disciplinary team working with feedback.
- Any organizational skills gained from involvement in society or sports committees.

Interview Process

Although the interview and selection process frequently changes, it is useful to have a general idea of what you may experience.

There are three stations at interview:

- Station A – Management station. Two scenario questions will be read to you at this station. You will have 5 min to answer each question. These questions encourage you to think on your feet.
- Station B – Portfolio station. You'll have a checklist to fill showing evidence of additional degrees, exceptional performance at undergraduate or foundation years, clinical and professional development courses, clinical/procedural experience, audits, teaching, presentation/abstracts/publications, demonstration of leadership, commitment to specialty. Proof for your answers in the checklist will be required. See section 'Beginning a Surgical Portfolio' below for more guidance. Figure 29.4 contains a table of the scoring guidance and supporting evidence.
- Station C – Clinical Scenario station. The first question is given outside the interview room, you'll have 3 min to read the question and prepare, and inside the room you'll have 5 min to answer. The second question is asked afterwards, and you are required to think on your feet. Both these questions will have an ethical slant.

An overall score is generated from each of the three stations. There is a different cut off each year, and if you score below this or score under 50 % in any one of the three stations your application may be unsuccessful.

You will be ranked based on both the interview process and your application. The higher the rank the more likely you are to get your first choice.

NB: Although you may be successful at interview, it does not mean you will get a place. This depends on your relevant national ranking and all the candidates applying for same posts as you.

If you do fail to get through first time, all remaining programs are placed into clearing and those applicants who were successful at interview are eligible to apply for these remaining places. If after clearing there are still posts remaining, a national round two is held, requiring a repeat of the entire application process. Detailed information is available on the NHS surgery recruitment website [1].

Part-Time Training

Part-time training (also known as working less than full-time [LTFT]) provides an adapted timetable for people with particular circumstances that make working full-time difficult. People who commonly apply to work LTFT include parents of young children, people with certain illnesses, and those who compete in sport at a professional level.

As a doctor in a foundation or registrar training post, you are required to complete a set number of hours of clinical exposure and achieve certain clinical competencies in order to complete your training. Therefore, those doing part-time training would spend the same number of hours working, but spread over more calendar time. For example, a foundation 'year' of working 3 days a week between 9 am and 5 pm would involve 20 months of training.

It is possible to switch to part-time training whilst in a full-time post, and this must be done through your assigned educational supervisor and training board. These are specific to each deanery and they can put in place a number of options to arrange for you to have more time off. Options include:

- **Annualised contracts** – these can be full- or part-time. An agreed number of hours or shifts must be completed over the course of a year, but there is a degree of flexibility in when these shifts are carried out.

Table adapted from Core Surgery National Recruitments Office for NHS (portfolio guidance)			
Key Skill	Range	Scoring Guide	Examples of Acceptable evidence for Portfolio
BSc Hons/MSc/MD MPhil/BDS/PhD	1–2	Dependent on whether degree has been awarded	• Original degree certificate
Exceptional performance in undergraduate/Foundation years or equivalent	0–4	SSM's or projects, undergraduate distinctions, prizes or awards. Evidence of extra abilities beyond required medical and non-medical abilities	• Original letter from medical school • Original certificate
CPD courses	0–3	Courses must have been completed, and passed, to score any points. (e.g. BSS, ATLS, ASIT, or RCS of England course or equivalent)	**Completed and passed courses only** • Certificate from completion • Letter confirming results
Clinical / Procedural Experience in both surgical and non-surgical posts	0–4	Score dependent on level of motivation to learn and develop practical or surgical skills at the level of your training	• Letter from educational supervisor confirming experience • Letter from medical staffing confirming length of appointment • Letter of appointment (providing this states the length of the post) • Written evidence of completion of undergraduate surgical module • Copy of essay, publication, project work completed in surgical as an undergraduate.
Audit	0–5	Score dependent on level of involvement and understanding of audits	(Excluding audit presentations) • Copy of presentation (hard copy) and copy of event programme • Copy of publication including PubMed number or link to publication
Teaching	0–5	Score dependent on level of experience in teaching and teaching training	• Original certificate for teaching qualification • Letter confirming attainment of teaching qualification • Letter confirming involvement in a teaching programme • Copy/ Copies of teaching completed and feedback received

Fig. 29.4 The scoring system for core surgical training portfolio applications in 2017. Further information can be found online

Presentations / Abstracts / Publications (Full papers only)	0–5	Score dependent on number of presentations and publications	**(Excluding audit presentations)** • Copy of presentation (hard copy) and copy of event programme • Copy of publication including PubMed number or link to publication
Demonstrates Leadership	0–3	Evidence of practical leadership roles, minor or major, within medical practice or outside medical practice	• Evidence of activities and achievements • Evidence of non-surgical/clinical skills/experience which have provided transferrable knowledge / skills/ behaviour relevant to your application
Commitment to Specialty	0–5	Gives clear examples of commitment to surgery in portfolio and during interview	• Copies of completed workplace assessments e.g. TAB/MSF, mini CEX, CBD, reflective learning reports, core procedures etc. • Any specific specialty level skills e.g. practical skills • Any specific surgical or related surgical experience or training (e.g. posts, specialist clinics, taster sessions, work abroad, etc.) • Research commenced or grants applied for that have not yet resulted in presentation or publications • Surgical audit or research project • Membership of surgical society • MRCS Part A • Presentations, papers etc. In preparation or submitted awaiting review

Table adapted from core surgery national recruitments office for NHS showing the different areas points can be achieved for your surgical portfolio

Fig. 29.4 (continued)

- **Compressed Hours** – instead of working over 5 days, one can opt to work longer but fewer days. For example, for a 40 h a week contract, you may work 10 h over 4 days.
- **Term-time contract** – you can negotiate to increase annual leave (unpaid) to coincide with school holidays.
- **Part-time** – working less than 40 h a week. This can vary depending on your hospital and requirements. Some people occupy a full-time post and work fewer hours such that other staff compensate for their absence., Others have contracts which allow a 60 % job share: two employees work 3 days a week, and therefore benefit the team by offering 6 days worth of work rather than five.

Evolving Specialties: The Future of Surgery

Future developments in surgery are predicted to vary widely between each surgical specialty. However, it is possible to make some general points. For example, it seems that the emphasis on sub-specialisation is likely to continue. In addition, similar to the growth of minimally invasive surgery over the last 15 years, methods using robotics and endovascular procedures are set to become increasingly widespread.

Traditional methods of open surgery are, however, nowhere near obsolete. Technologically advanced surgical techniques can be difficult to implement in complex or atypical presentations of disease, as seen in the elderly and obese. Both populations of patients are increasing in size.

Women in Surgery

Although the NHS was an early pioneer in supporting women through facilitating flexible careers and providing childcare support, there is still work to be done to correct the gender imbalance amongst NHS consultants. The disparity between the number of male and female consultants in surgery is particularly obvious: in 2013, only 9.95 % of consultant surgeons in England were women (http://surgicalcareers.rcseng.ac.uk/wins/statistics). The annual report of the Chief Medical Officer in 2006 highlighted several factors impeding the career progression of many women within medicine [2]. Key problem areas have been identified, but progress towards equal opportunities and representation of women in medicine, particularly at the top end of the career ladder, is highly dependent upon political climate and the ring-fencing of budgets which provide support for women with families

'*Women in Surgery*' (*WinS*) is a national initiative that was recently set up to support women surgeons in achieving their career goals, and to encourage more women to consider surgery as a profession. In its mission 'to encourage, enable and inspire women to fulfill their surgical ambitions', the WinS team is currently working on three main issues:

1. **Raising the profile of women surgeons** – This is being done through promoting a positive profile of female surgeons in the media, and through highlighting the many ways in which women can succeed in the profession.
2. **Understanding the issues facing women in surgery** – In 2006 the Department of Health Women in Medicine group was formed, and through work with WinS, they have sought to identify the issues affecting women in medicine and surgery. They are currently working with other organisations to assist implementation of the suggestions made in their final report.
3. **Research into factors that affect women and their career choices** – Work done by WinS in conjunction with Exeter University psychology department has shown that women are more likely to choose a medical career in which they perceive they are likely to succeed. Therefore WinS' work in raising the profile of women surgeons will help to persuade women that surgery is indeed a career option in which they can do well. WinS is also working closely with the Royal college of Surgeons, Scalpel and Medical Women's Federation in another collaborative project with the University of Exeter [9].This aims to raise awareness of the lack of women in surgery and challenges the stereotyped perceptions of the characteristics of surgeons. A vodcast for aspiring women surgeons was released on women's day in 2013 to promote awareness further [8].

Student Tip The best way to explore what it is like to be a female surgeon is to ask one! If you're concerned about what life is like balancing family and work for young female surgeons, ask your registrars and consultants how they are doing it. If you can't find any, ask your local surgical society to put on an information evening where you can meet surgeons further along the training pathway than you are.

Beginning a Surgical Portfolio

Your surgical portfolio is a reflection of you and your professional life. It must reflect your commitment to surgery including evidence of all the activities you have undertaken. It is strongly recommended to invest in a folder at the beginning of medical school and to store certificates and information in it as you go. This will make your applications for jobs later on much easier. The average portfolio is the size of one lever arch folder and should include the following sub-sections:

- CV (refer to the '*how to write a CV sub-section'*)
- Degree/GMC/MRCS certificates
- Course completion certificates
- Relevant prizes awarded
- Audits
- Presentations
- Peer-reviewed journal publications
- Audits
- Research
- Teaching experience
- Patient feedback
- Surgical E-logbook

Writing a Curriculum Vitae (CV)

The term CV loosely translates as 'the course of your life', and so your CV should be a chart of your professional career. Your CV will help you to get shortlisted for posts, and increasingly they are being used in interview processes. You want to give the impression that you are serious, professional and committed. The length of your CV will depend on the experience and information you wish to present. On average, the majority applying to ST1/2 will have a CV length of 5–7 pages, while ST3/4 applicants tend to have a total of between 8 and 10 pages. The document should be updated constantly. As you progress through your career you will find recent achievements will replace previous ones. Start your CV as early as possible, and target it to the specialty that you desire. Make it precise, succinct and easy to navigate. Avoid grammatical errors, jargon, long sentences and bold text.

Layout of a typical surgical CV:

- Personal Information
  - Details
  - Personal statement
  - Education and qualifications
  - Resuscitation training
  - Prizes and grants
- Employment history – current and previous
- Clinical Experience – target your experience to the job you are applying for
- Core Skills
  - Clinical governance and audit
  - Management
  - Teaching
  - Information technology
- Research
  - Research
  - Publications
  - Presentations
- Invited contributions
- Courses and Meetings
- Interests
- References

Layout of the Application for Specialist training:

- The first few sections will include personal details including your name, work, address, telephone and e-mail address.
- GMC registration and immigration status
- Professional Qualifications and Training Courses (remember advanced life support). All information must be up to date. Ensure that qualifications have not expired. Include teaching and educational courses with recognition from postgraduate medical centre (PGMC) or deanery-recognised provider.
- Additional Achievements such as awards, prizes and other distinctions. List the awards achieved in reverse chronological order and include the awarding body. Evidence will be required at interview.
- Present employment – ensure all the details are correct

- Previous appointments in specialty – list all appointments in chronological order
- Previous appointments other specialties and non-medical work – list all in chronological order
- Competencies – at foundation level keep your e-portfolio up to date and ensure you have achieved the requirements by the time of application. Competencies can be found on the modernising medical careers website and also from the relevant Royal College website. DOPS, min-CEX, CBD, ACAT or MSF/mini-PAT must all be signed off by your educational supervisor, clinical consultant or even supervising registrar. List the skills you are able to perform independently, and those you can do under supervision.
- Clinical Experience – such as critical life saving, independent interpretation of scans and results, independent outpatient lists and day case management. These all show experience for mature decision making and great levels of responsibility. List what you can do, and an indication of level of your competence and experience.
- Audit, management and other clinical governance – include your most recent audit (two audits if completed). Evidence of management and leadership roles, which can be from outside medicine, are highly regarded. Political and/or committee work is highly sought after.
- Academia (presentations and publications) and teaching responsibilities and experience
- Non-medical interests – Think back to applying for medical school.
- Commitment to specialty (why you want to be a…). Present any extra activities that you have not discussed earlier that have helped you choose the specialty. How you got to where you are, any experiences that have moulded you towards your specialty. Reflection should occur throughout this section. Aim for around 100–150 words in this section.
- References – inform these people that you are placing their names on your CV. Aim for referees that are no greater than 2 years old.
- Declaration
- Most application forms will ask for a short piece about your experience of a transferable skill. Try using a scenario of teamwork or leadership. Explain the situation, the action you implemented, and the result of your actions and reflect on your experience.

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30 International Careers: Training and Working Abroad

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Introduction

One of the highlights of being a medical student is the opportunity to travel abroad on an elective. This is often an inspiration for future work abroad. In this chapter we will provide an overview of electives with a surgical focus, as well as discussing the most common English-speaking destinations for British graduates, including the USA, Canada, Australia, New Zealand, the Republic of Ireland and developing countries.

Medical Electives

Medical electives are arguably one of the best parts of medical school – a chance to choose something that you really want to do where you really want to go. The possibilities are almost infinite and it is therefore worth spending time planning well in advance in order to get the most out of your elective as possible.

Where to Go?

Often the first question is 'should I stay in the UK or go abroad?' A lot of people use the elective as a chance to explore the world and gain an insight into healthcare abroad. Some may prefer to stay closer to home, using the time to gain more in-depth knowledge in one particular area or focus on a research project. When choosing where to

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Table 30.1 Choosing an elective destination

Country considerations	Placement considerations
Low-resource/developing country vs. high-resource/developed country Budget Visa and home office restrictions Language Time of year e.g. Monsoon season Cultural experience Opportunities for holiday	Particular specialty or 'general' surgery (often includes trauma and orthopaedics and paediatrics) Advanced technology Availability of resources Other medical students (having to share opportunities) Contacts known or recommended to you

go, consideration should be given to both the country of choice and the placement of choice, as outlined in Table 30.1.

It is useful to start your search for a placement with a contact. If you have a particular specialty that you wish to focus your elective on, ask a consultant in that specialty if they can recommend anywhere. Talk to FY1s about where they went – a personal recommendation beats any review you read on the internet. Most medical schools keep a list of past student electives with their elective reports – reading through these will give you a flavour of what options there are. Make sure you have an up to date copy of your CV ready to send with all enquiry emails as this may speed up the process.

When to Plan?

Start planning your elective as early as possible. Aim to start making contact with potential placements 18 months to a year before you will be going. Popular hospitals often get booked up well in advance and you may need several months to sort out visas, work permits and travel health.

Who to Go With?

If travelling abroad some students like to travel as a pair, but there is often no reason not to go alone, and you may find you get more out of the experience if you do so. If you do choose to go with someone else make sure you know them well – your friendship is likely to come under some stress during your time away!

Funding

If you choose to travel abroad you will need to start raising funds early as the costs can add up. Most medical schools will have some money available as small grants to those who apply for it – the best applications provide detailed proposals of what the elective will involve, including the possibility of research or audit. Local charities may also have some money available; they would usually expect a report or presentation on your return. www.money4medstudents.org offers practical advice on budgeting and also provides a list of contacts for grant applications.

Insurance and Indemnity

It is a good idea to take out insurance for your trip, and your medical school may insist on it. Check the small print and clarify that you will be covered for working/shadowing in a healthcare setting. Most countries do not require medical indemnity cover for electives, with the exception of Canada and the USA. Contact your medical defence union for advice.

Travel Health

Book an appointment at your local travel clinic at least 6 months before you travel – ask your GP practice for details of the nearest one.

When You're Away

- **Keep a logbook**. If you haven't already signed up, www.elogbook.org is free and used almost universally amongst surgical trainees – there is no excuse not to use it and you will need it as soon as you start specialty training anyway. Record all procedures, even those observed – they will provide evidence of your commitment to a career in surgery at interviews in the future

- **Consider ethics**. If you are going to be carrying out your elective in a low resource setting it is worth thinking about the ethical implications of your trip. Only work within the limits of your knowledge and technical ability. Make sure you know who your supervisors are and be sure to ask for help if you need it. Remember, the GMC's Good Medical Practice [1] states that *'you must work within the limits of your competence'*. This is just the same when you are on your elective. Be aware that if you include experiences you're not qualified for in your elective report, your medical school may decide to fail you on your elective for being unsafe.
- **Keep a blog**. Your family and friends will want to know what you are up to – this can make it easier for people to relate to what you may be going through, especially if you have had new or difficult experiences. It will also give you a permanent record of your experiences
- **Take a break**. Immersing yourself in a new setting can be exhausting. Plan some weekend trips to explore the local area, and if you can, try to fit some holiday onto the end of your elective to properly unwind before you head home

On Your Return

Remember to write your elective report or any other requirements that your university has for your elective. If you received funding from charities or organisations, make sure you send them a copy of your report too. They may have a meeting or event where you can arrange to give a presentation – this looks good on your CV as well.

Most importantly: enjoy yourself! Your medical elective is really a once in a lifetime experience so make the most of it while you can.

Useful Resources

- www.lonelyplanet.com – country information
- www.bma.org.uk/medicalelective – general advice for elective planning
- www.money4medstudents.org – budgeting and funding
- www.gov.uk/foreign-travel-advice – country specific advice
- www.nathnac.org/travel – health and travel advice, country specific information, diseases and outbreak updates

Working and Training Abroad

An increasing number of surgeons are working abroad to gain experience in a different healthcare system and continue developing specialty surgical skills all over the world. Work taken abroad can count toward certification in the UK, but this must be agreed in advance by making an appointment with a regional postgraduate dean.

Salary and Support

Opportunities to work and train abroad can either be salaried or voluntary. This will depend on a number of factors including the hosting institution or organisation, whether there is a locally unfilled area of need and your level of experience. Aside from salary, you will need to consider what other support may or may not be provided such as pre-deployment training, allowances, accommodation, flights, insurance, pension payments, membership fees and journal subscriptions.

If you are planning to work as an unpaid volunteer, you may wish to consider applying for a travelling bursary. A number or charities and organisations offer such grants including the Royal Colleges, the Health Technology Assessment Programme, the Association of Surgeons in Training, surgical specialty organisations and commercial sources.

Timing and Training: When to Go?

If taken around the time of training you need to consider whether time spent abroad will be between training programmes or during a training programme. It is strongly advised by the postgraduate medical education training board (PMETB) to complete your Foundation Years one and two (FY1/FY2) before going abroad. Being accepted onto a specialist or general practice training programme is only open to those who have completed and been signed off for the two years of the foundation programme.

Table 30.2 Options for breaks during surgical training

OOPT – out of programme training	Usually 1 year, up to three negotiable with Programme Director Prospective approval from GMC compulsory Counts towards training Requires educational supervisor and completion of assessments as in UK
OOPE – out of programme experience	As OOPT but does not count towards training Most voluntary/humanitarian work falls into this category
OOPR – out of programme for research	Usually MSc/MD/PhD
Career break	Break for reasons unrelated to surgery e.g. competing in sport at high level

Between Training Programmes

Working or volunteering abroad is theoretically possible between FY1 and FY2 but you will need to consider the practicalities of retaining a place on the programme for the second year through discussion with the Foundation School Director. A more popular time to go away is following completion of foundation training before entering higher surgical training.

For specialties entered at Specialty Training year 3 (ST3) there may be an opportunity for working abroad following the two years of Core Training (CT1/CT2). This will not apply to the few remaining run-through training programmes. Taking time out between CT1 and CT2 is not recommended, although in exceptional circumstances may be granted.

During Specialty Training

There are several opportunities for breaks during specialty training, which are highlighted in Table 30.2.

If you plan to work abroad during specialty training, you need to consider whether it will count towards training or whether your time away will be additional to your UK based training. If the training abroad is relevant to your chosen specialty and allows equivalent acquisition of the required knowledge and skills then it may be suitable for an OOPT and if so will not lengthen your training. The post must be prospectively approved by your Programme Director and the GMC prior to starting.

Out of programme years are not permitted within the first or final year of a training programme and applicants must have received an ARCP outcome 1 for the preceding year. At least 6 months' notice will be required, although a year is preferable.

Further information on OOPE/OOPT can be obtained from the relevant Local Education and Training Board (LETB) websites and the 'Gold Guide' to postgraduate specialty training in the UK [2].

Preparation

Preparation must be started early. Speak to others who have experience of working overseas and visit as many agency websites as possible to gain a broad understanding of the options available.

Discuss your plans early with those people that will need to know and ultimately may be responsible for sanctioning your leave. These include your Programme Director, employer, educational supervisor/departmental manager and, of course, your family.

Be clear on which professional bodies you will need to register with abroad, what paperwork will be needed and when. Consider your personal visa requirements especially if you are a non-UK/EEA national as spending time out of the UK may affect your immigration status with regards to qualifying for indefinite leave to remain in the UK (see UK visas and immigration policy).

Returning to the UK

Consider your plan for your return to the UK. Ideally, ensure you have a job to return to or at least be familiar with the application process if intending to seek a training or substantive post. It may be necessary to return to the UK for interviews during your time away; it is unlikely that telephone or video conference interviews will be offered for UK training programmes.

Pensions

If you are a member of the NHS pension scheme, you will need to consider how any potential break in service will affect your contributions. Some organisations offer to maintain your NHS contributions whilst you are working with them abroad, e.g. the Red Cross.

GMC Registration and License to Practice

When working abroad, you will have the option of whether or not to maintain GMC registration and if so whether to maintain a license to practice. Remaining registered enables a doctor to demonstrate a continued position of good standing, is an acknowledgement that your primary medical qualification allowed entry onto the UK medical register and means you will not need to go through the process of re-registering in order to work back in the UK which can take up to three months and incurs a fee. An annual registration fee is payable in order to maintain registration.

A doctor registered with the GMC but not working in the UK can choose whether or not to maintain a license to practice because this only applies to UK practice. If you relinquish your licence when leaving the UK to work abroad, you will have to restore it before working back in the UK. For more information on GMC registration, license to practice and fees, see the GMC website at www.gmc-uk.org/doctors/index.asp

United States of America

It is common for international graduates to move to the United States of America (USA) for training and practice. Due to the competitive nature of this move, completing all the steps to secure postgraduate training in the USA can be challenging, especially when balancing this with the completion of university and Foundation Training.

Training programs in the USA are becoming increasingly competitive for international as well as local medical graduates, with over 21,000 international medical graduates (IMGs) applying for residency programmes in the USA in 2014 [3]. In the same year, general surgery was the 5th most popular specialty program for international graduates. To enter a training programme it is mandatory to demonstrate that any medical education obtained elsewhere matches the standards of safe medical practice in USA.

Before applying to residency programmes, graduates must obtain an Educational Commission for Foreign Medical Graduates (ECFMG) [4] certificate, which is achieved by passing a series of tests which assess basic scientific and clinical knowledge, and ability to interact with patients. Once certification is obtained, an IMG can work in clinical environments and participate in patient care.

The ECFMG certification is obtained after successfully passing the United States Medical Licensing Examinations (USMLE) [5]. There are a total of three exams to be passed, namely the USMLE Step 1, Step 2 Clinical Knowledge (CK) and Step 2 Clinical Skills (CS) (Fig. 30.1). There are many books available to guide you through the USMLEs, and many UK students will choose to take USMLE Step 1 during early clinical years.

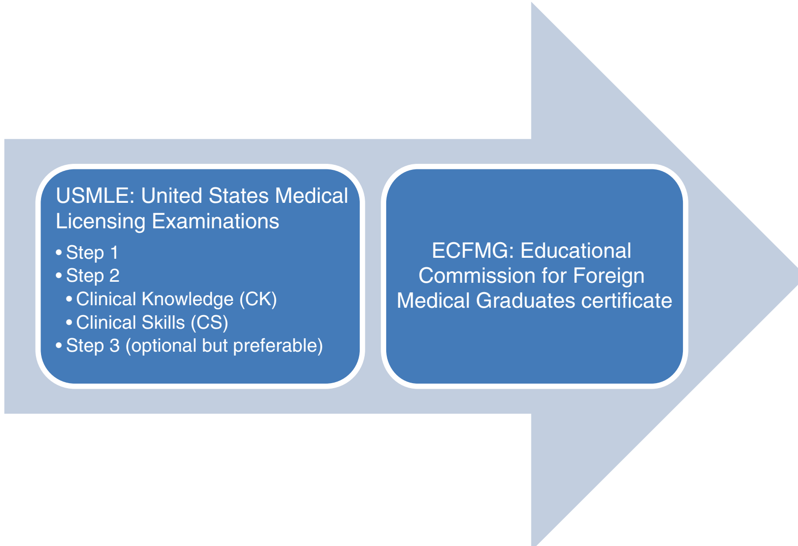

Fig. 30.1 Process of certification in the USA for International Medical Graduates

Residency Applications

When an ECFMG certificate has been achieved, an online application is completed and residency programmes hold interviews. There are a number of factors that make a strong application:

- *USMLE Scores*: Completion of all steps with outstanding scores is the vital aspect of an application. Scores higher than 220 in USMLE Step 1 and 2-CK, are considered to be respectable scores. USMLE Step 2-CS results are reported as a pass or fail. Additionally, the number of attempts to pass the exam also affects the application. Multiple attempts to pass an exam even with a good score are not favourable.
- *Work Experience*: Voluntary, elective and clinical experience in the field of application demonstrates the interest and dedication to the specialty. This makes the application strong and attracts more interview calls. Additionally, any type of clinical experience gained in the USA is beneficial. This can be achieved by completing electives in the USA as medical students, since medical students do not require USMLE to perform clinical work. The added advantages of a USA clinical elective include building a network of contacts, gaining recommendation letters, increasing understanding of the USA clinical system and assessment of the residency program for a future application.
- *Recommendation Letters* from past supervisors, including medical school rotations and any electives spent in the USA.
- *Research experience and publications*

Although USMLE Step 3 is not a requirement for residency applications, having passed the exam further strengthens your application and makes you eligible for a H-1B visa. The exam assesses your clinical management skills, using a computerized MCQ and simulated case management assessment. This is a 2-day exam and ECFMG certification along with other prerequisites (State Medical Board specific) are mandatory requirements. IMGs are strongly encouraged to complete the USMLE Step 3 at the time of interviews in order to improve their chances of success.

Residency Training

Residency training in general, and in surgery in particular, is considered to be very tough in the USA. Some hospitals start their morning rounds as early as 5 am in order to meet the day's schedule that usually starts at 7 am. The final year of training is known as the 'chief year'. This year allows you to work independently, improving your confidence, yet remaining under some supervision. Duration of training varies between specialties and subspecialty training requires another year or two of general surgery training as a pre-requisite. Some university-based residency programs also offer an additional year, which involves dedicated time to research in basic science. This experience can help establish a career as an academic surgeon.

After completion of training and meeting specific specialty board requirements, a trainee becomes board eligible. Board eligible candidates can begin unsupervised training and may take board examinations to become board certified surgeons. Career pathways after residency completion can progress to private practice, academic practice or fellowship training.

Fellowship Training

After completion of the residency, additional training experience can be obtained in a specific field of interest. This is beneficial for individuals seeking to develop specific subspecialty surgical skills. These fellowships are offered in high volume centres. Fellowships can be accredited, non-accredited or certified, as shown in Table 30.3.

Private Practice

After board certification, surgeons may develop a private practice. Private practice can be a group or individual practice. Group practice allows sharing of on call responsibilities, and allows early establishment of patients. As a young surgeon, group practice allows you to consult senior colleagues for advice. Private practice is associated with better remuneration, which remains the most attractive reason to join one.

Table 30.3 Fellowships available in the USA

Fellowship type	Details
Non-accredited	Offered by high volume centres but not approved by subspecialty societies Good for those who have completed training elsewhere and seek subspecialty experience Less competitive than accredited fellowships
Accredited	Approved via subspeciality societies Good for CV – may help secure future position at academic centre Do not offer certification on completion
Certified	Allows double board certification through sitting of board exam

Canada

For those in the medical profession, Canada remains a popular destination to work. Canada provides individuals with a huge variety of work opportunities from small hospital practice in rural areas to globally known research hospitals in cities. Canada provides publically funded medical services under a "Medicare" system, an interlocking set of health insurance plans common to ten provinces and three territories. Canadian Medicare provides universal access to essential hospital and physician services, and is therefore viewed as one of the most admired places to live and work as a medic. The process of training within Canada from a UK medical school is outlined in Fig. 30.2.

A stepwise approach for starting an application is outlined in Fig. 30.3.

In order to sit the exams, non-Canadian entrants must take the Medical Council of Canada Evaluating Examination (MCCEE) to apply for a residency position through the Canadian Resident Matching Service (CaRMS). More information can be found at www.carms.ca and www.physiciansapply.ca

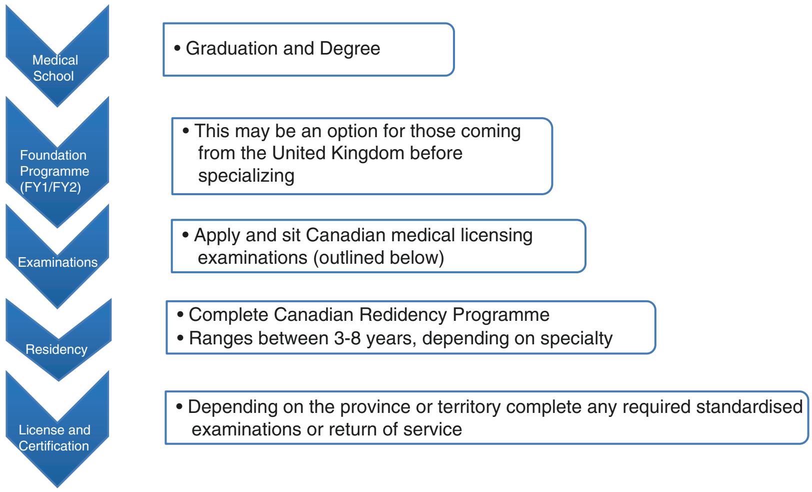

Fig. 30.2 Canadian surgical training pathway

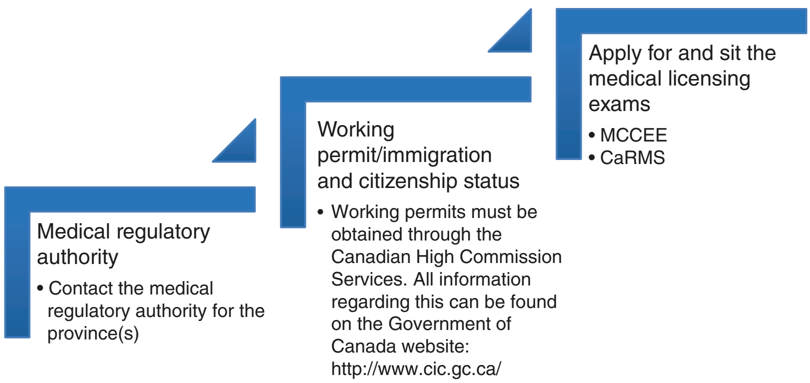

Fig. 30.3 Application process for International Medical Graduates in Canada

Australia

Australia is one the most popular destinations for UK medical school graduates to choose to work. With a common language and no need for additional examinations before specialist training, increasing numbers of UK-trained junior doctors are choosing Australia as a short or long-term destination for postgraduate training. It is possible to undertake specialist surgical training in Australia as a UK medical school graduate, however this requires permanent residency or citizenship status of Australia or New Zealand *and* general (unconditional) registration in Australia or registration for training in New Zealand (see section 'New Zealand' for further details). The generic training pathway is outlined in Fig. 30.4.

The majority of UK junior doctors who choose to work in Australia do so on a temporary basis, usually for one or two years. The most natural time to move abroad as a junior doctor tends to be after the FY2 year, prior to applying to a specialist training programme in the UK. It is possible to undertake the FY2 year in Australia in certain deaneries, but the entire FY2 curriculum requirements still need to be met while abroad – see individual deanery websites for specific details. The pathway for gaining provisional registration and working as a medical practitioner in Australia (post FY2 level) is outlined in Fig. 30.5, while Table 30.4 gives advantages and disadvantages of applying to work in Australia.

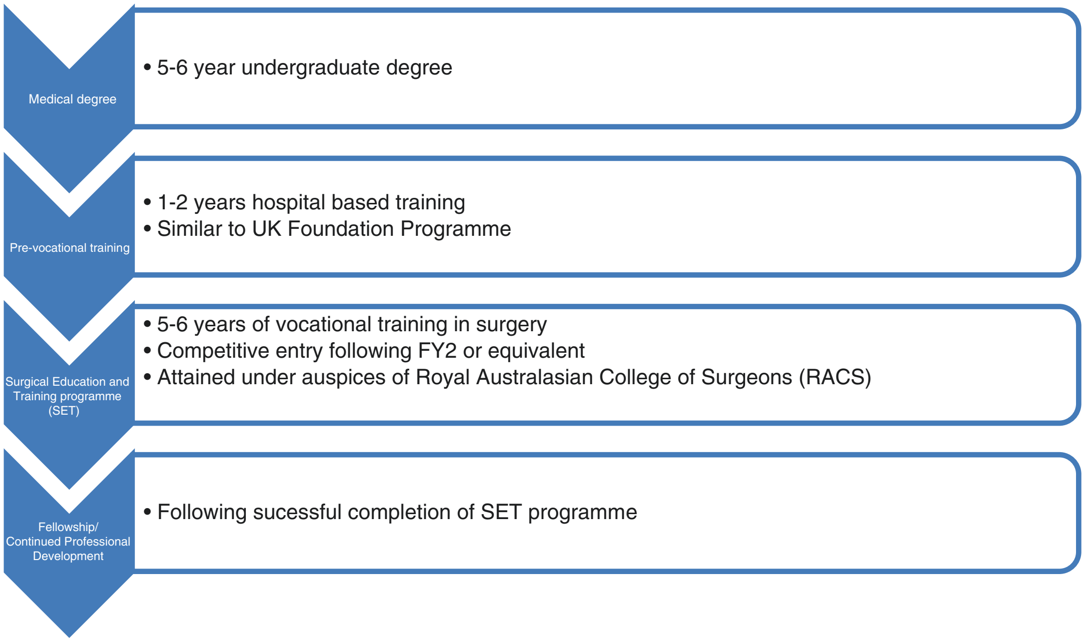

Fig. 30.4 Australian surgical training pathway

Fig. 30.5 Australian application pathway

Table 30.4 Advantages and disadvantages of working in Australia

Advantages	Disadvantages
Experience of working in a different country	Expensive initial outlay
Opportunity to travel while you work	Lots of paperwork
Experience of a different culture	Year out of official training
Opportunity to further develop career plans	

Useful Resources

- Australian Medical Council www.amc.org.au
- Australian Health Practitioner Regulation Agency www.ahpra.gov.au
- Australian Government Department of Immigration and Border Protection www.immi.gov.au

New Zealand

New Zealand is a popular place for UK medical graduates to work for short periods or for longer term postgraduate training. Working in surgery and being registered as a medical practitioner in New Zealand differs from the UK; rather than the core training/specialty registrar/consultant progression of the UK, New Zealand employs registration via 'scopes of practice'. There are different levels of 'scopes' that UK graduates can apply to depending on prior training and clinical experience. The process is summarised in Fig. 30.6.

Short Term Work

To apply to work in New Zealand on a short-term basis, applicants must apply for registrations within a provisional general scope of practice. Applicants must have full GMC registration and have completed their FY1 and FY2 years. The first 12 months of work are closely supervised with frequent assessments from a supervising doctor who has Medical Council of New Zealand approval.

Long Term Training

To enter long term surgical training in New Zealand following the Foundation Programme applicants must complete the first 12 months as a registered practitioner within a provisional general scope of practice, as described above. Following at least 12 months of supervised work, and providing all criteria are met the applicant is eligible to apply for registration within a general scope of practice.

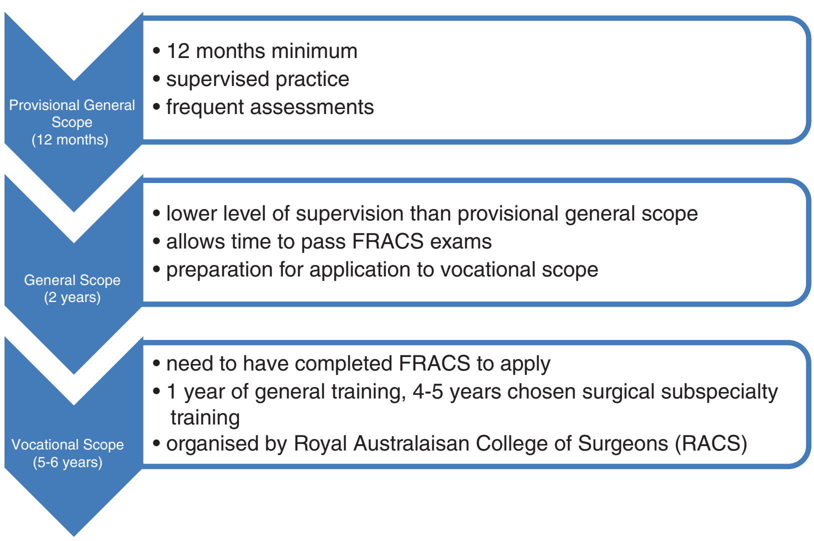

Fig. 30.6 Surgical training pathway in New Zealand

Registration within a general scope of practice involves two years of rotations with a lower level of supervision. During this time preparation is made to apply to a vocational scope of practice, including passing exams for the Fellowship of the Royal Australasian College of Surgeons (FRACS). Once eligible, candidates can apply to work within a vocational scope of practice; these include all the surgical specialities. Vocational scopes are applied to via the Royal Australasian College of Surgeons (RACS) Surgical Education and Training Programmes (SET). The SET programmes are 5–6 years in duration and in New Zealand consist of:

- cardiothoracics
- general surgery
- neurosurgery
- oral and maxillofacial surgery
- orthopaedic surgery
- otolaryngology
- paediatric surgery
- plastics and reconstructive surgery
- urology
- vascular surgery

Immigration

Visas and work permits are compulsory for international medical graduates planning to work in New Zealand. Those wishing to work in New Zealand for less than 3 years may apply for a temporary work permit. Those wishing to stay for more than 3 years should apply for a residence visa under the category 'General Skills'. Further information can be found at www.nzembassy.com

Useful Resources

Medical Council of New Zealand www.mcnz.org.nz

Royal Australasian College of Surgeons www.surgeons.org

Health Careers NZ www.healthcareers.org.nz

NHS medical careers in New Zealand www.medicalcareers.nhs.uk

Working in Developing Countries

Introduction

UK doctors have a long history of working in developing countries, often through partnerships between medical institutions, non-governmental organisations, charities, and professional bodies. Not only are there benefits to developing countries, but there are benefits to the NHS and to the individuals and teams involved. There is evidence to support this [6] and skills and knowledge gained from these roles can be used to contribute to appraisal, continuing professional development (CPD) and revalidation. Volunteering in developing countries is supported by the Academy of Royal Colleges [7].

Overseas work in developing countries tends to involve emergency relief, building infrastructure, running clinics, providing training, and healthcare needs assessment in addition to operative surgery [8].

Whilst personnel for emergency relief work is often needed at short notice, other positions in task-focused missions and follow up trips can be planned further in advance. The duration of placements can vary between a few days and a several years and depends on the nature of the work. A range of opportunities exist for professionals with different levels of experience, but typically at least 2–3 years postgraduate experience is required (see below for specific examples). The main issues to consider when planning to work or train in developed countries are outlined below.

When to Go?

Although like with other options it is always possible to work in developing countries during your years as a junior doctor, you may want to consider working in a developing country as a surgeon after completion of specialty training/after gaining CCT (certificate of completion of training)/CESR (certificate of eligibility for specialist registration). The advantage at this time is that you are more likely to be able to operate autonomously. In fact, some of the larger organisations offering salaried positions such as the Red Cross and Medecins Sans Frontieres now require surgeons to have completed training before they are eligible. Further training around the time of CCT in the form of a Fellowship is common but usually in developed countries in high volume, subspecialty units.

Personal Health

Vaccination status may well be part of the requirement for working abroad but regardless you must consider your personal health especially with pertaining to risk of transmissible disease. With regards to exposure prone procedures, usual personal precautions apply. However, it should be noted that many developing countries have much higher rates of blood-borne infections. You should therefore make sure that your Hepatitis immunity status is sufficient. You should consider the needle-stick policy where you will be working and whether there will be emergency HIV post-exposure prophylaxis available. You may even want to consider taking your own with you. Ensure that you have medical insurance in case you fall ill and require treatment abroad or repatriation.

How Long Should I Go For?

The length of time spent abroad will depend on your personal circumstances including family and relationship commitments, finances and level of training in addition to the area you wish to travel to and its needs. Time can be as short as a few days for delivering a specific training course such as a surgical skills course [9] or may be as long as 12–24 months if working with a large charity such as Volunteer Service Overseas (VSO).

Where to Go

All developing countries affected significantly by poverty, warfare or disaster will have opportunities for volunteering or working. If you are interested in a specific surgical problem or procedure then you may need to find an area where the problem is highly prevalent in the native population such as cataracts in Ethiopia or cleft lip in Bolivia.

How to Arrange a Placement

Placements can be arranged individually with an overseas hospital or healthcare institution. There are a number of partnerships already in place between UK trusts, colleges or academic institutions and developing countries through which regular trips or ongoing aid is provided. There are a number of charities, non-governmental organisations and agencies that can help you find a suitable placement and can also help with provide useful information and other support during the application process such as applying for visas, vaccinations and registering with the necessary professional bodies abroad.

Personal Qualities Needed

In addition to the relevant professional experience required of the post, the ability to adapt to different cultures, having experience living abroad and any other languages spoken (especially French or Spanish) can be helpful. Other non-clinical skill such as organisational and leadership skills can also be important.

Things to Consider While You Are Away

Congratulations on arranging your placement in a developing country. You are embarking what could be a life-changing journey for you and the patients you treat. However, you need to bear in mind some things while you are away. You need to keep a point of professional contact in the UK whether that is a clinical supervisor, programme director or medical director depending on your role. You should keep in contact with your deanery and/or previous/future employing trust as appropriate making sure that they have contact details for you should they need to reach you.

You should keep a record of your experiences for personal and professional reasons. This could include taking photos and videos, collating official paperwork, details of posts held, references, research/academic outputs, teaching roles, operative experience (log-book) and maintain your online portfolio (e-portfolio/ISCP). If in specialty training then you will need to submit paperwork relevant to your OOPE/OOPT at the required intervals for the Annual Review of Competence Progression (ARCP).

Specific Organisations and Charities

There are a great number of organisations and charities that recruit doctors to work in developing countries or that assist in the process of finding placements and applying to work overseas. The list below includes the major ones but is not exhaustive. There will be many local, regional and sub-specialty arrangements in addition to these that can provide useful links to working abroad.

UK International Emergency Trauma Register (UKIETR)

Volunteers can sign up to the UK International Emergency Trauma Register (UKIETR) which was established in 2010 and is hosted by UK-Med, an international emergency response unit developed by the South Manchester Accident Rescue Team. It is supported by the Department of health, the department for international development, the BMA and many of the specialty associations and colleges. It invites members to respond at short-notice as part of a national team to large scale international emergencies. It provides pre-deployment and technical training. Typically, members will be available at 12–24 h notice and are deployed overseas for 2–3 weeks in response to major international catastrophes.

www.uk-med.humanities.manchester.ac.uk/about-ukietr.html

Volunteer Service Overseas (VSO)

VSO is an international development charity. Volunteers work with local organisations that serve poor people in over 32 countries overseas. Part of their remit includes improving the standard of care in hospitals. Typical placement lengths are 12–24 months and require at least 3 years postgraduate experience therefore trainees need to be at CT2/ST2 level or above. Short-term (6 month) roles require at least 5 years' experience.

www.vso.org.uk/volunteer/opportunities/health/surgeons

Medecins Sans Frontieres (MSF)

MSF surgeons tend to work with emergency teams to treat people wounded in conflict zones or join teams providing long-term surgical care to communities without the necessary infrastructure. Typical placements are from 6 weeks to three months or more. Work involves general surgery, surgical-needs assessment and training of local staff.

Surgeons need to be post-MRCS or FRCS with higher surgical training completed such that they can work autonomously and are required to be registered with the GMC or Irish Medical Council. They need to have had previous experience of working, volunteering or travelling in developing countries.

www.msf.org.uk/job-profiles/surgeon

Medical Emergency Relief International (MERLIN)

MERLIN is part of the Save the Children charity and has an experienced network of medical experts working in some of the toughest places in the world affected by natural disasters or conflict (currently helping in 18 countries) to create a world-class humanitarian health force. Qualified surgeons tend to be recruited to their emergency work and have been involved in helping after the Indonesian Tsunami (2004/5), the Myanmar cyclone (Burma, 2008), the Manila typhoon (Philippines, 2009), the Haitian earthquake (2008) and the floods in Pakistan (2010).

www.merlin.org.uk/emergencies

International Medical Corps UK

The International Medical Corps respond rapidly to overseas humanitarian emergencies to provide lifesaving medical and health related emergency services.

www.internationalmedicalcorps.org.uk

RedR UK

RedR UK are an international humanitarian NGO supporting aid organisations across the world by selecting, training and providing competent and committed personnel to humanitarian programmes worldwide. Their work is concentrated in areas of natural or man-made disaster. RedR recruits professionals who can respond to emergencies or take longer-term placements. They require 5 years relevant professional experience and previous experience working abroad.

www.redr.org.uk

Red Cross

The Red Cross have a wide international remit in addition to their UK charity work. This includes not only first aid but emergency response to disaster areas with recent appeals in Ebola affected areas, Iraq, South Sudan and Syria. International delegates work directly on British Red Cross Programmes, or are seconded to work for the International Federation of Red Cross and Red Crescent Societies and the International Committee of the Red Cross. Contracts range from one month to two years in length. The Red Cross does not send volunteers abroad and all international posts are salaried. Additional advantages include full preparation for deployment, medical checks, vaccinations and visas. Return flights, accommodation, insurance and pension contributions are also included. Some postings allow accompanying family members.

www.redcross.org.uk/About-us/Jobs/Overseas

Mercy Ships

Mercy Ships provides the world's largest charitable floating hospital. They bring free care to some of the world's poorest people, have five operating theatres on board and run surgical skills training courses. Much of the work is in maxillofacial surgery, general surgery and ophthalmic surgery. The vessel typically spends 9 months on each mission at a single port location, currently in Madagascar. They tend to provide specialist as well as emergency surgical care and recruit fully trained surgeons.

www.mercyships.org.uk/

Operation Hernia

Operation hernia is an independent not-for-profit organisation providing high quality surgery at minimal costs to patients that otherwise would not receive it. They perform hernia repairs and train local surgeons. Missions are run across several sites mainly in Ghana and Rwanda. Typically, each mission lasts for 2–3 weeks and surgical teams travelling from the UK including trained surgeons and registrars. Other personnel including junior trainees can accompany missions as observers.

www.operationhernia.org.uk

African Health Placements

African Health Placements is a South African-based social profit organisation working to address the inequities in access to healthcare through human resource solutions and therefore has a wide remit including workforce planning, retention and strategic consulting but importantly co-ordinates staffing by registering, matching and placing healthcare workers focussing on rural and underserved areas in South Africa. As a junior doctor, once registered with the GMC, you can find placements that match any level of UK training. Posts are generally salaried and terms of at least 12-months are preferred. As well as helping to find the right job for you they will provide assistance with obtaining visas, credentialing documents and registering with the Health Professionals Council of South Africa (HPCSA).

www.ahp.org.za

Military Surgery

Most doctors will have decided prior to graduation whether they wish to pursue a career in military surgery. The armed forces in the UK recruit medical students/doctors between the ages of 21 and 42–54 years of age depending on regiment. Medical sponsorship is available to cover study throughout part or all of medical school training using a mixture of bursaries and cadetships. A career in the military offers a chance to work in some of the most challenging environments and adopt additional non-medical skills such as diving, aviation, and parachuting. There will be opportunities to deploy abroad and many of the countries recently afflicted by warfare such as Afghanistan, Kosovo and Iraq are considered part of the developing world. Further information is available from the following websites:

www.army.mod.uk/rolefinder/role/133/doctor
www.raf.mod.uk/careers/jobs/medicalofficer.cfm
www.royalnavy.mod.uk/careers/explore-jobs/all-jobs/medical-officer/whats-the-job

Summary

Time spent working, training or volunteering abroad can be hugely valuable with personal and professional benefits as well as having the opportunity to improve healthcare in some of the most deprived areas of the world. Working in a developing country may be associated with sacrifices with regards to finances, home comforts, vacations, family, personal life or relationships but there are a huge range of international opportunities that may suit different personal circumstances. Surgeons who have had these experiences suggest they are hugely rewarding and rarely regretted.

Other General Resources

The Health Partnership Scheme

The health partnership scheme was set up by the ministerial department for international development. It works to 'improve healthcare for some of the world's poorest people through partnerships between the NHS and UK institutions and developing countries' health systems.' It is providing financial grants to support 50 international partnerships over the next 4 years and has ensured that pension contributions of NHS employees can be maintained while volunteering abroad.

www.gov.uk/health-partnership-scheme

Medical careers.nhs.uk

Medical careers is an online career planning guide which is designed to assist you in understanding your options for choosing your future career as a doctor in the NHS. It has a useful section on training and volunteering in developing countries.

www.medicalcareers.nhs.uk/career_options/alternatives_to_working_in_nhs/working_abroad_-_undeveloped.aspx

British Medical Association (BMA)

The BMA has advice for anyone considering working as a doctor in developing countries available via its website:

www.bma.org.uk/developing-your-career/career-progression/volunteering-abroad

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The NHS and Private Healthcare

31

Tobias A. Rowland and Christopher Rao

Introduction

The National Health Service was founded in 1948 following the Second World War. Three core principles established then have guided its development to this day:

1. It would meet the needs of everyone
2. It would be free at the point of use
3. It could be accessed by all citizens based on clinical need and not ability to pay.

Since its inception, the NHS has grown into an enormous organisation. Employing over 1.7 million people, it is arguably the world's fourth largest employer behind Wal-Mart, the Indian Railways and the Chinese People's Liberation Army (NHS Confederation) [6]. In 2012, only around half of those employed by the NHS were clinically qualified and only 11.8 % were doctors (Health and Social Care Information Centre) [5].

The founders of the NHS anticipated that provision of healthcare for all would improve the general health of the population, and thus ultimately reduce the cost of ill health on the economy. Unfortunately, the cost of universal healthcare has risen year on year since the foundation of the NHS. There are three principle reasons for this rise:

1. An ageing population increases the demand for health and social care
2. The public's expectations of the health service have changed
3. Advances in medical technology result in increasingly costly investigations and interventions

Despite continually rising costs, the NHS remains one of the world's most efficient healthcare systems [3]. Expenditure is lower than most other western countries as a proportion of GDP, as is the ratio of doctors to population, yet the NHS still achieves comparable or superior outcomes according to the World Health Organisation (WHO) [9]. While debates over the structure, purpose and management of the NHS continue, overall it remains a very successful and effective system of healthcare.

Current Structure of the NHS

Major Organisations in the NHS

The structure of the NHS is large and complex. Multiple bodies and organisations within it are

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involved in varying roles, such as in managing NHS funding, accountability, decision-making and the delivery of services. The names and roles of these organisations have changed frequently, but there are some that are useful to know for the purposes of this discussion:

- The Department of Health – Originally called the Ministry of Health, this is the overarching body responsible for policy-making and decisions about the overall direction of the NHS. Secretary of State for Health heads the Department of Health, and is accountable to parliament. Specific decisions about funding, however, have always been devolved to regional and local authorities.
- National Institute of Health and Care Excellence (NICE) – Established in 1999 as the National Institute of Clinical Excellence, NICE is an independent public body that produces guidelines relevant to healthcare. For example, NICE guides the adoption of new health technology including novel devices, procedures and medications in the NHS. In addition, it provides clinical guidelines and protocols to optimise the treatment of patients with specific healthcare conditions in the NHS. NICE also influences the practice of healthcare professionals working in the public health and social care sectors.

Health Service Sectors

One can divide the care-giving sectors of the NHS into four distinct groups that interact with each other.

1. Primary Care – this is delivered by General Practices (GP) and other health services that the public can access directly, including dentists, opticians and pharmacies. GPs and other primary care providers have been independent contractors since the beginning of the NHS. As such, they are not directly employed by the NHS: rather than being salaried, they are paid for the number of patients they provide services to. They are able to run their practices like independent businesses.
2. Secondary care – this refers mainly to hospital inpatient, outpatient and to accident and emergency services. Secondary healthcare providers generally do not have the first contact with patients. Tertiary care refers to specialised hospital care for more complex or unusual conditions requiring advanced investigation and treatment. Patients are often referred from primary or secondary services to tertiary care professionals. For the purposes of this chapter, tertiary care is structured similarly to secondary care.
3. Community services – these are other specialist services that exist outside of the hospital. Examples include mental health services, maternity and child welfare services, care homes, district nurses and social care.
4. Public Health – this targets the health of the entire population. Public health schemes aim to promote preventative medicine via educational campaigns for ‘healthy living’ and national health initiatives. Every level of NHS care is concerned with public health, but issues of public health are guided overall by a national body, Public Health England (PHE) that coordinates NHS and government public health strategy.

A Brief History of the NHS

With the creation of the NHS, all healthcare in the UK became centrally funded from tax revenue. Prior to 1948, patients generally had to pay for their own healthcare, either directly or through health insurance schemes. Some free treatment could be accessed at ‘voluntary hospitals’, but these institutions relied heavily on philanthropy. Following the National Insurance Act 1911, implemented by David Lloyd George, all workers who paid National Insurance could register with a general practitioner and claim medical care. The scheme was funded by weekly deductions from the employee’s earnings, plus contributions from their employer and the Government. However, this scheme was flawed as it left much of the country – particularly women and children – without healthcare insurance.

In the early decades of the 1900s, politicians discussed how the shortfalls in British health provision could be met. Implementation of the ideas they conceived was delayed by both national political changes, and by the international turmoil caused by the Second World War. It was not until the cabinet-endorsed White Paper of 1944 that the founding three principles of a National Health Service were set out in writing. Under the guidance of Aneurin Bevan, the structure of the NHS of England and Wales was established in 1946, and the new system was launched on 5th July 1948.

This chapter will focus on the structure of NHS England. NHS Scotland, NHS Wales and Health and Social Care in Northern Ireland each have slightly different structures and operate independently with control over their own budget and policies.

Due to the increasing cost of healthcare, successive governments since 1948 have sought to reduce NHS spending. Early examples of cost-saving policies were the introduction of the standard charge of one shilling per prescription in 1951, and the decision that patients should pay a proportion of the cost of dentures and spectacles. Unsurprisingly, these were controversial changes when they were introduced.

Starting in the 1980s, private sector management practices were introduced into the NHS. The introduction of the "internal market" across the UK between 1991 and 1997 changed the structure and culture of the NHS more than any prior alteration. The internal market was a system by which primary healthcare organisations would "purchase" health care from secondary healthcare "providers". It was hoped that competition between healthcare organisations would result in the efficiency savings seen in the private sector.

The "internal market" was maintained as a central element of the NHS throughout successive NHS reforms, culminating most recently in the Health and Social Care Act 2012. Therefore, the changing structure of the NHS can be considered in two phases: the original structure from 1948 which remained largely unchanged for several decades, followed by the period from the 1980s after the internal market was introduced.

The Gradual Introduction of a Market

At the foundation of the NHS in 1948 the Ministry of Health funded regional hospital boards and local health authorities directly. The former managed the secondary care provided by hospitals, and the latter organised community health services delivered by nurses, midwives and others. For many years, local authorities and hospital boards had a degree of flexibility and control over the allocation of their budgets. There were numerous restructuring processes and renaming of the organisations in subsequent years, but the basic structure shown in Fig. 31.1 remained for decades.

Things began to change more drastically in the 1980s. Outsourcing was introduced for non-clinical services such as catering and cleaning,

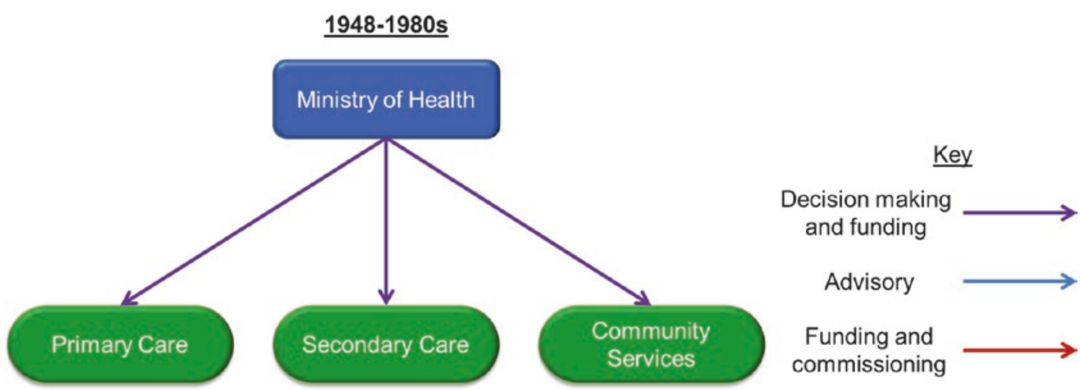

Fig. 31.1 Schematic of the structure of the NHS, prior to the introduction of the internal market

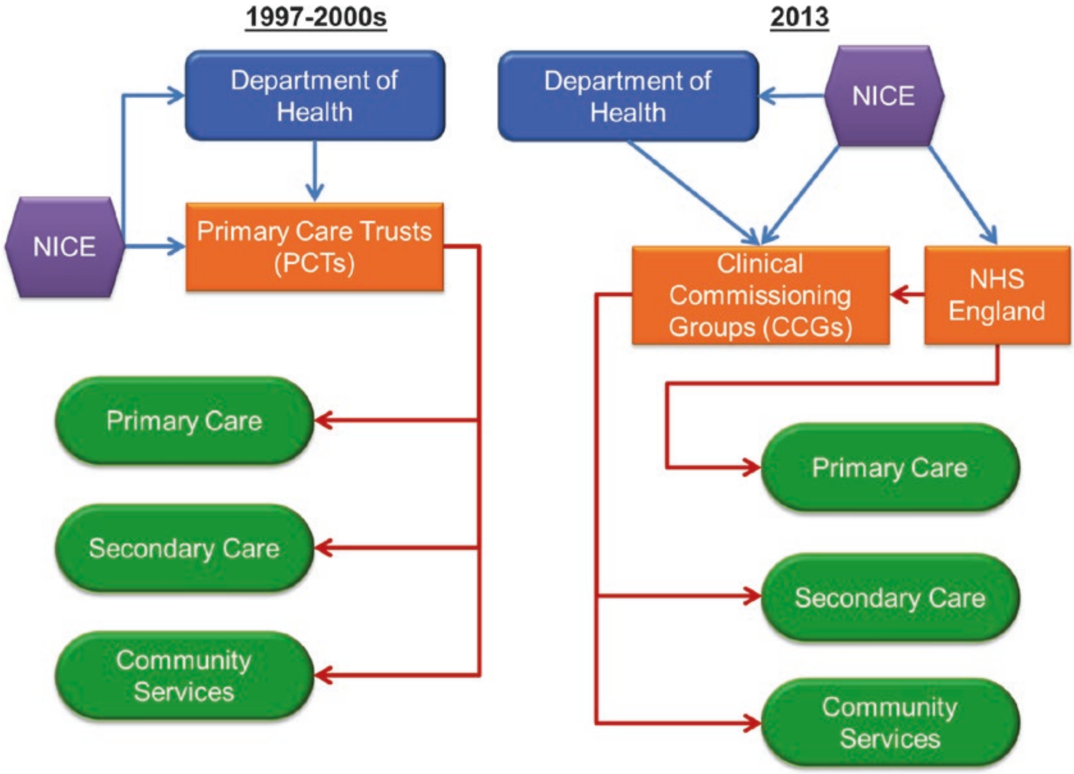

Fig. 31.2 Schematic of showing NHS organsiation following restructuring and introduction of the internal market

and the internal market, discussed above, was introduced in an attempt to create competition and improve efficiency. Then in the 1990s and 2000s Primary Care Groups and then Trusts were introduced, changing the funding of services significantly. Primary Care Trusts (PCTs) were run by groups of GPs. Their role was to allocate funding to NHS service providers, such as secondary care in hospitals, GP practices themselves, and community care services (Fig. 31.2). PCTs were responsible for allocating around 80 % of the NHS budget.

A further change in the structure and funding of the NHS came into practice in 2013. Most significantly, PCTs were replaced with Clinical Commissioning Groups (CCGs). CCGs perform a similar function to PCTs in commissioning community and secondary care services, and currently have control over around two thirds of the NHS budget. NHS England was created to commission primary care services and some specialised hospital services.

CCGs are essentially committees that include nurses, hospital doctors and members of the public in addition to GPs. All general practices now belong to CCGs. The groups 'commission' services for their patients on behalf of the NHS often from NHS hospitals. However, charities and private companies can also be contracted by CCGs to provide these services as long as they conform to minimum quality and safety standards. For example, a CCG could commission a private company to provide MRI scanning for NHS patients, if they felt it would provide better quality or more efficient care (Fig. 31.2).

Although the most recent health service reforms may significantly affect how healthcare is funded and delivered, when seen in context, they are arguably a continuation of the outsourcing of services and introduction of an internal market that began in the 1980s. This trend has not been affected by changes in government, ministers and civil servants.

Healthcare Economics

Healthcare economics began to emerge as a distinct branch of economics in the early 1960s. This included the study of the healthcare market in general, but also the evaluation of which interventions provided the best value for money for specific illnesses. The latter became known as economic *cost-effectiveness* analysis [4].

NICE places considerable emphasis on measures of relative cost-effectiveness when evaluating new health technologies. The introduction of this analysis in standard NHS practice has been controversial [2]. Some critics argue that the process of technology evaluation by NICE is too slow. Other critics argue that the analysis of what is in the best interest of the country does not necessarily reflect the best interest of individual patients. It is also argued that NICE has been ineffective in improving the efficacy and equity of resource allocation, and that the speed at which healthcare spending is increasing remains unchanged. Nevertheless, as there is currently no alternative methodology to consider the cost and effectiveness of medical interventions simultaneously, it is likely that cost-effectiveness analysis and NICE appraisals will remain. Therefore, in the following section we will discuss some key concepts and terms related to cost-effectiveness that may be encountered in the literature.

Perspective

When only costs and benefits relevant to a particular organisation or group are considered the analysis is said to have been performed from the perspective of that particular organisation or group. The perspective adopted for cost-effectiveness analysis significantly affects estimates of the costs and benefits associated with an intervention. For example, if we consider the total cost of a hernia repair to a ***third-party payer***, such as the government, we must include the cost of pre-operative care, the cost of the procedure itself, the cost of outpatient follow up, the costs incurred in primary healthcare, and the potential costs of treating recurrence of the hernia or complications of the procedure. If we consider the cost incurred by the patient for the same procedure, all of the previous costs would be irrelevant and we would only need to consider the cost of travel expenses and loss of earnings. A ***societal*** perspective is when all costs and consequences to all stakeholders within the borders of a country are considered. In the United Kingdom, NICE recommends an NHS (third-party payer) perspective. Ultimately, whatever perspective is adopted it must be explicitly stated, as interpretation of cost-effectiveness data is impossible when the perspective is unclear [7].

Measures of Effect

Cost-effectiveness analyses can be classified according to how outcomes (or effects) of the interventions are measured. In ***cost-minimisation*** analysis, it is assumed that alternative interventions are equally effective. Interventions are compared simply on the basis of cost. As we can rarely be sure that two interventions are equally effective on every occasion in all patients, cost-minimisation analysis is not appropriate in most cases.

The term ***cost-effectiveness*** analysis is confusingly also commonly applied to a subset of economic analysis in which the effect can be any non-monetary measure of the outcome of the intervention. For example, cost-effectiveness analysis of diagnostic tests may look at the number of cases detected. Whilst cost-effectiveness analysis allows comparison of alternative interventions within a narrow field, it is not possible to compare the cost-effectiveness of interventions for different diseases.

In ***cost-benefit*** analysis, both the costs and effects are expressed in monetary units. This allows the absolute benefits of a programme to be evaluated without comparison to other interventions. The other significant advantage of cost-benefit analysis is that it allows a comparison of health care interventions with other targets of public spending, such as educational projects. Many authors object to cost-benefit analysis, arguing that valuing health in monetary terms implicitly favours health-interventions for diseases of the affluent. Others simply find valuing life and suffering in monetary terms distasteful.

Economic analyses that make value judgements about health states, using measures such as Quality-Adjusted Life Years (QALY), are often described as ***cost-utility*** analyses. This allows consideration of both mortality and morbidity from all causes when evaluating the effectiveness of an intervention, and facilitates the comparison of cost-effectiveness between healthcare disciplines [7].

Quality Adjusted Life Years

QALYs provide a useful measure of both the quality and quantity of years that may be saved using a particular health intervention. The effect of an intervention on either the length or quality of life is discovered by multiplying the change in Health-Related Quality of Life (HRQoL) by the change in the length of life. HRQoL is quantified using a utility score, which is essentially measured on a continuum from 0 (death) to 1 (full health). It is possible to come across negative utility scores if the health state is considered to be worse than death, such as a permanent vegetative state.

Utility scores, or HRQoL weights, essentially give different health states different weights according to their perceived desirability to a group of patients. There are several methods for determining utility values such as interval scaling, the standard gamble, and the time trade-off methods. Unfortunately, these methods are time consuming and conceptually difficult for the patient. Alternatively, pre-scored multi-attribute health status classification systems such as the EQ-5D system can be used.

All methods are dependent on important assumptions: these include the assumptions that patients will behave rationally, that they are willing to trade years of life in a given health state for fewer years in a better health state, and that patients are risk neutral. Several authors suggest that these assumptions are not valid in clinical practice.

In addition, some take issue with the implicit assumption in cost-effectiveness analysis that QALYs are equally valuable no matter at what age and to whom they are assigned. For example, QALYs may be preferentially assigned to terminally ill patients at the end of their life.

It has also been argued that QALYs do not reflect societal preferences. The controversy widely reported in the national press surrounding novel therapies for patients with terminal cancer is an example of when such societal preferences do not align with decisions based on QALYs. This controversy led to the introduction of the Cancer Drugs Fund in 2011 as an attempt by the Government to fund life-extending drugs often rejected by NICE on the basis of cost.

A further difficulty with the use of QALYs is that while NICE applies a broadly consistent threshold to the amount that should be paid for each additional QALY, this is not reliably replicated across the health care system. Different thresholds are decided for different disease states locally: for example, cardiovascular care is often prioritised over mental health services. Finally, as funding is not necessarily available to fully implement NICE guidelines, local providers are often unable to readily fund services that offer cost-effective QALY payoffs. Bariatric surgery is one such example.

Despite the limitations of QALYs, it is argued that they represent a close enough approximation of individual and societal preference to justify their use, and in the absence of functional and robust alternatives they are widely used in cost-effectiveness analysis [7].

Private Practice

Role of Private Healthcare in England

The vast majority of healthcare in the UK is delivered within the NHS. In 2012, only 17.5 % of healthcare spending was in the private sector (World Bank) [8]. Most patients who use private medical care do so through private health insurance, but it is also possible to "self-fund". In the UK in 2008, 7.5 million people had private healthcare insurance, around 12 % of the population. The overall revenue generated by the private healthcare sector in the UK was £3.2 billion [1].

The proportion of spending on public and private healthcare has remained relatively stable over the past decade. However, this may underestimate the role of the private sector in the healthcare sector in the UK since it does not include healthcare that is paid for by the NHS, but provided by private companies. The amount paid by PCTs and now CCGs to private providers has increased consistently from 2006 to 2013. Indeed, private healthcare spending for certain operations such as hip and knee replacements has decreased over this period, as these operations continue to be performed by independent providers but are instead now funded by the NHS. The role of these private providers looks likely to become increasingly important in the future. Further changes, such as a lifting of the cap on the income that an NHS trust can derive from private services are also likely to increase the importance of private healthcare in the UK.

Working in the Private Sector

The majority of doctors who work in the private sector in the UK also work within the NHS. Although in theory any doctor with a licence to practice from the General Medical Council (GMC) can undertake private work, most private providers require a doctor to be on the GMC specialist or general practice register. As training for UK medical graduates is exclusively conducted within the NHS it is only at consultant level that private practice is realistically possible. At this stage, many doctors may choose to devote some of their time to private work, although the amount they can do in the working day is restricted by their NHS contract. In practical terms this might be one day a week doing private work. Some doctors may do only private work, forgoing their NHS contract altogether, but this is unusual.

Conclusion

The founders of the NHS were unquestionably ambitious in their vision of a comprehensive universal healthcare system, which they designed to be "free at the point of care". The combined pressures of an aging population, increasingly costly healthcare, and raising public expectations have forced the structure of the NHS and the way in which care is delivered to evolve. Whilst it remains "free at the point of care", the extent to which it is universal and comprehensive has arguably diminished. As the NHS responds to external pressure to evolve, cost-effectiveness is likely to remain an important part of the evaluation of new interventions. Finally, although the future direction of NHS reform is uncertain, it is likely that the private sector will continue to play an increasingly significant role in UK health provision.

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Glossary

3D	Three dimensional
A&E	Accident and emergency department
A/V	Atrioventricular
AAA	Abdominal aortic aneurysm
ABG	Arterial blood gas
ACL	Anterior cruciate ligament
ACST	Asymptomatic Carotid Surgery Trial
ACTH	Adrenocorticotrophic hormone
AFP	Academic Foundation Programme
AKI	Acute kidney injury
AOM	Acute otitis media
AP	Anterior-posterior
ASA	American Society of Anaesthesiologists
ASIS	Anterior superior iliac spine
AVN	Atrioventricular node
AVN	Avascular necrosis
AXR	Abdominal X-ray
BAOMS	British association of oral and maxillofacial surgeons
BBV	Blood borne virus
BMA	British Medical Association
BMJ	British Medical Journal
BP	Blood pressure
BPH	Benign prostatic hyperplasia
BSc	Bachelor of Science
CA 15–3	Carbohydrate antigen 15–3
CA 19–9	Carbohydrate antigen 19–9
CABG	Coronary artery bypass graft
CAD	Coronary artery disease
CBD	Common bile duct
CCG	Clinical Commissioning Group
CE	Cauda equina
CEA	Carcinoembryonic antigen
CES	Cauda equina syndrome
CHD	Coronary heart disease
CHF	Congestive heart failure
CK	Clinical knowledge
CLP	Cleft lip and palate
CNB	Core needle biopsy
CNS	Central nervous system
CO_2	Carbon dioxide
COPD	Chronic obstructive pulmonay disease
CPAP	Continuous positive airway pressure
CPB	Cardiopulmonary bypass
CPD	Continual professional development
CRP	C-reactive protein
CS	Clinical skills
CSF	Cerebrospinal fluid
CST 1,2	Core surgical trainee 1,2
CT	Computerised axial tomography
CT1, 2	Core trainee doctor 1, 2
CV	Curriculum vitae
CVP	Central venous pressure
CVS	Cardiovascular system
CXR	Chest X-ray
DEXA	Dual energy X-ray absorptiometry
DHS	Dynamic hip screw
DNA	Deoxyribonucleic acid
DPT	Dental panoramic pantomogram
DVT	Deep vein thrombosis
EBM	Evidence based medicine
ECFMG	Educational Commission for Medical Graduates
ECG	Electrocardiogram
EMQ	Extended matching questions
ENT	Ear nose and throat
ER	Estrogen receptor

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ERAS	Enhanced recovery after surgery
ESR	Erythrocyte sedimentation rate
ESWL	Extra-corporal shockwave lithotripsy
EVAR	Endovascular abdominal aortic aneurysm repair
F1, 2	Foundation doctor 1, 2
FAP	Familial adenomatous polyposis
FBC	Full blood count
FESS	Functional endoscopic sinus surgery
FEV_1	Forced expiratory volume/second
FNA	Fine needle aspiration
FPAS	Foundation Programme Application System
FRCS	Fellow of the Royal College of Surgeons
FVC	Forced vital capacity
GA	General anaesthetic
GA	General anaesthetics
GABA	Gamma-aminobutyric acid
GCS	Glasgow coma scale
GDP	Gross domestic product
GI	Gastrointestinal
GMC	General Medical Council
GP	General practitioner
GTN	Glycerol trinitrate
GTN	Glyceryl trinitrate
GU	Genitourinary
H&E	Hematoxylin & eosin
hCG	Human chorionic gonadotrophin
HDP	High density polyethylene
HDU	High dependency unit
Her2	Human epidermal growth factor
HF	Heart failure
HIV	Human Immunodeficiency Virus
HPC	History of presenting complaint
HPV	Human Papilloma Virus
I&D	Incision and drainage
IBD	Inflammatory bowel disease
ICU	Intensive care unit
ICU	Intensive care unit
ID	Inferior dental
IL	Interleukin
IMA	Inferior mesenteric artery
IMG	International medical graduate
INR	International normalized ratio
IPSS	Internation Prostate Symptom Score
IRAS	Integrated Research Application System
IV	Intravenous
IVC	Inferior vena cava
JVP	Jugular venous pressure
KUB	Kidney, ureter and bladder
LA	Local anaesthetics
LA	Left atrium
LCA	Left coronary artery
LETB	Local Education and Training Board
LFT	Liver function test
LIMA	Left internal mammary artery
LMA	Laryngeal mask airway
LMN	Lower motor neurone
LMWH	Low molecular weight heparin
LOS	Length of stay
LUQ	Left upper quadrant
LUTS	Lower urinary tract symptoms
LV	Left ventricle
LVH	Left ventricular hypertrophy
MAC	Minimum alveolar concentration
MCCEE	Medical Council of Canada Evaluating Examination
MCQ	Multiple choice questions
MDT	Multi-disciplinary team
MDT	Multi-disciplinary team
MDT	Multi-disciplinary team
MI	Myocardial infarction
MIS	Minimally invasive surgery
MRCS	Member of the Royal College of Surgeons
MRI	Magnetic resonance imaging
MRSA	Methicillin resistant Staphylococcus aureus
MSU	Mid-stream urine
N_2O	Nitrous oxide
NASCET	North American Symptomatic Carotid Endartectomy Trial
NG	Nasogastric
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
NMDA	N-methyl-D-aspartate
NOF	Neck of femur
NOTES	Natural orifice transluminal endoscopic surgery
NPA	Nasopharyngeal airway
NSAID	Non-steroidal anti-inflammatory drug
NYHA	New York Heart Association
OA	Osteoarthritis
ODP/ODA	Operating department practitioner/assistant

OME Otitis media with effusion
OMFS Oral and maxillofacial surgery
OP Osteoporosis
ORIF Open reduction internal fixation
OSCE Objective structures clinical examination
PCA Patient controlled analgesia
PCL Posterior cruciate ligament
PCNL Percutaneous nephrolithotomy
PCT Primary Care Trust
PDA Patent ductus arteriosus
PE Pulmonary embolism
PEF Peak expiratory flow
PETT Position emission tomography
PGMC Postgraduate medical centre
PHE Public Health England
PMETB Postgraduate Medical Education Training Board
PMH Past medical history
PR Progesterone receptor
PSA Prostate specific antigen
PTH Parathyroid hormone
PVD Peripheral vascular disease
PVD Peripheral vascular disease
QALY Quality-adjusted life years
RA Right atrium
RCA Right coronary artery
RCT Randomised control trials
RIF Right iliac fossa
RIMA Right internal mammary artery
RLQ Right lower quadrant
RV Right ventricle
SAN Sino-atrial node
SBAR Situation, background, action and recommendations
SIGN Scottish intercollegiate guidelines network
SILS Single incisional laparoscopic surgery
SIRS Systemic inflammatory response syndrome
SLE Systemic lupus erythematosus
SMA Superior mesenteric artery
SPC Suprapubic catheter
SSM Special study module
StR Speciality registrar
SVC Superior vena cava
TAPVR Total anomalous pulmonary venous return
TAVI Transcatheter aortic valve implantation
TCC Transitional cell carcinoma
TED Thromboembolism deterrent
TGA Transposition of the great arteries
THR Total hip replacement
TIA Transient ischaemic attack
TKR Total knee replacement
TLC Total lung capacity
TSH Thyroid stimulating hormone
TUR Trans-urethral resection
TURP Trans-urethral resection of the prostate
TV Tidal volume
TWOC Trial without catheter
U&Es Urea and Electrolytes
URS Uretero-renoscopy
US Ultrasound
USMLE United States Medical Licensing Examination
UTI Urinary tract infection
VATS Video assisted thoracoscopic surgery
VEGF Vascular endothelial growth factor
VTE Venous thromboembolism
vWF von Willebrand Factor
WHO World Health Organisation
WinS Women in Surgery
ZF Zygomaticofrontal

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