The Perioperative Medicine Consult Handbook

Molly Blackley Jackson
Ronald Huang
Elizabeth Kaplan
Somnath Mookherjee
Editors

Third Edition

Springer

The Perioperative Medicine Consult Handbook

Molly Blackley Jackson
Ronald Huang
Elizabeth Kaplan
Somnath Mookherjee
Editors

The Perioperative Medicine Consult Handbook

Third Edition

Springer

Editors
Molly Blackley Jackson
Department of Medicine
Division of General Internal Medicine
University of Washington
Seattle, WA
USA

Ronald Huang
Department of Medicine
Division of General Internal Medicine
University of Washington
Seattle, WA
USA

Elizabeth Kaplan
Department of Medicine
Division of General Internal Medicine
University of Washington
Seattle, WA
USA

Somnath Mookherjee
Department of Medicine
Division of General Internal Medicine
University of Washington
Seattle, WA
USA

ISBN 978-3-030-19703-2 ISBN 978-3-030-19704-9 (eBook)
https://doi.org/10.1007/978-3-030-19704-9

© Springer Nature Switzerland AG 2013, 2015, 2020
This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.
The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.
The publisher, the authors, and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Colleagues in perioperative care,
It is our great pleasure to offer a third edition of *The Perioperative Medicine Consult Handbook*. Every chapter has been reviewed and updated where necessary. We have added new chapters covering important topics including heart failure, care of transgender individuals, hormone therapy, thrombophilias, acute and chronic pain, spinal cord injury, post-operative hypoxemia, and post-operative tachycardia. To highlight the most important points and resources, we have added key points at the end of each chapter and indicated the most salient resources in the reference lists.

As with the previous editions, we aim to provide evidence-based recommendations to optimize the care of patients around the time of surgery. Moreover, we aspire to thoughtfully combine the calculators, pathways, decision tools, and algorithms necessary to improve patient care with a humanistic approach: delivering personalized, thoughtful care to every patient – as if they were our own family member. We believe that the most critical elements of delivering outstanding perioperative care are taking the time to know our patients as individuals, and collaborating effectively with our surgery, anesthesiology, primary care, nursing, and other hospital care team colleagues.

This handbook is written by our colleagues at the University of Washington Medical Center, Harborview Medical Center, the Seattle Veterans Affairs Puget Sound

Health Care System, and many others. We are honored to be a part of this larger community, and deeply grateful for the collaboration.

With respect,
Molly Blackley Jackson
Elizabeth Kaplan
Ronald Huang
Somnath Mookherjee

Seattle, WA, USA

Contents

Contributors

Oyebimpe O. Adesina, MD, MS Department of Medicine, Division of Hematology, University of Washington, Seattle, WA, USA

Tyler J. Albert, MD Department of Medicine, University of Washington and VA Puget Sound Health Care System, Seattle, WA, USA

Pallavi Arora, MBBS, MD, MPH Department of Medicine, Division of General Internal Medicine, Harborview Medical Center, University of Washington, Seattle, WA, USA

Maralyssa Bann, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Joshua O. Benditt, MD Department of Medicine, Division of Pulmonary, Critical Care & Sleep Medicine, University of Washington School of Medicine, Seattle, WA, USA

Gabrielle Berger, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Lauren Brown, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Tiffany Chen, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Paul B. Cornia, MD Department of Medicine, University of Washington and VA Puget Sound Health Care System, Seattle, WA, USA

Stefanie Deeds, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Sandra Demars, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Neha Deshpande, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Joana Lima Ferreira, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Divya Gollapudi, MD Department of Medicine, Division of General Internal Medicine, Harborview Medical Center, University of Washington, Seattle, WA, USA

Anna L. Golob, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Anna Fahy Hagan, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Scott Hagan, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Michael L. Hall, MD Department of Anesthesiology and Pain Medicine, University of Washington School of Medicine, Seattle, WA, USA

Meghaan Hawes, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Ken He, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Ronald Huang, MD, MPH Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Molly Blackley Jackson, MD Department of Medicine, Division of General Internal Medicine, University of Washington School of Medicine, Seattle, WA, USA

Kay M. Johnson, MD, MPH Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Elizabeth Kaplan, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Mehraneh Khalighi, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Christopher S. Kim, MD, MBA Department of Medicine, Division of General Internal Medicine, University of Washington School of Medicine, Seattle, WA, USA

Hojoong Kim, MD Department of Neurology, University of Washington, Seattle, WA, USA

Jared W. Klein, MD, MPH Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Preetma Kooner, MD Department of Anesthesiology and Pain Medicine, University of Washington, Seattle, WA, USA

Michael F. Krug, MD, FACP Department of Medicine, Division of General Internal Medicine, Boise VA Medical Center, Boise, ID, USA

Eve M. Lake, MD, MS Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Tyler Y. M. Lee, MD, MSPH Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Michael J. Lenaeus, MD, PhD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

David S. Levitt, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Jennifer R. Lyden, MD Department of Medicine, Division of Hospital Medicine, Denver Health, Denver, CO, USA

Eric Mar, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Susan E. Merel, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Kara J. Mitchell, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Kelly M. Nakamura, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Maya Narayanan, MD, MPH Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Kim O'Connor, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Brian Palen, MD Department of Medicine, Division of Pulmonary, Critical Care and Sleep Medicine, University of Washington, Seattle, WA, USA

Katherin Peperzak, MD Department of Anesthesiology and Pain Medicine, University of Washington, Seattle, WA, USA

Brian S. Porter, MD, FACC Core Physicians, Exeter, NH, USA

Alexander Pratt, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

George Alec Rooke, MD, PhD Department of Anesthesiology, University of Washington, Seattle, WA, USA

Mala M. Sanchez, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Karen Elaine Segerson, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Sabeena Setia, MD, MPH Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Edie P. Shen, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Tara Spector, MD Division of General Internal Medicine, Duke University Health System, Durham, NC, USA

Shobha W. Stack, MD, PhD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Wendy Suhre, MD Department of Anesthesiology and Pain Medicine, University of Washington, Seattle, WA, USA

Rachel Thompson, MD, MPH, SFHM Swedish Health Services, Seattle, WA, USA

Andrew A. White, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Jessica Woan, MD Division of General Internal Medicine, University of Washington Medical Center, Puget Sound Veterans Health Administration, Seattle, WA, USA

Christopher J. Wong, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Jeanie C. Yoon, MD Department of Medicine, Division of Hospital Medicine, Virginia Hospital Center, Arlington, VA, USA

Yilin Zhang, MD Department of Medicine, Division of General Internal Medicine, University of Washington, Seattle, WA, USA

Chapter 1
Perioperative Medicine Consultation

Ronald Huang, Divya Gollapudi, and Paul B. Cornia

BACKGROUND

Surgery is commonly performed every day throughout the world. There were an estimated 312 million surgeries in the world in 2012, an increase of 38% from 2004 [1]. In the USA alone, 17.2 million hospital visits (ambulatory or inpatient) included surgery in 2014 [2]. Both surgery and anesthesia have inherent risks and the perioperative care of patients can be complex, particularly those with multiple medical conditions. Medicine consultants are often asked to help evaluate and manage surgical patients perioperatively.

PERIOPERATIVE MEDICINE CONSULTATION

MODELS OF PERIOPERATIVE MEDICINE CONSULTATION

The perioperative period begins with the decision to perform surgery and ends when the patient has fully recovered from surgery. During this period, medicine consultants provide care in outpatient preoperative clinics, during the inpatient hospitalization, or in postdischarge clinics. The relationship between the referring provider, typically the operating surgeon, and the medicine consultant can be described as either consultative or co-management. In practice, medicine consultation of surgical patients varies substantially on the healthcare system, surgical service, and even individual providers and often combines elements of both models [3, 4].

- In a consultative model, the referring provider is primarily responsible for the patient. The referring provider requests the

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_1

opinion of the medicine consultant. The clinical question for the consultant is usually more specific and the consultant generally does not assume care of the patient (consultants do not place orders or make referrals to other providers). In a consultative model, the consultant sees the patient when asked by the referring provider or on an as needed basis.

- In a co-management model, there is a shared responsibility for the patient by the referring provider and the medical consultant. The scope of the consultant's role is more general, and the consultant often assumes care of the acute and chronic medical problems and assists with transitions of care. In some cases, the consultant may act as the primary service. In a co-management model, the consultant follows the patient regularly, often daily if the patient is hospitalized.

In the last two decades, co-management is becoming increasingly more common. By 2006, more than a third of patients received co-management, defined in one study as a medicine physician claiming services on at least 70% of a patient's days in the hospital [5]. This shift in the care of surgical patients is associated with the expanding role of hospitalists, which is driven by a growing number of older, more medically complex surgical patients, surgeons limiting the scope of their practice, and healthcare systems focusing on value and safety. Although it has been a widely accepted model, there are limitations and risks to co-management including miscommunication between providers, unclear responsibilities, additional cost, and provider dissatisfaction [6, 7]. The optimal model of medical consultation for surgical patients is unknown and must be tailored to the needs and resources of each healthcare system.

EVIDENCE FOR PERIOPERATIVE MEDICINE CONSULTATION

Studies show that perioperative medicine consultation has many potential benefits. However, most studies are retrospective and small; there is significant heterogeneity in the perioperative medicine consultation services studied; and the results so far have been are mixed. In the inpatient setting, recent studies have focused on comparing co-management and consultative perioperative medicine consultation.

- The majority of inpatient studies have focused on the co-management of orthopedic patients. In one study, 526 patients undergoing elective hip or knee arthroplasty who were at elevated risk of postoperative morbidity were randomized to either co-management or consultative care [8]. Patients randomized to co-management had lower rates of complications at discharge and lower adjusted length of stay compared to

patients randomized to consultative care. In a retrospective study of 466 elderly patients admitted with hip fracture, co-management was associated with decreased time to surgery and the length of stay without adversely affecting 30-day readmission rates or mortality [9]. Conversely in another study of 951 elderly patients admitted with hip fracture, the introduction of co-management was associated with decreased mortality, medical complications, and readmissions without a difference in length of stay [10].

- Studies looking at co-management are not limited to orthopedic patients. After implementation of a surgical co-management (SCM) hospitalist program, in which hospitalists screened inpatients on orthopedic and neurosurgical services, rounded on selected patients, and participated in daily multidisciplinary rounds, there was a decrease in the proportion of patients with at least one medical complication and patients with extended lengths of stay (5 or more days) [11]. SCM was also associated with a reduction in 30-day readmissions for a medical cause and was estimated to save $2,642 to $4,304 per patient. When the same SCM program was applied to a colorectal surgery service, there was a reduction in length of stay, but no reduction in medical complications or readmissions [12]. In another study of all surgeries performed at one hospital over a 2-year period, co-management of patients who had at least one postoperative complication (medical or surgical) was associated with lower risk-adjusted mortality. The authors of that study suggest that the lower mortality is because co-management of surgical patients promotes early identification and treatment of postoperative complications [13].
- While most studies demonstrate some benefits of co-management, in one study of 7,596 neurosurgical patients, co-management was associated with no difference in mortality, readmission, length of stay, or many measures of patient satisfaction [14].

In the outpatient setting, studies are available on the effects of anesthesiology-led and medicine-led preoperative evaluation clinics. More studies have evaluated outpatient preoperative anesthesiology evaluations than preoperative medicine evaluations. Given the clinical overlap between outpatient anesthesiology and medicine preoperative evaluations, data from studies of anesthesiology-led preoperative clinics may also be applicable to medicine-led evaluations [15].

- One study of VA patients found that restructuring the anesthesiology-led preoperative clinic to medicine oversight

was associated with a reduction in inpatient mortality and length of stay for patients with American Society of Anesthesia (ASA) scores of 3 or higher [16].

- Other studies of preoperative medicine evaluations have suggested no impact or a negative impact of medicine consultation, but these studies have limitations. A review of a population-based administrative database found that consultation by a medical provider within 4 months before surgery was associated with small increases in mortality and length of stay [17]. In another study, perioperative medicine consultation was associated with higher cost and length of stay, but perioperative medicine consultation was defined as occurring either the day before, day of, or day after surgery with the majority of consultations occurring postoperatively [18]. In both of these studies, consultation included specialist providers who are not likely to perform a general preoperative evaluation. Another study, a randomized trial comparing outpatient and inpatient medicine preoperative evaluations, found that outpatient evaluations did not reduce total length of stay, although they did reduce the preoperative length of stay and cancellations of surgery after admission [19].
- Studies of anesthesiology-led preoperative clinics have demonstrated decreases in same day cancellations, costs, testing, and length of stay. In addition, a propensity-matched retrospective study found that an assessment in an anesthesiology-led preoperative evaluation clinic visit was associated with a reduction in in-hospital mortality [20].

DIRECTION OF PERIOPERATIVE MEDICINE CONSULTATION

As the population of older, medically complex surgical patients continues to grow, there will be an increasing need for perioperative medicine consultation. Medicine consultants will be asked to provide high-value care that is evidence-based, collaborative, and patient-centered. Ongoing questions about what the optimal model is for perioperative medical consultation and what impact these programs have on patient care will need to be addressed. As part of this process, perioperative medicine consultants will play a key role in improving the overall perioperative care of patients by helping to create, implement, and assess innovative perioperative protocols and programs [21].

KEY CLINICAL PEARLS

- In a co-management model, there is a shared responsibility for the patient by the referring provider and the medical consultant.
- Studies show that perioperative medicine consultation has many potential benefits including decreased length of stay, mortality, complications, readmission, and cost.

REFERENCES

1. Weiser TG, Haynes AB, Molina G, Lipsitz SR, Esquivel MM, Uribe-Leitz T, Fu R, Azad T, Chao TE, Berry WR, Gawande AA. Size and distribution of the global volume of surgery in 2012. Bull World Health Organ. 2016;94(3):201–209F.
2. Steiner CA, Karaca Z, Moore BJ, Imshaug MC, Pickens G. Surgeries in hospital-based ambulatory surgery and hospital inpatient settings, 2014: statistical brief #223. Healthcare Cost and Utilization Project (HCUP) statistical briefs [Internet]. Rockville: Agency for Healthcare Research and Quality (US); 2006–2017.
3. Thompson RE, Pfeifer K, Grant PJ, Taylor C, Slawski B, Whinney C, Wellikson L, Jaffer AK. Hospital medicine and perioperative care: a framework for high-quality, high-value collaborative care. J Hosp Med. 2017;12(4):277–82.
4. Chen LM, Wilk AS, Thumma JR, Birkmeyer JD, Banerjee M. Use of medical consultants for hospitalized surgical patients: an observational cohort study. JAMA Intern Med. 2014;174(9):1470–7.
5. Sharma G, Kuo YF, Freeman J, Zhang DD, Goodwin JS. Comanagement of hospitalized surgical patients by medicine physicians in the United States. Arch Intern Med. 2010;170(4):363–8.
6. Siegal EM. Just because you can, doesn't mean that you should: a call for the rational application of hospitalist comanagement. J Hosp Med. 2008;3(5):398–402.
7. Sharma G. Medical consultation for surgical cases in the era of value-based care. JAMA Intern Med. 2014;174(9):1477–8.
8. Huddleston JM, Long KH, Naessens JM, Vanness D, Larson D, Trousdale R, Plevak M, Cabanela M, Ilstrup D, Wachter RM, Hospitalist-Orthopedic Team Trial Investigators. Medical and surgical comanagement after elective hip and knee arthroplasty: a randomized, controlled trial. Ann Intern Med. 2004;141(1):28–38.
9. Phy MP, Vanness DJ, Melton LJ 3rd, Long KH, Schleck CD, Larson DR, Huddleston PM, Huddleston JM. Effects of a hospitalist model on elderly patients with hip fracture. Arch Intern Med. 2005;165(7):796–801.
10. Fisher AA, Davis MW, Rubenach SE, Sivakumaran S, Smith PN, Budge MM. Outcomes for older patients with hip fractures: the impact of orthopedic and geriatric medicine cocare. J Orthop Trauma. 2006;20(3):172–8; discussion 179–80.
11. Rohatgi N, Loftus P, Grujic O, Cullen M, Hopkins J, Ahuja N. Surgical comanagement by hospitalists improves patient outcomes: a propensity score analysis. Ann Surg. 2016;264(2):275–82.
12. Rohatgi N, Wei PH, Grujic O, Ahuja N. Surgical comanagement by hospitalists in colorectal surgery. J Am Coll Surg. 2018;227(4):404–410.e5.
13. Hinami K, Feinglass J, Ferranti DE, Williams MV. Potential role of comanagement in "rescue" of surgical patients. Am J Manag Care. 2011;17(9):e333–9.
14. Auerbach AD, Wachter RM, Cheng HQ, Maselli J, McDermott M, Vittinghoff E, Berger MS. Comanagement of surgical patients between neurosurgeons and hospitalists. Arch Intern Med. 2010;170(22):2004–10.
15. Adesanya AO, Joshi GP. Hospitalists and anesthesiologists as perioperative physicians: are their roles complementary? Proc (Bayl Univ Med Cent). 2007;20(2):140–2.
16. Vazirani S, Lankarani-Fard A, Liang LJ, Stelzner M, Asch SM. Perioperative processes and outcomes after implementation of a hospitalist-run preoperative clinic. J Hosp Med. 2012;7(9):697–701.

17. Wijeysundera DN, Austin PC, Beattie WS, Hux JE, Laupacis A. Outcomes and processes of care related to preoperative medical consultation. Arch Intern Med. 2010;170(15):1365–74.
18. Auerbach AD, Rasic MA, Sehgal N, Ide B, Stone B, Maselli J. Opportunity missed: medical consultation, resource use, and quality of care of patients undergoing major surgery. Arch Intern Med. 2007;167(21):2338–44.
19. Macpherson DS, Lofgren RP. Outpatient internal medicine preoperative evaluation: a randomized clinical trial. Med Care. 1994;32(5):498–507.
20. Blitz JD, Kendale SM, Jain SK, Cuff GE, Kim JT, Rosenberg AD. Preoperative evaluation clinic visit is associated with decreased risk of in-hospital postoperative mortality. Anesthesiology. 2016;125(2):280–94.
21. Thompson RE. High value collaborative perioperative care programs. Perioper Care Operating Room Manag. 2017;9:3–5.

Chapter 2
Effective Perioperative Consultation

Edie P. Shen and Rachel Thompson

BACKGROUND

Medicine consultants engage in the care of the surgical patient at various points along the perioperative timeline. Four primary phases have been described in the perioperative continuum (see Table 2.1) [1]. The original commandments of effective medical consultations were first written by Lee Goldman in 1983, and their wisdom has been distilled into various publications since that time [2]. Referring physicians comply with consultant recommendations 54–95% of the time, varying by setting [3]. Compliance and effective consultation is most likely to result when these time-tested principles are applied consistently in day-to-day consultative workflow, regardless of when the consult occurs within the perioperative continuum.

EFFECTIVE CONSULTATION

DEFINE THE CLINICAL QUESTION CLEARLY

On an outpatient basis, the first step is to review the referral. If a referral is placed in the electronic medical record (EMR) without a specific reason, then reviewing the referring physician's clinic note may help elucidate whether the patient is being seen for general preoperative risk stratification and optimization or if there is a more focused question, or both. If the reason for consultation remains unclear, then a direct physician-to-physician conversation may be necessary.

In the inpatient setting, the consultation may be requested either prior to surgery or postoperatively. When the consult is requested, take the opportunity to clearly define the clinical question during the initial conversation. In addition to a preoperative evaluation or consultation for a specific question, medicine may be consulted to co-manage the

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_2

TABLE 2.1 PERIOPERATIVE CONTINUUM

Time period	Description
Preoperative	From the decision to have surgery to arrival in the preoperative area. Risk stratification and optimization are often requested in this timeline.
Day of surgery	From arrival to the preoperative area through OR, recovery, and transition to the inpatient floor.
Postoperative inpatient	From arrival to the postoperative floor to hospital discharge. Pathways involving protocol-driven early interventions (enhanced recovery) may be implemented in this period. This is the time period in which medical complications may arise and necessitate consultation.
Post-discharge	From hospital discharge through return to function. The patient's clinical course in this period, often managed by the primary care provider and the surgeon, may be influenced significantly by the quality of communication from the inpatient to outpatient setting and arrangement of appropriate post-discharge follow-up.

patient's medical comorbidities in the inpatient setting. In one study, 59% of surgeons preferred a general medicine consultation over a focused consult [4]. The importance of clearly defining the clinical question has been underscored by study findings indicating that 14% of requesting physicians and consultants disagree about the primary reason for consultation, and that in 12% of consults the requesting physician felt that consultants ignored explicit questions [3].

ESTABLISH URGENCY

In both the outpatient and inpatient settings, mutually agree upon an appropriate time frame for evaluating the patient and delivering recommendations—an accelerated timeline may be necessary depending on the reason for consultation (e.g., tachycardia in a patient who may be septic) or the timing and urgency of surgery. In the outpatient setting, the timing of the evaluation and recommendations largely depends upon the urgency of surgery.

KNOW YOUR ROLE

The perioperative care of medically complex patients often involves many providers from different specialties including surgery, anesthesia, and medicine. To avoid errors and confusion for the patient, it is important for each specialty to understand their role, including the medicine consultant.

- The role of the medicine consultant is typically either a consultative or co-management role. In the consultative role, the consultant provides only their opinion which can be for a specific question or can be more general. In the co-management role, the consultant typically takes over certain aspects of the patient's care, including placing orders.
- Avoid making recommendations to referring providers in areas in which the consultant is not an expert or communicating specific recommendations to the patient that the referring provider may not choose to follow. The medicine consultant should avoid recommendations on specific types of anesthesia or surgical planning, or telling the patient the surgery will be delayed or canceled.

TRUST YET VERIFY

Reviewing the data available in the electronic medical record and clinical impressions of the referring provider when the consult is received is vitally important for establishing background and context, but obtaining an independent history and physical exam remains critically important. Personally reviewing and interpreting outside records as well as directly communicating with outside providers such as the primary care physician or outpatient specialist(s) adds value to the consultation. Consultant-specific expertise may allow extraction of previously overlooked valuable clinical information [5].

CLOSE THE LOOP

Communicating and documenting consistently, effectively, and clearly is crucial for an effective consultation. The principles of good communication and documentation include:

- Initial or time-sensitive recommendations are best delivered verbally to a provider caring for the patient.
- Be as specific as possible with recommendations including medication names, dosages and duration of therapy, or specific tests.
- Consultations are often densely worded and recommendations may be hard to find or confusing. A separate or highlighted section (e.g., with bulleted items) for key recommendations is a service to the referring provider. Referring providers may prefer a written consultative format in which the reason for consult, impression, and plan are presented first.
- Consultation can be a teachable moment, but whether to educate a referring provider depends upon the consultant's tact

and timing in delivery, if the referring provider is receptive at that time, and if there is need to educate.

- Avoid engaging in chart wars. As a consultant, not all of your recommendations may be adopted by the primary service. If disagreements in care arise, these are best discussed verbally rather than documented in the EMR. Using language such as "consider" may help avoid disputes.
- Consider providing concrete recommendations to address clinical scenarios which are likely to arise. Not all contingencies can or should be planned for, however, and providing plans for every contingency is unnecessary and may result in recommendations that are difficult to follow.

FOLLOW UP APPROPRIATELY

The frequency of and need for follow-up consultation vary upon the patient's clinical status and comorbidities, recommended testing, and whether the consultation was requested for a focused question or a co-management relationship. In general, patients who need to be followed more closely include the following:

- Patients who are not improving with recommended treatment
- Patients who are at risk of complications due to their comorbidities
- Patients who have testing that requires further management
- Patients who are being co-managed

The consultant should communicate and document the follow-up plan clearly to the referring provider. In the inpatient setting, communicate whether the consultant will see the patient daily or not and clearly communicate when signing off on a patient including information of who to contact should new questions arise.

KEY CLINICAL PEARLS

- Referring providers may prefer a written consultative format in which the reason for consult, impression, and plan are highlighted or presented first.
- Building trust over time and collaborative relationships with referring providers increases the ability to advocate for and provide high value care.
- Direct communication is vital when referring providers and consultants have discordant perceptions of the key clinical question or their respective roles in the patient's care.

REFERENCES

1. Thompson RE, Pfeifer K, Grant PJ, Taylor C, Slawski B, Whinney C, Wellikson L, Jaffer AK. Hospital medicine and perioperative care: a framework for high-quality, high-value collaborative care. J Hosp Med. 2017;12(4):277–82.
2. Goldman L, Lee T, Rudd P. Ten commandments for effective consultations. Arch Intern Med. 1983;143(9):1753–5.
3. Cohn SL. The role of the medical consultant. Med Clin N Am. 2003;87:1–6.
4. Salerno SM, Hurst FP, Halvorson S, Mercado DL. Principles of effective consultation. Arch Intern Med. 2007;167(3):271–5.
5. Chang D, Gabriel E. 10 tips for hospitalists to achieve an effective medical consult. Hospitalist. 2015;2015(7).

Chapter 3
The Preoperative Evaluation

Christopher S. Kim and Molly Blackley Jackson

BACKGROUND

The "preop eval" consult remains a common and important role for the medical consultant. A good preoperative evaluation provides baseline information about the patient's preoperative state, identifies perioperative risks for the patient and clinical team, provides specific recommendations to help mitigate the perioperative risks, and serves as a starting point for postoperative management of the patient's medical conditions.

ELEMENTS OF THE PREOPERATIVE EVALUATION

HISTORY AND PHYSICAL

A careful medical history and physical examination will help identify patients at risk for surgical complications. The examiner should evaluate for diagnoses and assess the status of conditions that are associated with substantial perioperative risk, including:

- Heart failure
- Coronary artery disease
- Cardiac arrhythmias
- Severe valvular heart disease
- Poorly controlled hypertension
- Severe pulmonary hypertension
- Obstructive sleep apnea (OSA)

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_3

- Severe chronic obstructive pulmonary disease (COPD)
- Advanced liver disease
- Thromboembolic disease
- Poorly controlled diabetes
- Adrenal insufficiency
- Severe anemia
- Chronic kidney disease
- Cognitive impairment
- Poor functional status and frailty

See Table 3.1 for a summary of key elements of the evaluation, Table 3.2 for suggested preoperative review of systems, and Table 3.3 for components of the extended peroperative physical exam.

URGENCY OF THE SURGERY

Understanding the urgency of surgery is a critical part of the preoperative evaluation. For patients who require emergent or urgent surgery, the medical consultant's role may be limited to providing focused anticipatory guidance and postoperative recommendations. For patients who have a planned surgery that is considered "time-sensitive," the role of the medical consultant should be to anticipate and mitigate perioperative complications while avoiding unnecessary testing that may delay surgery and will not change perioperative management. Finally, for the patient who is being evaluated prior to an elective procedure, the preoperative

TABLE 3.1 ELEMENTS OF THE PREOPERATIVE EVALUATION

Requesting/referring physician	Usually the surgeon, sometimes a primary care provider (PCP) or specialist, or anesthesiologist
Reason for consult	Specific reason for consultation which may be for a general preoperative evaluation
Chief complaint	Include the reason for the intended surgical procedure
Date of surgery	Include the type of surgery
Care team	List the PCP and any active or relevant specialists
History of present illness (HPI)	A brief summary of the history as it pertains to the proposed surgery. As the surgical workup has already been completed by the surgery team, only the most important elements need to be repeated in the medical preoperative HPI

TABLE 3.1 (CONTINUED)

Active and past medical problems	Focus on conditions for which advice has been requested (e.g., coronary artery disease), but be complete, which entails explicitly asking the patient about conditions and/or chart review
Past surgical history and past surgical complications	Especially assess prior complications such as bleeding, thrombosis, infection, delirium, and any cardiopulmonary events. If any prior anesthesia complications have been identified, ensure the anesthesiology team is aware
Drug sensitivities	Include type of reaction(s) especially for medications relevant perioperatively such as antibiotics and opiates
Medications	Include prescription, over-the-counter, and herbal preparations
Family history	In addition to medical family history, assess family history of problems with anesthesia
Social history	Patient's living situation and care network are especially important if there are postop complications requiring additional support after discharge
Habits	Smoking, alcohol, illicit drug use
Review of systems	Conduct full review of systems to identify any potential health concerns that may need to be addressed prior to surgery. See Table 3.2
Functional status and exercise tolerance	Classify whether the patient is independent, partially dependent, or dependent within 30 days of surgery Clarify how many metabolic equivalents (METS) a patient can perform without significant limiting symptoms
Physical exam	See the chapter text and Table 3.3
Studies	See the chapter text and Table 3.4
Assessment	Problem list describing severity and control of medical comorbidities Full risk assessment, including not only cardiopulmonary risks
Recommendations	Be specific and concise with preoperative testing and medication management Include recommendations for postoperative care and preventative measures (e.g., venous thromboembolism (VTE) prophylaxis)

TABLE 3.2 PREOPERATIVE REVIEW OF SYSTEMS

Constitutional	Fevers, weight change (quantify), chills, night sweats, unexplained falls, fatigue
Eyes	Visual changes or impairment
Ears/Nose/Mouth/ Throat	Recent colds, hearing impairment, frequent nose bleeds, tooth pain, loose teeth or dentures
Cardiovascular	Chest pain (at rest and/or with exertion), orthopnea, paroxysmal nocturnal dyspnea, palpitations, edema, syncope or presyncope, claudication symptoms
Respiratory	Dyspnea (at rest and/or with exertion), cough, wheeze, snoring, apnea, excessive daytime sleepiness
Gastrointestinal	Abdominal pain, difficulty swallowing, nausea/ vomiting, diarrhea, constipation, reflux, black or bloody bowel movements
Genitourinary	Dysuria, hematuria, hesitancy, urgency, urinary retention or incontinence, contraception use if relevant, possibility of pregnancy
Musculoskeletal	Joint or muscular pain, problems with mobility
Skin	Rash, wound healing problems, sensitivities (e.g., medical tape), skin color changes (e.g., jaundice)
Neurologic	Difficulty with strength, sensation, balance, speech, memory, cognition, tremor, neuropathy, insomnia
Psychiatric	Depression, anxiety, psychosis
Endocrine	Hot or cold intolerance, dry skin, orthostasis, flushing, polydipsia, polyuria
Hematologic	Easy or excessive bruising or bleeding, blood transfusion preferences
Allergic/ Immunologic	Recurrent or significant allergic response (dyspnea, wheezing, swelling, rash) to an exposure

evaluation presents an opportunity to assess the patient's overall state and readiness to proceed, order diagnostic tests if appropriate, and partner with the patient and the patient's care team to optimize overall health.

TABLE 3.3 THE EXTENDED PREOPERATIVE PHYSICAL EXAM

Vital signs	Include blood pressure, resting heart rate, room air oxygen saturation, height and weight
General	Describe general appearance
Eyes/Ears/Nose/ Mouth/Throat	Assess pupillary symmetry and response to light. Survey for icterus and conjunctival pallor. Survey for difficult airway, oropharyngeal lesions, and note dentition
Cardiovascular	Evaluate for signs of decompensated heart failure and significant valvular disease. Routine inspection, and palpation for heaves, thrills, apical impulse. Auscultation with special attention for volume of S1/ S2, murmurs, gallops. Assess jugular venous pressure (JVP). Assess for peripheral edema
Respiratory	Assess work of breathing, and conduct routine auscultation for wheezes, rales, and rhonchi. Assess for increased expiratory time, especially in patients with obstructive lung disease. Assess for Cheyne-Stokes breathing (associated with decreased cardiac ejection fraction), clubbing
Gastrointestinal	Routine inspection especially for previous surgical scars and distention. Palpation for tenderness or organomegaly. Auscultation of bowel sounds
Genitourinary	Typically deferred unless indicated by history or reason for surgery
Musculoskeletal	Assess functional status, such as ability to get up from seated position without assistance, and ability to ambulate without assistance or labored breathing. Assess for muscular bulk, tone, and symmetry
Hematologic/ lymphatic	Skin survey for pallor, ecchymoses, petechiae. Consider lymph node survey in select patients
Neurologic	Consider basic assessment of orientation. Consider special testing in older adults including memory, cognition, grip strength. If history of stroke or other intracranial lesion, consider cranial nerve testing, extremity strength, sensory testing, gait, cerebellar examination to help establish baseline
Psychiatric	Note affect, pace of speech, thought content
Skin	Survey for skin lesions especially wounds. Assess for rashes at planned surgical site

TIMING OF PREOPERATIVE EVALUATION

For those patients who are planning to have an elective surgery, the timing of the preoperative evaluation should be discussed with the surgical team. An evaluation too close to the planned surgical date may not allow for adequate time to adjust and optimize the patient's medical status; an evaluation too far out from the planned surgical date may address the patient's state of health at that moment, only to have the patient's medical condition change in the interim, altering their perioperative risk at the time of surgery. Ideally patients should be seen about 3–4 weeks prior to their planned surgery when feasible, so that the medical consultant can conduct a thorough evaluation; make appropriate interventions to assess and optimize the patient's health and mitigate perioperative risk; and communicate effectively with the surgical, anesthesia, and other teams.

RISK ASSESSMENT

Guidelines from the American College of Cardiology and American Heart Association suggest a stepwise approach to assessment of perioperative cardiac risk, though these guidelines do not account for all types of surgery or medical risk factors [1]. Consultants should use a combination of available guidelines, tools, and clinical judgment to estimate the overall medical and surgical risk. Some clinical factors to take into consideration include:

- Duration of surgery and use of general anesthesia [2, 3]
- Emergency surgery [4]
- Estimated blood loss
- Surgical location and type of surgery, including route
- Medical comorbidities [5]
- Frailty/functional status (see Chap. 44)
- Presence of recent illness, or exacerbation of chronic disease

There are several tools and calculators available to estimate the risks of surgery. Some estimate specific risks or apply to specific surgeries, while others are broader in their scope. These tools have limitations, and judgment must be used to interpret the results to help the individual patient and clinical team decide on the best approach. Commonly used risk calculator tools include:

- The American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) Surgical Risk Calculator (https://riskcalculator.facs.org/) incorporates multiple patient variables and the specific surgery to calculate the risk of several clinical 30-day outcomes, such as MI or cardiac arrest, venous thromboembolism, pneumonia, surgical site infection, and readmission [6]. A printable summary report is

made available for the patient and surgeon/medical consultant to discuss the patient's risks.

- The Myocardial Infarction and Cardiac Arrest (MICA) risk calculator (https://qxmd.com/calculate/calculator_245/gupta-perioperative-cardiac-risk) uses five risk factors (surgery site, functional status, American Society of Anesthesiologists class [see Chap. 4], creatinine, and age) to estimate perioperative 30-day cardiac arrest or myocardial infarction [7].
- The Revised Cardiac Risk Index (RCRI) uses six variables (high-risk surgery, ischemic heart disease, congestive heart failure (CHF), cerebrovascular disease, diabetes treated with insulin, and serum Cr >2 mg/dL) to estimate risk of cardiac complications [8]. For further information on estimating cardiac risk, see Chap. 6.
- Other tools and calculators exist including those to estimate perioperative pulmonary risk (see Chap. 32), and risk of complications in patients with liver disease (see Chap. 17).

DIAGNOSTIC STUDIES

Inappropriate preoperative testing may result in additional costs, complications, anxiety, and delays to surgery [9–12]. Several professional societies, some participating in The Choosing Wisely campaign, recommend a thoughtful approach to preoperative diagnostic evaluation, avoiding testing that is low-yield and not likely to change management [13–17]. In general, the following principles should be followed for preoperative testing:

- Routine preoperative testing is not recommended, especially with low-risk surgery and/or patients without significant systemic disease.
- A selective approach based on the type of surgery and a careful history and physical is preferred.
- Good communication between the medical consultant, patient, surgeon, and anesthesia team is essential when considering preoperative testing that may affect the timing of surgery.

Table 3.4 provides general guidance on diagnostic tests that are appropriate for preoperative risk assessment and management.

DOCUMENTATION AND COMMUNICATION

The perioperative care of medically complex patients involves multiple providers in multiple settings. How the preoperative evaluation is documented and communicated is just as important as the evaluation itself.

- The patient should be informed of their risk and your recommendations. Discuss with the patient their perception of

TABLE 3.4 PREOPERATIVE TESTING

PT/INR, PTT	Obtain PT/INR in patients taking warfarin, known liver disease and severe malnutrition Consider obtaining coagulation studies in patients with personal or family history of abnormal bleeding
CBC	Consider white blood cell count if history or exam suggests infection, or myeloproliferative disorder Consider hematocrit in patients with history of anemia or who are at risk for anemia, or any patient undergoing surgery in which major blood loss expected Consider platelet count in patients with personal history of abnormal bleeding
Basic metabolic panel	Consider if history or exam suggests risk of an abnormality (e.g., medications that affect electrolytes or renal function) Consider creatinine in patients with known kidney disease, if required to manage medication perioperatively (e.g., anticoagulation), in any patient for whom nephrotoxins will be used, or if large fluid shifts or hypotension are likely
Liver function tests	Consider only if history or exam suggests an abnormality Consider albumin to assess nutritional status in patients who are at risk
Urinalysis	Consider only if history or exam suggests urinary tract infection. Surgeons may request for specific surgeries, e.g., joint replacements or genitourinary procedures
Pregnancy testing	Offer to all women of reproductive age for whom there is a possibility of being pregnant
ECG	Reasonable to perform for patients with coronary artery disease, significant cardiac arrhythmia, heart failure or significant structural heart disease, severe valvular disease, peripheral arterial disease, history of stroke or TIA if one has not been performed in the last 12 months Do not perform for those patients undergoing low-risk surgery
Chest X-ray	Consider only if active pulmonary disease indicated by history or exam
Pulmonary function tests (PFTs)	Obtain only if needed to diagnose and treat previously unknown pulmonary disease prior to elective surgery Used in some surgery specific protocols (e.g., thoracic surgery)
Arterial blood gas (ABG)	Obtain only if suspicion for hypoxemia or CO_2 retention that would affect postop management

what a "successful" surgery outcome would look like, and communicate back with the surgical team if the patient's expected outcome appears to be discordant from the description provided by the surgical team.

- The preoperative evaluation and recommendations should be summarized in a concise but thorough note, which should indicate if the patient's state of health is optimized to proceed with surgery. If not, summarize the recommendations to improve the state of readiness to proceed with surgery and specify who is going to be responsible for following the recommendations.
- Avoid the term "cleared for surgery." This term may be perceived as implying that nothing will go wrong; there may be complications with any surgical procedure. The key assessment is whether the anticipated benefits from proceeding with surgery outweigh the potential risks.
- Describe the estimated risks. Consider using risk calculators for specific areas when available, e.g., cardiac complications. If quoting a specific percent risk of a complication, it is important to provide context of whether the risk is higher than average and whether the risk is modifiable or unavoidable.
- See Table 3.5 for an example of a statement that may be appropriate in documenting specific recommendations.
- If specific recommendations require early attention, or the case is particularly challenging (e.g., surgery must be delayed or canceled), the referring surgeon should be contacted directly.
- The preoperative evaluation note should be copied to the surgeon, the primary care provider, and specialists as appropriate.
- The consult note should clearly state how you (or partners when appropriate) may be reached with questions.
- Find out who in your institution will be seeing the patient postoperatively—it may be the surgery team, a hospitalist, or someone else—and contact that provider if there is something in particular that needs attention postoperatively.

TABLE 3.5 CONSULT NOTE DOCUMENTATION EXAMPLE

Example of a summary statement of the evaluation:
Mr. ____ presents for elective total hip arthroplasty. He is an acceptable candidate for this surgery. He is at increased risk for cardiovascular complications due to diabetes and a prior stroke. However, his exercise tolerance is excellent, thus I do not recommend further cardiac testing prior to this intermediate risk procedure. He is at increased risk for pulmonary complications due to emphysema and obstructive sleep apnea. His pulmonary disease remains stable, and his sleep apnea is well treated. Finally, he is at risk for postoperative delirium due to his age.

Example of specific recommendations on the patient's condition, medication, or anticipatory guidance:
Recommendations:

1. Proceed with surgery without further cardiac testing.
2. Hold warfarin starting 5 days prior to surgery without the need for bridging therapy for his atrial fibrillation, as he is considered low risk for perioperative stroke while off his warfarin.
3. The morning of surgery, I instructed him to take his metoprolol with a small sip of water, and his tiotropium inhaler.
4. Continue beta-blocker without interruption postoperatively. He is anticipated to be taking oral medications immediately postop, so he may be given metoprolol tartrate 50 mg PO q12 hours (home dose), holding if SBP <110 or HR <60; if unable to take oral medications, this can be dosed IV (e.g., metoprolol 5 mg IV q6 hours).
5. Restart home dose of warfarin postoperatively when surgically acceptable without the need for bridging therapy. Typically warfarin can be restarted within 24–48 hours of surgery if hemostasis has been achieved.
6. Continue usual tiotropium inhaler postop without interruption, with albuterol nebulizers as needed.
7. Given OSA, we instructed him to bring his CPAP machine to the hospital, and it should be used postoperatively while sleeping/napping.
8. Pulmonary prophylaxis per routine including attention to pulmonary hygiene and incentive spirometry every hour while awake.
9. VTE prophylaxis per routine.
10. Follow up with PCP 2–4 weeks postop.

KEY CLINICAL PEARLS

- The American College of Surgeons (ACS) National Surgical Quality Improvement Program NSQIP) Surgical Risk Calculator (https://riskcalculator.facs.org/) is a useful tool to calculate the risk of specific 30 day outcomes measures.
- Several professional organizations have recommended against ordering routine tests prior to surgery.

REFERENCES

1. Fleisher LA, Fleischmann KE, Auerbach AD, Barnason SA, Beckman JA, Bozkurt B, Davila-Roman VG, Gerhard-Herman MD, Holly TA, Kane GC, Marine JE, Nelson MT, Spencer CC, Thompson A, Ting HH, Uretsky BF, Wijeysundera DN. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation. 2014;130(24):2215–45.
2. Reilly DF, McNeely MJ, Doerner D, et al. Self-reported exercise tolerance and the risk of serious perioperative complications. Arch Intern Med. 1999;159:2185–92.
3. Smetana GW, Lawrence VA, Cornell JE. Preoperative pulmonary risk stratification for noncardiothoracic surgery: systematic review for the American College of Physicians. Ann Intern Med. 2006;144:581–95.
4. Mullen MG, Michaels AD, Mehaffey JH, Guidry CA, Turrentine FE, Hedrick TL, Friel CM. Risk associated with complications and mortality after urgent surgery vs elective and emergency surgery: implications for defining "quality" and reporting outcomes for urgent surgery. JAMA Surg. 2017;152(8):768–74. https://doi.org/10.1001/jamasurg.2017.0918.
5. Glance LG, Lustik SJ, Hannan EL, Osler TM, Mukamel DB, Qian F, et al. The surgical mortality probability model: derivation and validation of a simple risk prediction rule for noncardiac surgery. Ann Surg. 2012;255:696–702.
6. Bilimoria KY, et al. Development and evaluation of the universal ACS NSQIP surgical risk calculator: a decision aid and informed consent tool for patients and surgeons. J Am Coll Surg. 2013;217(5):833–842.e3.
7. Gupta PK, Gupta H, Sundaram A, Kaushik M, Fang X, Miller WJ, Esterbrooks DJ, Hunter CB, Pipinos II, Johanning JM, Lynch TG, Forse RA, Mohiuddin SM, Mooss AN. Development and validation of a risk calculator for prediction of cardiac risk after surgery. Circulation. 2011;124(4):381–7.
8. Lee TH, Marcantonio ER, Mangione CM, et al. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. Circulation. 1999;100(10):1043–9.
9. Kaplan EB, Sheiner LB, Boeckmann AJ, Roizen MF, Beal SL, Cohen SN, Nicoll CD. The usefulness of preoperative laboratory screening. JAMA. 1985;253(24):3576–81.
10. Smetana GW, Macpherson DS. The case against routine preoperative laboratory testing. Med Clin North Am. 2003;87(1):7–40.
11. Benarroch-Gampel J, Sheffield KM, Duncan CB, Brown KM, Han Y, Townsend CM Jr, Riall TS. Preoperative laboratory testing in patients undergoing elective, low-risk ambulatory surgery. Ann Surg. 2012;256(3):518–28.
12. Sigmund AE, Stevens ER, Blitz JD, Ladapo JA. Use of preoperative testing and physicians' response to professional society guidance. JAMA Intern Med. 2015;175(8):1352–9.
13. Committee on Standards and Practice Parameters, Apfelbaum JL, Connis RT, Nickinovich DG, American Society of Anesthesiologists Task Force on Preanesthesia Evaluation,

Pasternak LR, Arens JF, Caplan RA, et al. Practice advisory for preanesthesia evaluation: an updated report by the American Society of Anesthesiologists Task Force on preanesthesia evaluation. Anesthesiology. 2012;116(3):522–38.
14. National Guideline Centre (UK). Preoperative tests (update): routine preoperative tests for elective surgery. London: National Institute for Health and Care Excellence (UK); 2016.
15. American Society of Anesthesthesiologists, Society of General Internal Medicine, American College of Surgeons, The Society of Thoracic Surgeons, American Society of Clinical Pathology, American Society of Echocardiography, American College of Radiology, American College of Physicians. "Five things physicians and patients should question." Choosing Wisely, http://www.choosingwisely.org/. Accessed 7 Dec 2018.
16. Feely MA, Collins CS, Daniels PR, Kebede EB, Jatoi A, Mauck KF. Preoperative testing before noncardiac surgery: guidelines and recommendations. Am Fam Physician. 2013;87(6):414–8. Review.
17. Cohn SL. Preoperative evaluation for noncardiac surgery. Ann Intern Med. 2016;165(11):ITC81–96.

Chapter 4
Anesthesia Fundamentals

Wendy Suhre

BACKGROUND

The anesthesiologist fulfills several critical roles in the perioperative period apart from the actual administration of the anesthetic. The anesthesiologist assesses and manages patients prior to administration of anesthesia and functions as a "primary care" physician for the patient's medical conditions in the operating room and the immediate postoperative period. Anesthesiologists have a wide range of core medical knowledge as well as broad experience in managing coexisting disease perioperatively. They have specialty knowledge in cardiovascular and respiratory physiology, and critical event management. Many issues of interest to the anesthesiologist in the perioperative period overlap with concerns of the medicine consultant.

PREOPERATIVE ANESTHESIA EVALUATION

Evaluation of complex patients well in advance of surgery can decrease day of surgery cancellations and delays [1, 2]. Comprehensive preoperative evaluation by the anesthesiologist involves obtaining pertinent information from the surgical patient, clinical optimization, and assessment of perioperative risk [3]. The preoperative evaluation is entered into the medical record and serves as the centralized location for patient information required by the anesthesia team to ensure safe patient care perioperatively. The preoperative anesthesia assessment should include the following:

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_4

TABLE 4.1 AMERICAN SOCIETY OF ANESTHESIOLOGISTS (ASA) PHYSICAL STATUS CLASSIFICATION [4]

ASA PS classification	Definition
ASA I	Normal healthy patient
ASA II	Mild systemic disease without substantive functional limitations
ASA III	Severe systemic disease with substantive functional limitations
ASA IV	Severe systemic disease that is a constant threat to life
ASA V	Moribund who is not expected to survive without the operation

Examples of each ASA class are available at https://www.asahq.org/standards-and-guidelines/asa-physical-status-classification-system

TABLE 4.2 MALLAMPATI CLASSIFICATION [6]

Mallampati class	Visible
Class I	Pillars, fauces, soft palate, uvula
Class II	Fauces, soft palate visible, uvula
Class III	Soft palate, base of uvula
Class IV	Soft palate not visible

- American Society of Anesthesiologists (ASA) Physical Status Classification (see Table 4.1). This classification system has been shown to be predictive of perioperative complications and mortality. One study showed mortality rates of 0.1%, 0.7%, 3.5%, and 18.3% for ASA class I, II, III, and IV, respectively [5].
- Basic airway exam including mouth opening, Mallampati Class (see Table 4.2) [6], head extension, jaw protrusion, thyromental distance, and assessment of dentition to detect probable indicators of a difficult intubation or ventilation with a mask.
- History of surgical or anesthetic complications including postoperative nausea or vomiting, difficult intubation, or adverse reaction to anesthesia.
- Patient education regarding types of anesthesia that may be used and the plan for postoperative pain management (see Chap. 56) may alleviate some of the patient's fears and anxiety in the perioperative period.

- Discharge planning particularly for outpatient procedures and surgeries.
- Preparation for transfusions. Although the responsibility for obtaining consent and lab testing for transfusion is typically initiated by the surgical team, the anesthesia providers may initiate such action themselves or ensure that the appropriate blood testing has been performed prior to surgery to avoid delays on the day of surgery.

The remainder of the preoperative anesthesia assessment overlaps with the medical preoperative evaluation (see Chap. 3) and includes current medical comorbidities and whether they have been optimized; current list of medications and instructions as to which drugs should be continued or discontinued prior to surgery (Chap. 5); history and physical exam to assess for any undiagnosed medical conditions that could affect anesthesia and surgery; and functional status assessment in metabolic equivalents (METS) (see Chap. 6).

PERIOPERATIVE ANESTHETIC MANAGEMENT

TYPES OF ANESTHESIA

The anesthetic plan is determined by the anesthesiologist and depends upon surgical and patient factors. The anesthetic plan includes the type of anesthesia, opioids and adjunctive medications for pain control, as well as various other medications used to treat medical comorbidities and to prevent anesthetic complications such as postoperative nausea and vomiting. Anesthetic options include several broad categories.

General Anesthesia

General anesthesia produces a state of unconsciousness, amnesia, immobility, and attenuation of the responses to noxious stimuli [7]. There are three phases of general anesthesia: Induction, maintenance, and emergence.

- Induction involves preoxygenation, administration of inhalational or IV anesthetics, and sometimes opioid and paralytic medications depending on airway management. Following induction, an endotracheal tube (ETT) or laryngeal mask airway (LMA) is placed. The patient's native airway may be used for some procedures. The type of surgery, surgeon requirements, and patient factors determine which airway device is chosen.

- Maintenance of general anesthesia is required for the duration of the surgery and is typically achieved using inhalational or IV anesthetics such as sevoflurane or propofol. Opioid administration is often used as it decreases other anesthetic agent requirements and provides some initial postoperative analgesia. Patients are monitored closely ensuring adequate oxygenation, ventilation, and hemodynamic stability. Underlying comorbidities, such as diabetes, are also managed throughout the procedure.
- Emergence from general anesthesia is a continuum that occurs after the anesthesia has been discontinued, muscle relaxants have been reversed, and the patient begins to arouse and respond to verbal stimulation and continues through extubation and arousal in the recovery room. Breathing devices are typically removed once the patient has demonstrated the ability to adequately oxygenate, ventilate, and maintain an open airway on their own.

Regional Anesthesia

Regional anesthesia refers to the use of local anesthetic drugs in peripheral nerve blocks (PNB) and neuraxial anesthesia (NA)(spinal, epidural). Blocks may be performed as a single shot injection (spinal, PNB) or as a continuous infusion through a catheter (epidural, PNB). Regional techniques may be used as the sole anesthetic for a procedure, or in conjunction with general anesthesia or sedation.

Monitored Anesthesia Care (MAC)

Monitored anesthesia care refers to "instances in which the anesthesiologist has been requested to provide specific anesthesia services in connection with which a patient receives local anesthesia or, in some cases, no anesthesia at all" [8]. MAC may simply consist of the anesthesiologist monitoring the patient and providing medical care as appropriate, but often MAC includes the administration of sedative and pain medications. Hypervigilance is required, as the patient may progress to a level of deep sedation making them at risk for airway obstruction, oxygen desaturation, or aspiration.

Moderate Sedation

Many procedures are performed without the specialized care of an anesthesiologist if only light or moderate sedation is needed. In these instances, an RN with specific training in moderate sedation, under the supervision of the proceduralist, can administer the appropriate medications. Care is taken to avoid deep sedation and need for airway

management. Oxygen is generally administered via nasal cannula or facemask during these procedures.

ANESTHESIA CONSIDERATIONS

No one type of anesthetic is appropriate for all patients, so an anesthetic plan must be formulated and individualized for each patient. Important considerations for the anesthesiologist are as follows:

- Premedications. A wide variety of medications, in addition to what the patient may already be taking, may be given to the patient in the preoperative holding area. The use of premedications depends on the patient's medical history and may be used to manage their comorbidities or may be administered to prevent perioperative complications.
- Type of anesthesia. When choosing which anesthetic to use for the procedure, the anesthesiologist considers patient factors (airway assessment, comorbidities, patient preference), type and duration of surgery, patient positioning, and surgeon preference.
- Monitoring. Standard monitoring used on virtually all patients include EKG, pulse oximetry, blood pressure (noninvasive vs. intra-arterial), end-tidal CO_2, and temperature (if changes in temperature are expected) [9]. Special circumstances may require neuromuscular monitoring, EEG, central venous catheters, pulmonary artery catheters, or transesophageal echocardiography.
- Intravenous (IV) access. Depending on type of surgery, estimated blood loss, and preoperative lab values, the number and size of IV or central venous catheters should be determined and obtained prior to the commencement of the procedure.
- Positioning. Proper positioning of the patient is extremely important and requires a team effort in the operating room, including the anesthesiologist. Certain positions may result in significant cardiovascular or respiratory changes such as with steep Trendelenburg, steep reverse Trendelenburg, and sitting/beach chair. It is important to consider whether or not the patient can tolerate the positioning required.
- Pain control. Although opioid medications are still an important mainstay of pain control, many other drugs and regimens are available and being used more commonly. These include acetaminophen, gabapentin, celecoxib, ketamine, dexmedetomidine, local anesthetics, and regional anesthesia. Surgical and patient factors affect which medications are chosen and which may be continued throughout the postoperative period.

- Cardiac device management. All cardiac implantable electronic devices (CIEDs) should be interrogated to determine if they are functioning normally, that the battery has adequate remaining life, and a determination made as to whether the device needs specific programming for surgery or if magnet placement is all that might be required for intraoperative management. Depending on the institution, this may be done in a pre-anesthesia clinic or in the preoperative holding area typically by a cardiologist or anesthesiologist trained to manage CIEDs perioperatively (see Chap. 11).
- Deep brain/peripheral nerve stimulators. These nerve stimulators can be damaged during surgery and are usually turned off prior to surgery. The patients should always bring their programmer with them to surgery so the device may be turned off if needed.
- Postoperative management. Anesthetic plans also include caring for the patient in the post-anesthesia care unit (PACU). Pain management, antiemetics, use of CPAP/BiPAP, blood pressure control, adequate monitoring, and appropriate discharge of the patient from the PACU are managed by the anesthesiologist [10].

ANESTHETIC COMPLICATIONS

The administration of anesthesia (medications, positioning, airway management) can result in various complications. Any provider who manages patients postoperatively should be aware of the more likely or serious complications and how to manage them.

- Hypotension. All anesthetics, both general and regional, can lower blood pressure. Generally, these aberrations are easily treated with fluids or vasopressors. Patients taking ACE/ARBs are at an increased risk of more profound hypotension following induction of anesthesia [11].
- Nerve injury/neuropathy. Unless caused by the surgery or by tissue edema, most postoperative nerve injury is caused by compression from malpositioning. Ulnar neuropathies are the most common but the sciatic, common peroneal, radial, and median nerves can also be damaged. Patients may require evaluation if neuropathy persists. The best way to avoid nerve injuries is with proper positioning.
- Dental/lip/tongue injuries. One of the most common complications with anesthesia. Injuries can occur during bag mask ventilation, intubation/LMA placement, or upon emergence/

extubation. Assessing a patient's dentition prior to surgery can help avoid dental injury.

- Awareness. Anesthesia awareness refers to patients having explicit recall of events that occurred while under a general anesthetic. To decrease risk of awareness, the depth of anesthesia is monitored during general anesthesia. Risk factors include emergent surgery, hemodynamic instability (severe hypotension), and issues with anesthesia delivery (e.g., infiltrated IV with total intravenous anesthesia) [8].
- Vision loss/eye injury. Postoperative vision loss is a rare complication, but devastating. Risk factors include steep Trendelenburg position, blood loss, anemia, and hypotension in the prone position. The most common eye injury related to anesthesia is corneal abrasion. Care should be taken to protect the eyes during and after the administration of anesthesia.
- Allergic reactions/malignant hyperthermia. Allergic reactions to antibiotics are the most common. Other adverse reactions to drugs can occur including malignant hyperthermia (MH). MH is a syndrome triggered by succinylcholine and volatile anesthetics (e.g., sevoflurane) in genetically susceptible patients. The initial presentation is characterized by hypercarbia, tachycardia, muscle rigidity while hyperthermia is typically a late sign. The treatment of malignant hyperthermia includes dantrolene, hyperventilation, active cooling, and the treatment of complications of MH including hyperkalemia, metabolic acidosis, and rhabdomyolysis/renal injury.
- Postoperative delirium and postoperative cognitive dysfunction (POCD). These problems are more common in older patients and have been receiving significant attention. Treatments and preventive measures are being studied for both postoperative delirium and POCD, but no effective treatments have been established [12, 13]. See Chap. 53 for more details on postoperative delirium.
- Postoperative nausea and vomiting (PONV). PONV is one of the most common complications and most bothersome to patients after anesthesia. Risk factors include female gender, age <50 years old, nonsmoker, history of PONV or motion sickness, undergoing gynecologic or laparoscopic procedure, postoperative opioids, and inhalational anesthetic use. Total intravenous anesthesia with propofol, regional anesthesia, opioid sparing techniques, and preoperative/intraoperative antiemetics are strategies used to decrease the risk of PONV [14].

- Postoperative urinary retention (POUR). Risk factors for POUR include history of benign prostatic hypertrophy, prior POUR, advanced age, type of surgery (urologic, inguinal, genital), neuraxial anesthesia, and perioperative opioids. A bladder ultrasound is obtained if a patient has been unable to void after 4 hours postoperatively. If greater than 600 mL is measured, then catheterization is performed. For ambulatory patients, a single catheterization may be enough. Ambulatory patients should be instructed to seek medical care if they are unable to void for 8 hours after discharge. For patients who are admitted, the catheter may be left in place and a voiding trial should be performed prior to discharge.

KEY CLINICAL PEARLS

- Evaluation of complex patients well in advance of surgery can decrease day of surgery cancellations and delays.
- The anesthesiologist determines the type of anesthetic, airway management, and perioperative pain plan.
- Many anesthetic complications can be mitigated or prevented with proper planning.

REFERENCES

1. Ferschl MB, Tung A, Sweitzer B, Huo D, Glick DB. Preoperative clinic visits decrease operating room delays and cancellations. Anesthesiology. 2005;103:855–9.
2. Blitz JD, Kendale SM, Jain SK, Cuff GE, Kim JT, Rosenberg AD. Preoperative evaluation clinic visit is associated with decreased risk of in-hospital mortality. Anesthesiology. 2016;125:280–94.
3. American Society of Anesthesiologists Task Force on Preanesthesia Evaluation. Practice advisory for preanesthesia evaluation. Anesthesiology. 2012;116:522–38.
4. ASA Physical Status Classification System, American Society of Anesthesiologists. https://www.asahq.org/resources/clinical-information/asa-physical-status-classification-system. Accessed 10 Aug 2018.
5. Wolters U, Wolf T, Stutzer H, et al. ASA classification and perioperative variables as predictors of postoperative outcome. Br J Anaesth. 1996;77:217–22.
6. Samsoon GL, Young JR. Difficult tracheal intubation: a retrospective study. Anaesthesia. 1987;42(5):487–90.
7. Crowder MC, Palanca BJ, Evers AS. Mechanisms of anesthesia and consciousness. In: Barash PG, Cullen BF, Stoelting RK, Calahan MK, Stock MC, Ortega R, Sharar SR, Holt NF, editors. Clinical anesthesia. 8th ed. Philadelphia: Wolters Kluwer; 2017.
8. Smith I, Skules M, Phillip BK. Ambulatory (outpatient) anesthesia. In: Miller RD, Cohen NH, Eriksson LI, Fleischer LA, Wiener-Kronish JP, Young WL, editors. Miller's anesthesia. 8th ed. Philadelphia: Elsevier Saunders; 2015.
9. Standards for Basic Anesthetic Monitoring, American Society of Anesthesiologists. http://www.asahq.org/quality-and-practice-management/standards-guidelines-and-related-resources/standards-for-basic-anesthetic-monitoring. Accessed 10 Aug 2018.

10. Committee on Standards and Practice Parameters; Apfelbaum JL; The Task Force on Postanesthetic Care; Silverstein JH; Chung FF, et al. Practice guidelines for Postanesthetic care: an updated report by the American Society of Anesthesiologists Taskforce on Postanesthetic care. Anesthesiology. 2013;118:291–307.
11. Hollman C, Fernandes NL, Biccard BM. A systematic review of outcomes associated with witholding or continuing angiotensin converting enzyme inhibitors and angiotensin receptor blockers before noncardiac surgery. Anesth Analg. 2018;127(3):678–87.
12. Humeidan M, Deiner SG, Koenig N. Chapter 30. In: Reves JG, et al., editors. Geriatric anesthesiology. 3rd ed. Cham: Springer International Publishing; 2018.
13. Hood R, Budd A, Sorond FA, Hogue CW. Peri-operative neurological complications. Anaesthesia. 2018;73 Suppl 1:67–75.
14. Gan TJ, Diemunsch P, Habib AS, Kovac A, Kranke P, Meyer TA, Watcha M, Chung F, Angus S, Apfel CC, Bergese SD, Candiotti KA, Chan MT, Davis PJ, Hooper VD, Lagoo-Deenadayalan S, Myles P, Nezat G, Philip BK, Tramèr MR; Society for Ambulatory Anesthesia. Consensus guidelines for management of postoperative nausea and vomiting. Anesth Analg. 2014;118:85–113.

Chapter 5
Perioperative Medication Management

Sabeena Setia

BACKGROUND

The management of a patient's home medication regimen around a surgical procedure is an important component of perioperative medicine. Clinicians must weigh the risk for a patient's routine medications to cause perioperative harm versus the risk of stopping the medication with regard to the underlying medical condition. This chapter provides guidance for clinicians in this risk–benefit assessment while acknowledging that there is a general lack of outcome data about routine medication management in the perioperative setting.

PREOPERATIVE EVALUATION

It is essential to obtain a comprehensive medication list prior to surgery, including over the counter medications, supplements, inhalers, eye drops, and oral contraceptives, as well as usage, dose, and route (e.g., oral, transdermal, and subcutaneous) for all medications. Clinicians should also consider the type of surgery and expected postoperative course and how these may impact perioperative medication management, including prolonged postoperative nil-per-os (NPO) state, potential to affect liver or kidney function and hence drug clearance, etc. Likewise, the underlying medical condition that is being treated (e.g., organ transplant, severe inflammatory bowel disease) must also be considered in the decision to continue or hold specific medications.

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_5

PERIOPERATIVE MANAGEMENT

PREOPERATIVE

Recommendations for preoperative medication management are shown in Table 5.1. If time permits, it is ideal to stop any medication that may prove harmful perioperatively (e.g., anticoagulants, oral hypoglycemics) while continuing essential medications (e.g., long-term corticosteroids, beta blockers, and organ transplant medications) without interruption. Consider using parenteral or topical forms of essential medications if a patient is NPO for a prolonged period (e.g., esophageal surgery or major head and neck surgery).

TABLE 5.1 PREOPERATIVE MEDICATION MANAGEMENT

Antiarrhythmic medications	Continue on morning of surgery, including digoxin
Anticoagulants Warfarin Direct oral anticoagulants (DOAC)	In general, warfarin is held 5–7 days prior to surgery and DOACs are held 24–48 hours prior to surgery (depending on renal function) Dabigatran may need to be held for up to 72–120 hours prior to surgery See Chap. 26 for additional recommendations
Antihypertensives (nondiuretic) Calcium channel blockers Nitrates (long and short-acting) Alpha blockers Combined alpha/beta blockers Alpha antagonists (clonidine)	In general, continue these antihypertensive medications on morning of surgery Abrupt discontinuation of clonidine can cause rebound hypertension, see Chap. 10
Antihypertensives ACE-inhibitors, ARBs Loop diuretics Thiazide diuretics Potassium sparing diuretics Direct vasodilators (hydralazine, minoxidil)	In general, hold ACE-Is, ARBs, and loop diuretics 12–24 hours prior to surgery, unless patient has uncontrolled hypertension or advanced CHF Perioperative management of thiazide diuretics, potassium sparing diuretics and direct vasodilators should be individualized based on patient factors or at clinician's discretion See Chaps. 8 and 10 for detailed discussion and recommendations

TABLE 5.1 (CONTINUED)

Antiplatelet medications	In general, aspirin and clopidogrel are discontinued 5–7 days preoperatively. See Chap. 7 for further recommendations
Asthma and COPD medications Inhaled steroids or inhaled steroid combinations Inhaled anticholinergics Inhaled beta-agonists Oral medications (Montelukast)	In general, continue all inhaled and oral medications for asthma and COPD. Consider holding theophylline perioperatively, see Chap. 33 for further recommendations
Bladder and prostate medications Alpha-1 adrenergic antagonists 5-alpha reductase inhibitors	In general, continue on morning of surgery Notify eye surgeon if patient is taking one of these medications prior to cataract surgery, given risk of floppy iris syndrome
Cholesterol lowering medications	In general, continue statins on morning of surgery Hold nonstatin medications (niacin, gemfibrozil, fenofibrate, cholestyramine, colestipol, ezetimibe) on morning of surgery
Diabetes medications Oral and noninsulin injectable medications Insulin	In general, hold oral hypoglycemic agents and noninsulin injectable mediations on morning of surgery Hold SGLT2 inhibitors (canagliflozin, dapagliflozin, empagliflozin) 3 days prior to surgery due to potential risk of euglycemic ketoacidosis In general, hold prandial insulin on morning of surgery and continue basal insulin, with dose adjustments on night before and morning of surgery. See Chap. 13 for detailed recommendations on insulin management
Gastrointestinal medications PPIs, H2 blockers, anti-emetics	Continue most gastrointestinal medications perioperatively with the exception of particulate antacids (e.g., calcium carbonate, tums)
Gout medications	In general, continue preventative medications preoperatively. See Chap. 42 for further recommendations

(continued)

TABLE 5.1 (CONTINUED)

Hormones Estrogen Progesterone Testosterone	OCPs and HRT management should be individualized based on patient and surgical risk factors Continue testosterone perioperatively See Chaps. 15 and 45 for further details on perioperative management of hormone therapies
Hormonal medications SERMs (tamoxifen) Aromatase inhibitors (anastrozole)	Recommend stopping SERMs 2–4 weeks when patient or surgery factors confer high risk for VTE Aromatase inhibitors can usually be continued perioperatively. See Chap 15 for detailed recommendations
Immunosuppressant for organ transplant Mycophenolate mofetil, tacrolimus, cyclosporine	Continue perioperatively, in consultation with transplant specialists
Neurologic medications Antiepileptics Parkinson's disease	In general, continue antiepileptics perioperatively See Chap. 30 for recommendations on medication management in Parkinson's disease, including discussion of MAO inhibitors
Osteoporosis medications Bisphosphonates, calcium, and vitamin D	Hold on morning of surgery
Pain medications Opioids, acetaminophen, GABA analogs, muscle relaxants, baclofen, NSAIDs	In general, most pain medications can be continued perioperatively Consider stopping NSAIDs 3–5 days prior to surgery See Chap. 43 for guidelines on opioid partial agonists or antagonists (buprenorphine–naloxone) and naltrexone
Psychiatric medications Antidepressants (SSRIs and SNRIs), bupropion and antianxiety medications (benzodiazepines, buspirone) Mood stabilizers/ neuroleptic Stimulants (methylphenidate, Ritalin)	In general, continue psychiatric medications perioperatively In consultation with psychiatry, consider holding lithium perioperatively due to risk of lithium toxicity in patients with GFR <60 or in patients undergoing procedures with major fluid shifts. Individualize management of stimulants based on patient's factors and in consultation with anesthesia, given paucity of data

TABLE 5.1 (CONTINUED)

Pulmonary hypertension medications PDE-5 inhibitors sGC stimulators Endothelin receptor antagonists	In general, continue medications for pulmonary hypertension perioperatively, with consultation from pulmonary or cardiology specialist
Rheumatologic medications and medications for SLE	Management of biologic agents for RA and SLE should be individualized based on severity of disease and nature of surgery, in consultation with rheumatologist and surgeon. See Chaps. 40 and 41 for details
Steroids	In general, continue steroids perioperatively and consider "stress dose steroids" depending on type of surgery. See Chap. 14 for details
Thyroid medications	Continue on morning of surgery
Vitamins and nutritional supplements	Stop for 1 week prior to surgery Supplements such as iron, calcium, and vitamin D prescribed for nutritional deficiency do not need to be held for 1 week prior to surgery, but should not be taken on the morning of surgery

POSTOPERATIVE

See Table 5.2 for recommendations on restarting common outpatient medications.

Resume usual outpatient medications as tolerated by patient's ability to take oral medications and current and expected medical indication, with certain exceptions (such as diabetes medications if the patient is not eating—see Chap. 13 for details). Always discuss with the surgeon when restarting antiplatelet agents and anticoagulants (see Chaps. 7, 9, and 26 for details), including nonsteroidal anti-inflammatory drugs (NSAIDs).

Most cardiovascular medications should be continued postoperatively. However, a patient's blood pressure often falls postoperatively (especially if the patient has an epidural or spinal anesthesia), so we suggest writing holding parameters for all vasoactive medications. Dose reduction is frequently necessary for the first 2–3 days. Sequentially add back each vasoactive medication as blood pressure permits.

Following some surgeries, particularly those involving major manipulation of the gastrointestinal tract, the administration of oral

TABLE 5.2 POSTOPERATIVE MEDICATION MANAGEMENT

Drugs to restart as soon as clinically possible	Beta blockers Antiarrhythmics Statins Nebulizers and inhalers Corticosteroids (discuss with surgical team as needed and see Chap. 14) Thyroid medications Most psychiatric medications Medications for pulmonary hypertension Parkinson medications Immunosuppressive, transplant, and antiretroviral medications (discuss with surgery and transplant teams as needed)
Drugs to restart carefully based on clinical status and discussion with surgical team)	Antiplatelet agents Anticoagulants (see Chap. 26) Antihypertensives and diuretics Insulin and non-insulin diabetes medications (see Chap. 13) Rheumatologic agents

medications might be temporarily prohibited. For essential medications, consider using alternate formulations such as intravenous (IV), transdermal, or per rectum if available. In other cases (e.g., after gastric bypass surgery, esophagectomy, or with feeding tubes), medications may need to be crushed for administration. Keep in mind that extended release formulations cannot be crushed, necessitating a substitution with shorter acting equivalents. We advise reviewing the medication list with a pharmacist and the surgical team to ensure that appropriate adjustments are made.

CONSIDERATIONS FOR SPECIFIC MEDICATIONS

ACE inhibitors (ACE-I) and angiotensin receptor blockers (ARBs) The perioperative use of ACE-Is and ARBs has been a subject of debate. A recent meta-analysis confirms that continuation of ACE-Is and ARBs in noncardiac surgery is associated with an increased risk of intraoperative hypotension, without increased risk of mortality [1]. Conversely, holding these agents in patient with severe hypertension or advanced heart failure may complicate perioperative management

due to increased afterload and hypertension. We recommend that these agents be held the morning of surgery unless the patient is persistently hypertensive with a systolic BP consistently above 180 mmHg. Consider holding the evening dose the night before surgery if the ACE-I or ARB is normally taken in the evening. The other situation in which these medications should be held is if renal blood flow will be compromised during the surgical procedure (e.g., some AAA repairs). For patients with advanced heart failure, cirrhosis, or severe hypertension, decisions about continuing these medications should be made on a case by case basis.

Antiplatelet agents In general, aspirin is continued perioperatively in patients with known cardiovascular disease. The data on this issue however, remain controversial. For patients with recent acute coronary syndrome, recently placed cardiac stents, high risk mechanical heart valves, or recent stroke, one or more antiplatelet agents (usually aspirin) should be continued perioperatively without interruption, if reasonable from a surgical perspective (see Chap. 7 for more details). The PeriOperative ISchemic Evaluation 2 (POISE-2) trial raised questions about the safety and utility of perioperative continuation of aspirin, though high-risk patients (those who received a bare metal stent within 6 weeks, or a drug-eluting stent within 1 year) were excluded from the study. In addition, the range of aspirin used in this trial was between 75 and 300 mg. In general, we recommend that there be shared decision making regarding the risks of continuing or stopping antiplatelet therapy among the patient, cardiologist, neurologist, and the surgical team [2, 3].

Beta blockers Abrupt withdrawal of beta blockers can precipitate rebound tachycardia, hypertension, and angina. If the patient already takes a beta blocker, it should be continued perioperatively (use IV equivalent if NPO). The initiation of beta blockade strictly for perioperative reasons is no longer routinely recommended in light of evidence of potential harm in low-risk patients—see Chap.7 for a more detailed discussion.

Calcium channel blockers These agents are generally safe to continue; consider holding perioperatively if the patient's blood pressure runs low preoperatively. Calcium channel blockers are usually continued if given for rate control for atrial fibrillation.

Clonidine Abrupt withdrawal may precipitate hypertension and tachycardia. Substitute an equivalent dose transdermal patch if possible. It takes 2–3 days for the patches to begin working. If possible, initiate the patch preoperatively. Have the patient take their full oral

dose on the first day the patch is applied, 1/2 the usual dose on day 2, 1/4 of the usual dose on day 3, and then stop the oral medication. Patches are changed every 7 days.

Diuretics Conventional practice and our recommendation are to hold diuretics on the morning of surgery due to concern for intraoperative hypotension. One small 2010 study, however, found no difference in intraoperative hypotension in a lower risk patient population [4]. Diuretics may be restarted postoperatively based on clinical assessment of volume status rather than resuming based on a predetermined schedule. Many patients are intravascularly depleted postoperatively due to third spacing, poor PO intake, etc., though some may become hypervolemic from intraoperative resuscitation or maintenance IV fluids, especially in the setting of heart failure or chronic kidney disease (CKD).

Statins Data from a few studies in vascular surgery patients suggest that the use of the HMG-CoA reductase inhibitors (statins) perioperatively may reduce the risk of perioperative cardiovascular events (e.g., myocardial infarction (MI), angina, and stroke) [5, 6]. A systemic review suggested treating statin-naïve patients perioperatively may reduce the risk of perioperative atrial fibrillation, myocardial infarction, and decrease mean length of hospital stay in both cardiac and noncardiac surgery [7]. For statin-naïve patients, consider initiating a statin prior to vascular surgery and in patients with increased risk for cardiovascular events, as these patients usually also have indications for lipid lowering therapy. If the patient is already on a statin, it should be continued preoperatively and resumed postoperatively when able.

Estrogen-related medications Estrogen-related medications including combined hormonal contraceptives (oral, vaginal, or transdermal) and hormone replacement therapy carry an increased risk of thrombosis, which is further increased by high-risk surgical procedures. For high-risk patients and/or procedures, these medications should be held 2–4 weeks prior to surgery if they can be safely stopped. For those on Oral Contraceptive Pill (OCPs), the potential risk of unintended pregnancy while this medication is held should be considered very carefully; it may be better to continue OCPs in some cases. See Chap.15 for a detailed discussion.

Selective estrogen receptor modulators (SERMs) The most commonly used SERM in the United States is the first-generation SERM tamoxifen, which is well known to increase risk of venous thromboembolism (VTE). Data among breast cancer patients have

shown that the VTE risk is significantly increased following surgical procedures among patients on recent chemotherapy or on long-term tamoxifen therapy. We recommend stopping SERMs 2–4 weeks preoperatively for procedures or patient factors that confer or high risk for VTE, e.g., major joint surgery, spine, or neurosurgery. Among patients undergoing microvascular surgery, tamoxifen may be held 2–4 weeks prior and 2–4 weeks after the procedure in consultation with patient's surgeon and oncologist [8, 9].

Selective serotonin reuptake inhibitors (SSRIs) Currently, there is no compelling evidence to recommend the routine discontinuation of SSRIs preoperatively, especially in patients being treated for depression. Expert consensus is that the psychiatric risks associated with discontinuation of SSRIs outweigh the potential risks of severe perioperative bleeding. The putative mechanism for potential increased bleeding risk is a serotonin mediation effect on platelet aggregation. Two retrospective cohort studies of patients receiving coronary artery bypass graft surgery did not show a difference in perioperative bleeding or mortality but did show an increase in the volume of red blood cell unit transfusion in the postoperative period among patients on SSRIs [10, 11]. A large retrospective study of more 500,000 patients found an association with in-hospital mortality, bleeding, and 30-day readmission rate in patients receiving SSRIs prior to major surgery. Of note, the increased risk for mortality is absent if adjusted for patients with depression [12]. A systematic review consisting of 14 observational studies did demonstrate an increased risk of perioperative bleeding and RBC transfusions, though the increased risk of transfusion was highly associated with concurrent use of antiplatelet and anticoagulant medications [13]. The type of surgery appears to play a role with an increased risk in breast and orthopedic surgeries. There are no prospective studies to date that examine this issue.

Monoamine oxidase inhibitors (MAOIs) There are a number of drug interactions with MAO B inhibitors, especially with opiate medications and antidepressants including labile blood pressures and serotonin syndrome. We recommend discussing perioperative management of MAO B inhibitors with the anesthesia team. See Chap. 30 for a more detailed discussion.

Nonsteroidal anti-inflammatory drugs (NSAIDs) NSAIDS are excellent medications for controlling perioperative pain however are often underutilized due to concerns for GI bleeding, compromised anastomotic healing (particularly in colorectal surgery) or kidney

injury. A large statewide retrospective cohort study showed a significantly increased risk of anastomotic complications in patients undergoing urgent colorectal resection. However, there was no major difference in mortality between patients in the NSAID and non-NSAID groups [14]. In a multi-institutional retrospective study of patients undergoing emergency bowel surgery, a post-hoc analysis demonstrated no differences in small bowel anastomotic failure between patients on NSAIDS versus those not on NSAIDs [15]. In carefully selected patients, NSAIDS can be safely stopped 3–5 days preoperatively depending on the type of surgery as well as the half-life of the NSAIDS. NSAIDs vary greatly in half-life, COX-2 selectivity, brand names, and formulations. In general, NSAIDs with shorter half-lives include ibuprofen, indomethacin, diclofenac, and ketoprofen; NSAIDs with longer half-lives include naproxen, nabumetone, meloxicam, and piroxicam. Keep in mind that there are also extended release preparations of several of the shorter acting medications. Selective COX 2 inhibitors are more widely being used an accepted opiate-sparing strategy for perioperative pain control. Still, discussions regarding perioperative continuation of all NSAIDS are necessary given known increased risk of surgical site bleeding and anastomotic leak in selected patients' populations (e.g., bariatric surgery, colorectal surgery).

Opioid pain medications Management of chronic opioid pain medications perioperatively requires discussion with the surgeon, the physician prescribing the pain medications (if different from the surgeon), and the patient. There is limited evidence that patients undergoing orthopedic surgery may have worse outcomes if receiving chronic opioid therapy [16], but whether reduction in preoperative opioid medication results in better outcomes is unknown. Pain management specialist consultation, if available, should be considered for patients receiving chronically high doses of opioid medications preoperatively.

Rheumatologic and biologic medications for autoimmune disease Among patients with autoimmune disease such as RA, SLE, spondyloarthropathies, and inflammatory bowel disease, disease-controlling agents may increase the risk of perioperative infection or impair wound healing. This risk must be balanced with the risk for disease flare, if these agents are held. There are very limited data to address general perioperative management of these medications. In 2017, guidelines for the management of rheumatologic medications among patients underwent elective total hip and total knee arthroplasty were published [17]. See Chaps. 40 and 41 for detailed recommendations.

REFERENCES

1. Hollmann C, Fernandes NL, Biccard BM. A systematic review of outcomes associated with withholding or continuing angiotensin-converting enzyme inhibitors and angiotensin receptor blockers before noncardiac surgery. Anesth Analg. 2018;127:678.
2. Devereaux PJ, Mrkobrada M, Sessler D. Aspirin in patients undergoing noncardiac surgery. N Engl J Med. 2014;370:1494–150.
3. Gerstein NS, Schulman PM, Gerstein WH, et al. Should more patients continue aspirin therapy perioperatively? Clinical impact of aspirin withdrawal syndrome. Ann Surg. 2012;255(5):811–9.
4. Khan NA, Campbell NR, Frost SD, et al. Risk of intraoperative hypotension with loop diuretics: a randomized controlled trial. Am J Med. 2010;123:1059e1–8.
5. Durazzo AE, Machado FS, Ikeoka DT, et al. Reduction in cardiovascular events after vascular surgery with atorvastatin: a randomized trial. J Vasc Surg. 2004;39:967–76.
6. Schouten O, Boersma E, Hoeks SE, et al. Fluvastatin and perioperative events in patients undergoing vascular surgery. N Engl J Med. 2009;361:980–9.
7. Chopra V, Wesorick DH, Sussman JB, et al. Effect of perioperative statins on death, myocardial infarction, atrial fibrillation, and length of stay. Arch Surg. 2012;147(2):181–9.
8. Hussain T, Kneeshaw PJ. Stopping tamoxifen peri-operatively for VTE risk reduction: a proposed management algorithm. Int J Surg. 2012;10(6):313–6.
9. Ellis AJ, Hendrick VM, Williams R, Komm BS. Selective estrogen receptor modulators in clinical practice: a safety overview. Expert Opin Drug Saf. 2015;14(6):921–34.
10. Andreasen JJ, Riis A, Hjortdal VE, et al. Effect of selective serotonin reuptake inhibitors on requirement for allogeneic red blood cell transfusion following coronary artery bypass surgery. Am J Cardiovasc Drugs. 2006;6:243–50.
11. Xiong GL, Jiang W, Clare RM, et al. Safety of selective serotonin reuptake inhibitor use prior to coronary artery bypass grafting. Clin Cardiol. 2010;33(6):E94–8.
12. Auerbach AD, Vittinghoff E, Maselli J, et al. Perioperative use of selective serotonin reuptake inhibitors and risks for adverse outcomes of surgery. JAMA Intern Med. 2013;173(12):10751081.
13. Mahdanian AA, Rej S, Bacon SL, Ozdin D, Lavoie KL, Looper K. Serotonergic antidepressants and perioperative bleeding risk: a systematic review. Expert Opin Drug Saf. 2014;13(6):695–704.
14. Hakkarainen TW, Steele SR, Bastaworous A, et al. Nonsteroidal anti-inflammatory drugs and the risk for anastomotic failure, a report from Washington State's Surgical Care and Outcomes Assessment Program (SCOAP). JAMA Surg. 2015;150(3):223–8.
15. Haddad NN, et al. Perioperative use of nonsteroidal anti-inflammatory drugs and the risk of anastomotic failure in emergency general surgery. J Trauma Acute Care Surg. 2017;83(4):657–61.
16. Zywel MG, Stroh A, Lee SY, Bonutti PM, Mont MA. Chronic opioid use prior to total knee arthoplasty. J Bone Joint Surg Am. 2011;93:1988–93.
17. Goodman SM, Spring B, Guyatt G. American College of Rheumatology/American Association of hip and knee surgeons guideline for the perioperative management of antirheumatic medication in patients with rheumatic diseases undergoing elective total hip or total knee arthroplasty. Arthritis Care Res. 2017;69:1111–24.

Chapter 6
Cardiac Risk Stratification

Paul B. Cornia, Kay M. Johnson, and Molly Blackley Jackson

BACKGROUND

Perioperative cardiovascular complications pose serious risk, especially to patients with pre-existing cardiac disease. The degree of risk varies widely depending on the patient's medical comorbidities and type of surgery. A careful medical evaluation before surgery can help inform a discussion of risk for patients and providers and suggest management strategies to mitigate risk.

PREOPERATIVE CARDIAC RISK EVALUATION

A focused history and physical examination (including an assessment of functional capacity) and an understanding of the proposed surgery provide the initial foundation for a discussion of perioperative cardiac risk and can help inform the need for additional evaluation. Guidelines from the American College of Cardiology/American Heart Association (ACC/AHA) and European Societies of Cardiology and Anaesthesiology (ESC/ESA) provide an evidence-based approach to perioperative cardiovascular risk stratification [1, 2]. For patients at elevated risk for major cardiac complications, preoperative noninvasive stress testing may be considered, if the results will alter perioperative decision making. We advocate for a similar stepwise approach (Fig. 6.1), recognizing that guidelines are not intended to replace good clinical judgment.

Type of surgery, expected blood loss, duration of anesthesia, and anticipated fluid shifts each contribute to surgical stress. Surgeries in the same general category may have varying degrees of risk (e.g., among intraperitoneal surgeries, the laparoscopic band surgery likely has lower risk than a complex open abdominal surgery). Procedures

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_6

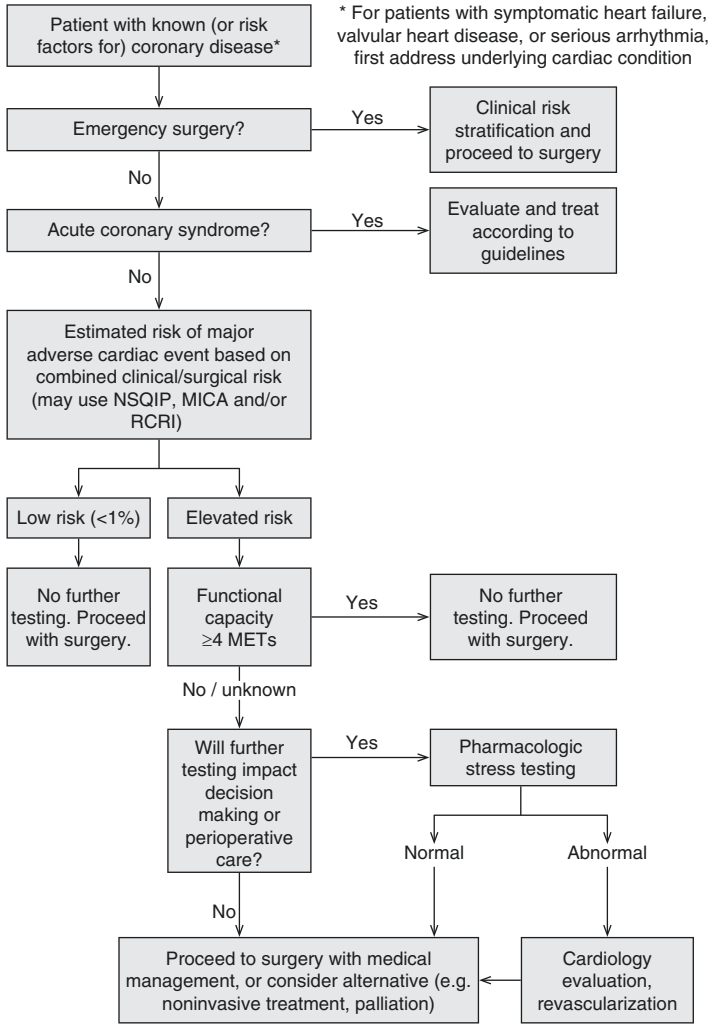

Fig. 6.1 Stepwise approach to preoperative cardiac assessment. (Reprinted from [1] (Fig. 1), with permission from Elsevier)

with prolonged anesthesia (especially >8 hours) and cases with extensive fluid shifts or blood loss impose a higher risk for perioperative complications.

The current ACC/AHA guidelines classify surgical urgency as *emergent* (life or limb threatened; operation typically must be done within

6 hours; minimal, if any, time for clinical evaluation), *urgent* (life or limb threatened; operation typically must be done within 6–24 hours; limited time for clinical evaluation), *time-sensitive* (a delay of weeks may adversely affect outcome), and *elective* (the surgery may be delayed for an extended period [months] without adversely affecting outcomes). The cardiac risk (death or myocardial infarction (MI)) of a procedure is defined as low (<1%) or elevated (≥1%) risk.

FUNCTIONAL CAPACITY/EXERCISE TOLERANCE

Assessment of a patient's functional capacity is a key part of the preoperative assessment and figures prominently in the current ACC/AHA and ESC/EHA guidelines. It is used to estimate surgical risk and to determine if additional cardiac testing is appropriate. Functional status may be ascertained by a directed history of a patient's activities; patient self-report is a validated measure and has been used in many studies to assess functional capacity (Table 6.1) [3]. Functional status is commonly expressed as metabolic equivalents (METs). One MET is defined as the amount of oxygen consumed while seated at rest. The MET concept is a simple, validated tool to express the intensity of effort of various activities as a multiple of the resting metabolic state. Self-reported reduced exercise tolerance (inability to walk four blocks or climb two flights of stairs) predicts an increased risk of perioperative complications [4]. Notably, a more recent study found that a clinician's subjective assessment of functional status did not accurately predict poor exercise tolerance (based on cardiopulmonary assessment) or perioperative morbidity or mortality [5]; however the standardized Duke Activity Status Index (DASI) questionnaire and N-terminal pro-B-type natriuretic peptide were both useful in predicting postoperative cardiac events and death. This evidence may influence subsequent guideline recommendations.

TABLE 6.1 EXAMPLES OF ESTIMATED METABOLIC EQUIVALENTS

METs	Activity
1–3	Care of self (eat, dress, toilet), walk around the house, walk a block or two on level ground at 2–3 mph
4–10	Light housework (e.g., washing dishes), climb a flight of stairs/walk up a hill, walk on level ground at 4 mph, heavy housework (scrubbing floors, moving heavy furniture), moderate recreational activities (bowling, dancing, doubles tennis, and moderate cycling)
>10	Strenuous sports (swimming, running, basketball, and singles tennis)

Reprinted from [3] (Table 2), with permission from Elsevier

CLINICAL TOOLS TO ESTIMATE CARDIAC RISK

Several clinical tools to estimate perioperative cardiovascular risk are available. We find these tools most helpful when combined with a traditional medical evaluation and clinical gestalt. When discussing risk with patients, we generally avoid quoting specific numerical estimates; rather, we prefer to categorize a patient as low, moderate, or high risk for cardiac complications. It is important to recognize that the specific cardiac complications predicted, the timeframe (in-hospital complication vs. 30-day), and the study population vary in each of these studies [5].

Three commonly used calculators include:

- *Revised Cardiac Risk Index (RCRI)*: The Revised Cardiac Risk Index (Table 6.2) estimates the risk of cardiac arrest, nonfatal MI, complete heart block, and pulmonary edema for patients ≥50 years undergoing major noncardiac surgery [6]. It has subsequently been validated in a variety of patient populations and is a user-friendly tool. Notably, pooled estimates of more recent studies published in the Canadian Cardiovascular Society Guidelines [7] have demonstrated higher rates of cardiac complications than the original RCRI study. This is likely due to increased detection of MI by routine postoperative screening, use of troponin (rather than

TABLE 6.2 REVISED CARDIAC RISK INDEX

Independent risk predictors for major cardiac complications		
1. High-risk surgery (intraperitoneal, intrathoracic, suprainguinal vascular)		
2. Ischemic heart disease (pathologic Q waves, angina, nitrates, prior MI, positive stress test)		
3. History of congestive heart failure		
4. History of CVA or TIA		
5. Insulin therapy for diabetes		
6. Preoperative serum creatinine >2.0 mg/dL		
Number of risk predictors	**Rate of major cardiac complications* %, (95% CI)**	
	Original RCRI study [6]	CCS Guideline, pooled estimate [12]
0	0.4 (0.05–1.5)	3.9 (2.8– 5.4)
1	0.9 (0.3–2.1)	6.0 (4.9–7.4)
2	6.6 (3.9–10.3)	10.1 (8.1–12.6)
≥3	11 (5.8–18.4)	15.0 (11.1–20.0)

*Major cardiac complications MI, pulmonary edema, VF or primary cardiac arrest, complete heart block

creatinine kinase), and inclusion of emergency surgeries in several of these trials, including the large international VISION trial [8, 9]. We include the original as well as the recent pooled risk estimates in Table 6.2.

- *MICA/Gupta Perioperative Cardiac Risk Calculator*: The MICA (perioperative *m*yocardial *i*nfarction or *c*ardiac *a*rrest) risk calculator estimates risk of perioperative myocardial infarct or cardiac arrest based on five risk factors: Type of surgery, functional status, American Society of Anesthesiologists class, elevated creatinine, and advanced age. The MICA was created using the American College of Surgeons' 2007 National Surgical Quality Improvement Program (NSQIP) database and included over 200,000 surgical patients [10]. The calculator is available online: https://www.surgicalriskcalculator.com/miorcardiacarrest
- *American College of Surgeons (ACS) NSQIP Surgical Risk Calculator*: The ACS Surgical Risk Calculator utilizes procedure-specific risk and incorporates 21 patient-specific variables [11]. In addition to risk of MI or cardiac arrest within 30 days after surgery, several additional postoperative complications are calculated including death, any serious complication, pneumonia, hospital readmission, and discharge to a nursing or rehabilitation facility. The calculator is available online: https://riskcalculator.facs.org/

PREOPERATIVE CARDIAC TESTING

ACC/AHA perioperative guidelines include the following recommendations [1].

12-LEAD ELECTROCARDIOGRAM

- For asymptomatic patients undergoing low-risk surgical procedures, do not obtain routine electrocardiogram (ECG). (Class III recommendation, level of evidence: B)
- For patients undergoing elevated-risk surgery with history of cardiovascular disease, significant arrhythmia, peripheral arterial disease, cerebrovascular disease, or other significant structural heart disease, 12-lead ECG is reasonable. (Class IIa recommendation, level of evidence: B)

- For elderly patients (e.g., >70 years) undergoing higher risk surgery, we consider preoperative ECG. Although the ACC/AHA guidelines do not support routine ECG based on advanced age alone, an abnormality on ECG may change our risk prediction and will provide a baseline to help interpret changes postoperatively, should cardiac complications occur.

RESTING ECHOCARDIOGRAPHY

- For patients with dyspnea of unknown etiology or patients with heart failure and increased dyspnea or a change in clinical status, transthoracic echocardiography to assess ventricular function is reasonable. (Class IIa recommendation, level of evidence: C)

CARDIAC STRESS TESTING

Before ordering a stress test to evaluate for myocardial ischemia, consider whether or not the results will change your management and what you will do with the data. Preoperative cardiac stress testing is intended to offer improved preoperative risk stratification and to identify patients in whom cardiology consultation, revascularization, or other cardiac optimization are warranted. Several noninvasive cardiac stress test modalities are available.

EXERCISE TESTING

The exercise tolerance test (ETT) is an inexpensive, well-validated study to assess a patient's functional capacity, and symptomatic, hemodynamic, and ECG response to exercise. Each of these factors has independent prognostic value.

- The Duke Treadmill Score provides a risk score based on exercise duration on a Standard Bruce Protocol, exercise limiting symptoms, and ECG ST segment changes [12].
- An ETT with ECG monitoring coupled with either myocardial perfusion imaging (see below) or transthoracic echocardiography provides additional prognostic information. High-risk findings, such as a large region of anterior wall ischemia or multiple regions of myocardial infarction, may change perioperative management.
- However, exercise testing is often not possible (e.g., due to orthopedic limitations, vascular claudication) or may not be recommended (e.g., large aortic aneurysms).

PHARMACOLOGIC CARDIAC STRESS TESTS

These tests are useful for patients who are unable to perform an exercise tolerance test. In general, the negative predictive value is high (i.e., a normal result indicates a low likelihood of a perioperative cardiac event). Evidence of myocardial ischemia increases perioperative cardiac risk, whereas evidence of prior myocardial infarct has low positive predictive value [1]. Two main types of pharmacologic stress studies are available:

- *Dobutamine Stress Echocardiography*: Dobutamine stress echo provides important prognostic information including left/right ventricular size and function, resting wall motion abnormalities (consistent with prior infarction), stress-induced wall motion abnormalities (consistent with ischemia), and valvular abnormalities. Beta blockers must be held for 12–24 hours prior to the study as they block the effects of dobutamine on the myocardium. A history of unstable angina, recent MI, ventricular arrhythmias, and severe hypertension are contraindications to high-dose dobutamine infusion.
- *Vasodilator Myocardial Perfusion Imaging (MPI)*: MPI provides useful prognostic information including left ventricular size and function, fixed perfusion abnormalities (consistent with prior infarction), and reversible perfusion abnormalities (consistent with ischemia). Dipyridamole, adenosine, or regadenoson can be used for vasodilation during myocardial perfusion imaging, each with its own set of contraindications. Regadenoson has the most favorable profile, and may be safely given to patients with severe chronic obstructive pulmonary disease (COPD), asthma or pulmonary fibrosis, though as is the case with all vasodilators, is contraindicated in patients with severe aortic stenosis. Single-photon emission computed tomography (SPECT) remains the most commonly utilized imaging modality in nuclear medicine. Positron emission tomography (PET) is less widely available and more expensive, but offers better image quality (and thus higher sensitivity for ischemia), particularly in patients with morbid obesity, multivessel coronary disease, and/or severe ischemic cardiomyopathy. The complete rest/stress perfusion PET can be accomplished in <1 hour, with less than half the radiation exposure of SPECT.

STRESS TEST FINDINGS AND SUBSEQUENT MANAGEMENT

- Independent of a potential surgery and even in the absence of symptoms, the ACC/AHA guidelines recommend cardiology evaluation and coronary angiography for patients with high-risk features on cardiac testing (Table 6.3) [13].

TABLE 6.3 HIGH-RISK NONINVASIVE TEST RESULTS

Severe resting left ventricular dysfunction (LVEF < 35%)
High-risk treadmill score (score ≤ −11)
Severe exercise left ventricular dysfunction (LVEF < 35%)
Stress-induced large perfusion defect (particularly if anterior)
Stress-induced multiple moderate perfusion defects
Large, fixed perfusion defect with LV dilatation or increased lung uptake (thallium 201)
Stress-induced moderate perfusion defect with LV dilatation or increased lung uptake (thallium 201)
Echocardiographic wall motion abnormality (>2 segments) developing at low dose of dobutamine (≤10 mg/kg) or low HR (<120 beats per minute)
Stress echocardiographic evidence of extensive ischemia

Reprinted from [13] (Table 5), with permission from Wolters Kluwer

- ACC/AHA guidelines recommend coronary revascularization only in situations for which it is indicated independent of the noncardiac surgery, since percutaneous coronary intervention (PCI) prior to noncardiac surgery has not been demonstrated to reduce perioperative cardiac events. The Coronary Artery Revascularization Prophylaxis (CARP) trial demonstrated that among patients undergoing elective vascular surgery, prophylactic revascularization (PCI or coronary artery bypass grafting (CABG)) did not decrease perioperative mortality, MI, or stroke [14]. This trial excluded patients with left main stenosis (≥50%), severe left ventricular dysfunction (ejection fraction <20%), and severe aortic stenosis.
- Our practice is to clarify the urgency and necessity of the noncardiac surgery, consider whether the patient has an indication for revascularization independent of surgery, and engage in a discussion of benefits and risks with the patient, surgeon, and cardiologist.

CASE DISCUSSIONS

1. A 65-year-old woman with hypertension, hyperlipidemia, and poorly controlled insulin-dependent type 2 diabetes mellitus is diagnosed with pancreatic cancer and is evaluated prior to pan-

creaticoduodenectomy. She has poor exercise tolerance. A vasodilator stress MPI scan is positive for a small region of mild ischemia involving the inferior wall. *Comment*: This patient is undergoing a necessary surgery, which should not be delayed for a low-risk stress test result. It would also be reasonable to proceed to surgery without a stress test because it is unlikely to change perioperative management. Optimal care includes medical management of probable coronary disease, hypertension and pain control, and observation for signs of ischemia.

2. A 65-year-old man with history of tobacco use, type 2 diabetes mellitus, and poor exercise tolerance is diagnosed with a 5.6-cm abdominal aortic aneurysm (AAA). He has exertional dyspnea. A vasodilator stress MPI scan reveals several areas of myocardial ischemia (multiple territories at risk), including a large region of severe myocardial ischemia involving the entire anterior wall. *Comment*: This patient is considering major elective vascular surgery. He has a high-risk stress test and is likely symptomatic. Surgery should be postponed to allow for cardiology consultation. Subsequent, cardiac catheterization confirms three-vessel disease with a normal left main artery. He therefore meets criteria for CABG independent of the AAA repair and this is recommended prior to the AAA repair. Importantly, the coronary revascularization may not alter the perioperative cardiac risk for the future AAA repair.
3. A 60-year-old woman with hypertension, type 2 diabetes mellitus, hyperlipidemia, and chronic obstructive pulmonary disease (COPD) is to undergo partial lobectomy for non-small cell lung cancer. Vasodilator stress MPI scan is positive for a large area of moderate myocardial ischemia involving the entire anterior wall (LAD distribution). *Comment*: This patient is undergoing thoracic surgery and has significant risk factors for coronary artery disease (CAD). Consultation with cardiology including possible cardiac catheterization would be prudent. Several options exist, including: (a) Placement of a bare metal stent and postponing surgery for 1 month, if delay would not pose significant risk of spread of cancer, (b) CABG, single vessel, with combined partial lobectomy, (c) extrapolating the CARP trial results to nonvascular surgery, no coronary intervention prior to the partial lobectomy; optimize medical management for CAD and alert

anesthesia, (d) defer surgical intervention completely, if consistent with patient preference, or if reasonable nonsurgical treatment exists.

4. The same patient as in #3 is to undergo elective total knee arthroplasty (TKA) for degenerative joint disease. *Comment*: This patient is undergoing an elective surgery but has a high risk of cardiac complications. Surgery should be delayed and outpatient cardiology evaluation completed.

KEY CLINICAL PEARLS

- Do not obtain routine electrocardiogram (ECG) in asymptomatic patients undergoing low-risk surgical procedures.
- Order cardiac stress testing only in patients with estimated risk for cardiac complications of ≥1% using standard cardiac risk prediction tools (if the findings would change your management), or in patients with symptoms or ECG changes concerning for ischemia.
- In patients with morbid obesity, multivessel coronary disease, and/or severe ischemic cardiomyopathy who meet criteria for stress testing, consider positron emission tomography (PET) if available, which offers higher sensitivity for the detection of myocardial ischemia when compared to standard SPECT.

ACKNOWLEDGMENTS

Laurie A. Soine, Ph.D. A.R.N.P, Teaching Associate, Department of Medicine.

REFERENCES

1. Fleisher LA, Fleischmann KE, Auerbach AD, et al. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery. J Am Coll Cardiol. 2014;64:e77. https://doi.org/10.1016/j.jacc.2014.07.944.
2. Kristensen SD, Knuuti J, Saraste A, et al. ESC/ESA guidelines on non-cardiac surgery: cardiovascular assessment and management: the joint task force on non-cardiac surgery: cardiovascular assessment and management of the European Society of Cardiology (ESC) and the European Society of Anaesthesiology (ESA). Eur Heart J. 2014;35:2383. https://doi.org/10.1093/eurheartj/ehu282.
3. Eagle KA, Berger PB, Calkins H, et al. ACC/AHA guideline update for perioperative cardiovascular evaluation for noncardiac surgery--executive summary: a report of the American College of Cardiology/American Heart Association task force on practice guidelines (committee to update the 1996 guidelines on perioperative cardiovascular evaluation for noncardiac surgery). J Am Coll Cardiol. 2002;39:542.
4. Wijeysundera DN, Pearse RM, Shulman MA, et al. Assessment of functional capacity before major non-cardiac surgery: an international, prospective cohort study. Lancet. 2018;391(10140):2631–40.

5. Cohn SL, Ros NF. Comparison of 4 cardiac risk calculators in predicting postoperative cardiac complications after noncardiac surgery. Am J Cardiol. 2018;121:125–30.
6. Lee TH, Marcantonio ER, Mangione CM, et al. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. Circulation. 1999;100:1043–9.
7. Duceppe E, Parlow J, MacDonald P, et al. Canadian cardiovascular society guidelines on perioperative cardiac risk assessment and management for patients who undergo noncardiac surgery. Canadian J Cardiol. 2017;33(1):17–32.
8. Association between postoperative troponin levels and 30-Day mortality among patients undergoing noncardiac surgery. JAMA. 2012;307(21):2295.
9. Devereaux PJ, Biccard BM, Sigamani A, et al. Association of postoperative high-sensitivity troponin levels with myocardial injury and 30-Day mortality among patients undergoing noncardiac surgery. JAMA. 2017;317(16):1642.
10. Gupta PK, Gupta H, Sundaram A, et al. Development and validation of a risk calculator for prediction of cardiac risk after surgery. Circulation. 2011;124:381–7.
11. Cohen ME, Ko CY, Bilimoria KY, et al. Optimizing ACS NSQIP modeling for evaluation of surgical quality and risk: patient risk adjustment, procedure mix adjustment, shrinkage adjustment, and surgical focus. J Am Coll Surg. 2013;217:336–346.e1.
12. Mark DB, Shaw L, Harrell FE, et al. Prognostic value of a treadmill exercise score in outpatients with suspected coronary artery disease. N Engl J Med. 1991;325:849–53.
13. Scanlon PJ, Faxon DP, Audet AM, et al. ACC/AHA guidelines for coronary angiography: executive summary and recommendations. Circulation. 1999;99:2345–57.
14. McFalls EO, Ward HB, Moritz TE, et al. Coronary-artery revascularization before elective major vascular surgery. N Engl J Med. 2004;351:2795–804.

Chapter 7
Ischemic Heart Disease

Karen Elaine Segerson

BACKGROUND

History of ischemic heart disease is a significant risk factor for perioperative cardiac complications, including postoperative myocardial infarction, heart failure, arrhythmia, cardiac arrest, and death [1]. A careful history and physical examination in patients with ischemic heart disease, including prior infarction and/or extent of coronary artery disease (CAD), is crucial prior to surgery to better assess and communicate risk to the patient and surgeon, and to suggest management that may mitigate risk perioperatively.

PREOPERATIVE EVALUATION

HISTORY AND PHYSICAL EXAMINATION

Key historical elements to ascertain are summarized in Table 7.1. See Chap. 6 for details regarding preoperative cardiac risk assessment and consideration for stress testing. Other considerations include:

- Obtain electrocardiogram (ECG) in preoperative patients with known ischemic heart disease undergoing at least intermediate risk surgery. New and/or concerning changes (e.g., pathologic Q wave, ST-T wave changes, or new arrhythmia) may help with risk assessment and/or perioperative optimization. An ECG is not indicated prior to low risk surgery, even in patients with ischemic heart disease, unless there is a clinical concern [2]. ECG within 1–3 months of surgical date is generally acceptable in stable patients [2].

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_7

TABLE 7.1 PREOPERATIVE HISTORY ELEMENTS FOR PATIENTS WITH ISCHEMIC HEART DISEASE

History of myocardial ischemia (MI)	Date, symptoms
History of stent placement	Date(s) and vascular location of stents Reason for stent (MI?Abnormal stress test?) Type of stent: Bare metal, drug eluting (including drug/brand name)
History of bypass	Date, vessels bypassed (and harvested)
Current symptoms	Angina, dyspnea (especially with exertion), edema, palpitations, presyncope/syncope, recent change in symptoms
Prior cardiac testing (stress studies, ECG, echo, catheterization)	Dates and results
Medication review	Obtain a careful medication list, including recent/frequency of nitroglycerin use, beta blockers, antiplatelet, and statins. Specifically ask about medication compliance
Primary cardiologist	Communicate with cardiologist, especially when patient is at high risk for cardiac complications, and/or antiplatelet therapy is being held

- If symptoms of active cardiac disease are present (e.g., exertional chest pain, dyspnea, and recent syncope), consider prompt cardiology evaluation.
- If surgery is urgent, discuss case directly with the anesthesia team, and consider engaging a cardiac anesthesiologist in patients with severe coronary disease.

MANAGEMENT OF PATIENTS WITH CARDIAC STENTS

Drug-eluting stents (DES) are commonly used in patients with CAD and can present challenges perioperatively if recently placed. Dual antiplatelet therapy (DAPT) (e.g., aspirin and clopidogrel) is recommended to reduce the risk of stent thrombosis for a full year after DES placement for acute coronary syndrome (ACS) and at least 6 months after DES in stable ischemic heart disease (SIHD) [3]. Several recent trials have suggested a shorter minimum duration of DAPT (3–6 months) may be acceptable in patients receiving newer

generation DES [4–7]. In some high-risk cases, dual antiplatelet therapy is extended beyond 12 months [8–10]. The timing of surgery and the risk of bleeding with surgery should be weighed against the risk of interruption in DAPT. The current recommendation is optimally to avoid elective procedures for 365 days after DES implantation [2, 11–13]. Surgery may be considered after 180 days if the need of surgery is felt to outweigh the potential risk of thrombosis [3, 11]. Elective noncardiac surgery may be considered within 6 months following DES placement, if the procedure may be performed without interrupting DAPT [3, 11–13].

Bare metal stents (BMS) have higher rates of restenosis than DES, yet may be considered for patients for whom cessation of DAPT for nonelective surgery is an anticipated necessity. The current recommendation is to delay elective surgery for at least 1 month after BMS placement to avoid unacceptably high rates of stent thrombosis [14–16].

If urgent or emergent surgery must be performed within the above windows, strongly consider the risks and benefits of withholding antiplatelet agents, and work with the surgeon, anesthesiologist, cardiologists, and patient to determine appropriate timing to resume these medications. Aspirin should be continued if possible and P2Y12 inhibitor therapy restarted as soon as possible after surgical bleeding risk permits [17, 18].

PERIOPERATIVE MANAGEMENT

MEDICATION MANAGEMENT (ALSO SEE CHAP. 5)

Antiplatelet Agents

The potential benefits of uninterrupted aspirin (especially in patients with vascular disease or prior percutaneous coronary intervention (PCI)) may be greater than the surgical bleeding risk. A multidisciplinary approach involving the surgeon, cardiologist, and patient is recommended to find consensus.

- Studies have shown that cessation of aspirin may result in a transient aspirin withdrawal syndrome, increasing the risk of stroke, and MI among patients with cardiovascular disease (especially those patients with indwelling stents) [18].
- The extent to which low-dose aspirin increases perioperative bleeding risk remains unclear with conflicting study data [17–21].

- Stop aspirin 7–14 days prior to surgery, in patients on aspirin for primary prevention.
- Consider continuing low-dose aspirin (81 mg daily) perioperatively for patients with significant cardiovascular disease, especially if indwelling cardiac stents or ACS within the last year, if the type of surgery allows [17–19].
- Stop aspirin 7–14 days before neurosurgery, intramedullary spine, posterior eye, middle ear, and transurethral prostatectomy cases (stop 14 days prior to neurosurgery/spine cases), even in patients with cardiovascular disease.
- Stop clopidogrel 5–7 days before most surgical interventions.
- Restart aspirin postoperatively as soon as safe from a surgical perspective.
- For patients with ACS within the last year, resume DAPT as soon as it is safe to do so postoperatively, regardless of revascularization status [3, 22, 23].

Beta Blockers

- Prescribed beta blockers should be continued preoperatively without interruption, including the morning of surgery.
- Beta blockade initiation within 1 day prior to surgery reduces nonfatal MI but may increase risk of stroke, death, hypotension, and bradycardia.
- The safety of starting beta blockade two or more days prior to surgery remains unclear [24].

Other Medications

- Continue statins without interruption.
- Data are conflicting regarding use of angiotensin-converting-enzyme (ACE) inhibitors and angiotensin-receptor blockers (ARBs) perioperatively; see Chaps 5 and 10 for further discussion.

SURVEILLANCE FOR POSTOPERATIVE ISCHEMIA

The PeriOperative ISchemic Evaluation (POISE) trial found a higher than expected incidence of postoperative MI in high-risk patients (5%); many of these patients had no symptoms of ischemia [25]. The use of serum biomarkers to screen for myocardial injury after noncardiac surgery (MINS) is an area of ongoing investigation [26]. Although markers may offer prognostic information [27–29], there is currently insufficient evidence that routine surveillance improves outcomes in the absence of clinical suspicion of ischemia.

Thus, postoperative monitoring in patients with ischemic heart disease should include:

- Consideration of telemetry monitoring in patients at highest risk for cardiac complications (including patients with history of ischemia, heart failure, cerebrovascular disease, diabetes, and chronic kidney disease).
- Closely monitoring blood pressure and heart rate; if any symptoms or signs of cardiac ischemia ensue, check serial cardiac enzymes and ECG.

KEY CLINICAL PEARLS

- An ECG is not indicated prior to low risk surgery, even in patients with ischemic heart disease, unless there is a clinical concern.
- Stop aspirin 7–14 days prior to surgery, in patients on aspirin for primary prevention; consider continuing low-dose aspirin for patients with significant cardiovascular disease, especially if indwelling cardiac stents or ACS within the last year, if the type of surgery allows.
- Previously prescribed beta blockers and statins should be continued preoperatively without interruption.

REFERENCES

1. Lee TH, Marcantonio ER, Mangione CM, et al. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. Circulation. 1999;100:1043–9.
2. Fleisher LA, Fleischmann KE, Auerbach AD, et al. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: a report of the American College of Cardiology/American Heart Association task force on practice guidelines. Circulation. 2014;130:3278–333.
3. Levine GN, Bates ER, Bittl JA, et al. 2016 ACC/AHA guideline focused update on duration of dual antiplatelet therapy in patients with coronary artery disease. J Am Coll Cardiol. 2016;68(1):1082–115.
4. Colombo A, Chieffo A, Frasheri A, et al. Second-generation drug-eluting stent implantation followed by 6- versus 12-month dual antiplatelet therapy: the SECURITY randomized clinical trial. J Am Coll Cardiol. 2014;64:2086–97.
5. Gwon H-C, Hahn J-Y, Park KW, et al. Six-month versus 12-month dual antiplatelet therapy after implantation of drug-eluting stents: the efficacy of Xience/Promus versus cypher to reduce late loss after stenting (EXCELLENT) randomized, multicenter study. Circulation. 2012;125:505–13.
6. Schulz-Schupke S, Brune RA, Ten Berg JM, et al. ISAR-SAFE: a randomized double-blind, placebo-controlled trial of 6 vs. 12 months of clopidogrel therapy after drug-eluting stenting. Eur Heart J. 2015;36:1252–63.
7. Palmerini T, Sangiorgi D, Valgimigli M, et al. Short- versus long-term dual antiplatelet therapy after drug-eluting stent implantation: an individual patient data pairwise and network meta-analysis. J Am Coll Cardiol. 2015;65:1092–102.

8. Mauri L, Kereiakes DJ, Yeh RW, et al. Twelve or 30 months of dual antiplatelet therapy after drug-eluting stents. N Engl J Med. 2014;371:2155–66.
9. Hermiller JB, Krucoff MW, Keriakes DJ, et al. Benefits and risks of extended dual antiplatelet therapy after everolimus-eluting stents. JACC Cardiovasc Interv. 2016;9:138–47.
10. Leon MB, Baim DS, Popma JJ, et al. A clinical trial comparing three antithrombotic drug regimens after coronary artery stenting. Stent Anticoagulation Restenosis Study Investigators. N Engl J Med. 1998;339:1665–71.
11. Wijeysundera DN, Wijeysundera HC, Yun L, et al. Risk of elective major noncardiac surgery after coronary stent insertion: a population-based study. Circulation. 2012;126:1355–62.
12. Berger PB, Kleiman NS, Pencina MJ, et al. Frequency of major noncardiac surgery and subsequent adverse events in the year after drug-eluting stent placement results from the EVENT (Evaluation of Drug-Eluting Stents and Ischemic Events) Registry. JACC Cardiovasc Interv. 2010;3:920–7.
13. Mehran R, Baber U, Steg PG, et al. Cessation of dual antiplatelet treatment and cardiac events after percutaneous coronary intervention (PARIS): 2 year results from a prospective observational study. Lancet. 2013;382:1714–22.
14. Schömig A, Neumann FJ, Kastrati A, et al. A randomized comparison of antiplatelet and anticoagulant therapy after the placement of coronary-artery stents. N Engl J Med. 1996;334:1084–9.
15. Wilson SH, Fasseas P, Orford JL, et al. Clinical outcome of patients undergoing noncardiac surgery in the two months following coronary stenting. J Am Coll Cardiol. 2003;42:234–40.
16. Nuttall GA, Brown MJ, Stombaugh JW, et al. Time and cardiac risk of surgery after bare metal stent percutaneous coronary intervention. Anesthesiology. 2008;109:588–95.
17. Oscarsson A, Gupta A, Fredrickson M, et al. To continue or discontinue aspirin in the perioperative period: a randomized, controlled clinical trial. Br J Anaesth. 2010;104:305–12.
18. Burger W, Chemnitius J-M, Kneissl GD, et al. Low-dose aspirin for secondary cardiovascular prevention- cardiovascular risks after its perioperative withdrawal versus bleeding risks with its continuation- review and meta-analysis. J Intern Med. 2005;257:399–414.
19. Graham M, Sessler D, Parlow J, et al. Aspirin in patients with previous percutaneous coronary intervention undergoing noncardiac surgery. Ann Intern Med. 2018;168:237–44.
20. Devereaux PJ, Mrkobrada M, Sessler D. Aspirin in patients undergoing noncardiac surgery. N Engl J Med. 2014;370:1494–150.
21. Gerstein NS, Schulman PN, Gerstein WH, et al. Should more patients continue aspirin therapy perioperatively? Clinical impact of aspirin withdrawal syndrome. Ann Surg. 2012;255:811–9.
22. Wallentin L, Becker RC, Budaj A, et al. Ticagrelor versus clopidogrel in patients with acute coronary syndromes. N Engl J Med. 2009;361:1045–57. 📖
23. Wiviott SD, Braunwald E, McCabe CH, et al. Prasugrel versus clopidogrel in patients with acute coronary syndromes. N Engl J Med. 2007;357:2001–15.
24. Wijeysundera DN, Duncan D, Nkonde-Price C, et al. Perioperative beta blockade in noncardiac surgery: a systematic review for the 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery. Circulation. 2014;130:2246–64.
25. Devereaux PJ, Xavier D, Pogue J, et al. Characteristics and short-term prognosis of perioperative myocardial infarction in patients undergoing noncardiac surgery: a cohort study. POISE (PeriOperative Ischemic Evaluation) Investigators. Ann Intern Med. 2011;154(8):523.
26. Botto F, Alonso-Coello P, Chan MR, et al. Myocaardial injury after noncardiac surgery: a large, international, prospective cohort study establishing diagnostic criteria, characteristics, predictors, and 30-day outcomes. Anesthesiology. 2014;120:564–78.
27. Devereaux PJ, Biccard BM, Sigamani A, et al. Association of post-operative high-sensitivity troponin levels with myocardial injury and 30-day mortality among patients undergoing noncardiac surgery. JAMA. 2017;317:1642–51.
28. Karthikeyan G, Moncur RA, Levine O, et al. Is a pre-operative brain natriuretic peptide or N-terminal pro-B-type natriuretic peptide measurement an independent predictor of adverse cardiovascular outcomes within 30 days of noncardiac surgery? A systematic review and meta-analysis of observational studies. J Am Coll Cardiol. 2009;54(17):1599.
29. Rodseth RN, Bicard BM, Le Manach Y, et al. The prognostic value of pre-operative and post-operative B-type natriuretic peptides in patients undergoing noncardiac surgery: B-type natriuretic peptide and N-terminal fragment of pro-B-type natriuretic peptide: a systematic review and individual patient data meta-analysis. J Am Coll Cardiol. 2014;63(2):170. Epub 2013 Sep 26.

Chapter 8
Heart Failure

Michael J. Lenaeus and Kelly M. Nakamura

BACKGROUND

Heart failure (HF) affects approximately six million Americans, and its prevalence is increasing [1]. It is a heterogeneous condition that may result from several etiologies including myocardial infarction, hypertension, and valvular disease. Independent of the underlying etiology, heart failure is a clinical syndrome in which elevated left ventricular (LV) filling pressures lead to symptoms, such as dyspnea and volume overload. This chapter will focus on identifying decompensated or undiagnosed HF, as well as considerations for perioperative optimization and monitoring.

HF is especially common in older patients having surgery, having been found in nearly 20% of patients in one study of Medicare patients referred for common surgical procedures [2]. HF is an especially important predictor of perioperative mortality and hospital readmission [3, 4]. In one study of Medicare recipients undergoing noncardiac surgery, for example, patients with HF were found to have twice the risk of perioperative mortality relative to matched controls and even to those with coronary artery disease (CAD) [3]. A larger Canadian study had similar findings, with patients with HF having an approximately threefold increased risk for 30-day postoperative mortality relative to controls and those with CAD alone [4].

Accordingly, HF has been incorporated into a number of perioperative cardiac risk schemata, including the widely used Revised Cardiac Risk Index (RCRI) as well as the Vascular Study Group of New England (VSGNE) index and the American College of Surgeons National Surgical Quality Improvement (NSQIP) Surgical Risk Calculator [5–7]. The heterogeneity of HF and cardiomyopathies is not yet reflected in these surgical risk calculators, though some

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_8

evidence suggests that patients with asymptomatic LV dysfunction or HF with preserved ejection fraction (HFpEF) are at lower risk than those with heart failure with reduced ejection fraction (HFrEF) and that those with a stable HF syndrome for many years are at lower risk than those with acutely decompensated HF or evolving disease [8–11]. The latter distinction is particularly important as perioperative HF outcomes may be improved by optimizing HF therapy prior to noncardiac surgery [12].

PREOPERATIVE EVALUATION

Perform a focused history and physical exam to determine nature and degree of stability of the heart failure, and inquire about any history of perioperative HF to identify high-risk patients who would benefit from cardiology consultation. Standard perioperative evaluation may also detect patients with symptoms of heart failure but no prior diagnosis of HF; in these patients, pursue further testing to diagnose HF or an alternate cause of symptoms.

HISTORY

- Inquire about symptoms of heart failure: functional status, exercise tolerance, dyspnea, orthopnea, paroxysmal nocturnal dyspnea, weight change, abdominal distension, and leg edema.
- Inquire about symptoms of comorbid conditions. These conditions may identify worsening HF and may require preoperative or perioperative management (e.g., chest pain in a patient with ischemic cardiomyopathy or palpitations in a patient with atrial fibrillation).
- Determine severity of heart failure, and recognize patients who should be referred for preoperative cardiology evaluation. We advise preoperative cardiology consultation for patients with severe HF symptoms (e.g., dyspnea at rest or with minimal activity), advanced HF (e.g., HFrEF with ejection fraction <25%, inotropic therapy, or mechanical circulatory support, such as left-ventricular assist device or LVAD), or uncommon HF syndromes (e.g., restrictive cardiomyopathy, constrictive pericarditis, hypertrophic obstructive cardiomyopathy, and adults with congenital heart disease). When possible, patients with advanced HF or uncommon HF syndromes should be referred to a regional center with expertise in advanced heart failure. In all other patients, even those who are stable and

compensated, the best practice is to alert the patient's cardiologist by telephone to alert them to the upcoming operation and discuss perioperative care.

- HF patients with HFrEF are also commonly treated with cardiac implantable electronic device (CIED) therapies, such as implantable cardiac defibrillators (ICDs) or cardiac resynchronization therapy (CRT). Obtain device information as outlined in Chap. 11 and communicate with cardiology or anesthesia regarding plan for management.

PHYSICAL EXAM AND DIAGNOSTIC TESTING

- Traditional signs of decompensated heart failure on physical exam include elevated jugular venous pressure, S3 or S4 heart sounds, resting tachycardia, changed cardiac murmurs, pulmonary rales, ascites, or lower extremity edema.
- A positive abdomino-jugular test and abnormal Valsalva response are also predictive of elevated left heart filling pressures and should be considered in cases where the diagnosis of decompensated heart failure is equivocal [13].
- Patients with decompensated HF or signs/symptoms concerning for undiagnosed HF should undergo further diagnostic testing, which may include electrocardiogram and chest x-ray as evaluations for coexistent cardiac or pulmonary disease, and transthoracic echocardiogram to evaluate LV function and assess for other interval changes that explain symptoms and/or require perioperative optimization [14].
- Coronary angiography, stress testing, or right heart catheterization are not indicated for preoperative evaluation of HF—though could be considered if another indication for their use is present (e.g., suspected coronary disease as the cause of worsening HF).

PERIOPERATIVE MANAGEMENT

Standard medical management of HF includes diuretics for symptoms of volume overload, as well as neurohormonal blockade (i.e., angiotension-converting enzyme (ACE) inhibitors or angiotension II receptor blockers (ARBs), β-blockers, and mineralocorticoid receptor antagonists) for patients with HFrEF [15]. Other medications are commonly prescribed for patients with HFrEF—including angiotensin-neprilysin inhibitors (ARNIs, sacubitril/valsartan),

digoxin, hydralazine, nitrates, ivabradine, and antiarrhythmics like amiodarone. The perioperative use of these agents differs depending on the patient's cardiomyopathy and degree of decompensation. HF patients with HFrEF are also commonly treated with cardiac implantable electronic device (CIED) therapies; preoperative management of CIEDs should be discussed with the cardiologist or anesthesiologist.

PERIOPERATIVE MANAGEMENT FOR STABLE HF

- Patients with stable HF should generally have their HF medications continued in the perioperative period, including ACE inhibitors, β-blockers, and mineralocorticoid receptor antagonists [14].
- Diuretics should be dosed based on assessment of volume status, with some practitioners withholding diuretics on the morning of surgery and resuming them when the patient resumes oral intake postoperatively.
- There are limited data for the perioperative use of ARBs, ARNIs, and hydralazine/nitrates, though expert recommendation is to treat them as ACE inhibitors in the perioperative setting and continue them in patients with HF [14].
- If the patient is at risk for hypotension or is felt to be overdiuresed, it is reasonable to withhold diuretic and/or ACE inhibitor on the morning of surgery [14]. Data are mixed on the use of ACE inhibitors in patients without HF in the perioperative setting—with a recent observational study showing increased risk of intraoperative hypotension in patients who continue ACE inhibitor therapy preoperatively and decreased risk of death and postoperative vascular events in patients who held their ACE/ARB before surgery [16]. However, randomized trials and a systematic review have shown no difference in perioperative complications between patients who took an ACE inhibitor preoperatively and those who did not [17–19]. These trials have not been powered to detect differences among patients with HF or its subclasses, though provide some basis for withholding ACE inhibitor therapy in patients with HFpEF or those at risk for intraoperative hypotension.
- Other medications for HF should generally be continued (e.g., digoxin, amiodarone, ivabradine)—though data are lacking and use of these agents must be individualized.
- If HF medications are held in the perioperative period, they should be resumed as soon as possible postoperatively [14]. Delay in the resumption of HF therapy has been associated with worsened clinical outcomes and increased rates of readmission [14].

PERIOPERATIVE MANAGEMENT FOR DECOMPENSATED HF

- Patients with decompensated or newly diagnosed HF should delay elective surgery until their HF is stabilized with appropriate therapy. There are no specific studies to guide the duration of therapy prior to elective surgery, so we advise decision making based on clinical response and the urgency of surgery. If emergent or very urgent surgery is required or if the patient has severe HF (e.g., severe symptoms or LV ejection fraction <25%), then we advise cardiology consultation to guide perioperative medical therapy and monitoring.
- Heart failure should be optimized prior to surgery, typically utilizing diuretic therapy to treat volume overload until a new steady state is reached. For patients with HFrEF, neurohormonal blockade should also be titrated, by increasing ACE inhibitors to goal doses at 1-to-2 week intervals, then titrating β-blockers to goal doses if time allows prior to surgery.
- Data are mixed on the prophylactic use of β-blockers prior to noncardiac surgery. It takes weeks to months for patients with HFrEF to accrue benefit from β-blocker therapy [14–20]. We advise perioperative initiation of β-blockade at a conservative dose if surgery can be delayed by at least several weeks, with subsequent titration to occur in the postoperative setting based on the patient's tolerance of β-blocker therapy. Patients with HFpEF may be treated with perioperative β-blockers if indicated (e.g., ≥3 RCRI risk factors, intermediate or high-risk preoperative tests), though should be started as far in advance of surgery as possible to ensure tolerability [15].
- Do not begin mineralocorticoid receptor antagonist (e.g., spironolactone) therapy in the perioperative setting. There are no data on their use in this fashion, the doses used are not typically those effective as diuretics, and benefit in HF is expected to accrue over long periods.
- Clinical response to the above therapies should be monitored closely with referral for cardiology consultation if symptoms persist despite initial attempts at pharmacotherapy, a comorbid condition is discovered (e.g., incessant atrial fibrillation, unstable CAD) or surgery is needed urgently.
- As described for stable HF, medications (once titrated) should be continued without interruption. If hypotension is a concern, diuretic and/or ACE inhibitor may be held on the morning of surgery—particularly in patients with HFpEF. HF medications should be resumed as soon as possible postoperatively.

POSTOPERATIVE MONITORING

Patients with HF should be monitored closely for volume overload, hypotension, and acute kidney injury (AKI) in the postoperative period.

- Evaluation of volume status includes review of fluids infused during surgery, strict postoperative intake and output, daily weights, and targeted physical examination (i.e., jugular venous distension and peripheral or pulmonary edema). When present, treat volume overload with diuretics, giving preference to intravenous formulations at the outset of therapy with subsequent transition to oral formulations or home regimens based on response.
- Hypotension may develop due to decreased oral intake or insensible losses in the perioperative period. We advise holding or dose adjusting diuretics as needed, and providing intravenous fluid in small increments as needed [15]. HF pharmacotherapy should be reinstituted at the earliest possible time [14].
- AKI is a common complication in the perioperative period, especially among patients with HF. We recommend monitoring serum creatinine daily in the perioperative period while carefully titrating diuretic therapy and/or withholding ACE inhibitors (or ARBs/ARNIs) until AKI improves.

KEY CLINICAL PEARLS

- 🗝 Carefully evaluate the perioperative HF patient for decompensated HF, as preoperative decompensation is a risk factor for perioperative adverse events and hospital readmission and these risks can be decreased by optimizing HF therapy prior to surgery.
- 🗝 Patients with dyspnea of unknown origin or patients with decompensated HF should undergo preoperative echocardiogram to guide the timing of surgery and preoperative care, which may include medication titration and/or cardiology referral.
- 🗝 Continue all medications for heart failure without holding, both prior to surgery and after surgery. Delay in resuming heart failure medications has been associated with worsened clinical outcomes and increased rates of readmission [14].

REFERENCES

1. Mozaffarian D, et al. Heart disease and stroke statistics – 2015 update. Circulation. 2015;131:e29–e322.
2. Hammill BG, et al. Impact of heart failure on patients undergoing major noncardiac surgery. Anesthesiology. 2008;108:559–67.
3. Hernandez AF, et al. Outcomes in heart failure patients after major noncardiac surgery. J Am Coll Cardiol. 2004;44:1446–53.
4. Van Diepen S, Bakal JA, McAlister FA, Ezekowitz JA. Mortality and readmission of patients with heart failure, atrial fibrillation, or coronary artery disease undergoing noncardiac surgery: an analysis of 38 047 patients. Circulation. 2011;124(3):289–96.
5. Lee TH, et al. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. Circulation. 1999;100:1043.
6. Bertges DJ, et al. The Vascular Study Group of New England Cardiac Risk Index (VSG-CRI) predicts cardiac complications more accurately than the revised cardiac risk index in vascular surgery patients. J Vasc Surg. 2010;52:674.
7. Bilimoria KY, et al. Development and evaluation of the universal ACS NSQIP surgical risk calculator: a decision aid and informed consent tool for patients and surgeons. J Am Coll Surg. 2013;217:833.
8. Healy KO, et al. Perioperative outcome and long term mortality for heart failure patients undergoing intermediate and high risk non-cardiac surgery: impact of left ventricular ejection fraction. Congest Heart Fail. 2010;16(2):45–9.
9. Kazmers A, Cerqueira MD, Zierler RE. Perioperative and late outcome in patients with left ventricular ejection fraction of 35% or less who require major vascular surgery. J Vasc Surg. 1988;8(3):307–15.
10. Doughty RN. The survival of patients with heart failure with preserved or reduced left ventricular ejection fraction: an individual patient data meta-analysis: Meta-analysis Global Group in Chronic Heart Failure (MAGGIC). Eur Heart J. 2012;33:1750–7.
11. Flu W-J, et al. Prognostic implications of asymptomatic left ventricular dysfunction in patients undergoing vascular surgery. Anesthesiology. 2010;112:1316.
12. Xu-Cai YO, et al. Elective noncardiac surgery in stable heart failure. Outcomes of patients with stable heart failure undergoing elective noncardiac surgery. Mayo Clin Proc. 2008;83:280–8.
13. McGee S. Evidence-based physical diagnosis: 4th edition, Elsevier Inc; Philadelphia, PA, 2018.
14. Fleisher LA, et al. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: a report of the American College of Cardiology/American Heart Association task force on practice guidelines. J Am Coll Cardiol. 2014;64:2373.
15. Yancy CW, et al. 2013 ACCF/AHA guideline for the management of heart failure: a report of the American College of Cardiology Foundation/American Heart Association Task Force on practice guidelines. Circulation. 2013;128(16):e240–327.
16. Roshanov PS, et al. Enzyme inhibitors or angiotensin II receptor blockers. Anesthesiology. 2017;126:16–27.
17. Zou Z, et al. Perioperative angiotensin-converting enzyme inhibitors or angiotensin II type 1 receptor blockers for preventing mortality and morbidity in adults. Cochrane Database Syst Rev. 2016;(1):CD009210.
18. Rouleau JL, et al. Effects of angiotensin-converting enzyme inhibition in low-risk patients early after coronary artery bypass surgery. Circulation. 2008;117:24–31.
19. Turan A, et al. Angiotensin converting enzyme inhibitors are not associated with respiratory complications or mortality after noncardiac surgery. Anesth Analg. 2012;114:552–60.
20. Devereaux PJ, et al. Effects of extended-release metoprolol succinate in patients undergoing non-cardiac surgery (POISE trial): a randomised controlled trial. Lancet. 2008;371(9627):1839–47.

Chapter 9
Atrial Fibrillation

Kay M. Johnson and Paul B. Cornia

BACKGROUND

Management of preexisting atrial fibrillation is commonly addressed by the medical consultant, as is the new onset of atrial fibrillation in the postoperative period. Decisions about perioperative management of anticoagulation and antiplatelet medications must balance the risk of arterial thromboembolism (especially stroke) versus the risk of bleeding complications. Guidelines for assessing stroke risk, and for heparin "bridging" therapy for patients on warfarin, have been updated in the past few years. Warfarin is also prescribed less frequently now, since direct-acting oral anticoagulants (DOACs) have become more available. Perioperative consultants must also address rate and rhythm control in the pre- and postoperative settings. This chapter addresses perioperative management of nonvalvular atrial fibrillation (i.e., patients without rheumatic mitral valve disease, mitral stenosis from any cause, or prosthetic heart valves) for patients undergoing noncardiac surgery.

PREOPERATIVE EVALUATION

For patients with preexisting atrial fibrillation

- Determine whether the atrial fibrillation is paroxysmal versus persistent [1].
- Reconcile the medication list with the patient/caregiver, with particular attention to rate-controlling agents, antiarrhythmics, anticoagulants, or antiplatelets.

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_9

- Identify any history of significant valvular heart disease, heart failure, hypertension, transient ischemic attack (TIA), or stroke.
- Review prior echocardiogram report(s).
- Review previous management of interruptions in anticoagulant therapy, including prior use of bridge heparin therapy for patients on warfarin (see below).
- Perform a complete cardiovascular examination. Unless the anticipated procedure is very low risk (e.g., cataract extraction), perform an electrocardiogram (ECG) [1].
- Estimate the risk for arterial thromboembolism using the CHA_2DS_2-VASc scoring system [2] (see below).

PERIOPERATIVE MANAGEMENT

Key issues for the medicine consultant include optimal perioperative rate and rhythm control, and management of antithrombotic medications, which may include antiplatelet agents, warfarin, or DOACs.

RHYTHM AND RATE CONTROL

In the nonoperative setting, a goal resting heart rate less than 110 beats per minute (bpm) is generally recommended for asymptomatic patients [3] with atrial fibrillation, and less than 80 bpm for symptomatic patients or those with systolic dysfunction [4]. Elective surgery should be delayed if there are any signs of hemodynamic instability (e.g., ischemia, pulmonary edema, and hypotension), and as a general rule, we would also delay elective surgery for a resting rate of 110 bpm or more. Rate and rhythm control medications (e.g., beta blockers, calcium channel blockers, and amiodarone) are typically continued perioperatively, and a postoperative plan should be made for continuing these agents, taking into account whether the patient is anticipated to be able to take oral medications (see Table 9.1).

MANAGEMENT OF ANTIPLATELET AGENTS

Patients with atrial fibrillation who are treated only with aspirin for stroke prophylaxis are usually at low risk for stroke; holding aspirin perioperatively is generally considered safe and reduces the risk of perioperative bleeding associated with uninterrupted aspirin [5]. Patients with atrial fibrillation and a history of stroke, TIA, or other thromboembolism usually are treated with anticoagulants instead of

TABLE 9.1 POSTOPERATIVE MANAGEMENT OF PATIENTS WITH PREEXISTING ATRIAL FIBRILLATION

Rate control	For patients taking oral medications: In most cases, resume patient's usual outpatient rate control regimen. Watch for hypotension, since some patients are relatively volume depleted and the blood pressure-lowering effect of some rate control medications may be less well tolerated initially postoperatively If NPO: Individualize desired rate control target, depending on the patient's baseline rate control goals, the presence of ischemic heart disease, and the patient's postoperative blood pressure. In most cases, a heart rate of 60–100 is reasonable. Options include: Metoprolol IV (start 5 mg IV q 6 hours and individualize dosing) OR Diltiazem IV infusion Continue digoxin (IV) at same dose as prescribed orally preoperatively Transition to PO meds when tolerating a diet
Anticoagulation	Resume anticoagulation when surgically acceptable (see text) If indicated, bridge with heparin until therapeutic on warfarin If anticoagulation is not started immediately due to bleeding risk, venous thromboembolism prophylaxis should still be given, unless there is a contraindication

IV intravenous, *NPO* nil per os (nothing by mouth), *PO* per os (by mouth)

aspirin (see below). However, if these patients are treated with aspirin (e.g., because they decline anticoagulants, or there is a contraindication), we typically continue baby aspirin perioperatively, unless the risk of bleeding for the anticipated procedure is very high. Clopidogrel carries a higher risk of bleeding than aspirin [6] and should almost always be held before surgical procedures (for 5–7 days); in some cases, low dose aspirin can be substituted during this time. Dipyridamole is also generally held (for 7–10 days). Consider whether the patient has additional indications for antiplatelet therapy beyond their atrial fibrillation, such as a history of coronary stents, in

which case discussion with their cardiologist may be warranted (see Chap. 7, Ischemic Heart Disease).

WARFARIN ANTICOAGULATION AND HEPARIN BRIDGE THERAPY

For most surgical procedures, warfarin must be interrupted perioperatively (see below for exceptions). Since the half-life of warfarin is long (36–42 hours) and somewhat variable, and since it takes 5–10 days to achieve full anticoagulation after it is resumed, the patient is left without therapeutic anticoagulation for several days [7]. A decision must be made about whether bridging with heparin is warranted to minimize the duration of the interruption in anticoagulation. The BRIDGE trial [8] showed that periprocedural bridging did not reduce thromboembolism but did increase bleeding complications, though the study enrolled few high-risk patients (i.e., $CHADS_2$ [9] score >4, or history of stroke or TIA). The newer and slightly more complicated CHA_2DS_2-VASc score [2] is used for risk prediction in the 2017 American College of Cardiology (ACC) guidelines for periprocedural management of anticoagulation for patients with nonvalvular atrial fibrillation [7]. See Chap. 26 (Chronic Anticoagulation) for our approach to bridging anticoagulation, which is based on these guidelines. For instance, we do not bridge with heparin when the CHA_2DS_2-VASc score is 0–4 and there is no history of stroke/TIA or systemic embolism. Chapter 26 also discusses whether to use subcutaneous low molecular weight heparin versus intravenous (IV) unfractionated heparin. Some points to bear in mind:

- Develop a plan for perioperative anticoagulation prior to surgery, which often requires consultation with the anticoagulant management team, primary care provider, surgeon, cardiologist, neurologist, etc.
- Discuss the plan with the patient/caregiver, provide written instructions, and clearly document the plan in the medical record. The plan should anticipate postoperative conditions affecting resumption of anticoagulation.
- Warfarin need not be stopped for very low bleeding risk procedures, for example, dental extractions, dermatologic procedures, and cataract surgery. Ensure that the surgeon is in agreement with this plan and that the preop international normalized ratio (INR) is <3.0 [7].
- For other procedures, warfarin is generally held for 5 days (five doses) prior to surgery. Individualize the number of days that anticoagulation will be held preoperatively based on the type of surgery (e.g., neurosurgery, spine surgery, and highly

vascular tumors may warrant a longer period off of anticoagulation to ensure safety), the surgeon's preference, and the baseline dose of warfarin (patients requiring lower doses tend to have INRs that normalize more slowly) [7].

- Do not assume that outpatient procedures are low-risk for bleeding (e.g., angioembolization). Discuss with the surgeon or interventionalist.

MANAGEMENT OF DIRECT-ACTING ORAL ANTICOAGULANTS (DOACs)

- Dabigatran, rivaroxaban, apixaban, and edoxaban are approved for stroke prophylaxis in patients with nonvalvular atrial fibrillation.
- Dabigatran is a direct competitive inhibitor of Factor IIa, and the others are direct factor Xa inhibitors.
- Unlike warfarin, none require routine anticoagulation monitoring [e.g., with prothrombin time (PT)/INR].
- Because of their short half-lives and rapid onset of action, they generally do not require bridging with heparin when stopped temporarily for procedures.
- The timing of the last dose of a DOAC prior to surgery depends on the bleeding risk of the procedure and on the patient's renal function (see Chap. 26).
- Though warfarin is often resumed the evening of surgery because of the long delay in anticoagulation effect, DOACs achieve full anticoagulation in only a few hours, so hemostasis should be assured prior to resuming them (see Chap. 26).

POSTOPERATIVE MANAGEMENT

Recommendations for the postoperative management of patients with preexisting atrial fibrillation are summarized in Table 9.1. Adjustments may be necessary, depending on postoperative blood pressure and heart rate, the surgeon's assessment of the patient's bleeding risk, or if unanticipated complications arise. If therapeutic anticoagulation is not restarted immediately postoperatively, patients should still receive venous thromboembolism prophylaxis, as appropriate for the patient and the operation. Patients should be monitored for thromboembolic complications.

MANAGEMENT OF NEW ONSET POSTOPERATIVE ATRIAL FIBRILLATION

- Identify precipitating causes (e.g., heart failure, myocardial infarction, electrolyte abnormalities, infection, alcohol withdrawal, hyperthyroidism, anemia, hypovolemia, lung disease, valvular heart disease, pulmonary embolism, and volume overload/reabsorbed third-spaced fluids).
- Assess for symptoms and signs that may be related to the arrhythmia, such as hypotension, heart failure, or myocardial ischemia.
- Obtain an echocardiogram to assess structural contributors to atrial fibrillation, such as left ventricular dysfunction and valvular heart disease.
- In atrial fibrillation with rapid ventricular response, if rate control is needed urgently, we start with IV agents. Use caution when considering beta-blockers and calcium channel blockers in patients with heart failure or hypotension (see Table 9.2). Have a low threshold to consult Cardiology for assistance.

TABLE 9.2 RATE CONTROL STRATEGIES FOR NEW-ONSET POSTOPERATIVE ATRIAL FIBRILLATION WITH RAPID VENTRICULAR RESPONSE

Metoprolol	5 mg IV × 1. May repeat × 2 if additional rate control needed and BP remains stable
Diltiazem	Bolus 10–20 mg IV, then start IV infusion at 10–20 mg/h, titrate to HR 80–100
Digoxin	Acts more slowly. 0.5 mg IV × 1, then 0.25 mg IV Q6H × 2 Give daily and titrate to effect; typical dose is 0.125 mg IV or PO daily Reduce dose if renal dysfunction. Use caution in elderly patients
Amiodarone	150 mg IV bolus, then load with 1 mg/min IV × 6 hours, then 0.5 mg/min × 18 hours Indicated for refractory atrial fibrillation, or atrial fibrillation with heart failure Check baseline TSH, PFTs
Esmolol	Bolus 0.5 mg/kg IV over one minute, followed by 50 mcg/kg/min, titrating up to a maximum of 200 mcg/kg/min Watch for hypotension
PO medications	Multiple options: Metoprolol, atenolol, or diltiazem. Digoxin or amiodarone, if indicated
Cardioversion	Immediate cardioversion is indicated if hemodynamically unstable

BP blood pressure, *IV* intravenous, *HR* heart rate, *PO* per os (by mouth), *TSH* thyroid stimulating hormone, *PFTs* pulmonary function tests

When atrial fibrillation persists or continues to recur, antiplatelet or anticoagulant therapy must be considered, based on the patient's risk factors for stroke. This decision should be made on an individual basis, taking into consideration the patient's risk of stroke (or other thromboembolism), bleeding risks, and patient preferences. Consultation with the patient's primary care provider may be helpful. The CHA_2DS_2-VASc score is commonly used as a risk stratification tool [2]. It better predicts thromboembolic events than the simpler $CHADS_2$ score, particularly among those with a lower risk score (e.g., $CHADS_2$ 0–1) [7]; see Tables 9.3 and 9.4.

TABLE 9.3 $CHADS_2$ AND CHA_2DS_2-VASC RISK STRATIFICATION FOR ATRIAL FIBRILLATION [2, 9]

Criteria	$CHADS_2$ scoring	CHA_2DS_2-VASc scoring
CHF	1	1
HTN	1	1
Age ≥75	1	2
Diabetes	1	1
Stroke/TIA/systemic embolism	2	2
Vascular disease (CAD, MI, PAD, aortic plaque)		1
Age 65–74		1
Female		1

TIA transient ischemic attack, *CAD* coronary artery disease, *CHF* congestive heart failure, *HTN* hypertension, *MI* myocardial infarction, *PAD* peripheral arterial disease

TABLE 9.4 ANNUAL STROKE RISK IN ATRIAL FIBRILLATION WITHOUT ANTICOAGULATION, BASED ON $CHADS_2$ AND CHA_2DS_2-VASC SCORES [9, 12]

	$CHADS_2$ score	CHA_2DS_2-VASc score
Score	Annual (%) stroke risk without anticoagulation	
0	1.9	0
1	2.8	1.3
2	4.0	2.2
3	5.9	3.2
4	8.5	4.0
5	12.5	6.7
6	18.2	9.8
7	–	9.6
8	–	6.7
9	–	15.2

Postoperative atrial fibrillation is often brief or self-limited and resolves once the postoperative stress resolves. There are no clear guidelines on whether transient postoperative atrial fibrillation warrants chronic anticoagulation. Transient atrial fibrillation after noncardiac surgery may be a marker for increased long-term risk of stroke. Administrative data for 1.7 million patients hospitalized for noncardiac surgery suggest that patients diagnosed with perioperative atrial fibrillation have a much higher risk of stroke in the following year (1.47 vs. 0.36%) compared to those without perioperative atrial fibrillation [adjusted hazard ratio 2.0, 95% confidence interval (CI) 1.7–2.3] [10]. Unfortunately, the duration of perioperative atrial fibrillation was not available. Another study using adminstrative data from Denmark showed that the risk of stroke and other thromboembolism among patients with new postoperative atrial fibrillation was equal to the risk in patients admitted with new atrial fibrillation unrelated to surgery [11]. Again, the duration of postoperative atrial fibrillation was not available. In this cohort study, starting oral anticoagulation within 30 days in patients with new postop atrial fibrillation was associated with a decreased long-term risk of stroke or other thromboembolism (adjusted hazard ratio 0.52, 95% CI 0.40-0.67). Authors of one set of guidelines comment that for noncardiac illness (including the perioperative state), the role of anticoagulation after transient atrial fibrillation is unclear and should be addressed on the basis of the patient's risk profile and the duration of the atrial fibrillation episode, but provide no guidance on how to do this [4].

When rhythm control is considered, we typically obtain cardiology consultation to advise on pharmacologic versus electrical cardioversion, and potential need for transesophageal echocardiogram to assess for left atrial thrombi. Key points for the medicine consultant include:

- Amiodarone is often used but has a very long half-life and may cause significant long-term side effects.
- Other antiarrhythmic agents (e.g., dofetilide, flecainide, propafenone, and sotalol) and cardioversion may be considered in consultation with a cardiologist.

KEY CLINICAL PEARLS

- Direct acting oral anticoagulants (DOACs, e.g., dabigatran, rivaroxaban, apixaban, and edoxaban) almost never require bridging when temporarily discontinued prior to a procedure.

- The timing of the last dose of a DOAC prior to surgery depends on the bleeding risk of the procedure and on the patient's renal function.
- For patients on warfarin for atrial fibrillation, we do not bridge with heparin when the CHA_2DS_2-VASc score is 0–4 and there is no history of stroke/TIA or systemic embolism.

ACKNOWLEDGMENTS

Dr. Kai-Chun (Daniel) Yang, Acting Assistant Professor, Division of Cardiology, Department of Medicine, University of Washington, and Staff Cardiologist at VA Puget Sound Health Care System.

REFERENCES

1. Fleisher LA, et al. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol. 2014;64(22):e77–137.
2. Lip GY, Nieuwlaat R, Pisters R, Lane DA, Crijns HJ. Refining clinical risk stratification for predicting stroke and thromboembolism in atrial fibrillation using a novel risk factor-based approach: the euro heart survey on atrial fibrillation. Chest. 2010;137(2):263–72.
3. Van Gelder IC, et al. Lenient versus strict rate control in patients with atrial fibrillation. N Engl J Med. 2010;362(15):1363–73.
4. January CT, et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation. JACC. 2014;64(21):e1–e76.
5. Devereaux PJ, et al. Aspirin in patients undergoing noncardiac surgery. N Engl J Med. 2014;370:1494–503.
6. Hansen ML, et al. Risk of bleeding with single, dual, or triple therapy with warfarin, aspirin, and clopidogrel in patients with atrial fibrillation. Arch Intern Med. 2010;170(16):1433–41.
7. Doherty JU et al. 2017 ACC expert consensus decision pathway for periprocedural management of anticoagulation in patients with nonvalvular atrial fibrillation: a report of the American College of Cardiology Clinical Expert Consensus Document Task Force. J Am Coll Cardiol. 2017;69(7):871–898.
8. Douketis JD, et al. Perioperative bridging anticoagulation in patients with atrial fibrillation. N Engl J Med. 2015;373(9):823–33.
9. Gage BF, et al. Validation of clinical classification schemes for predicting stroke: results from the national registry of atrial fibrillation. JAMA. 2001;285(22):2864.
10. Gialdini G, et al. Perioperative atrial fibrillation and the long-term risk of ischemic stroke. JAMA. 2014;312(6):616–22.
11. Butt JH, et al. Risk of thromboembolism associated with atrial fibrillation following noncardiac surgery. J Am Coll Cardiol. 2018;72:2027–36.
12. Lip GY, et al. Identifying patients at high risk for stroke despite anticoagulation: a comparison of contemporary stroke risk stratification schemes in an anticoagulated atrial fibrillation cohort. Stroke. 2010;41:2731–8.

Chapter 10
Hypertension

Tiffany Chen

BACKGROUND

Although hypertension alone is not a significant risk factor for major perioperative cardiovascular events, patients with hypertension-related end-organ damage such as congestive heart failure, renal impairment, and cardiovascular disease are at additional risk [1, 2]. Severe hypertension (systolic blood pressure >180 or diastolic blood pressure >110) upon admission to the preoperative area is associated with intraoperative blood pressure lability and myocardial ischemia [3]; it is suggested to postpone elective surgery in those cases, based on limited available data [4, 5]. While it remains unclear whether postponing surgery for blood pressure control improves outcomes [6], in practice many providers would be hesitant to proceed. Optimization of blood pressure preoperatively in clinic may help avoid unnecessary cancellations and minimize perioperative complications.

PREOPERATIVE EVALUATION

- Assess level of blood pressure control
- Assess for complications of long-standing hypertension (stroke, cardiomyopathy, and nephropathy)
- Consider delaying elective surgery in patients with poorly controlled hypertension (BP > 180/110)
- Advise preoperative medication management (see Table 10.1)

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_10

TABLE 10.1 PREOPERATIVE MANAGEMENT OF ANTIHYPERTENSIVE MEDICATIONS

Beta blockers	Continue, and take on morning of surgery
ACE-I/ARB	Hold for 24 hours prior to surgery, unless patient has poorly controlled hypertension (SBP > 180 or DBP > 110)
Diuretics	Hold on the morning of surgery Can continue if poorly controlled hypertension, or based on volume status assessment
Calcium channel blockers	Continue, and take on morning of surgery unless blood pressure is tightly controlled
Clonidine	Continue, and take on morning of surgery Transition to clonidine transdermal preoperatively if expected to be strict NPO postoperatively: Place equivalent patch on 3 days preoperatively Simultaneously taper PO off
Nitrates	Continue, and take the morning of surgery
Hydralazine	Continue, and take the morning of surgery

PERIOPERATIVE MANAGEMENT

Depending on the surgical approach, there can be large blood pressure fluctuations intraoperatively; this lability is augmented in patients with hypertension. Sympathetic activation during induction increases blood pressure, which is followed by a progressive decline due to the reduction of systemic vascular resistance [4, 7]. While both severe hypertension and hypotension have been reported to be associated with poor outcomes, intraoperative hypotension especially seems to be associated with an increase in 30-day postoperative mortality in noncardiac surgery [7].

PREOPERATIVE MANAGEMENT

General Principles

- For patients who are severely hypertensive in preoperative clinic, the initiation of antihypertensive medications should be based on usual evidence-based guidelines guided by their comorbidities, ideally when the surgery is far enough away that the patient can be re-evaluated for blood pressure control and adverse drug effects.
- If the surgery is very soon or the patient is severely hypertensive (SBP > 180, DBP > 110) on the day of surgery, an individual

assessment must be made whether to proceed or cancel the surgery. In the absence of end-organ damage (hypertensive emergency), there is a paucity of postoperative outcome data for these patients and it is unclear if postponing surgery to optimize blood pressure is superior to acute blood pressure control in the preoperative holding area [6].

- Blood pressure risk is a continuum and must be balanced with other factors, including the urgency of surgery. If considering cancellation, it is usually best to discuss with the surgeon and anesthesiologist.

Medication Management

Most blood pressure medications can be continued safely through surgery (see Table 10.1). However, patients with excessively tight blood pressure control may develop profound intraoperative hypotension, so careful attention should be given to antihypertensive medication recommendations, especially angiotensin-converting enzyme inhibitors (ACE-Is), angiotensin receptor blockers (ARBs), and diuretics.

- ACE-I/ARBs: While these classes of medications are associated with intraoperative hypotension [8–10], the data are conflicting about whether they affect postoperative outcomes, including mortality or vascular events [9, 10]. As such, whether or not to hold them prior to surgery remains controversial [2, 11]. Our practice is to hold ACE-I and ARB medications the 24 hours prior to surgery unless the patient has uncontrolled hypertension or systolic congestive heart failure.
- Diuretics: There is a theoretical risk of volume depletion (which can worsen intraoperative hypotension) and hypokalemia (which can predispose to arrhythmias or potentiate muscle blockade). One small study showed no difference in outcomes whether loop diuretics were held or continued through surgery [12]. Our practice is to hold diuretics the morning of surgery unless the patient has uncontrolled hypertension or has challenging volume overload (e.g., severe heart failure or end stand renal disease) with diuretic dependence.
- Beta blockers: Guidelines recommend continuation of beta blockers through surgery, as acute withdrawal perioperatively can increase cardiovascular morbidity and mortality [2].
- Clonidine: Abrupt withdrawal can cause severe rebound hypertension.

POSTOPERATIVE MANAGEMENT

Postoperative hypotension is common due to blood loss, volume depletion, sedatives/pain medications, and epidural use. Thus, home blood pressure medications should be carefully reintroduced after surgery (see Table 10.2). Conversely, some patients may be hypertensive from pain, agitation, withdrawal, or hypervolemia. Mild to moderately elevated blood pressures generally do not require further treatment; our practice is to treat SBP >180 or DBP > 110. Before using blood pressure medications, ensure underlying causes like pain or withdrawal syndromes (alcohol, benzodiazepines) are addressed.

- Unless there are concerns for acute end-organ damage, postoperative hypertension can generally be treated with oral agents—ideally with resumption of their chronic blood pressure medications.
- It is important to clarify NPO status with surgical team (many patients can still take and absorb oral medications, even if they have not advanced to a diet).

If patient is strictly NPO including medications, IV, or transdermal routes are utilized (see Table 10.3). There are not strong data to support any particular blood pressure medication in the postoperative period.

TABLE 10.2 POSTOPERATIVE MANAGEMENT OF ANTIHYPERTENSIVE MEDICATIONS

Beta blockers	Continue; if strict NPO, give as IV equivalent dose Hold or reduce if symptomatic hypotension or bradycardia Common hold parameters are for SBP < 100 or HR < 60, but individualize as needed
ACE-I/ARBs	Restart if SBP > 120 and no concerns for acute kidney injury
Diuretics	Consider holding for first few days post op after major surgery, especially if reduced PO or NPO—patients are at risk for hypovolemia and electrolyte derangements like hyponatremia and hypokalemia
Calcium channel blockers	Continue, but hold or reduce if hypotension or bradycardia
Clonidine	Continue PO or transdermal, to avoid rebound hypertension
Nitrates	Continue, but hold or reduce if hypotension
Hydralazine	Continue, but hold or reduce if hypotension

TABLE 10.3 IV AND TRANSDERMAL OPTIONS FOR TREATING HYPERTENSION

Metoprolol	2.5–5 mg IV q4–6 hours PO to IV conversion is 2.5:1
Labetalol	10–20 mg IV initial dose, double q10 min to desired response up to a single maximal dose of 80 mg or a cumulative dose of 300 mg/day. Dose may be limited by bradycardia
Nitroglycerin	1/2–2" ointment q6h As drip: Initial rate of 5 mcg/min, titrate by 5 mcg/min every 5 minutes
Hydralazine	10–20 mg IV q30–60 min
Esmolol	Initial rate of 250–500 mcg/kg/min for first minute then 25–50 mcg/kg/min; titrate up to max of 300 mcg/kg/min
Nicardipine	Initial rate of 5 mg/h, increase 2.5 mg/h every 5 min to max of 15 mg/h
Enalaprilat	0.625–1.25 mg IV q6 hours, double at 4–6 hours intervals to a single max dose of 5 mg or cumulative dose of 20 mg/day

KEY CLINICAL PEARLS

- Evaluate for hypertensive-related end-organ damage, which is associated with increased major perioperative cardiac events.
- Consider postponing elective surgery for SBP > 180 or DBP > 110, although it is unclear whether outpatient blood pressure control is superior to acute preoperative blood pressure management.
- Perioperative ACE-I and ARB management remains controversial, but it is reasonable to hold 24 hours prior to avoid intraoperative hypotension in most cases.

ACKNOWLEDGMENTS

G. Alec Rooke, MD, Professor, Department of Anesthesiology and Pain Medicine, University of Washington.

REFERENCES

1. Lee TH, Marcantonio ER, Mangione CM, Thomas EJ, et al. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. Circulation. 1999;8:1043–9.
2. Fleisher LA, Fleischmann KE, Auerbach AD, et al. 2014 ACC/AHA guideline on Perioperative Cardiovascular Evaluation and Management of Patients Undergoing Noncardiac Surgery: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation. 2014;130(24):2215–45.

3. Howell SJ, Sear JW, Foex P. Hypertension, hypertensive heart disease and perioperative risk. Br J Anaesth. 2004;92(4):570–82.
4. Hartle A, McCormack T, Carlisle J, et al. The measurement of adult blood pressure and management of hypertension before elective surgery: joint guidelines from the Association of Anaesthetists of Great Britain and Ireland and the British Hypertension Society. Anaesthesia 2016;71:326–337.
5. Nadella V, Howell SJ. Hypertension: pathophysiology and perioperative implications. BJA Education. 2015;15(6):275–9.
6. Weksler N, Klein M, Szendro G, et al. The dilemma of immediate preoperative hypertension: to treat and operate, or to postpone surgery? J Clin Anesth 2003;15:179–183.
7. Monk TG, Bronsert MR, Henderson WG, et al. Association between intraoperative hypotension and hypertension and 30 day postoperative mortality in noncardiac surgery. Anesthesiology. 2015;123(2):307–19.
8. Rosenman DJ, McDonald FS, Ebbert JO, et al. Clinical consequences of withholding versus administering renin-angiotensin-aldosterone system antagonists in the perioperative period. J Hosp Med. 2008;3(4):319–25.
9. Roshanov PS, Rochwerg B, Patel A, et al. Withholding versus continuing antiogensin-converting enzyme inhibitors or angiotensin II receptor blockers before noncardiac surgery: an analysis of the vascular events in noncardiac surgery patients cohort evaluation prospective cohort. Anesthesiology. 2017;126(1):16–27.
10. Hollman C, Fernandes NL, Biccard BM. A systematic review of outcomes associated with withholding or continuing angiotensin-converting enzyme inhibitors and angiotensive receptor blockers before noncardiac surgery. Anesth Analg. 2018;127:678.
11. Kristensen SD, Knuuti J, Saraste A, et al. 2014 ESC/ESA guidelines on non-cardiac surgery: cardiovascular assessment and management: the joint task force on non-cardiac surgery: cardiovascular assessment and management of the European Society of Cardiology (ESC) and the European Society of Anaesthesiology (ESA). Eur Heart J. 2014;35(35):2383–431.
12. Khan NA, Campbell NR, Frost SD, et al. Risk of intraoperative hypotension with loop diuretics: a randomized control trial. Am J Med. 2010;123:1059e1–9.

Chapter 11
Implantable Cardiac Electronic Devices

Michael L. Hall and G. Alec Rooke

BACKGROUND

OVERVIEW OF DEVICE-RELATED COMPLICATIONS

Patients with pacemakers or internal cardioverter-defibrillators (ICDs) are at risk for device malfunction or exposure to electromagnetic interference (EMI) from monopolar cautery, magnetic resonance imaging (MRI), radiofrequency ablation, electroconvulsive therapy, lithotripsy, and therapeutic radiation [1]. The most common and potentially life-threatening adverse effects of EMI are:

- Inhibition of cardiac pacing leading to severe bradycardia or asystole.
- Inadvertent shocks if an ICD interprets the EMI as a heart rate higher than the therapy trigger rate.

However, EMI may also lead to tachycardia from:

- Noise reversion (when EMI makes the rhythm uninterpretable to the device, the device may automatically switch to asynchronous pacing and thereby create a rhythm that competes with the intrinsic rhythm).
- Activation of the rate-response feature by EMI may cause the pacing rate to increase, which typically results in a paced tachycardia (see below).
- EMI sensed as intrinsic atrial beats that lead to ventricular paced beats.
- Pacemaker-mediated tachycardia (PMT), which is most commonly caused by a retrograde P wave triggering a ventricular pacing beat and repeating loop.

In addition, if the EMI becomes intense, such as if the cautery occurs within 8 cm of the device, the device may:

- Transiently turn off and when it reboots, revert to default settings instead of the original programmed settings.

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_11

- Burn the myocardium at the pacer lead tip if there is a break in the lead insulation.
- If cautery is applied to the device, it may fry the electronics and render the device nonfunctional.

BASIC PACEMAKER AND ICD FUNCTIONS

Pacemaker function is often summarized with a three- or four-letter code, with the letters designating the chambers that are paced, the chamber(s) where sensing is performed, and the device's response to a sensed beat [2–4] (see Table 11.1). A fourth letter, "R," is often added if a rate-adaptive or rate-responsive mechanism is operational. When the activity sensor within the device determines that the patient is active, the backup (demand) pacing rate increases. Sensor options include the following [5]:

- A piezoelectric crystal that detects either muscle pressure on the device or body movement: In the operating room (OR), shaking the patient can cause increases in heart rate.
- Bioimpedance measurement within the chest to estimate minute ventilation: To make this measurement the device emits a small current between the generator and the lead. This permits an impedance measurement that reflects tidal volume, and its frequency provides the respiratory rate. The respiratory rate module of most OR/intensive care unit (ICU) monitors has similar technology and can fool the pacer/ICD into thinking the patient is physically active. This results in an inappropriate paced tachycardia.
- Bioimpedance measurement within the myocardium (an index of sympathetic nervous system activity): This measurement is made at the tip of the lead. There is no known activation with EMI, but increases in sympathetic outflow during surgery could cause increases in the minimum pacing rate.

TABLE 11.1 PACEMAKER FUNCTION CODES

First letter	Second letter	Third letter
Chamber(s) paced	Chamber(s) sensed	Response to sensing
A = atrium	A = atrium	I = inhibited
V = ventricle	V = ventricle	T = trigger
D = dual (both chambers)	D = dual (both chambers) O = no sensing	D = dual (inhibit or trigger depending on the situation) O = nothing

COMMON PACING MODES

- *VVI*: Senses and paces the ventricle (demand pacing)
- *DDD*: Both atrium and ventricle are sensed and paced individually
- *VVIR and DDDR*: Same as VVI or DDD, but with rate-responsive mechanism

IMPLANTABLE CARDIOVERTERS [2, 3]

- Respond to tachyarrhythmias (typically ventricular tachycardia and fibrillation) based on detection of defined, high ventricular rates.
- Therapies include rapid pacing (known as antitachycardia pacing, ATP), low-energy synchronized shocks, or high-energy unsynchronized shocks.
- All ICDs have pacing capability. The pacemaker component of an ICD is the same as a regular pacemaker and the four-letter code still applies. In an ICD, the pacemaker settings vary from very basic (patient with no need for a pacemaker) to as complex as any patient with pacemaker requirement.

CARDIAC RESYNCHRONIZATION THERAPY

- These devices pace both the right and left ventricles to produce a more coordinated left ventricular contraction [2, 3].
- If defibrillation capability is present, it is referred to as cardiac resynchronization therapy (CRT)-D.
- The four-letter pacing mode nomenclature can still be used to describe the pacemaker capability of the cardiac resynchronization therapy (CRT) or CRT-D device.

Subcutaneous ICD

The subcutaneous ICD system allows for implantation of a defibrillator in the subcutaneous extrathoracic space. This system eliminates complications from venous leads such as infection or vascular and cardiac damage [1, 2]. These devices can only deliver shocks, no antitachycardia pacing is possible. Routine demand pacing is also unavailable. As with all ICDs, shock therapies should be disabled with a magnet or be reprogrammed if EMI will be generated by the procedure. It is important to note that they have their own programming box and the standard programmer will not recognize the device. Furthermore, magnet placement must be centered at the top or bottom edge of the device. If placed correctly, beeps with each QRS will be heard for the first 60 seconds after magnet placement.

Leadless Pacemaker

Leadless pacemakers currently consist of the Micra Transcatheter Pacemaker System (TPS; Medtronic, Minneapolis MN) and the Nanostim leadless pacemaker (St. Jude, St. Paul, MN). These pacemakers are novel and management at this time is based on expert opinion as there are no society guidelines that mention intraoperative management [1]. A leadless device is not as easily recognizable as a conventional lead pacemaker on radiographic images and due to its entirely intracardiac implantation, it is also not identifiable on physical exam. There is no magnet mode in the Medtronic TPS system; however, the St. Jude Nanostim reverts to a rate of VOO rate 65 when a magnet is used. These devices are programmable.

PREOPERATIVE EVALUATION

Most experts recommend that a plan for device management for surgery be made by a qualified individual with the recommendation based on knowledge of the proposed surgery and the information gleaned from a recent interrogation of the device [1, 6, 7]. The typical recommendations will be one of the following:

- Nothing required (e.g., surgery on the leg, where EMI detection by the device is virtually unheard of).
- Placement of a magnet (fine for an ICD when the cautery is below the umbilicus) or having a magnet available for use with a pacemaker if unacceptable bradycardia is observed during periods of EMI.
- A prescription for what programming changes is needed for surgery. If a prescription is needed, then arrangements must be made for a qualified individual to perform the programming.

The decision to proceed with surgery without formal device evaluation should be made cautiously. Clearly the urgency of the surgery is a factor, but the risk of adverse events increases whenever monopolar cautery will be applied within 8 cm of the device, the leads use monopolar sensing (almost all devices use bipolar sensing but it is almost impossible to know without interrogation), the patient is pacemaker dependent, the ICD is programmed so that it will not respond to a magnet (rare, but potentially disastrous) [8], the device battery is at its end of life, or if the grounding pad is improperly placed.

In the absence of qualified practitioner involvement, there is still a great deal that can be learned without formal device interrogation. Indeed, such analysis can aid in the determination of the need for qualified practitioner involvement [9].

Step 1—Device identification: Pacer or ICD?

- Patients may not know the distinction, but most carry a card with the device and lead(s) model numbers, implant dates, and implanting cardiologist. Also determine when the device was last interrogated. In general, ICDs should have been checked within 3 months of surgery, and pacemakers within 6 months.
- A chest X-ray provides clear information as to the device and potential pacing capabilities. If all the leads are thin, then the device must be a pacemaker. If some leads have fat, densely radio-opaque sections (usually in the superior vena cava and right ventricle) then the device is an ICD.
- Careful scrutiny of the device on the chest X-ray also typically reveals a symbol and letter/number code identifying the manufacturer and model. One can call the manufacturer (see Table 11.2) or check their website to obtain information about the device capability including the device's response to a magnet, but the company will not have any patient-specific information.

Step 2—Determine pacer dependency.

- Obtain a long rhythm strip or observe on a monitor. All monitors have electrical filters that prevent visualization of the spikes unless special circuitry is turned on, so make sure the monitor is set to "pacing on." If the patient has a reasonable rhythm with no or few pacing spikes, the patient is clearly not pacing dependent. Consistent pacing spikes suggests but does not prove pacing dependency. For example, perhaps the patient has a sinus rhythm that is slightly lower than the minimum pacing rate. Patients with cardiac resynchronization therapy (CRT) have deliberately short P-R pacing intervals to ensure consistent ventricular pacing to improve cardiac output. The rhythm strip will not reveal whether the patient has an intact AV conduction. In such situations, the only way to determine true pacing dependency is via a formal interroga-

TABLE 11.2 PACEMAKER COMPANY CONTACT INFORMATION

Company and phone number	Good battery pacemaker magnet rate
Biotronik: (800) 547–0394	90
Ela Sorin: (303) 467–6101	96
Guidant/Boston Scientific: (800) 227–3422	90
Medtronic: (800) 723–4636	85
St. Jude: (800) 933–9956	98.6 or 100

tion, although communication with the cardiologist who follows the patient may provide that information.

Step 3—Place a magnet over the device during EKG monitoring.

- If asynchronous pacing at the expected battery rate is then observed (see Table 11.2), the device (a) is not an ICD and (b) the battery has adequate remaining charge.
- As batteries become depleted, the magnet rate drops at least 10 bpm below the normal battery rate (see below for specific normal values).
- The presence of a weak battery should be a trigger for expert involvement before proceeding to surgery for anything other than the most dire circumstances.

Step 4—Check electrolytes.

- Patients on diuretics or acutely ill should have their electrolytes checked. Pacing thresholds can be affected by electrolyte disturbances as well as acid–base disturbances.

Step 5—Contact a qualified individual.

- This step should be performed whenever possible. This could be the person who normally manages the device or someone within your system.
- With your knowledge of the device and proposed surgery, it can be determined if interrogation is needed prior to surgery and which option is best (do nothing, place magnet, reprogram for surgery).

PERIOPERATIVE MANAGEMENT

INTRAOPERATIVE CARE

For all patients, the following management points should be employed:

- The cautery grounding pad should be located on the patient such that the cautery current is directed away from the device and leads.
- Some form of pulse monitor must be used during cautery. The pulse oximeter, routinely used during surgery, is adequate for this purpose.
- Recommendations for the use of bipolar cautery or short cautery bursts are almost always impractical and should be left to the OR personnel.
- Depending on the proximity of the cautery to the device and leads, patients dependent on the device to maintain a reason-

able heart rate will typically be changed to asynchronous pacing. Magnet use on pacemakers will prevent bradycardia/asystole, but the high heart rate associated with the magnet use may not be appropriate for all patients.

- A discussion about the device settings between the programmer and the anesthesia team is helpful as the anesthesia team can contribute to the decision-making process and be better aware of how the device might perform during surgery.
- The worst-case scenario is a patient with an ICD and pacemaker dependency having surgery above the umbilicus. Use of a magnet may prevent inadvertent shocks but will not prevent the cautery EMI from inhibiting the demand pacing. Should demand pacing be inhibited and the patient develops an inadequate pulse or asystole, then cautery bursts must be infrequent and of limited duration.
- Noise reversion mode exists in many but not all devices. If noise reversion is activated by EMI, the device will pace asynchronously during the EMI or pacing may be inhibited based on programming.

Implantable cardioverter-defibrillator management

- Tachycardia sensing should be disabled to prevent unwanted shocks.
- If a magnet is used, the operator needs to know (1) whether or not the device is programmed to disable the ICD in response to the magnet and (2) what tones the device will emit (if any) to indicate that the device has sensed the magnet. In the event of an intraoperative tachyarrhythmia, simple removal of the magnet will reactivate the device.
- If tachy therapy has been programmed off, then defibrillation pads and a defibrillator should be kept with the patient, if not placed on the patient.

POSTOPERATIVE MANAGEMENT

Device interrogation after surgery should be performed [1]:

- To restore the original device settings.
- To make sure that the EMI has not caused any damage to the device or leads or resulted in a return to default settings. This is primarily a concern only when the cautery was applied close to the device or leads.

Other situations that should prompt postoperative interrogation include the following:

- Monopolar cautery was performed within 8 cm of the device.
- Cardioversion/defibrillation was performed.
- The patient had serious hemodynamic problems intraoperatively (such as chest compressions, massive bleeding, and prolonged hypotension).
- The patient had radiofrequency ablation.
- A central line was placed.
- There were concerns about device function in the operating room.

Patients who were exposed to monopolar cautery below the umbilicus, had lithotripsy, or electroconvulsive therapy do not need interrogation after the procedure but should see their cardiologist within 1 month.

KEY CLINICAL PEARLS

- Document the type of device (pacemaker, ICD, resynchronization therapy), the manufacturer, implantation date, and the indications for the device as part of the preoperative assessment.
- Document when the device was last evaluated and obtain a copy of that report if possible, in the preoperative evaluation. ICDs should be checked within 3 months of surgery, and pacemakers within 6 months.
- For all patients with pacemakers or ICDs, involve a qualified professional as needed to determine the best plan for intraoperative device management.
- The most common and potentially life-threatening adverse effects of electromagnetic interference are inhibition of cardiac pacing (pacemakers or ICDs) and the delivery of inappropriate shocks (ICDs).

REFERENCES

1. Gold MR, Aasbo JD, El-Chami MF, Niebauer M, Herre J, Prutkin JM, Knight BP, Kutalek S, Hsu K, Weiss R, Bass E, Husby M, Stivland TM, Burke MC. Subcutaneous implantable cardioverter-defibrillator post-approval study: clinical characteristics and perioperative results. Heart Rhythm. 2017;14(10):1456–63.
2. Chang PM, Doshi R, Saxon LA. Subcutaneous implantable cardioverter-defibrillator. Circulation. 2014;129(23):e644–46.

3. Mickus GJ, Soliman GI, Reed RR, Martin AK. Perioperative management of a leadless pacemaker_ the paucity of evidence-based guidelines. J Cardiothorac Vasc Anesth. 2016;30(6):1594–8.
4. Crossley GH, Poole JE, Rozner MA, Asirvatham SJ, Cheng A, Chung MK, Ferguson Jr TB, Gallagher JD, Gold MR, Hoyt RH, Irefin S, Kusumoto FM, Moorman LP, Thompson A. The Heart Rhythm Society expert consensus statement on the perioperative management of patients with implantable defibrillators, pacemakers and arrhythmia monitors: facilities and patient management. Heart Rhythm. 2011;8:1114. 📖
5. Allen M. Pacemakers and implantable cardioverter defibrillators. Anaesthesia. 2006;61:883–90.
6. Moses HW, Mullin JC. A practical guide to cardiac pacing. 6th ed. Philadelphia: Lippincott Williams & Wilkins; 2007. ISBN 978-0-7817-8881-6.
7. Bernstein AD, Daubert JC, Fletcher RD, et al. The revised NASPE/BPEG generic code for antibradycardia, adaptive-rate, and multisite pacing. Pacing Clin Electrophysiol. 2002;25:260–4.
8. Leung S-K, Lau C-P. Developments in sensor-driven pacing. Cardiol Clin. 2000;18:113–55.
9. Gallagher MD, David Hayes MD, Jane EH. ASA task force on perioperative management of patients with cardiac implantable electronic devices. Practice advisory for the perioperative management of patients with cardiac implantable electronic devices: pacemakers and implantable cardioverter-defibrillators. Anesthesiology. 2011;114:247–61.

Chapter 12
Valvular Heart Disease

Pallavi Arora and Divya Gollapudi

BACKGROUND

Severe valvular disease is identified as a cardiac risk factor in the American College of Cardiology/American Heart Association (ACC/AHA) perioperative guidelines [1, 2]. Attention to the type and severity of valvular heart disease during the preoperative visit can help guide perioperative risk assessment and management. Severe aortic stenosis and mitral stenosis are considered to pose the greatest perioperative risk, as compared to regurgitant lesions [1, 2]. Distinguishing pathologic from functional murmurs and assessing a patient's functional status by careful history and exam are the first essential steps. The ACC/AHA perioperative cardiac risk assessment guidelines generally recommend to obtain a preoperative echocardiogram in patients with clinically suspected moderate or severe valvular disease if change in symptoms or exam or if no prior echocardiogram within 1 year [1].

Perioperative considerations in patients with other structural heart conditions, such as congenital cyanotic heart disease, are beyond the scope of this book—the patient's cardiologist should generally be involved in the care of these patients.

AORTIC STENOSIS

PREOPERATIVE EVALUATION

Aortic stenosis (AS) is a common valvular abnormality in elderly adults [3, 4]. Symptoms include angina, exertional syncope, dyspnea, and decreased exercise tolerance, and coronary artery disease is a

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_12

TABLE 12.1 ECHOCARDIOGRAPHIC SEVERITY FOR AORTIC STENOSIS

Stage	Aortic jet velocity m/s	Mean gradient (mm Hg)	Valve area (cm^2)
Mild	<3.0	<25	1.5
Moderate	3.0–4.0	25–40	1.0–1.5
Severe	>4.0	>40	<1.0

common comorbidity. The murmur of AS is systolic, located at the right second intercostal space, and can radiate to the right carotid or clavicular area.

Physical examination findings suggestive of severe AS that might warrant preoperative echocardiogram include [5]:

- Late peaking murmur (positive likelihood ratio: +LR 4.4)
- Sustained apical pulse (+LR 4.1)
- Delayed carotid artery upstroke (+LR 3.3)
- Brachioradial delay (+LR 2.5)

Table 12.1 shows severity classification by echocardiogram.

In AS, the average decrease in valve area is approximately 0.1 cm^2 per year, but progression is unpredictable and can occur rapidly [6]. Preoperative echocardiogram is warranted in patients with new or worsening symptoms or physical exam findings suggestive of significant AS. It is also reasonable to obtain an echocardiogram within:

- 6–12 months for severe AS
- 1–2 years for moderate AS
- 3–5 years for mild AS

PERIOPERATIVE RISK STRATIFICATION

Severe AS is associated with an increased perioperative mortality rate in patients undergoing noncardiac surgery [1, 2].

The risk of postoperative adverse cardiac events increases with higher risk noncardiac surgeries, increasing severity of AS, presence of symptoms preoperatively, coexisting moderate to severe mitral regurgitation (MR), and underlying coronary artery disease.

Patients with severe aortic stenosis may have impaired platelet function and decreased levels of von Willebrand factor, which can be associated with clinically significant bleeding (usually epistaxis or ecchymosis) [6].

Aortic sclerosis without stenosis is not considered an independent perioperative risk factor.

PERIOPERATIVE MANAGEMENT

Preoperative Considerations

- Evaluation for valve replacement is recommended in symptomatic patients prior to noncardiac surgery [6].
- Consider cardiology consultation in asymptomatic patients with severe and moderate AS prior to elevated risk noncardiac surgery or those with coexisting moderate to severe MR, decreased left ventricular ejection fraction (LVEF), or preexisting coronary artery disease (CAD), as these factors have been associated with higher odds ratio of postoperative MI and 30-day mortality [1].
- Balloon valvotomy is not recommended as a temporizing measure in patients with severe AS undergoing noncardiac surgery [6].

Intra- and Postoperative Considerations

For asymptomatic patients with moderate to severe disease, consider close postoperative hemodynamic monitoring in an intensive care unit (up to 48 hours).

AS results in reduced left ventricular (LV) compliance from chronic pressure overload, leading to preload dependence. Therefore, maintenance of intravascular volume, avoidance of hypotension, tachycardia, and maintenance of sinus rhythm are paramount in the intraoperative and postoperative periods [6, 7].

In the event of major bleeding or volume loss, maintenance of excellent IV access and rapid resuscitation are vital.

Avoid the use of nitrates in patients with severe or critical AS, as nitrates reduce filling pressures (preload) and may precipitate cardiac arrest.

Patients with subaortic stenosis (i.e., idiopathic hypertrophic subaortic stenosis) should be managed similarly to patients with AS.

MITRAL STENOSIS

PREOPERATIVE EVALUATION

While the incidence of mitral stenosis is low in developed countries, it is still prevalent in developing countries owing to higher prevalence of rheumatic fever. Patients with mitral stenosis are at increased risk for perioperative tachyarrhythmias and heart failure; thus, it is important to identify these patients preoperatively [1].

Common symptoms of mitral stenosis are dyspnea, fatigue, decreased exercise tolerance, palpitations, and syncope.

Mitral stenosis causes a low-pitched, blowing diastolic murmur, which is best heard with the bell of the stethoscope [5]. Findings of increasingly severe mitral stenosis include:

- Faint or inaudible murmur [5]
- Diminished S1

In addition to new or worsening symptoms in a patient with known mitral stenosis, it is reasonable to obtain an echocardiogram prior to non-cardiac surgery within [6]:

- 12 months for severe mitral stenosis
- 1–2 years for moderate mitral stenosis
- 3 years for mild mitral stenosis

PERIOPERATIVE MANAGEMENT

- Percutaneous or surgical repair should be considered in patients with severe mitral stenosis who have symptoms and/or severe pulmonary hypertension [1, 6].
- Patients with asymptomatic, severe mitral stenosis can proceed with noncardiac surgery with close intraoperative and postoperative monitoring [1, 6].
- Perioperative heart rate control and maintenance of sinus rhythm is important, as tachycardia can reduce diastolic filling and lead to pulmonary congestion; discussion with a cardiologist is warranted [1, 6].
- Mitral stenosis leads to a fixed stroke volume, making it important to avoid hypotension and maintain normal systemic vascular resistance perioperatively. Patients with mitral stenosis are sensitive to sudden increases in left atrial pressure, which can precipitate pulmonary edema. Judicious use of intravenous fluids has to be counterbalanced with maintenance of systemic vascular resistance and avoidance of hypotension [1, 6, 7].

AORTIC REGURGITATION

PREOPERATIVE EVALUATION

Limited data suggest that patients with moderate to severe aortic regurgitation (AR) have increased risk of perioperative cardiac and pulmonary morbidity and mortality, as compared to patients without significant AR [8].

Symptoms of chronic AR include palpitations, dyspnea, and chest pain.

There are several physical exam findings associated with AR, the most important being the presence of an early, blowing, high-frequency diastolic murmur [5, 9].

Physical exam findings suggestive of moderate to severe AR include [5]:

- Diastolic blood pressure ≤50 mm Hg (+LR 19.3)
- Pulse pressure ≥80 mm Hg (+LR 10.9)
- Murmur grade 3 or louder (+LR 8.2)
- S3 gallop (+LR 5.9)

In addition to new or worsening symptoms in a patient with known AR, it is reasonable to obtain an echocardiogram within [6]:

- 6–12 months for severe AR (or more frequently if dilating left ventricle)
- 1–2 years for moderate AR
- 3 years for mild AR

PERIOPERATIVE MANAGEMENT

- Symptomatic patients or asymptomatic patients with significantly reduced LV function with AR should be considered for valve replacement [6].
- Patients with asymptomatic severe AR and a normal LVEF can generally proceed with surgery with close intraoperative and postoperative hemodynamic monitoring [6].
- Perioperative management should include attention to volume control and afterload reduction [1].
- Bradycardia should be avoided, as low heart rates can acutely worsen regurgitation by increasing diastolic time [7].

MITRAL REGURGITATION

PREOPERATIVE EVALUATION

Mitral regurgitation (MR) is the most common valvular disorder [3]. The most common etiologies are papillary muscle dysfunction from ischemic heart disease and mitral valve prolapse. Recent observational and retrospective studies have reported that patients with severe MR are at greatest risk for perioperative heart failure (20%) and atrial fibrillation (14%)—these risks are increased in patients with ischemic MR and decreased LV function [10, 11].

The murmur of MR is holosystolic, high-pitched, and is heard best at the apex. The characteristics of moderate to severe MR include [5]:

- Murmur grade 3 or louder (+LR 4.4)
- S3 (89% of patients with severe MR)

Echocardiogram findings

- LVEF measured on echocardiogram may be overestimated in the setting of severe MR [1, 6].
- Ventricular dysfunction may be present with a normal or only mildly reduced ejection fraction on echocardiogram.

In addition to new or worsening symptoms in a patient with known MR, it is reasonable to obtain an echocardiogram within [6]:

- 6–12 months for severe MR (or more frequently if dilating left ventricle)
- 1 year for moderate MR
- 3 years for mild MR

PERIOPERATIVE MANAGEMENT

- Patient with symptomatic MR or asymptomatic MR with significantly decreased LVEF should be considered for valve repair or replacement [6].
- In patients with severe MR undergoing elevated risk procedures, perioperative hemodynamic goals should be directed toward maximizing left ventricular forward output and minimizing regurgitant flow by maintaining afterload reduction and allowing a high heart rate. Postoperative intensive care unit (ICU) monitoring is recommended in these patients [1, 7].
- Bradycardia increases diastolic time and can increase regurgitation, thus should be minimized; however, maintaining a higher heart rate in patients with significant coronary artery disease and ischemic MR, may precipitate demand ischemia [7].
- Antibiotic prophylaxis against infective endocarditis is not recommended for patients with mitral valve prolapse or MR [12–14].

PROSTHETIC HEART VALVES

PERIOPERATIVE CONSIDERATIONS

Function of the Prosthetic Valve

Echocardiography is indicated if there is a new murmur, new symptoms, or change in clinical status (including evidence of new or worsening heart failure, hemolytic anemia, systemic embolism) [6, 15].

Transesophageal echocardiogram may be required to adequately assess mitral and posterior aspect of aortic prosthesis.

Management of Anticoagulation

Anticoagulation in patients with mechanical or bioprosthetic valves requires careful perioperative planning and coordination with the surgical team.

See Chap. 26 on perioperative anticoagulation for further discussion of anticoagulation.

ENDOCARDITIS PROPHYLAXIS

Based on the 2017 ACC/AHA guideline update for valvular heart disease, endocarditis prophylaxis is recommended for the below patients before undergoing dental procedures (procedures with gingival disruption, adenoidectomy, or tonsillectomy) [12]:

- Prosthetic heart valves or prosthetic material used for cardiac valve repair
- History of previous infective endocarditis
- Cardiac transplantation recipients with valve regurgitation due to structurally abnormal valve
- Unrepaired cyanotic congenital heart disease or repaired congenital heart disease, with residual shunts or valvular regurgitation at the site of or adjacent to the site of a prosthetic patch or prosthetic device

Prophylaxis against infective endocarditis is not recommended for nondental procedures in the absence of active infection or in patients with common valvular abnormalities, including bicuspid aortic valve, aortic stenosis, and mitral valve prolapse.

Antibiotic regimens for endocarditis prophylaxis are listed in Table 12.2 [13].

TABLE 12.2 ANTIBIOTIC REGIMENS FOR ENDOCARDITIS PROPHYLAXIS IN HIGH-RISK PATIENTS UNDERGOING PROCEDURE-SPECIFIC INDICATIONS

	Antibiotic regimen	Antibiotic regimen if penicillin or ampicillin allergic
Oral	Amoxicillin 2 g	Cephalexin 2 g or clindamycin 600 mg or azithromycin 500 mg or clarithromycin 500 mg
Unable to take oral medication	Ampicillin 2 g IM/IV or cefazolin 1 g IM/IV or ceftriaxone 1 g IM/IV	Cefazolin 1 g IM/IV or ceftriaxone 1 g IM/IV or clindamycin 600 mg IM/IV

All doses are 30–60 min prior to procedure. Adapted with permission from [13]

KEY CLINICAL PEARLS

- Assessment of presence and severity of valvular heart disease is an important part of the preoperative assessment.
- Obtain an echocardiogram preoperatively if concern for symptomatic or significant valvular stenosis or regurgitation.
- Patients with symptomatic and/or severe valvular disease should be referred to cardiology for consideration of possible valve repair or replacement prior to noncardiac surgery.
- Patients with severe valvular regurgitation or stenosis should be monitored closely in the postoperative setting, with careful attention being paid to hemodynamics and volume status.
- Endocarditis prophylaxis is recommended for patients with prosthetic heart valves, history of infective endocarditis, and congenital heart disease with certain characteristics undergoing dental procedures.

REFERENCES

1. Fleischmann KE, Auerbach AD, et al. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing non-cardiac surgery. J Am Coll Cardiol. 2014. https://doi.org/10.1016/j.jacc.2014.07.944.
2. Goldman L, Caldera DL, Nussbaum SR, et al. Multifactorial index of cardiac risk in non-\ cardiac surgical procedures. N Engl J Med. 1977;297:845–50.
3. Nkomo VT, Gardin JM, Skelton TN, et al. Burden of valvular heart diseases: a population-based study. Lancet. 2006;368(9540):1005–11.
4. Wright D. Aortic stenosis and surgery. J Hosp Med. 2012;7(8):655–6.
5. McGee S. Evidence-based physical diagnosis. 3rd ed. Philadelphia: Elsevier Saunders; 2012. p. 736.
6. Nishimura RA, Otto CM, Bonow RO, et al. 2014 AHA/ACC guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association task force on practice guidelines. J Am Coll Cardiol. 2014;63(22):e57–185.
7. Frogel J, Galusca D. Anesthetic considerations for patients with advanced valvular heart disease undergoing non-cardiac surgery. Anesthesiol Clin. 2010;28(1):67–85.
8. Lai HC, Lai HC, Lee WL, et al. Impact of chronic advanced aortic regurgitation on the perioperative outcome of non-cardiac surgery. Acta Anaesthesiol Scand. 2010;54(5):580–8.
9. Choudhry NK, Etchells EE. The rational clinical examination. Does this patient have aortic regurgitation? JAMA. 1999;281(23):2231–8.
10. Bajaj NS, Agarwal S, Rajamanickam A, et al. Impact of severe mitral regurgitation on postoperative outcomes after non-cardiac surgery. Am J Med. 2013;126(6):529–35.
11. Lai HC, Lai HC, Lee WL, et al. Mitral regurgitation complicates postoperative outcome of non-cardiac surgery. Am Heart J. 2007;153(4):712–7.
12. Nishimura RA, Otto CM, Bonow RO, et al. 2017 AHA/ACC focused update of the 2014 AHA/ACC guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. Circulation. 2017;135(25):e1159–95.
13. Nishimura RA, Carabello BA, Faxon DP, et al. ACC/AHA 2008 guideline update on valvular heart disease: focused update on infective endocarditis. Circulation. 2008;118:887–96.
14. Wilson W, Taubert KA, Gewitz M, et al. Prevention of infective endocarditis: guidelines from the American Heart Association. Circulation. 2007;115:1736–54.
15. Pibarot P, Dumesnil JG. Prosthetic heart valves: selection of the optimal prosthesis and longterm management. Circulation. 2009;119:1034–48.

Chapter 13
Diabetes

Tiffany Chen

BACKGROUND

Diabetes and perioperative hyperglycemia are common and associated with an increased risk of infections and other complications [1–6]. Perioperative control of hyperglycemia can help improve postoperative outcomes [7, 8]. Preoperative evaluation is important for both risk stratification in this higher risk population and to recommend a perioperative glycemic management plan. Basal insulin therapy is key to glycemic control. Utilize a Basal, Bolus, and Correctional insulin approach (see Table 13.1), rather than relying on "sliding scale" insulin [8].

PREOPERATIVE EVALUATION

The preoperative evaluation is focused on assessing for complications, estimating cardiac and other perioperative risks, and formulating a perioperative glycemic management plan that is individualized to the patient and the surgery. Although an elevated A1c is associated with increased postoperative infection and adverse events [2], it is unclear whether postponing surgery to optimize glycemic control decreases this risk. There is no consensus for an A1c cutoff for which elective surgery should be postponed, although it can be considered if an A1c if >8.5% [9]. Similarly, there is no absolute cutoff for a very elevated blood glucose on the day of surgery, although most would cancel elective procedures for a blood glucose >500 or if there is evidence of hyperosmolar hyperglycemic state, diabetic ketoacidosis, or severe electrolyte derangements.

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_13

TABLE 13.1 INSULIN TERMINOLOGY

Basal	Longer-acting insulin (e.g., glargine, detemir, NPH) that provides constant "background" insulin regardless of meals. All patients with type 1 DM *require* this. Many patients with type 2 DM need this, especially in the perioperative period.
Bolus (prandial/ mealtime)	Fixed dose (or altered dose for larger/smaller meals) of rapid-acting insulin (e.g., lispro, aspart, regular) that is given before a meal to mimic the body's normal response to a caloric load.
Correctional	Variable amount of rapid-acting insulin given *in addition to* prandial and/or basal insulin to correct hyperglycemia. Suggested to correct blood glucoses >180. Can also be given at bedtime, although reasonable to be more conservative at this time due to greater risk of nocturnal hypoglycemia. Patients requiring frequent correctional insulin usually need adjustments to either their basal or prandial insulin regimens. Most institutions have a protocol based on a patient's total daily insulin requirement.

- Determine the type of diabetes, as type 1 diabetics must have basal insulin at all times to prevent diabetic ketoacidosis.
- Assess for presence of complications associated with diabetes (especially cardiovascular and kidney disease) and assess the risk for major perioperative cardiac events (see Chap 6).
- Review current medication management.
- Assess quality of glycemic control. Review a recent hemoglobin A1c, although recognize this measurement may be inaccurate in many situations (end-stage renal disease, erythropoietin therapy, acute anemia, recent blood transfusions, chronic hemolysis, etc.) [10]. It is also a crude marker of dysglycemia and does not reflect glucose variability or postprandial hyperglycemia. When possible, review home glucose readings including log book, finger stick, and/or continuous glucose meter data.
- Be alert for "over-basalization," if a patient's basal insulin is more than 60% of their total daily dose (TDD) of insulin or they report nocturnal/fasting hypoglycemia. This will impact perioperative management, as giving close to their usual dose of basal insulin may result in severe hypoglycemia while nil per os (NPO).

- Assess for hypoglycemia, and if present, determine frequency, timing, severity, and awareness.
- Review the characteristics of the surgery and patient's expected caloric intake perioperatively. Some enhanced recovery after surgery (ERAS) pathways include preoperative carbohydrate loading, which can cause severe hyperglycemia in some diabetics and should be avoided. Conversely, bariatric surgeries require severely restricted caloric intake preoperatively, putting patients at risk for hypoglycemia.
- Determine if an elective surgery should be postponed if diabetes is poorly controlled and there is insufficient time to modify their regimen. It may not be practical to postpone surgery until the A1c reaches a certain target, but blood glucose checks can be used to assess for improved glucose control.
- If surgery is time sensitive, if unable to achieve adequate glucose control as outpatient, or if unsafe to correct the glucose more quickly, consider admission for preoperative IV insulin drip.
- Provide recommendations for preoperative medication management.

PERIOPERATIVE MANAGEMENT

Perioperative hyperglycemia is associated with multiple postoperative complications including infection, increased length of stay, and mortality [3–6]. This effect is even more pronounced in patients who were not previously diagnosed with diabetes [5, 6]. There is evidence that treatment of perioperative hyperglycemia with insulin can improve outcomes [7, 8], although there is no consensus on the optimal blood glucose range. Guidelines by different societies suggest anywhere between 80 and 200 [11–16]. Our practice is to target 100–180. We avoid the lower end for patients at risk for hypoglycemia as tight postoperative glucose control does not seem to be superior to more liberal strategies [17] and is associated with increased mortality in critically ill patients [18].

PREOPERATIVE MANAGEMENT

For outpatient morning procedures in which the patient is expected to only miss breakfast, their basal insulin can be continued without dose adjustment. Oral medication and prandial insulin can then be resumed postoperatively.

TABLE 13.2 PREOPERATIVE MANAGEMENT OF ORAL AND NONINSULIN INJECTABLE AGENTS

	Recommendation	Notes
Metformin	Hold morning of surgery	Risk of lactic acidosis with acute kidney injury
Sulfonylureas	Hold morning of surgery	Risk of hypoglycemia
Meglitinides	Hold morning of surgery	
Thiazolidinediones	Hold morning of surgery	May cause fluid retention
SGLT2 inhibitors	Hold 3 days prior to surgery	Has been associated with euglycemic diabetic ketoacidosis
DPP-IV inhibitors	Hold morning of surgery	
GLP-1 receptor agonists	Hold morning of surgery	Slows gastric motility

Below are recommendations for patients who are NPO at midnight before surgery and likely to have decreased caloric intake postoperatively.

- Oral and non-insulin injectable agents are discontinued the morning of surgery (Table 13.2). Sodium-glucose-cotransporter-2 (SGLT2) inhibitors are held 3 days prior to surgery due to their risk of euglycemic diabetic ketoacidosis [19, 20].
- Hold prandial insulin the morning of surgery. Continue basal insulin the night before and morning of surgery, but reduce the dose. Table 13.3 gives suggested guidelines.

POSTOPERATIVE MANAGEMENT

Many dynamic variables affect postoperative blood glucoses, making glycemic management challenging. Major surgery, general anesthesia, and intraoperative dexamethasone (usually given for postoperative nausea control) contribute to short-term hyperglycemia and insulin resistance. Conversely, caloric intake is often reduced in the postoperative period, although this can be highly variable between patients. We rely on insulin for hyperglycemia management and hold all oral and noninsulin injectable diabetes medications until the patient is medically stable and eating a regular, consistent diet.

TABLE 13.3 PREOPERATIVE MANAGEMENT OF INSULIN

		Type 2 DM	Type 1 DM
Basal Insulin	NPH	75% of usual evening dose before surgery 50% of usual morning dose	No less than 80% of the usual evening dose before surgery or morning dose
	Glargine	If <50 units: Take 75% of usual dose If >50 units: Take 50% of usual dose	No less than 80% of the usual dose
	Detemir	If <50 units: Take 75% of usual dose If >50 units: Take 50% of usual dose	No less than 80% of the usual dose
	Degludec U200 or U100 (Tresiba®)	Take 75% usual dose	No less than 80% of the usual dose
	Glargine U300 (Toujeo®)	Take 75% usual dose	No less than 80% of the usual dose
	Premixed insulin *(NPH/regular 70/30, Humalog® 75/25 or 50/50, Novolog® 70/30)*	75% the usual dose evening dose before surgery 50% the usual morning dose	80% of usual evening dose before surgery and morning dose
	Insulin pump	In general, continue basal rate, then switch to D5NS and an insulin infusion just prior to surgery and disconnect the pump. Continue IV insulin until patient is tolerating adequate diet. Resume SC pump when patient is alert and able to manage. Consider endocrinology consult	
Bolus/ Prandial	Short acting insulins (regular, lispro, aspart, fiasp, glulisine)	Do not take on the morning of surgery with the exception of correction algorithms for hyperglycemia using rapid-acting analogs (lispro, aspart, fiasp, or glulisine) Note: Do not use regular insulin (U-100 and U-500) for correction due to prolonged duration of effect	

These are general guidelines and should be tailored to each individual patient

The key to good blood glucose control is thinking in terms of basal, bolus (prandial), and correctional insulin (B-B-C), rather than relying on just "sliding scale" insulin treatment (Table 13.1). This B-B-C strategy is shown to both improve postoperative glycemic control and decrease complications [8].

Below are some management tips for other special considerations:

NPO with institutional IV insulin protocol

- An IV insulin infusion is useful as patients' insulin requirements in the very immediate postoperative period can be unpredictable (stress-induced hyperglycemia highly variable between patients) and dynamic (insulin requirements will generally go down with time away from surgery).
- Transition to subcutaneous (SC) insulin when the patient is eating or has reasonably stable blood glucoses on an insulin infusion. See Table 13.4 for IV to SC calculations.
- Overlap SC basal insulin with IV insulin infusion by 2 hours due to its slow onset of action (Table 13.5). This is especially critical in type 1 diabetes.

TABLE 13.4 TRANSITIONING FROM IV TO SC INSULIN: CALCULATING THE DOSE

Guidelines	Example
The subcutaneous (SC) dose is only 60–80% of the IV dose. Postop insulin requirements also tend to go down with time, so a reasonable plan is to calculate the amount of IV insulin given over the last 16 hours to estimate the 24 hours SC insulin requirement	Required 3 units/hours of IV insulin in last 16 hours
Last 16 hours total IV dose = Next 24 hours total SC Dose	Calculate SC dose: 3 × 16 = 48 units total SC dose
Divide the 24 hours SC dose into basal and prandial bolus ~50% estimated requirement is given as basal ~50% estimated requirement is given as prandial ∗ If patient is not eating three full meals a day, you may want to give >50% basal and less prandial. If not eating at all, give 60–70% basal ∗ Add correctional insulin and modify scheduled basal/prandial based on usage	*Basal*: ½ × 48 = 24 units (ex. glargine QHS) *Prandial*: ½ × 48 = 24 units (ex. lispro) divided before each meal 24 units/3 = 8 units before each meal (if isocaloric)

TABLE 13.5 ONSET, PEAK, AND DURATION OF EFFECT OF VARIOUS INSULINS

	Onset	Peak	Duration	Notes
NPH	1–1.5 hours	4–12 hours	12–16 hours	Typically dosed twice a day for basal coverage. Has a peak and thus can have some prandial coverage
Glargine (U100)	1 hour	None	20–24 hours	Typically dose once daily but some require twice daily, especially in type 1 DM
Detemir	1 hour	None	20–24 hours	Similar to glargine
U300 glargine (Toujeo®)	1–2 hours	None	Up to 36 hours	1:1 conversion with U100 glargine
U200 or U100 Degludec (Tresiba®)	0.5–1.5 hours	None	>42 hours	1:1 conversion with U100 glargine Takes about 3–4 days to reach steady state If patient on glargine while hospitalized and transitions back to Degludec U200 upon discharge, may have blood glucose excursions first couple of days
Lispro/aspart/glulisine, Fiasp (faster acting Aspart)	5–20 min	0.5–1.5 hours	3–6 hours	Residual effect can be seen out to 6–8 hours. Prone to "stacking" with frequent correctional doses. Do not dose more frequently than every 2 hours to minimize this risk
Regular	30–60 min	2–4 hours	8–10 hours	Should not be used as correctional insulin (use rapid acting analogue instead)
U-500	Entails special concerns. Usually used in obstetric patients, patients with lipodystrophy, and very insulin resistant patients. Pharmacokinetics varies depending on dose. If patient is on U-500 at home, it is suggested that an endocrinologist be involved			

NPO without IV insulin infusion protocol available

- Devise a SC basal and correctional insulin plan for use while the patient is NPO.
- Add bolus insulin when the patient is eating.
- If the patient was previously on insulin, use their home regimen as a guide.
- Otherwise, calculate their estimated TDD requirement of insulin by weight (0.2–0.5 units/kg), using the lower end of the range for elderly patients and those with renal impairment. Give 1/2 the estimated daily requirement as basal and then give the other 1/2 as prandial in divided doses once patient is able to take PO.

Total parental nutrition (TPN)

- An insulin infusion takes the guesswork out of calculating the correct dose.
- Add insulin to the TPN bag when the patient is stable and insulin requirement has been established using the insulin infusion protocol.
- Calculate the insulin requirement by adding up the number of units of insulin the patient received via IV protocol for the last 12 hours and multiply by 2 for the 24-hour requirement.
- Add 80–100% of the calculated 24-hour dose to the next bag of TPN.
- Stop the insulin infusion when the insulin containing TPN bag begins and start additional SC correctional insulin every 6 hours.
- Adjust the amount of insulin in the TPN bag daily as needed.
- If cyclic TPN, make sure to only use the infusion rate during the time when the TPN is running to calculate how much insulin to put in the TPN bag. Add basal coverage as needed (with insulin infusion or SC NPH) for the period they are off TPN.
- When IV insulin infusion is not available, or a total of 20 units of correction insulin per day have been required with TPN, a conservative insulin to carbohydrate ratio can be utilized to estimate the first introduction of Regular insulin into the TPN bag. Start with 1 unit for every 10 gm of carbohydrate and adjust daily [16].

Tube feeds

- See Table 13.6 for recommendations

TABLE 13.6 INSULIN MANAGEMENT FOR PATIENTS RECEIVING TUBE FEEDS

Continuous	If on IV insulin infusion, then continue infusion until on a stable requirement. Then, give ½ as NPH twice daily, and use regular insulin q6 hours to satisfy the remaining ½ of TDD of insulin (see Table 13.4). Give as NPH in divided doses either q12hours (if TDD ≤20 units) or q6hours (if TDD >20 units) If *not* on IV insulin—Continue prior home basal insulin. In addition to this, add regular insulin to satisfy tube feeding every 6 hours, using an insulin to carbohydrate ratio 1 unit for every 10–15 grams of carbohydrate [16] If patient has not been on continuous infusion, then calculate the SC daily basal/prandial requirement using body weight, 0.2–0.5 units/kg. Age, renal function, home insulin regimen, and baseline blood glucose control need to be considered in dosing
Bolus	Give prandial insulin prior to each bolus and give basal insulin separately
Cyclic	8-hour cycle: Give ½ the prandial requirement as regular at start of tube feeds 12-hour cycle: Give ½ the prandial requirement as NPH at start of tube feeds Give basal requirement with separate agent. To simplify the regimen, can use q12h NPH for basal coverage and add the basal NPH to the prandial NPH together at the start of tube feeds

Cyclic tube feeds are challenging. Covering an 8–12 hour "meal" followed by 16–12 hour of "fasting" requires constant titration of insulin doses based on glucose monitoring
Additionally, tube feeds might be interrupted due to clogging of the tube or procedures, thus increasing the risk for hypoglycemia. If tube feeds are interrupted for >1 hour, it is suggested to consider starting a dextrose infusion

Bariatric surgery

- Patients are often much more insulin sensitive after bariatric surgery, especially after a Roux-en-Y gastric bypass [21].
- Use an insulin infusion in the immediate postoperative setting to get a sense of patient's new basal requirement, if any. Patients requiring less than 1 unit of IV insulin per hour postoperatively, may transition from IV to correction insulin only.
- Prandial insulin is initially impractical due to severely restricted caloric intake.

- Consider dosing NPH twice a day with a higher dose in the morning to provide both basal and coverage for smaller meals during the day.
- While the oral diet remains low immediately after surgery and initially after discharge, it is not unexpected for patients previously managed with insulin, to achieve blood glucose below 180 mg/dL without exogenous insulin.

Ongoing steroid use:

- Steroids tend to worsen postprandial hyperglycemia.
- If patient is eating a regular diet, give no more than 40% basal and at least 60% prandial insulin.

U200 Degludec (Tresiba®)

- This basal insulin has a very long half-life and takes several days to reach steady state (Table 13.5).
- Its use is increasingly common as an outpatient, but it is infrequently on hospital formularies.
- It is important to know that due to its pharmacokinetics, it may have prolonged effects after discontinuation. Also, a patient may experience a day or two of hyperglycemia after discharge since they will have stopped the medication while hospitalized, and it will take several days again to reach steady state upon reinitiation at home.

Continuous glucose monitors

- These have not been approved for blood glucose monitoring or medication administration outside the ambulatory care setting. In general, use standard finger stick blood glucose testing when patient is in the operating room or hospitalized.

POST-DISCHARGE FOLLOW-UP

The trend in surgery is to implement systems (like ERAS pathways) to standardize postoperative care, improve outcomes, and decrease length of stay. As such, patients overall are being discharged earlier then they have in the past after surgery. It is important to identify which patients may have an insulin regimen that is still in a state of flux and arrange appropriate follow-up.

KEY CLINICAL POINTS

- Aim for a perioperative blood glucose target of around 100–180.
- The key to good glycemic control is using a strategy of basal, bolus, and correctional (B-B-C) insulin, rather than relying on "sliding scale."
- Reassess and modify postoperative insulin regimens often, as patients' insulin sensitivity and caloric intake are frequently dynamic.

ACKNOWLEDGMENTS

Cora Espina, MN, ARNP, CWCN, Teaching Associate, Division of Endocrinology, UW School of Medicine.

REFERENCES

1. Lee TH, Marcantonio ER, Mangione CM, Thomas EJ, et al. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. Circulation. 1999;8:1043–9.
2. Underwood P, Askari R, Hurwitz S, et al. Preoperative A1c and clinical outcomes in patients with diabetes undergoing major noncardiac surgical procedures. Diabetes Care. 2014;37:611–6.
3. Van den Boom W, Schroeder RA, Manning MW, et al. Effect of A1c and glucose on postoperative mortality in noncardiac and cardiac surgeries. Diabetes Care. 2018;41(4):782–8.
4. Kwon S, Thompson R, Dellinger P, et al. Importance of perioperative glycemic control in general surgery. Ann Surg. 2013;257(1):8–14.
5. Kotagal M, Symons RG, Hirsch IB, et al. Perioperative hyperglycemia and risk of adverse events among patients with and without diabetes. Ann Surg. 2015;261(1):97–103.
6. Frisch A, Chandra P, Siley D, et al. Prevalence and clinical outcome of hyperglycemia in the perioperative period in non cardiac surgery. Diabetes Care. 2010;33:1783–8.
7. Furnary AP, Gao G, Grunkemeier GL, et al. Continuous insulin infusion reduces mortality in patients with diabetes undergoing coronary artery bypass grafting. J Thorac Cardiovasc Surg. 2003;125(5):1007–21.
8. Umpierrez GE, Smiley D, Jacobs S, et al. Randomized study of basal bolus insulin therapy in the inpatient management of patients with type 2 diabetes undergoing general surgery (RABBIT 2 Surgery). Diabetes Care. 2011;34:256–61.
9. Dhatariya K, Levy N, Kilvert A, et al. Diabetes UK position statements and care recommendations: NHS diabetes guideline for the perioperative management of the adult patient with diabetes. Diabet Med. 2012;29:420–33.
10. Write LAC, Hirsch IB. The challenge of the use of glycemic biomarkers in diabetes: Reflecting on hemoglobin A1c, 1,5-anhydroglucitol, and the glycated proteins fructosamine and albumin. Diabetes Spectr. 2012;25:141–8.
11. Duggan EW, Carlson K, Umpierrez GE. Perioperative hyperglycemia management: an update. Anesthesiology. 2017;126(3):547–60.
12. Upierrez GI, Hellman R, Korytkowski MT, et al. Management of hyperglycemia in hospitalized patients in non-critical care setting: an endocrine society clinical practice guideline. J Clin Endocrinol Metab. 2012;97:16.
13. American Diabetes Association Standards of medical care in diabetes–2017. Diabetes Care. 2017;40(5 Suppl. 1):S120–7.
14. Moghissi ES, Korytkowski MT, DiNardo M, et al. American Association of Clinical Endocrinologists and American Diabetes Association consensus statement on inpatient glycemic control. Endocr Pract. 2009;15(4):1–17.

15. Lazar HL, McDonnell M, Chipkin SR, et al. The society of thoracic surgeons practice guideline series: blood glucose management during adult cardiac surgery. Ann Thorac Surg. 2009;87:663–9.
16. American Diabetes Association Diabetes care in the hospital. Diabetes Care. 2017;40(Suppl. 1):S120–7.
17. Buchleitner AM, Martinez-Alonso M, Hernandez M, et al. Perioperative glycaemic control for diabetic patients undergoing surgery. Cochrane Database Syst Rev. 2012;(9):CD007315.
18. The NICE-STUDY Investigators. Intensive versus conventional glucose control in critically ill patients. NEJM. 2009;360(13):1283–97.
19. U.S. Food and Drug Administration. FDA drug safety communication: FDA revises labels of SGLT2 inhibitors for diabetes to include warnings about too much acid in the blood and serious urinary tract infections. Wilver Spring: U.S. Food and Drug Administration; 2018. Available at https://www.fda.gov/Drugs/DrugSafety/ucm475463.htm. Accessed 9 May 2016.
20. Handelsman Y, Henry RR, Bloomgarden ZT, et al. American Association of Clinical Endocrinologists and American College of Endocrinology position statement on the association of SGLT-2 inhibitors and diabetic ketoacidosis. Endocr Pract. 2016;22:753–62.
21. Rubino F, Gagner M, Gentileschi P, et al. The early effect of the Roux-En-Y gastric bypass on hormones involved in body weight regulation and glucose metabolism. Ann Surg. 2004;240(2):236–42.

Chapter 14
Stress-Dose Steroids

Kara J. Mitchell

BACKGROUND

Adrenal insufficiency is a clinical entity associated with potentially serious findings such as hypotension, mental status changes, nausea and vomiting, hyponatremia, and/or hyperkalemia. Patients with adrenal insufficiency and some of those with suppressed hypothalamic-pituitary-adrenal (HPA) axis due to chronic glucocorticoid (GC) use are at risk for adrenal crisis, which can cause hypotension or even death. This chapter addresses supplemental steroid dosing (commonly called "stress-dose steroids") for the prevention of adrenal crisis in patients with adrenal insufficiency undergoing surgery.

Patients are treated with glucocorticoids for a multitude of conditions, including primary adrenal insufficiency, organ transplantation, autoimmune diseases, and other inflammatory states. The use of supplemental perioperative steroids in such patients is controversial [1, 2]; according to the Cochrane Library, "There is insufficient evidence on whether additional steroids are required at the time of surgery for patients with adrenal insufficiency." Given significant potential risk, and in the absence of adequate clinical trials, many experts still recommend perioperative administration of supplemental steroids [3].

PREOPERATIVE EVALUATION

First, assess whether the patient's hypothalamic-pituitary-adrenal (HPA) IS suppressed, MAY BE suppressed, or is NOT suppressed:

- All patients with primary adrenal insufficiency (Addison's disease) or ACTH deficiency (hypothalamic/pituitary dysfunction) have inadequate GC production [4].

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_14

- Higher doses and longer duration of GC therapy render the HPA axis more suppressed, but considerable variability is seen between patients [3–5]; see Table 14.1 for information on how to risk-stratify patients with chronic GC exposure.
- Recovery from tertiary adrenal insufficiency may take months [4, 5], so the clinical history should include all GC use within the past year.

TABLE 14.1 HPA AXIS SUPPRESSION BASED ON GLUCOCORTICOID EXPOSURE HISTORY [3]

HPA axis status	Glucocorticoid (GC) exposure	Management
NOT suppressed	<3 weeks Every-other-day therapy AM dose of <5 mg prednisone or equivalent[a]	Take usual AM dose of GC
MAY be suppressed	Intermediate-dose GC use (5–20 mg prednisone or equivalent/day) Inhaled GC use >3 intra-articular or spinal GC injections in the past 3 months Class I topical GC use[b] Significant GC use in the past year	Check 8 AM serum cortisol (24 hours off usual GC dose) vs. empiric supplemental GC without testing If <5 mcg/dL, give supplemental GC If >10 mcg/dL, take usual AM dose of GC If 5–10 mcg/dL, do ACTH stimulation test [6] vs. give empiric supplemental GC
IS suppressed	>20 mg/day of prednisone or equivalent for >3 weeks Clinically Cushingoid appearance[c]	Supplemental GC

[a]5 mg prednisone = 4 mg methylprednisolone = 0.75 mg dexamethasone = 20 mg hydrocortisone

[b]Class I topical glucocorticoids include betamethasone dipropionate 0.05%, clobetasol propionate 0.05%, diflorasone diacetate 0.05%, fluocinonide 0.1%, and halobetasol propionate 0.05%

[c]Prominent central obesity, "moon" facies, dorsocervical fat pad, and/or bulging supraclavicular fat pads

PERIOPERATIVE MANAGEMENT

If you decide that supplemental steroids are indicated for a patient, use Table 14.2 to find the recommended dose. These recommendations are based on expert opinion; all trials on this topic to date have been small [1, 2, 7–9]. Also, the anesthetic agent etomidate can cause clinically significant and prolonged adrenal insufficiency [10]; if this agent is to be used for induction or maintenance of anesthesia in an at-risk patient, steroid supplementation should be considered. Consider:

- The patient's preoperative GC dose
- Anticipated duration and stress of surgery
- Concomitant use of medications (i.e., rifampin) that alter GC metabolism

TABLE 14.2 DOSING FOR SUPPLEMENTAL GLUCOCORTICOIDS [7]

Surgical risk	Examples	Recommendation
Minor surgery	Inguinal hernia repair Colonoscopy	Take usual AM steroid dose
Moderate surgery	Open cholecystectomy Total knee replacement Abdominal hysterectomy	Take usual AM steroid dose plus give 25–50 mg hydrocortisone IV prior to surgery followed by 25 mg q 8 hours × 24 hours; then resume baseline dose[a]
Major surgery	Whipple Esophagectomy Total proctocolectomy Cardiac surgery	Take usual AM steroid dose plus give 25–100 mg hydrocortisone prior to surgery followed by 100–150 mg of hydrocortisone equivalent per day for 2–3 days (e.g., 50 mg q 8 hours × 48 hours); then taper dose by 1/2 per day until baseline dose reached[b]

[a]The exact dosing may be tailored to take into account the patient's baseline corticosteroid dose. In some cases, the baseline dose exceeds stress dosages and continuing the baseline dose is reasonable

[b]For very long surgeries, some advocate giving additional doses intraoperatively, or using dexamethasone. Also, if surgical complications (such as bleeding or infection) are encountered postoperatively, a longer duration of supplemental steroid administration may be indicated

TABLE 14.3 COMPLICATIONS OF GLUCOCORTICOID THERAPY

Hypothalamic pituitary adrenal (HPA) axis suppression
Impaired wound healing
Skin thinning and easy bruising
Reduced bone mass, leading to fracture
Increased susceptibility to infections
Insomnia, mania, psychosis
Ulcer/gastrointestinal bleeding
Insulin resistance
Fluid retention/worsened blood pressure control
Cardiovascular morbidity
Subcapsular cataract formation
Myopathy/proximal muscle weakness

- Use of medications (i.e., etomidate) that may suppress endogenous steroid synthesis
- Postoperative impairment of gastrointestinal function, which might warrant intravenous GC administration
- Complications of surgery that may warrant prolonged supplemental steroid dosing

Patients receiving GC therapy should be followed clinically for complications, such as those noted in Table 14.3 [3–5, 7]—especially increased susceptibility to infection and the risk that steroids may mask signs or symptoms of postoperative infection.

KEY CLINICAL PEARLS

- All patients with primary adrenal insufficiency (Addison's disease) and secondary adrenal insufficiency (ACTH deficiency) have absolute cortisol deficiency and require exogenous steroid administration perioperatively.
- Many experts still recommend supplemental steroids for patients with tertiary (iatrogenic) adrenal insufficiency due to recent or chronic glucocorticoid use; this is controversial, however, and a large randomized trial is needed.
- Etomidate can cause clinically significant adrenal insufficiency.

ACKNOWLEDGMENTS

Dr. R. Alan Failor, Clinical Professor, Department of Medicine, Division of Metabolism, Endocrinology and Nutrition, University of Washington.

REFERENCES

1. Yong SL, Marik P, Esposito M, Coulthard P. Supplemental perioperative steroids for surgical patients with adrenal insufficiency. Cochrane Database Syst Rev. 2009;(4):CD005367. [Note that a subsequent review (Cochrane Database Syst Rev 2012; 12:CD005367) continues to be withdrawn from publication as of 10/17/2013, due to "correspondence which have challenged the eligibility criteria and interpretation of the evidence summarized."].
2. Kelly KN, Domajnko BD. Peroperative stress-dose steroids. Clin Colon Rectal Surg. 2013; 26:163–7.
3. Hamrahian AH, Sanziana R, Milan S. The management of the surgical patient taking glucocorticoids. In: Post TW, editor. UpToDate. Waltham: UpToDate Inc; 2018. http://www.uptodate.com. Accessed on 30 Mar 2018.
4. Lamberts SW, Bruining HA, deJong FH. Corticosteroid therapy in severe illness. N Engl J Med. 1997;337:1285–92.
5. Coursin DB, Wood KE. Corticosteroid supplementation for adrenal insufficiency. JAMA. 2002;287(2):236–40.
6. Dorin RI, Qualls CR, Crapo LM. Diagnosis of adrenal insufficiency. Ann Intern Med. 2003;139(3):194–204.
7. Salem M, Tainsh RE, Bromberg J, et al. Perioperative glucocorticoid coverage: a reassessment 42 years after emergence of a problem. Ann Surg. 1994;219:416–25.
8. Aytac E, Londono JMR, Erem HH, et al. Impact of stress dose steroids on the outcomes of restorative proctocolectomy in patients with ulcerative colitis. Dis Colon Rectum. 2013;56:1253–8.
9. Zaghiyan K, Melmed GY, Berel D, et al. A prospective, randomized, noninferiority trial of steroid dosing after major colorectal surgery. Ann Surg. 2014;259(1):32–7.
10. Wagner RL, White PF, Kan PB, et al. Inhibition of adrenal steroidogenesis by the anesthetic etomidate. N Engl J Med. 1984;310(22):1415.

Chapter 15
Hormone Therapy

Alexander Pratt

BACKGROUND

Use of hormone therapy, including hormone replacement therapy (HRT), oral contraceptive pills (OCPs), and testosterone, is common. Perioperative consultants may be asked to provide an assessment of risks and recommendations for management of these medications perioperatively.

Male reproductive hormone therapy consists of exogenous testosterone, which is typically taken either as an oral formulation or via transdermal gels or creams. Testosterone is typically used to treat male hypogonadism and is sometimes used by men with intact gonadal axes. For information on the use of testosterone in transgender individuals, refer to Chap. 45. The most common types of hormone therapy for women are OCPs (used for birth control as well as other indications) and HRT (commonly used by women after menopause); use of either is associated with increased risk for venous thromboembolism (VTE) [1–3].

For the purposes of this chapter, the term OCPs will refer to estrogen-containing contraceptives. Progesterone-only contraceptives are likely less associated with VTE than estrogen-containing formulations, though their association with VTE is not as well studied. OCPs are very effective at preventing pregnancy, and disruptions in medication schedule can lead to unintended pregnancy, thus the perioperative management of OCPs should be carefully considered.

HRT most commonly consists of oral estrogen (17-beta estradiol or conjugated estrogens), though transdermal formulations and combined estrogen/progesterone formulations exist. Most women on HRT take these therapies for symptoms experienced during and after menopause, such as vasomotor symptoms ("hot-flashes") vaginal

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_15

dryness, and dyspareunia. HRT is usually quite effective at treating these symptoms, and women who quickly stop HRT while in the postmenopause period may have breakthrough symptoms.

Other exogenous hormones include selective estrogen receptor modulators (SERMs) and aromatase inhibitors (AIs), both typically used in patients undergoing treatment for a hormone-sensitive malignancy.

PREOPERATIVE EVALUATION

The cardiovascular risks of HRT are not yet conclusively delineated [4, 5]. Similarly, while there are theoretical cardiac risks associated with testosterone therapy (it has been shown to lower circulating high-density lipoprotein), there is no study yet that conclusively shows an associated cardiac risk [6]. The impact of OCPs on cardiac perioperative risk has not been well studied, but consensus suggests that individuals taking OCPs are not at additional cardiac risk. No additional preoperative evaluation is recommended based only on the use of HRT, OCPs, or testosterone.

PERIOPERATIVE MANAGEMENT

TESTOSTERONE

- In studies following the postoperative courses of men on testosterone therapy undergoing surgery for a variety of reasons, there has been no observed difference in their postoperative outcomes and relative risk of complications when compared to age-matched controls [7].
- We suggest continuing testosterone therapy prior to surgery and postoperatively.

HRT OR OCPS

Women on HRT and OCPs are at higher risk of venous thromboembolism (VTE) when compared to age-matched controls [1–3]. The data that inform this are largely derived from observational studies and have shown anywhere between a two- to sixfold increase in VTE in women receiving these therapies. The risk is more pronounced in those on oral estrogen rather than transdermal [2–4]; some studies have shown no effect of transdermal HRT on incidence of VTE [2, 3].

The hypothesized mechanism of action is estrogen-induced resistance to activated protein-C and reduced levels of protein-S; both compounds act as endogenous anticoagulants. The changes to coagulation seen on HRT and OCPs are similar to physiologic hormonal changes that occur during pregnancy. Patients taking SERMs are also at higher risk of VTE, likely due to a similar mechanism. Aromatase inhibitors (AIs) have not been shown to be associated with VTE.

The risk of VTE associated with the use HRT or OCPs is synergistic with other underlying causes of hypercoagulability. When paired with an underlying coagulopathy, the prothrombotic mechanism of female reproductive hormone therapy results in an exponential increase in the likelihood of VTE. This is significant as the postoperative state is prothrombotic due to a variety of factors, such as endothelial damage, venous stasis, and increased inflammation. The rates of VTE in patients on female reproductive hormone therapy with underlying inherited or acquired coagulopathy are particularly high, likely 20–40 times increased relative risk [8–10]. However, there is a paucity of high-quality data regarding the effects of continued OCP use in the perioperative period.

- For patients who take OCPs, we discuss risks and benefits of holding these agents perioperatively. We often lean toward recommending that patients continue OCPs to avoid unintended pregnancy in lower risk surgery (and based on lack of quality data suggesting risk for OCP use perioperatively), and holding OCPs for higher risk procedures, while discussing contraceptive alternatives with our patients.
- Our practice is to hold HRT approximately 2–4 weeks prior to surgery, in women who are willing and able, given the combined prothrombotic risks of surgery and estrogen, and relative safety of holding these medications.
- All patients who elect to continue HRT or OCPs perioperatively should receive pharmacologic VTE prophylaxis while in the hospital or less mobile, if safe from a surgical perspective.

SELECTIVE ESTROGEN RECEPTOR MODULATORS (SERMS)

SERMs (especially first generation, such as tamoxifen) are commonly used in the United States in the treatment of breast cancer, as part of a chemotherapy regimen. In breast cancer patients undergoing surgery while on tamoxifen, a higher incidence of VTE has been demonstrated. The risk is highest among those undergoing major surgery and is elevated in microvascular procedures as well.

- For patients undergoing major surgery (spinal surgery, joint replacement, etc.) or microvascular procedures, we recom-

mend stopping tamoxifen and other first-generation SERMs 2–4 weeks preoperatively and resuming 2–4 weeks postoperatively, or at a time when full mobility has returned [11, 12]. All decisions regarding the risks/benefits of cessation should be made in consultation with the patient's oncologist and surgeon.

- There is insufficient and inconsistent evidence regarding the VTE risk of the third-generation SERMs (raloxifene, toremifene, and ospemifene) to issue a definitive statement regarding their use perioperatively. Decisions regarding their continuation/cessation perioperatively should be made in consultation with the patient's oncologist and surgeon.

OTHER HORMONES

- Aromatase inhibitors (AIs) can be continued without interruption perioperatively.

KEY CLINICAL PEARLS

- Postmenopausal women receiving HRT are at increased risk of VTE compared to age-matched controls. The decision to continue or stop HRT should be made on an individualized basis.
- Guidance regarding management of OCPs perioperatively should be tailored to the individual and the type of surgery, due to OCP association with VTE risk, and the risk of unplanned pregnancy if held; individuals on these medications should receive VTE prophylaxis for the duration of their hospitalization.
- Testosterone can be continued perioperatively without cessation.

REFERENCES

1. Lidegaard O, et al. Risk of venous thromboembolism from use of oral contraceptives containing different progestogens and oestrogen doses: Danish cohort study, 2001-9. BMJ. 2011;343:d6423.
2. Canonico M, et al. Hormone replacement therapy and risk of venous thromboembolism in postmenopausal women: systematic review and meta-analysis. BMJ. 2008;336:1227.
3. Canonico M, et al. Hormone replacement therapy and risk of venous thromboembolism in postmenopausal women: sytematic review an meta-analysis. BMJ Online First. 2008;336:1227.
4. Cushman M, et al. Estrogen plus progestin and risk of venous thrombosis. JAMA. 2004;292(13):1573.
5. Anderson GL, et al. Effects of conjugated equine estrogen in postmenopausal women with hysterectomy: the Womans health initiative randomized controlled trial. JAMA. 2004;291(14):1701.

6. Wierckx K, et al. Long-term evaluation of cross-sex hormone treatment in transexual persons. J Sex Med. 2012;9:2641–51.
7. Maged Y, et al. Association of testosterone replacement therapy and the incidence of a composite of postoperative in-hospital mortality and cardiovascular events in men undergoing noncardiac surgery. Anesthesiology. 2017;127:457–65.
8. de Bastos M, et al. Combined oral contraceptives: venous thrombosis. Cochrane Database Syst Rev. 2014;(3):CD010813.
9. Vandenbroucke JP, et al. Increased risk of venous thrombosis in oral-contraceptive users who are carriers of factor V Leiden mutation. Lancet. 1994;344(8935):1453.
10. van Vlijmen EF, et al. Oral contraceptives and the absolute risk of venous thromboembolism in women with single or multiple thrombophilic defects: results from a retrospective family cohort study. Arch Intern Med. 2007;167(3):282.
11. Hussain T, Kneeshaw PJ. Stopping tamoxifen peri-operatively for VTE risk reduction: a proposed management algorithm. Int J Surg. 2012;10(6):313–6. https://doi.org/10.1016/j.ijsu.2012.05.001. Epub 2012 May 16.
12. Ellis AJ, Hendrick VM, Williams R, Komm BS. Selective estrogen receptor modulators in clinical practice: a safety overview. Expert Opin Drug Saf. 2015;14(6):921–34.

Chapter 16
Thyroid Disease

Eve M. Lake, Jennifer R. Lyden, and Jeanie C. Yoon

BACKGROUND

Thyroid gland disorders are common. Millions of Americans are living with subclinical or overt thyroid dysfunction [1–3], and physicians who provide perioperative care are frequently asked to assess surgical risks and assist in the management of patients with thyroid disease.

Thyroid hormone affects virtually every organ system in the body [1, 4]. In the perioperative period, the effects of thyroid imbalance range from clinically insignificant to shock and catastrophic multiorgan system failure [5]. Despite the prevalence of thyroid dysfunction and its potential impact on surgical patients, there is a paucity of data examining surgical outcomes in those with thyroid disease.

PREOPERATIVE EVALUATION

PATIENTS NOT KNOWN TO HAVE THYROID DYSFUNCTION

There is no evidence to support routine preoperative thyroid testing in asymptomatic patients. Consider testing for thyroid disease with a serum thyroid-stimulating hormone (TSH) if there is a clinical concern for new or poorly controlled thyroid disease. Symptoms and signs of significant thyroid dysfunction include:

- Hypothyroidism: Weight gain, lethargy, fatigue, cold intolerance, dry skin, brittle hair, goiter, bradycardia, delayed relaxation phase of deep tendon reflexes
- Hyperthyroidism: Weight loss, tremor, tachycardia, atrial fibrillation, goiter, exophthalmos

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_16

PATIENTS WITH KNOWN HYPOTHYROIDISM

- Patients with stable disease (e.g., no recent medication changes, and recently documented euthyroid state) do not require testing TSH preoperatively.
- Those with recent initiation or changes to thyroid hormone replacement therapy, or those with recent initiation or changes of drugs (e.g., estrogen) that affect thyroid hormone concentration, should have TSH checked preoperatively.
- Check TSH preoperatively in hypothyroid patients treated with animal-derived desiccated thyroid preparations (e.g., Armour Thyroid ®, Naturethroid ®), given greater risk of product variability [6].

PATIENTS WITH KNOWN HYPERTHYROIDISM

- Check baseline thyroid function tests (TSH and free T4) in all hyperthyroid patients, if not done within the last 3 months.
- Those with recent initiation or changes to antithyroid drugs, or those with recent initiation or changes of drugs (e.g., estrogen) that affect thyroid hormone concentration, should have TSH and free T4 checked preoperatively. Consider adding a total T3 if TSH is suppressed and there is clinical concern for thyrotoxicosis.
- If a patient has symptoms of dysphagia or dyspnea, or has stridor on exam, consult with an anesthesiologist.

PERIOPERATIVE MANAGEMENT

HYPOTHYROIDISM

Patients with treated hypothyroidism should continue thyroid hormone replacement therapy in the perioperative period including the morning of surgery and postoperatively.

- If oral access is unavailable, hormone replacement can be held safely for 6–7 days given its long half-life [7]; it can also be given parenterally (usually between 50% and 75% of the oral dose).
- Patients receiving thyroid hormone replacement via feeding tube, with or without concurrent enteral nutrition, are at risk of developing subclinical or overt hypothyroidism [8, 9]. Hold tube feeds for at least 1 hour before and after administration of levothyroxine.

There are little published data to help guide the management of hypothyroid patients perioperatively:

- No randomized trials have examined perioperative outcomes in euthyroid patients compared to those with thyroid dysfunction.
- Retrospective cohort studies have shown increased rates of complications associated with hypothyroid states [10].

Most experts agree that decisions to delay surgery should be based on the degree of hypothyroidism, presence of clinical features of hypothyroidism, and urgency of surgical intervention [11, 12]:

- In general, if time and clinical circumstances allow, achieving a euthyroid state prior to surgical intervention is optimal; however, patients with subclinical or mild hypothyroidism can typically proceed with elective surgeries (Table 16.1) [12–14].

TABLE 16.1 PERIOPERATIVE MANAGEMENT OF PATIENTS WITH HYPOTHYROIDISM

Degree of thyroid dysfunction	Laboratory findings	Elective	Urgent/ emergent	Treatment
Subclinical	Increased TSH Normal free T4	Proceed	Proceed	None
Mild – Moderate	Increased TSH Low free T4	Decision based on degree of thyroid dysfunction, presence of clinical features	Proceed	Standard replacement (1.7 mcg/kg PO daily; adjust dose q4-6wks based on TFTs)
Severe	Myxedema syndrome[a] Free T4 <1mcg/dL	Delay	Proceed	Endocrinology consult ICU transfer Emergent hormone replacement[b] Hydrocortisone 100 mg IV q8hours

[a]Myxedema syndrome is a medical emergency with a high mortality rate. Optimal management for myxedema syndrome is unclear [16] (see below)
[b]Treat with both T3 and T4 if suspicion for myxedema syndrome

TABLE 16.2 PERIOPERATIVE COMPLICATIONS IN PATIENTS WITH HYPOTHYROIDISM

Cardiovascular [3, 12, 13, 15]
Decreased cardiac output from decreased heart rate and stroke volume contractility
Decreased total blood volume from increased peripheral vascular resistance (increased mean arterial pressure suppresses the renin-angiotensin-aldosterone system which in turn decreases sodium absorption and blood volume)
Pulmonary [3, 12, 13, 15]
Respiratory failure from decreased hypoxic and hypercapneic ventilatory drive
Respiratory muscle weakness
Renal [3, 12, 13, 15]
Decreased renal perfusion
Inappropriate secretion of antidiuretic hormone leading to free water retention and hyponatremia
Decreased renal clearance of medications/anesthesia
Gastrointestinal [3, 12, 13, 15]
Delayed gastric emptying and gut motility
Metabolic [3, 12, 13, 15]
Delayed metabolism leading to prolonged half-life of certain medications
Immunologic [3, 12, 15]
Impaired ability to mount a febrile response

- In the absence of symptoms or signs of hypothyroidism, there is no need to postpone elective surgery for TSH <10. The anesthesiologist should be informed. These recommendations are based on the physiological effects of mild hypothyroidism and not on clinical trials.
- If surgical intervention is necessary or emergent, surgeons, anesthesiologists, and internists should be aware that perioperative complications may occur in those with mild to moderate hypothyroidism [3, 12, 13, 15]. Close cardiovascular, respiratory, and renal monitoring is suggested (Table 16.2).

Thyroid Function in the Critically Ill

Critical illness is associated with alterations in concentrations of thyroid hormones. Previously known as "euthyroid sick syndrome," this syndrome is now termed "non-thyroidal illness." Laboratory data are consistent with central hypothyroidism:

- T3 usually low
- T4 and free T4 low or normal
- TSH low or normal

The degree of thyroid hormone abnormalities generally correlates with the degree of illness. In this setting, there is no evidence that thyroid hormone replacement is beneficial, and it may be harmful. Thyroid function should not be checked in critically ill patients unless there is strong suspicion and/or clinical evidence of thyroid dysfunction (e.g., unexplained bradycardia, tachycardia, atrial dysrhythmia, hypothermia, altered mental status) [20–23].

The Hypothyroid Patient Undergoing Cardiovascular Surgery

Thyroid hormone has profound effects on the cardiovascular system [24], but replacement is controversial in cardiac surgeries. Thyroid hormone replacement might increase coronary ischemia; in patients with severe coronary artery disease (CAD) who are undergoing cardiovascular surgery and are initiating thyroid hormone replacement, we recommend starting at a more modest initial dose (50–75% replacement dose by weight). If there is clinical concern for severe hypothyroidism, consult an endocrine specialist. Patients with CAD undergoing cardiovascular surgery who have been on a stable dose of thyroid hormone replacement should continue current dosing.

Myxedema Syndrome (Severe Hypothyroidism)

In rare cases, the stress of surgery in patients with undertreated hypothyroidism can trigger myxedema syndrome: Severe hypothyroidism representing a medical emergency with a high mortality rate [3, 16, 25]. The clinical presentation of myxedema syndrome includes [15]:

- Decreased level of consciousness
- Hypothermia
- Cardiovascular effects: Hypotension, bradycardia, cardiac arrhythmias
- Hypoventilation
- Hyponatremia
- Hypoglycemia

The diagnosis is based on a high TSH, very low free T4, and the clinical presentation. If myxedema syndrome is suspected, cortisol (and if possible a Cosyntropin stimulation test) should be sent to assess for associated adrenal insufficiency. Treatment usually requires intensive supportive measures, depending on the severity of hypothyroidism [16, 17]:

- Admission to intensive care unit
- Mechanical ventilation

- Re-warming
- Volume resuscitation and/or vasopressor support
- Cardiac monitoring
- Stress dose corticosteroids until adrenal insufficiency excluded

Thyroid hormone replacement should be initiated in any patient suspected of myxedema syndrome, in collaboration with a thyroid specialist. There is limited evidence for exact hormone replacement regimens, but the American Thyroid Association recommends IV administration of both T4 (strong recommendation) and T3 (weak recommendation) [17–19].

- Initial T4 loading dose of 200–400 mcg × 1 followed by 1.6 mcg/kg daily, reduced to 75% if given IV [19].
- In addition to T4, consider giving IV T3 with initial loading dose of 5–20 mcg, followed by 2.5–10 mcg every 8 hours; lower dosages should be used for smaller or older patients and those with history of coronary artery disease or arrhythmia.
- T3 has been associated with increased risk of cardiac ischemia and/or arrhythmias [26]; however, there are minimal data to support this [27, 28].

HYPERTHYROIDISM

Nonthyroid Surgery

There are scant data evaluating the risk of hyperthyroidism in nonthyroid surgery. A hyperthyroid state has significant cardiopulmonary effects that might increase the risk of surgery; however, the decision regarding whether to pursue surgery depends on the clinical status of the patient, degree of thyroid hormone imbalance, and urgency of surgery [24, 29] (See Table 16.3). Care should usually be coordinated with a thyroid specialist, but general principles include:

- Patients with known hyperthyroidism should continue hyperthyroid medications throughout the perioperative period, including the morning of surgery.
- Patients with subclinical hyperthyroidism (low TSH, normal free T4 and T3) can typically proceed with elective surgeries. Subclinical hyperthyroidism has been associated with increased risk of atrial fibrillation in older, ambulatory patients [30, 31]. Observe for perioperative atrial fibrillation.
- In general, in the absence of symptoms or signs of hyperthyroidism, there is no need to postpone elective surgery for TSH 0.1–0.4, or a TSH that is undetectable and free T4 <1.5 times the upper limit of normal. The anesthesiologist should be informed. These recommendations are based on the physiological effects of mild hyperthyroidism and not on clinical trials.

TABLE 16.3 PERIOPERATIVE COMPLICATIONS IN PATIENTS WITH HYPERTHYROIDISM

Cardiovascular [34]
Arrhythmias, e.g., atrial fibrillation [35]
Tachycardia, systolic hypertension, widened pulse pressure from decreased peripheral vascular resistance
Congestive heart failure
Pulmonary hypertension [36, 37]
Angina from increased myocardial oxygen demand
Pulmonary
Dyspnea due to increased oxygen consumption and CO_2 production
Respiratory and skeletal muscle weakness
Decreased lung volume
Gastrointestinal
Increased gut motility with malabsorption, malnutrition
Metabolic
Increased basal metabolic rate
Psychiatric
Delirium, psychosis, altered mental status

- Elective surgery should be postponed in patients with poorly controlled or untreated hyperthyroidism (i.e., those with thyroid function tests outside these general parameters, or with symptoms or signs of hyperthyroidism) until they are euthyroid, due to the risk of thyroid storm (see Table 16.4).
- For patients with overt hyperthyroidism requiring urgent surgery, treatment for hyperthyroidism should start as soon as possible. If there are no contraindications, preoperative initiation of beta blockers is recommended. For patients with Graves' disease or toxic adenoma/multinodular goiter, consider adding thionamides followed by iodine and corticosteroids if thyrotoxicosis is severe, in consultation with a thyroid specialist [32]. Maintain a lower index of suspicion for potential cardiovascular complications, including arrhythmia, heart failure, and ischemia.

Thyroid Surgery

In general, care should be coordinated with a thyroid specialist. Studies suggest that perioperative beta-blockers alone effectively control the clinical manifestations of hyperthyroidism and are as effective

TABLE 16.4 PERIOPERATIVE MANAGEMENT OF PATIENTS WITH HYPERTHYROIDISM

Degree of thyroid dysfunction	Laboratory findings	Elective	Urgent/ emergent	Treatment
Subclinical	Low TSH Normal free T4	Proceed	Proceed	None Monitor for perioperative atrial fibrillation
Mild – Moderate	Low TSH High free T4	Decision based on degree of thyroid dysfunction, presence of clinical features	Proceed	Endocrinology consultation Beta-blockade (e.g., atenolol, metoprolol) for goal HR 60–80[a] Thionamide (methimazole preferred) for patients with Graves' or toxic adenoma/ multinodular goiter; add potassium iodide (e.g., SSKI) if thyrotoxicosis is severe
Severe	Severe clinical signs, thyroid storm	Delay	Proceed	Intensive care unit transfer Endocrinology consultation High dose thionamide (propylthiouracil or methimazole, oral or rectal), beta-blockade (propranolol, esmolol), inorganic iodide (SSKI), and glucocorticoids (hydrocortisone, dexamethasone) [35]. Start treatment empirically while awaiting test results Consider use of iodinated radiocontrast agent, e.g., iopanoic acid if available[b] [36] Supportive care: Acetaminophen, cooling blankets, volume resuscitation, glycemic control Workup for other precipitating causes (e.g., infection)

[a]Propranolol can be used intraoperatively [38]
[b]Iopanoic acid and iopate are currently not available in the USA [39]

as thionamides with similar low rates of anesthetic and cardiovascular complications [33]. In thyroidectomy for Graves' disease, inorganic iodide can be used starting 10 days before to decrease thyroid vascularity and surgical blood loss. For post-thyroidectomy patients, the medicine consultant should be vigilant for:

- Neck wound hemorrhage or infection
- Vocal cord paralysis
- Hypocalcemia (sign of hypoparathyroidism)
- Symptoms of thyrotoxicosis

Thyroid Storm

Occurring very rarely, thyroid storm is the most serious perioperative complication associated with hyperthyroidism. Thyroid storm usually occurs during or within a few hours of a complicated thyroid surgery (e.g., one requiring heavy manipulation of the thyroid gland). It carries a high mortality, up to 40% [40]. Diagnosis of thyroid storm is clinical: Degree of TSH suppression or thyroid hormone elevation does not help differentiate between thyroid storm and uncomplicated hyperthyroidism. Signs include tachycardia, heart failure, hyperpyrexia, altered mental status, nausea, diarrhea, and hepatic failure. If thyroid storm is suspected, empiric treatment should be started promptly and workup initiated for precipitating causes (e.g., infection) while awaiting thyroid test results (see Table 16.4).

KEY CLINICAL PEARLS

- No need to test for thyroid disease preoperatively, unless suggested by history or physical exam.
- Patients with subclinical or mild hypo- or hyperthyroidism, without clinical features of thyroid dysfunction, can generally proceed to elective or urgent surgery.
- Patients with severe hypothyroidism or hyperthyroidism for whom surgery cannot be postponed should have preoperative treatment of their thyroid disease initiated as soon as possible, as well as close monitoring for potential complications perioperatively.

ACKNOWLEDGMENTS

Bradley Anawalt, MD. Professor, Department of Medicine, Division of General Internal Medicine, University of Washington, banawalt@medicine.washington.edu.

REFERENCES

1. Brent GA. Mechanisms of thyroid hormone action. J Clin Invest. 2012;122(9):3035–43.
2. Vanderpump MP. The epidemiology of thyroid disease. Br Med Bull. 2011;99:39–51.
3. Werner SC, Ingbar SH, Braverman LE, Utiger RD. Werner & Ingbar's the thyroid: a fundamental and clinical text. 9th ed. Philadelphia: Lippincott Williams & Wilkins; 2005.
4. Palace MR. Perioperative management of thyroid dysfunction. Health Serv Insights. 2017;10:1178632916689677.
5. Taylor PN, Razvi S, Pearce SH, Dayan CM. Clinical review: a review of the clinical consequences of variation in thyroid function within the reference range. J Clin Endocrinol Metab. 2013;98(9):3562–71.
6. Garber JR, Cobin RH, Gharib H, et al. Clinical practice guidelines for hypothyroidism in adults: cosponsored by the American Association of Clinical Endocrinologists and the American Thyroid Association. Endocr Pract. 2012;18(6):988–1028.
7. Schiff RL, Welsh GA. Perioperative evaluation and management of the patient with endocrine dysfunction. Med Clin North Am. 2003;87(1):175–92.
8. Dickerson RN, Maish GO 3rd, Minard G, Brown RO. Clinical relevancy of the levothyroxine-continuous enteral nutrition interaction. Nutr Clin Pract. 2010;25(6):646–52.
9. Manessis A, Lascher S, Bukberg P, et al. Quantifying amount of adsorption of levothyroxine by percutaneous endoscopic gastrostomy tubes. JPEN J Parenter Enteral Nutr. 2008;32(2):197–200.
10. Weinberg AD, Brennan MD, Gorman CA, Marsh HM, O'Fallon WM. Outcome of anesthesia and surgery in hypothyroid patients. Arch Intern Med. 1983;143(5):893–7.
11. Gualandro DM, Pinho C, et al. I Guidelines for perioperative evaluation. Arq Bras Cardiol. 2007;89(6):210–37.
12. Stathatos N, Wartofsky L. Perioperative management of patients with hypothyroidism. Endocrinol Metab Clin N Am. 2003;32(2):503–18.
13. Graham GW, Unger BP, Coursin DB. Perioperative management of selected endocrine disorders. Int Anesthesiol Clin. 2000;38(4):31–67.
14. Vanderpump MP, Tunbridge WM. Epidemiology and prevention of clinical and subclinical hypothyroidism. Thyroid. 2002;12(10):839–47.
15. Murkin JM. Anesthesia and hypothyroidism: a review of thyroxine physiology, pharmacology, and anesthetic implications. Anesth Analg. 1982;61(4):371–83.
16. Kwaku MP, Burman KD. Myxedema coma. J Intensive Care Med. 2007;22(4):224–31.
17. Klubo-Gwiezdzinska J, Wartofsky L. Thyroid emergencies. Med Clin North Am. 2012;96(2):385–403.
18. Wall CR. Myxedema coma: diagnosis and treatment. Am Fam Physician. 2000;62(11):2485–90.
19. Jonklaas J, Bianco AC, Bauer AJ, Burman KD, Cappola AR, Celi FS, Cooper DS, Kim BW, Peeters RP, Rosenthal MS, Sawka AM, American Thyroid Association Task Force on Thyroid Hormone Replacement. Guidelines for the treatment of hypothyroidism: prepared by the American Thyroid Association task force on thyroid hormone replacement. Thyroid. 2014;24(12):1670–1751.
20. Stockigt JR. Guidelines for diagnosis and monitoring of thyroid disease: nonthyroidal illness. Clin Chem. 1996;42(1):188–92.
21. Wartofsky L, Burman KD. Alterations in thyroid function in patients with systemic illness: the "euthyroid sick syndrome". Endocr Rev. 1982;3(2):164–217.
22. DeGroot LJ. "Non-thyroidal illness syndrome" is functional central hypothyroidism, and if severe, hormone replacement is appropriate in light of present knowledge. J Endocrinol Investig. Dec 2003;26(12):1163–70.
23. Adler SM, Wartofsky L. The nonthyroidal illness syndrome. Endocrinol Metab Clin N Am. 2007;36(3):657–72, vi.
24. Klein I, Danzi S. Thyroid disease and the heart. Circulation. 2007;116(15):1725–35.
25. Arlot S, Debussche X, Lalau JD, et al. Myxoedema coma: response of thyroid hormones with oral and intravenous high-dose L-thyroxine treatment. Intensive Care Med. 1991;17(1):16–8.
26. Yamamoto T, Fukuyama J, Fujiyoshi A. Factors associated with mortality of myxedema coma: report of eight cases and literature survey. Thyroid. 1999;9(12):1167–74.
27. Guden M, Akpinar B, Saggbas E, Sanisoglu I, Cakali E, Bayindir O. Effects of intravenous triiodothyronine during coronary artery bypass surgery. Asian Cardiovasc Thorac Ann. 2002;10(3):219–22.
28. Hamilton MA, Stevenson LW, Fonarow GC, et al. Safety and hemodynamic effects of intravenous triiodothyronine in advanced congestive heart failure. Am J Cardiol. 1998;81(4):443–7.

29. Sawin CT, Geller A. Low serum thyrotropic concentrations as a risk factor for atrial fibrillation in older persons. N Engl J Med. 1994;331:1249–52.
30. Sawin CT, Geller A, Wolf PA, Belanger AJ, Baker E, Bacharach P, Wilson PW, Benjamin EJ, D'Agostino RB. Low serum thyrotropin concentrations as a risk factor for atrial fibrillation in older persons. N Engl J Med. 1994;331:1249–52.
31. Cappola AR, Fried LP, Arnold AM, Danese MD, Kuller LH, Burke GL, Tracy RP, Ladenson PW. Thyroid status, cardiovascular risk, and mortality in older adults. JAMA. 2006;295:1033–41.
32. Langley RW, Burch HB. Perioperative management of the thyrotoxic patient. Endocrinol Metab Clin N Am. 2003;32:519.
33. Adlerberth A, Stenström G, Hasselgren PO. The selective beta 1-blocking agent metoprolol compared with antithyroid drug and thyroxine as preoperative treatment of patients with hyperthyroidism. Results from a prospective, randomized study. Ann Surg. 1987;205(2):182.
34. Woeber KA. Thyrotoxicosis and the heart. N Engl J Med. 1992;372(2):94.
35. Frost L, Vestergaard P, Mosekilde L. Hyperthyroidism and risk of atrial fibrillation or flutter: a population-based study. Arch Intern Med. 2004;164(15):1675.
36. Mercé J, Ferrás S, Oltra C, Sanz E, Vendrell J, Simón I, Camprubí M, Bardají A, Ridao C. Cardiovascular abnormalities in hyperthyroidism: a prospective Doppler echocardiographic study. Am J Med. 2005;118(2):126.
37. Siu CW, Zhang XH, Yung C, Kung AW, Lau CP, Tse HF. Hemodynamic changes in hyperthyroidism-related pulmonary hypertension: a prospective echocardiographic study. J Clin Endocrinol Metab. 2007;92(5):1736.
38. Das G, Krieger M. Treatment of thyrotoxic storm with intravenous administration of propranolol. Ann Intern Med. 1969;70(5):985.
39. Ross DS. Iodinated radiocontrast agents in the treatment of hyperthyroidism. UpToDate. 2013.
40. Burch HB, Wartofsky L. Life-threatening thyrotoxicosis. Thyroid storm. Endocrinol Metab Clin N Am. 1993;22(2):263.

Chapter 17
Liver Disease and Perioperative Risk

Kay M. Johnson and Kara J. Mitchell

BACKGROUND

Acute hepatitis and cirrhosis are major risk factors for complications of surgery due to a number of physiologic changes [1–3]:

- Baseline decreased systemic vascular resistance, augmented by anesthetics and blood loss
- Poor hepatic metabolism of some medications, and risk for hepatic encephalopathy
- Bleeding risk from impaired synthesis of thrombopoietin and clotting factors, splenic platelet sequestration, and portal hypertension-induced varices
- Pulmonary risk from ascites or pleural effusions (restriction); portopulmonary hypertension and/or hepatopulmonary syndrome
- Infection risk due to impaired reticuloendothelial cell function, ascites-related risk for abdominal wound dehiscence
- Risk for renal insufficiency due to hypotension, ascites, diuretic therapy, and/or hepatorenal syndrome

Patients with compensated liver disease (mild chronic hepatitis, nonalcoholic fatty liver disease, etc.) generally tolerate surgery well [2, 4]. Patients with severe or decompensated liver disease, however, may have a mortality approaching 80% [1, 2, 5, 6]. The role of the medical consultant includes preoperative risk assessment, optimization of liver disease, and prevention and management of postoperative complications.

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_17

PREOPERATIVE EVALUATION

ASYMPTOMATIC PATIENTS NOT KNOWN TO HAVE LIVER DISEASE

- Ask about: Alcohol use, blood transfusions, intravenous (IV) drug use, and sexual history.
- Look for: Jaundice, spider telangiectasias, palmar erythema, gynecomastia, splenomegaly, encephalopathy, ascites, and peripheral edema.
- Checking liver biochemical tests for screening purposes in asymptomatic patients is generally not recommended [2].

RISK STRATIFICATION IN KNOWN OR SUSPECTED LIVER DISEASE

History and exam should be directed at the current state of the patient's liver disease, medication regimen, volume status, and prior history of complications, including response to previous surgeries or anesthesia. Surgeries that carry the highest risk for patients with liver disease include the following:

- Emergency and trauma surgery
- Surgery involving significant blood loss (>150 ml)
- Intra-abdominal surgery, especially if there has been previous abdominal surgery and lysis of adhesions is required
- Hepatic resection
- Cardiac surgery

Hepatitis

Acute viral hepatitis carried a 10–13% mortality in two studies of open liver biopsy between 1958 and 1963 [1, 2]. A similar study and a small case series of patients with alcoholic hepatitis demonstrated a 55–100% mortality after laparotomy [1, 2]. Obese patients with nonalcoholic fatty liver disease (NAFLD) are not thought to be at increased risk for bariatric surgery, in the absence of portal hypertension or other independent risk factors [4].

Cirrhosis

Both the Child–Turcotte-Pugh (CTP) classification and the model for end-stage liver disease (MELD) score predict the perioperative mortality of patients with cirrhosis.

- The CTP classification is calculated using INR, albumin, bilirubin, and the presence or absence of encephalopathy and/or

TABLE 17.1 CHILD-TURCOTTE-PUGH CLASSIFICATION FOR CIRRHOSIS [7]

Variable	1 point	2 points	3 points
Albumin (g/dL)	>3.5	2.8–3.5	<2.8
INR	<1.7	1.7–2.3	>2.3
Bilirubin (mg/dL)[a]	<2	2–3	>3
Ascites	Absent	Slight-moderate	Tense
Encephalopathy	None	Grade I–II	Grade III–IV

[a]For cholestatic diseases (i.e., primary biliary cirrhosis), the bilirubin elevation is disproportionate to the impairment of hepatic synthetic function and portal hypertension; therefore, assign 1 point for bilirubin <4 mg/dL, 2 points for bilirubin 4–10 mg/dL, and 3 points for bilirubin >10 mg/dL

TABLE 17.2 MORTALITY IN PATIENTS WITH CIRRHOSIS UNDERGOING ABDOMINAL SURGERY [1, 2, 5, 8]

Class A	5–6 points	~10% mortality
Class B	7–9 points	~17–30% mortality
Class C	10–15 points	~63–82% mortality

ascites, as detailed in Table 17.1; 5–6 points is Class A, 7–9 points is Class B, and 10–15 points is Class C. Table 17.2 shows the approximate postoperative risk for patients with CTP class A, B, and C cirrhosis.

- Higher MELD scores generally correlate with worse outcomes [9–13]. For patients with MELD >15, the finding of serum albumin <2.5 has been shown to correlate with worse outcomes [14]. Calculators are widely available online to determine the MELD score. MELD = 3.78 × $\log_e$ (bilirubin in mg/dl) + 11.2 × $\log_e$ (INR) + 9.57 × $\log_e$ (creatinine in mg/dl) + 6.43. Enter 1 for creatinine <1.0 or 4 for creatinine >4 or dialysis. Round to nearest integer. Mortality stratified by MELD score is shown in Table 17.3 [12].
- The Mayo model (calculator available online) adds American Society of Anesthesiologists (ASA) classification to MELD score for the prediction of postoperative mortality [13]. It is based on a retrospective study of 772 patients undergoing abdominal, cardiovascular, and orthopedic surgeries. Limitations of the calculator include the median MELD of only 8 in their study, and exclusion of low-risk surgeries (appendectomy, herniorrhaphy, and laparoscopic cholecystectomy).

TABLE 17.3 POSTOPERATIVE MORTALITY OF PATIENTS WITH CIRRHOSIS AS PREDICTED BY MELD SCORE

	MELD	5	10	15	20	25	30	35	40	45
Probability of death (%) (95% CI)	All surgeries	5 (2–13)	7 (3–15)	11 (6–19)	17 (11–25)	26 (17–38)	36 (21–53)	50 (27–73)	59 (31–82)	67 (34–89)
	Intra-abdominal surgeries	5 (1–16)	8 (3–20)	14 (7–27)	25 (15–39)	35 (21–51)	58 (34–79)	75 (43–92)	83 (48–96)	

Reprinted with permission from [12]

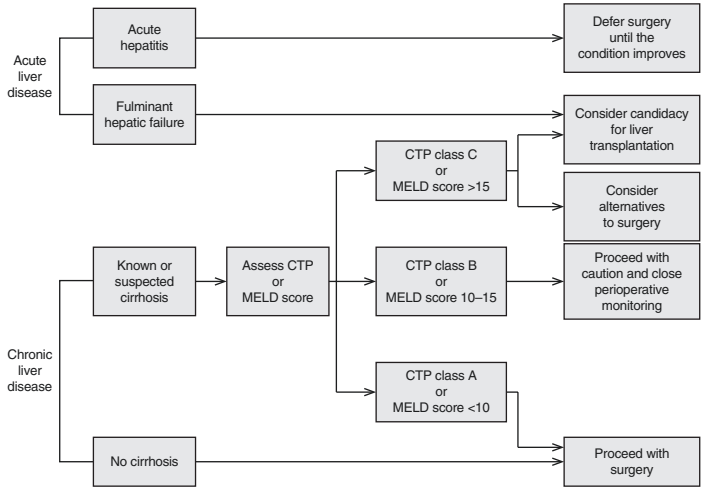

Fig. 17.1 Preoperative evaluation and risk stratification in suspected liver disease (Reprinted with permission from [16])

- Another risk calculator developed in Japan takes into account age, CTP class, Charlson Comorbidity Index, and duration of anesthesia [15].

Figure 17.1 shows a risk stratification strategy for both acute hepatitis and chronic liver disease [16].

PERIOPERATIVE MANAGEMENT

PREOPERATIVE CONSIDERATIONS

Although the internist should refrain from making recommendations about intraoperative care, it is helpful to have some familiarity with issues that may arise during or as a result of anesthesia; these are well-detailed elsewhere [17]. Consider making the following recommendations for patients proceeding to surgery:

- Delay surgery until after liver transplantation and/or suggest a less-invasive option when reasonable (e.g., cholecystostomy in place of cholecystectomy) [18].
- If screening for esophageal varices and starting a nonselective beta blocker are indicated [19], consider doing this prior to elective surgery.

- Preoperative transjugular intrahepatic portosystemic shunt (TIPS) may reduce perioperative GI bleeding for patients with severe portal hypertension, but at the expense of worsened encephalopathy [20, 21].
- Treat ascites with diuretics (if peripheral edema present), salt restriction, and/or paracentesis.
- Anticipate the way in which surgical site may impact perioperative treatment of encephalopathy (e.g., patients unable to take oral medications may require rectal administration of lactulose, or enemas may be contraindicated in rectal surgery).
- Evaluate renal function preoperatively, recalling that calculated creatinine clearance may underestimate the degree of impairment.
- Vitamin K can be given preoperatively to try to correct a high INR, though is not always effective. Patients with cholestasis may not absorb oral vitamin K properly and should be given IV or subcutanous doses. However, recent data suggest that the INR may not be predictive of perioperative bleeding in cirrhotic patients [22]. Low fibrinogen levels may contribute to bleeding, but correcting this with fresh frozen plasma can expand plasma volume and increase portal hypertension [22]. In high bleeding risk situations, consider consulting a hematologist for guidance in administering prothrombin complex concentrate.
- Keep extra cross-matched blood on hand, but note that transfusion may be associated with worsened outcomes [13].
- Consider transfusing platelets if severe thrombocytopenia is present. Optimal platelet count is unknown, but many providers use a goal of >50 K for average risk procedures [3] and >100 K for high-risk procedures (such as neurosurgery)—although these targets are not always achievable.

POSTOPERATIVE MANAGEMENT

- Watch clinically (consider intensive care unit (ICU)) for exacerbation of liver disease postoperatively: Ascites, jaundice, encephalopathy, etc. [23].
- Monitor renal function (BUN, Cr, and electrolytes) and hepatic synthetic function (albumin, PT/INR, and glucose) closely.
- Particularly after intra-abdominal surgery, patients experience significant third spacing and are susceptible to acute kidney

injury; limit routine maintenance IV fluids postoperatively (to avoid exacerbating ascites and/or edema), but do not neglect to resuscitate an intravascularly volume-depleted patient.

- Be cautious with use of diuretics for treatment of ascites or edema that may develop during the first couple of days after surgery while patients are still actively third-spacing fluids.
- Monitor bowel movements, aiming for 2–4 per day. Manage encephalopathy in the usual fashion (lactulose or polyethylene glycol (PEG) 3350–electrolyte solution [24], rifaximin, etc.), and consider potential causes such as gastrointestinal bleeding, infection, CNS depressing medications, electrolyte disturbances, hypoxia, constipation, or renal insufficiency. Order aspiration precautions. Do not restrict dietary protein [25].
- Use short-acting analgesics, such as fentanyl. Avoid benzodiazepines; if one must be used (e.g., to treat alcohol withdrawal), lorazepam is preferred.
- Avoid hypercarbia, which may cause splanchnic vasodilation and decrease portal blood flow.
- Continue nonselective beta-blockade (unless contraindicated) and avoid fluid overload or over-transfusion in patients with gastroesophageal varices.
- Optimize perioperative nutritional support.
- Limit acetaminophen use to not more than 2 g/day.

KEY CLINICAL PEARLS

- Patients with compensated liver disease, such as mild chronic hepatitis, nonalcoholic fatty liver disease or CTP Class A (or MELD < 10) cirrhosis, generally tolerate surgery.
- Risks and benefits of surgery should be considered carefully for CTP Class B (MELD 11–15); preoperative optimization and perioperative monitoring are essential for this moderate risk group.
- CTP Class C patients (MELD >15) are at high risk for mortality; liver transplantation or alternatives to surgery should be considered.

ACKNOWLEDGMENTS

Iris W. Liou, MD; Assistant Professor, Gastroenterology/Hepatology; Department of Medicine, University of Washington.

REFERENCES

1. Friedman LS. Surgery in the patient with liver disease. Trans Am Clin Climatol Assoc. 2010;121:102–204.
2. O'Leary JG. Surgery in the patient with liver disease. Clin Liver Dis. 2009;13(2):211–31.
3. Paolino J, Steinhagen RM. Colorectal surgery in cirrhotic patients. The Sci World J. 2014;2014:1–5. 239293.
4. Ribeireiro T, Swain J, et al. NAFLD and insulin resistance do not increase the risk of postoperative complications among patients undergoing bariatric surgery—a prospective analysis. Obes Surg. 2011;21(3):310–5.
5. Mansour A, Watson W, Shayani V, et al. Abdominal operations in patients with cirrhosis: still a major surgical challenge. Surgery. 1997;122(4):730–6.
6. De Goede B, et al. Morbidity and mortality related to non-hepatic surgery in patients with liver cirrhosis: a systematic review. Best Pract Res Clin Gastroenterol. 2012;26: 47–59.
7. Pugh RN, Murray-Lyon IM, Dawson JL, Pietroni MC, Williams R. Transection of the oesophagus for bleeding oesophageal varices. Br J Surg. 1973;60:646–9.
8. Neeff H, Mariaskin D, Spangenberg HC, et al. Perioperative mortality after non-hepatic general surgery in patients with liver cirrhosis: an analysis of 138 operations in the 2000s using Child and MELD scores. J Gastrointest Surg. 2011;15:1–11.
9. Farnsworth N, Fagan SP, Berger DH, et al. Child-Turcotte-Pugh versus MELD score as a predictor of outcome after elective and emergent surgery in cirrhotic patients. Am J Surg. 2004;188:580–3.
10. Perkins L, Jeffries M, Patel T. Utility of preoperative scores for predicting morbidity after cholecystectomy in patients with cirrhosis. Clin Gastroenterol Hepatol. 2004;2(12):1123–8.
11. Befeler AS, Palmer DE, Hoffman M, et al. The safety of intra-abdominal surgery in patients with cirrhosis: model for end-stage liver disease score is superior to Child-Turcotte-Pugh classification in predicting outcome. Arch Surg. 2005;140:650–4.
12. Northup PG, Wanamaker RC, Lee VD, et al. Model for end-stage liver disease (MELD) predicts nontransplant surgical mortality in patients with cirrhosis. Ann Surg. 2005;242(2):244–51.
13. Teh SH, Nagorney DM, Stevens SR, et al. Risk factors for mortality after surgery in patients with cirrhosis. Gastroenterology. 2007;132:1261–9.
14. Telem DA, Schiano T, Goldstone R, Han DK, Buch KE, Chin EH, Nguyen SQ, Divino CM. Factors that predict outcome of abdominal operations in patients with advanced cirrhosis. Clin Gastroenterol Hepatol. 2010;8:451–7.
15. Sato M, Tateishi R, Yasunaga H, et al. The ADOPT-LC score: a novel predictive index of in-hospital mortality of cirrhotic patients following surgical procedures, based on a national survey. Hepatol Res. 2017;47:E35–43.
16. Hanje AJ, Patel T. Preoperative evaluation of patients with liver disease. Nat Clin Prac Gastroenterol Hepatol. 2007;4(5):266–76.
17. Kiamanesh D, Rumley J, Moitra VK. Monitoring and managing hepatic disease in anaesthesia. Br J Anaesth. 2013;111(Suppl 1):i50–61.
18. Curro G, Lapichino G, Melita G, et al. Laparoscopic cholecystectomy in child-Pugh class C cirrhotic patients. JSLS. 2005;9:311–5.
19. Garcia-Tsao F, Abraldes JG, Berzigoti A, et al. Portal hypertensive bleeding in cirrhosis: risk stratification, diagnosis and management: 2016 practice guidelines by the American Association for the Study of Liver Disease. Hepatology. 2017;65(1):310–5.
20. Azoulay D, Buabse F, Damiano I, et al. Neoadjuvant transjugular intrahepatic portosystemic shunt: a solution for extrahepatic abdominal operation in cirrhotic patients with severe portal hypertension. J Am Coll Surg. 2001;193(1):46–51.
21. Kim JJ, Narasimham LD, Yu E, Fontana RJ. Cirrhotic patients with a transjugular intrahepatic portosystemic shunt undergoing major extrahepatic surgery. J Clin Gastroenterol. 2009;43(6):574–9.
22. Northrup PG, Friedman LS, Kamath PS. AGA clinical practice update: surgical risk assessment and perioperative management in cirrhosis. Clin Gastroenterol Hepatol. 2019;17(4):595–606.
23. Olson JC, Karvellas CJ. Critical care management of the patient with cirrhosis awaiting liver transplant in the intensive care unit. Liver Transpl. 2017;23:1465–76.
24. Rahimi RS, Singal AG, Cuthbert JA, Rockey DC. Lactulose vs polyethylene glycol 3350--electrolyte solution for treatment of overt hepatic encephalopathy: the HELP randomized clinical trial. JAMA Intern Med. 2014;174:1727–33.
25. Im GY, Lubezky N, Facciuto ME, et al. Surgery in patients with portal hypertension: a preoperative checklist and strategies for attenuating risk. Clin Liv Dis. 2014;18(2):477–505.

Chapter 18
Inflammatory Bowel Disease

Neha Deshpande and Gabrielle Berger

BACKGROUND

Despite the widespread use of medical therapy in the management of inflammatory bowel disease (IBD), up to 30% of patients with ulcerative colitis (UC) and 70% of patients with Crohn's disease (CD) will require intra-abdominal surgery [1, 2]. Patients with IBD are at risk for postoperative complications including surgical site infection, intra-abdominal abscess, bacteremia, strictures and fistulae, small bowel obstruction, portal vein thrombosis, and poor wound healing including anastomotic leak and wound dehiscence [3–6]. For patients with moderate-to-severe disease activity, current data support the use of combination therapy including an antitumor necrosis factor-alpha (anti-TNF) inhibitor in combination with an immunomodulator, usually a thiopurine (e.g., azathioprine or 6-mercaptopurine). However, limited data exist to guide the management of combination therapy in the perioperative setting.

This chapter focuses on evidence for perioperative management of IBD patients undergoing intra-abdominal surgery; however, the medication recommendations are applicable for IBD patients undergoing other types of surgery.

PREOPERATIVE EVALUATION

PATIENT-SPECIFIC RISKS

In addition to a standard comprehensive physical examination, the medical consultant should assess the patient for risk factors for postsurgical complications.

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_18

History and Physical Examination

- Evaluate for symptoms of occult infection including fevers, chills, night sweats
- Evaluate for symptoms of hypothalamic pituitary adrenal (HPA) axis suppression if the patient has taken glucocorticoids in the previous 3 months; observe for Cushingoid features (see Chap. 14)
- Inquire about smoking history
- Assess for evidence of malnutrition
- Examine for fistulizing disease and evidence of intra-abdominal abscess

Laboratory Work-Up

- CBC—many immunomodulators used to treat IBD cause anemia and leukopenia.
- Basic metabolic panel (BMP)—look for evidence of acute kidney injury (AKI) or chronic kidney disease (CKD), which can be caused by aminosalicylates and methotrexate.
- Consider liver function tests (LFTs)—some immunomodulators can cause hepatotoxicity.
- Glucose—optimizing perioperative glycemic control helps ensure appropriate wound healing, particularly for patients on glucocorticoids.

SURGERY-SPECIFIC RISKS

Most procedures for IBD are considered intermediate or high-risk surgeries and may involve a two- or three-stage operation. These patients are often at increased risk for postsurgical complications due to the complexity of the surgical procedures as well as the underlying inflammation of the tissue in the surgical site [5]. Specific considerations include:

- Simple laparoscopic resection—generally well-tolerated without significant morbidity [7].
- Laparoscopic resection for penetrating and fistulizing Crohn's disease—associated with increased operative time, risk for conversion to open procedures, and need for diverting stoma.
- Ileal pouch-anal anastomosis (IPAA)—a two- or three-stage procedure used to manage ulcerative colitis refractory to medical therapy. Pouch leaks can lead to intraabdominal infection or sepsis in the period following pouch creation or ileostomy takedown. IPAA is also associated with an increased risk of portal vein thrombosis, which occurs in up to 40% of patients [5].

- Emergency colectomy—patients who require emergency surgery are acutely ill and may not be medically optimized, thus increasing risk of intraabdominal sepsis and mortality compared to elective surgery [8].

Risk Stratification

- Patients with extensive small bowel and colon involvement are at higher risk for postoperative complications than those with only ileal involvement [9].
- Comorbid conditions such as malnutrition and anemia, as well as older age, may contribute to worse postoperative outcomes [5, 10].
- Use of glucocorticoids and opioid medications has been associated with increased mortality and postoperative morbidity [9].
- Active smokers have increased risk of postoperative complications and overall mortality [8, 11].

PERIOPERATIVE MANAGEMENT

MEDICATION MANAGEMENT

Appropriate perioperative medication management for patients with IBD remains challenging. Since the advent of biologic therapy to control IBD, numerous studies evaluating the postoperative complications in patients on anti-TNF alpha agents have shown conflicting results. Most of these studies are limited by retrospective design, small sample size, and an inability to control for confounders [12, 13]. Furthermore, most of the data are derived from patients on infliximab; there are less data available regarding the risks associated with newer anti-TNF medications (adalimumab, certolizumab pegol) and non-anti-TNF agents (vedolizumab, ustekinumab) [11, 15].

- Despite significant heterogeneity among studies, the evidence increasingly supports timing elective surgery with the nadir of biologic drug levels to reduce postoperative morbidity including infection.
- To minimize risk of disease relapse, expert opinion supports resuming biologic therapy within 4 weeks after surgery once the concern for infection has resolved [8, 11, 15, 16].
- A multicenter, prospective cohort study of patients with IBD on biologic therapy is underway to determine if exposure to anti-TNF agents preoperatively is independently associated

TABLE 18.1 MEDICATION MANAGEMENT DURING THE PERIOPERATIVE PERIOD

Glucocorticoids	Continue; consider stress dose steroids if patient on moderate or high dose for >3 weeks (see Chap. 14) [9, 15]
5-Aminosalicylic acid (5-ASA)	Hold on the day of surgery and resume 3 days postoperatively if renal function normal [9]
Azathioprine, 6-mercaptopurine (6-MP)	Hold on the day of surgery and resume with other oral medications if renal function normal [9, 10, 15]
Methotrexate	Continue if renal function normal and no signs of infection [9, 15]
Cyclosporine	Continue but carefully monitor for renal dysfunction and opportunistic infection [9, 10, 15]
Biologic therapies	Time elective surgery with drug nadir and resume within 4 weeks after surgery if no signs of infection [7, 10, 14, 15]

with risk for postoperative infections and pouch-specific complications (PUCCINI trial) [17].

- See Table 18.1 for general guidelines for management of immunomodulatory medications perioperatively.

PREVENTION OF POSTOPERATIVE COMPLICATIONS

Patients undergoing surgery for IBD present clinicians with unique postoperative challenges that can delay recovery including limited options for pain management, hyperglycemia in patients on glucocorticoids, poor nutritional status, and increased risk for postoperative venous thromboembolism (VTE). The following measures may help guide clinicians for preoperative risk optimization as well as postoperative management of patients with IBD.

- Advise smoking cessation prior to elective surgery.
- Address perioperative glycemic control for patients on glucocorticoids, as persistent hyperglycemia can delay wound healing and lead to surgical site complications.
- Attempt to minimize the use of opioid analgesia, though it is important to note that opioids are preferred over other pain medications, as studies have shown a possible association between nonsteroidal antiinflammatory drug (NSAID) use and IBD flares [18].

- Transfuse to maintain hemoglobin >7 g/dL.
- Treat iron deficiency anemia with iron supplementation (IV or PO).
- Collaborate closely with nutrition colleagues to maintain adequate supplementation and aid postoperative healing—patients may need total parenteral nutrition (TPN) depending on underlying malnutrition and disease severity, particularly if patient is undergoing a two or three-stage procedure.
- Pursue early antibiotic therapy and surgical exploration if concerned for an intra-abdominal source of sepsis.
- Initiate pharmacologic VTE prophylaxis as soon as bleeding risk is acceptable and continue for the duration of hospitalization [8, 11].

KEY CLINICAL PEARLS

- Patients with IBD are at risk for postoperative complications including surgical site infection, intra-abdominal abscess, bacteremia, strictures and fistulae, small bowel obstruction, portal vein thrombosis, venous thromboembolism, and poor wound healing including anastomotic leak, and wound dehiscence.
- Use of glucocorticoids and opioid analgesia has been associated with increased postoperative morbidity.
- Current data and expert opinion suggest timing elective surgery for IBD with the nadir of anti-TNF drug levels and resuming the anti-TNF agent within 4 weeks after surgery.

REFERENCES

1. Narula N, Charleton D, Marshall JK. Meta-analysis: peri-operative anti-TNFα treatment and post-operative complications in patients with inflammatory bowel disease. Aliment Pharmacol Ther. 2013;37(11):1057–64.
2. Nasir BS, Dozois EJ, Cima RR, et al. Perioperative anti-tumor necrosis factor therapy does not increase the rate of early postoperative complications in Crohn's disease. J Gastrointest Surg. 2010;14(12):1859–66.
3. Appau KA, Fazio VW, Shen B, et al. Use of infliximab within 3 months of Ileocolonic resection is associated with adverse postoperative outcomes in Crohn's patients. J Gastrointest Surg. 2008;12(10):1738–44.
4. Bafford AC, Powers S, Ha C, et al. Immunosuppressive therapy does not increase operative morbidity in patients with Crohn's disease. J Clin Gastroenterol. 2013;47(6):491–5.
5. Beddy D, Dozois EJ, Pemberton JH. Perioperative complications in inflammatory bowel disease. Inflamm Bowel Dis. 2011;17(7):1610–9.
6. Kunitake H, Hodin R, Shellito PC, Sands BE, Korzenik J, Bordeianou L. Perioperative treatment with infliximab in patients with Crohn's disease and ulcerative colitis is not associated with an increased rate of postoperative complications. J Gastrointest Surg. 2008;12(10):1730–7.

7. Maggiori L, Panis Y. Surgical management of IBD – from an open to a laparoscopic approach. Nat Rev Gastrenterol Hepatol. 2013;10(5):297–306.
8. Patel K, Darakhshan A, Griffin N, Williams A, Sanderson J, Irving P. Patient optimization for surgery relating to Crohn's disease. Nat Rev Gastroenterol Hepatol. 2016;13(12):707–19.
9. Lichtenstein GR, Feagan BG, Cohen RD, et al. Serious infection and mortality in patients with Crohn's disease: more than 5 years of follow-up in the TREAT™ registry. Am J Gastroenterol. 2012;107(9):1409–22.
10. Kumar A, Auron M, Aneja A, Mohr F, Jain A, Shen B. Inflammatory bowel disease: perioperative pharmacological considerations. Mayo Clin Proc. 2011;86(8):748–57.
11. Zangenberg M, Horesh N, Kopylov U, El-Hussuna A. Preoperative optimization of patients with inflammatory bowel disease undergoing gastrointestinal surgery: a systematic review. Int J Color Dis. 2017;32(12):1663–76.
12. Sewell JL, Mahadevan U. Infliximab and surgical complications: truth or perception? Gastroenterology. 2009;136(1):354–5.
13. Ali T. Risk of post-operative complications associated with anti-TNF therapy in inflammatory bowel disease. WJG. 2012;18(3):197.
14. Kotze PG, Magro DO, Martinez CA, et al. Adalimumab and postoperative complications of elective intestinal resections in Crohn's disease: a propensity score case-matched study. Color Dis. 2017;20(3):211–8.
15. Holubar SD, Holder-Murray J, Elasar M, Lazarev M. Anti–tumor necrosis factor-a antibody therapy management before and after intestinal surgery for inflammatory bowel disease: a CCFA position paper. Inflamm Bowel Dis. 2015;21(11):2658–72.
16. Lightner AL, Shen B. Perioperative use of immunosuppressive medications in patients with Crohn's disease in the new "biological era". Gastroenterol Rep. 2017;5(3):165–77.
17. ClinicalTrials.gov [Internet]. Bethesda (MD): National Library of Medicine (US). 2000 Feb 29. Identifier NCT02054533, Study to determine risk factors for post-operative infection in inflammatory bowel disease (PUCCINI); [cited 2018 Apr 2]; [about 8 pages]. Available from: https://clinicaltrials.gov/ct2/show/NCT02054533.
18. Singh S, Graff LA, Bernstein CN. Do NSAIDs, antibiotics, infections, or stress trigger flares in IBD? Am J Gastroenterol. 2009;104(5):1298–314.

Chapter 19
Nutrition

Tara Spector

BACKGROUND

Nutrition assessment should be a routine part of the preoperative evaluation. Malnutrition is associated with increased rates of postoperative infection, impaired wound healing [1], higher readmission rates, and increased length of stay [2]. The stress of surgery causes catecholamine and cortisol release, which results in a hypermetabolic state that can further exacerbate underlying malnutrition [3]. Identifying patients with malnutrition and stratifying them according to severity of malnutrition allows for perioperative interventions that reduce surgical complications. In select cases, it may be beneficial to delay surgery to optimize nutritional status, bolster the immune system, and prepare the body for the systemic stress response to surgery.

In the perioperative and postoperative period, both well-nourished and malnourished patients benefit from interventions focused on optimizing nutritional state and minimization of time spent nil-per-os (NPO). Additionally, the consulting internist should be aware of recommendations regarding initiation of nutrition postoperatively, with a focus on early advancement of diet or enteral feeding, and indications for parenteral nutrition.

PREOPERATIVE EVALUATION

EVALUATION OF NUTRITION STATUS

While there are no universally accepted criteria, most experts require two of the following to diagnose malnutrition: Inadequate caloric intake, unintentional weight loss, low body mass index (BMI), visible loss of muscle mass or subcutaneous fat, or poor handgrip strength

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_19

[4]. Note that serum hepatic proteins such as the negative acute phase proteins albumin, prealbumin, and transferrin are not valid indicators of nutritional status; they more accurately reflect severity of disease/inflammation [5]. Furthermore, low levels of these serum proteins are not responsive to nutrition intake during an active inflammatory state [4]. A routine preoperative evaluation for nutritional status should include the following:

- History of recent weight loss and adequacy of caloric intake.
- Identification of comorbid conditions that can influence nutritional status (i.e., prior GI surgery, chronic kidney disease, cancer, recent trauma or infection).
- Identification of disease states that necessitate dietary restriction (e.g., congestive heart failure, chronic kidney disease).
- Identification of significant alcohol or substance abuse history.
- Physical exam: Height, weight (to allow body mass index calculation), evidence of muscle wasting, and ascites/edema.
- Laboratory evaluation: If there is concern for malnutrition based on history and physical exam, order basic metabolic panel and phosphate level to evaluate for electrolyte abnormalities and renal dysfunction, and a complete blood count (CBC) to evaluate for anemia.

RISK STRATIFICATION

Preoperative nutrition evaluation addresses both current nutritional status and the risk for nutritional deterioration as a result of increased demands caused by metabolic stress [5]. The Nutritional Risk Screening-2002 (NRS 2002) is a validated method for identifying malnourished patients that may benefit from nutritional support [5]. This tool also helps to classify patients with mild, moderate, or severe malnutrition. Details of this screening tool are found in Tables 19.1 and 19.2.

TABLE 19.1 NUTRITIONAL RISK SCREENING (NRS 2002) – INITIAL SCREENING [5]

Is BMI < 20.5?	Yes	No
Has the patient lost weight within the last 3 months?		
Has the patient had a reduced dietary intake in the last week?		
Is the patient severely ill? (e.g., in intensive therapy)		

Yes If the answer is "Yes" to any question, the screening in Table 19.2 is performed

No If the answer is "No" to all questions, the patient is rescreened at weekly intervals. If the patient is scheduled for a major operation, a preventative nutritional care plan is considered to avoid the associated risk status

TABLE 19.2 NRS [5] – FINAL SCREENING [5]

Impaired nutritional status		Severity of disease (≈ increase in requirements)	
Absent *score 0*	Normal nutrition status	Absent *score 0*	Normal nutritional requirements
Mild *score 1*	Wt loss > 5% in 3 months or food intake below 50–70% of normal requirement in preceding week	Mild *score 1*	Hip fracture; chronic patients with acute complications; cirrhosis; COPD; chronic hemodialysis; diabetes, oncology
Moderate *score 2*	Wt loss > 5% in 2 months or BMI 18.5–20.5 + impaired general condition or food intake 25–60% of normal requirement in preceding week	Moderate *score 2*	Major abdominal surgery; stroke; severe pneumonia; hematologic malignancy
Severe *score 3*	Wt loss > 5% in 1 month or BMI < 18.5 + impaired general condition or food intake below 50–70% of normal requirement in preceding week	Severe *score 3*	Head injury; bone marrow transplantation; intensive care patients (APACHE > 10)

Score: [nutritional status score] + [disease severity score] = *total score*
Age If ≥70 years: Add 1 to total score above = *age-adjusted total score*
Score ≥ *3*: The patient is nutritionally at risk and a nutritional care plan is initiated
Score < *3*: Weekly rescreening of the patient. If the patient, e.g., is scheduled for a major operation, a preventive nutritional care plan is considered to avoid the associated risk status.

PERIOPERATIVE MANAGEMENT

OPTIMIZING NUTRITION STATUS PRIOR TO SURGERY

Preoperative Enteral and Parenteral Nutrition

Patients with severe malnutrition (defined as nutritional risk screen [NRS] greater than 3 OR weight loss of 10–15% of total body mass in past 6 months or BMI < 18.5) undergoing major elective surgery (i.e.,

gastrointestinal surgery, cardiothoracic surgery, complex head, and neck surgery) benefit from supplemental nutrition prior to surgery [6]. Just 5–7 days of adequate preoperative nutrition can prepare the body for the metabolic insult and stress of surgery and results in improved surgical outcomes including reduced rates of infection and surgical complications [7].

- Enteral nutrition is preferred to parenteral nutrition as it has lower risk of infection, is less expensive, and maintains the integrity of the gut mucosal lining. Supplemental nutrition (as oral supplements or by tube feeds) should provide 25 kcal/kg/day of calories and 1.5–2 g/kg/day of protein [7].
- If enteral nutrition is contraindicated (bowel obstruction, bowel ischemia, and acute peritonitis) and the patient is severely malnourished, surgery should be delayed for 5– 7 days to administer parenteral nutrition, if feasible.
- Parenteral nutrition should be stopped 2–3 hours prior to surgery, and then resumed the morning after surgery [8].

Management of Nutrition Immediately Preoperatively

Patients are routinely made NPO after midnight on the day prior to surgery based on the long-standing belief that the stomach must be empty of food to prevent aspiration during induction of anesthesia, but there are little data to support such a prolonged period of fasting. Due to delays in operating room scheduling, patients often end up fasting 12 or more hours, which has been shown to increase insulin resistance [9]. The most recent guidelines from the American Society of Anesthesiologists (ASA) recommend:

- Cessation of fried and fatty foods for 8 hours prior to surgery
- Cessation of solid food 6 hours prior to surgery
- Cessation of clear liquids 2 hours prior to surgery [10]

Outpatients presenting for elective surgery can be instructed to follow these dietary guidelines prior to presenting for surgery. For inpatients, consultants should discuss with surgeons if they are comfortable permitting patients to have a more limited period of NPO.

POSTOPERATIVE MANAGEMENT

Traditionally, diet advancement following surgery occurs only after return of bowel function as evidenced by bowel sounds, flatus, or a bowel movement; however, there is no evidence that these indicators of bowel function truly correlate with bowel activity or tolerance of oral intake [11]. Prolonged NPO status may result in endothelial

microvilli atrophy, increased risk of bowel dysfunction, and infection [12]. Enteral nutrition given within 24 hours postoperatively has numerous documented benefits, including [11–13]:

- Maintenance of intestinal mucosal barrier
- Decreased septic and infectious complications
- Less weight loss after surgery
- Improved wound healing
- Reduced insulin resistance
- Improved muscle function
- Reduced mortality
- Shorter length of hospital stay

Evidence-based guidelines advise starting enteral feedings within 24 hours postoperatively if deemed safe by the surgeon, as soon as postoperative nausea resolves [12]. A "regular" diet, or high protein diet is preferred to "clear liquid" or "full liquid" diets, which do not provide adequate protein intake [14].

While enteral nutrition is preferred, parenteral nutrition (PN) may be required in patients with certain conditions, such as postoperative gastrointestinal anastomotic leak, gastrointestinal fistulas, small bowel obstruction, or ileus. Parenteral nutrition should not be started until at least 5 to 7 days postoperatively if it is clear that patient is not able to tolerate enteral feeding; conversely, PN should not be delayed for more than 14 days postoperatively, as prolonged periods of starvation are associated with higher rates of complications. Additionally, PN should only be started if the anticipated duration of use is at least 7 days; short-term provision of PN for less than 5 days does not improve patient outcomes and may increase risk for infectious complications [15].

KEY CLINICAL PEARLS

- Elective surgery should be delayed for 5–7 days to optimize nutrition in patients who are severely malnourished.
- Preoperatively, patients can safely consume solid food for up to 6 hours prior to surgery, and clear liquids up to 2 hours prior to most surgical procedures.
- Enteral nutrition should be initiated within 24 hours postoperatively, unless there is a contraindication.
- Parenteral nutrition should be initiated within 5–7 days postoperatively in patients unable to tolerate enteral intake.

REFERENCES

1. Haydock DA, Hill GL. Impaired wound healing in surgical patients with varying degrees of malnutrition. JPEN. 1986;10(6):550–4.
2. Garth AK, Newsome CM, Simmance N, et al. Nutritional status, nutrition practices and post-operative complications in patients with gastrointestinal cancer. J Hum Nutr Diet. 2010;23(4):393–401.
3. Donald RA, Perry EG, Wittert GA, et al. The plasma ACTH, AVP, CRH and catecholamine responses to conventional and laparoscopic cholecystectomy. Clin Endocrinol. 1993;38(6):609–16.
4. White JV, Guenter P, Jensen G, et al. Academy Malnutrition Work Group; A.S.P.E.N. malnutrition task force; A.S.P.E.N. Board of directors. Consensus statement: academy of nutrition and dietetics and American Society for Parenteral and Enteral Nutrition: characteristics recommended for the identification and documentation of adult malnutrition (undernutrition). JPEN. 2012;36(3):275–83.
5. Kondrup J, Allison SP, Elia M, et al. ESPEN guidelines for nutrition screening 2002. Clin Nutr. 2003;22(4):415–21. 📖.
6. Weimann A, Braga M, Harsanyi L, et al. ESPEN guidelines on enteral nutrition: surgery including organ transplantation. Clin Nutr. 2006;25(2):224–44.
7. Miller KR, Wischmeter PE, Taylor B, et al. An evidence-based approach to perioperative nutrition support in the elective surgery patient. JPEN. 2013;37(39S):39–50S.
8. McClave SA, Kozar R, Martindale RG, et al. Summary points and consensus recommendations from the North American surgical nutrition summit. JPEN. 2013;37(1S):99–105s. 📖.
9. Peres Pimenta G, Aguilar-Nascimento JE. Prolonged preoperative fasting in elective surgical patients: why should we reduce it? Nutr Clin Prac. Online publication, available at: http://ncp.sagepub.com/content/early/2013/12/10/0884533613514277. Accessed 18 Dec 2013.
10. American Society of Anesthesiologists Committee. Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedures: an updated report by the American Society of Anesthesiologists Committee on standards and practice parameters. Anesthesiology. 2011;114(3):495–511.
11. Warren J, Bhalla V, Cresci G. Postoperative diet advancement: surgical dogma vs. evidence-based medicine. Nutr Clin Pract. 2011;26(2):115–25.
12. Enomoto TM, Larson D, Martindale RG. Patients requiring perioperative nutritional support. Med Clin N Am. 2013;97(6):1181–200.
13. Lewis SJ, Andersen HK, Thomas S. Early enteral nutrition within 24 h of intestinal surgery versus later commencement of feeding: a systematic review and meta-analysis. J Gastrointest Surg. 2009;13(3):569–75.
14. Wischmeyer PE, Carli F, Evans DC, et al. American society for enhanced recovery and perioperative quality initiative joint consensus statement on nutrition screening and therapy within a surgical enhanced recovery pathway: anesthesia and Anaglesia, epub ahead of publication. Accessed online 2 Apr 2018. https://doi.org/10.1213/ANE.0000000000003366.
15. Washington P, Balint J, Bechtold M, et al. When is parenteral nutrition appropriate? J Parenteral and Enteral Nutrition. 2017;41(3):324–77.

Chapter 20
Anemia

Gabrielle Berger and Ronald Huang

BACKGROUND

Preoperative and postoperative anemia are associated with increased morbidity and mortality after surgery [1–3]. Studies indicate that up to one-third of patients admitted for elective surgery will have anemia [4]. Despite the prevalence of anemia among surgical patients, liberal transfusion strategies do not improve outcomes [5, 6]. The goals of managing anemia in the perioperative setting include optimizing hemoglobin and hematocrit, preventing unnecessary blood loss, and using red blood cell transfusions judiciously.

PREOPERATIVE EVALUATION

HISTORY AND PHYSICAL

Identifying signs, symptoms, and risk factors for anemia are key components of the preoperative evaluation.

- Ask about symptoms of anemia such as fatigue, exertional dyspnea, palpitations, lightheadedness, and angina.
- Obtain a history of anemia, blood transfusions, bleeding, medications, nutrition, and chronic medical conditions that may be associated with anemia (e.g., chronic kidney disease, malignancy, rheumatologic diseases).
- Evaluate for signs of anemia on physical exam (e.g., pallor, tachycardia).
- Review the planned surgery for anticipated blood loss and risk of bleeding.

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_20

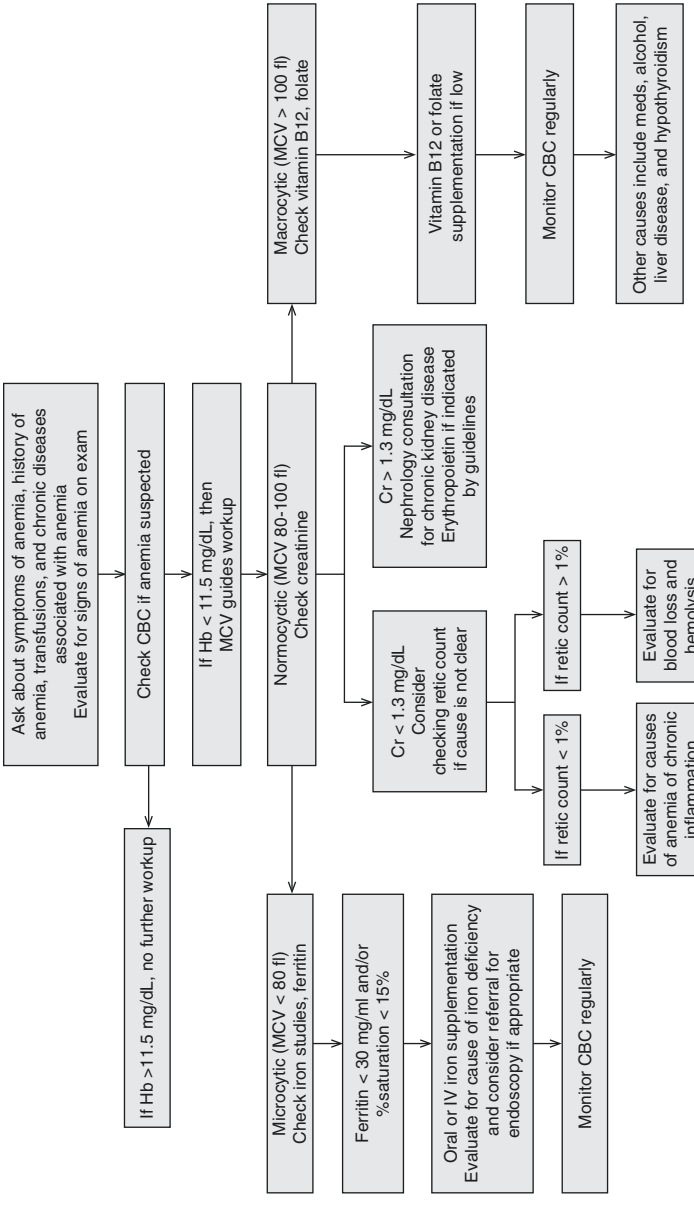

Fig. 20.1 Preoperative Evaluation of Anemia

LABORATORY EVALUATION

Routine testing for anemia is not indicated. A complete blood count (CBC) is recommended preoperatively to review hemoglobin, hematocrit, and mean corpuscular volume (MCV) when:

- Anemia is suspected based on the history and physical exam [7].
- Significant blood loss is expected with surgery [7].
- Patients are undergoing major surgery [8].
- A CBC should be considered for patients undergoing intermediate surgery with American Society of Anesthesiologists [ASA] class 3 or 4.

Whether to order additional laboratory studies depends on results of the history and physical and CBC with MCV (see Fig. 20.1).

PERIOPERATIVE MANAGEMENT

PREOPERATIVE MANAGEMENT

The decision to delay surgery depends on the urgency of the surgery, anticipated blood loss, severity of the anemia, and suspected cause of anemia. If surgery is elective, then unexplained or severe anemia should be evaluated and treated. The perioperative consultant should focus on causes of anemia that are easily reversible in a relatively short period of time (1–2 months for common nutritional deficiencies), or that require attention prior to elective surgery (e.g., occult GI bleeding, malignancy). See Fig. 20.1 for additional information. Consult hematology if there is concern for anemia due to hemolysis or hematologic malignancy.

- The treatment for iron deficiency anemia (low serum iron, high TIBC, low ferritin) has traditionally been ferrous sulfate 325 mg BID to TID with vitamin C, but studies have demonstrated that increased absorption with once every other day dosing may increase absorption [9]. An iron solution is available and may be tolerated better. Intravenous iron (ferric gluconate, iron sucrose, iron dextran) is available for patients who do not respond to oral preparations or if a faster response is required. Referral for endoscopy should be considered in patients with unexplained iron deficiency anemia, especially for patients over 50 years old.
- The treatment for vitamin B12 deficiency is 1,000 mcg PO daily. Vitamin B12 is available in IM preparation for those who do not respond to oral supplementation.

- Folate deficiency is treated with folate 1 mg PO daily.
- Erythropoiesis-stimulating agents (ESA) are used to treat anemia in patients with chronic kidney disease when hemoglobin in <10 g/dL and may be used for patients who decline blood transfusions with anemia (see Chap. 21).

In addition to evaluating and treating anemia, an important aspect of managing anemia is preventing excessive blood loss by evaluating and treating bleeding disorders (see Chaps. 22 and 23), and discontinuing anticoagulants (see Chap. 26) and antiplatelet agents appropriately before surgery.

INTRAOPERATIVE MANAGEMENT

While the intraoperative management of anemia is performed by the anesthesia and surgical teams, the perioperative consultant should be aware of the intraoperative techniques used to limit the need for allogeneic blood product transfusion.

- The amount of blood loss can be estimated by direct visualization using standard methods for quantification (e.g., suction devices), monitoring for physiologic changes of anemia, and laboratory studies.
- Surgical technique and careful hemostasis are central to minimizing blood loss.
- Significant intraoperative anemia is primarily managed with allogeneic red blood cell transfusion.
- Besides transfusion, the anesthesiology team will help manage intraoperative anemia by optimizing tissue perfusion (e.g., intravenous fluids, pressors, oxygenation), and correcting hemostatic abnormalities.
- Blood conservation techniques such as the transfusion of autologous red blood cells collected preoperatively (preoperative autologous blood donation), immediately preoperatively (acute normovolemic hemodilution), or intraoperatively (red blood cell salvage) may be used when significant blood loss is expected or when trying to avoid allogeneic red blood cell transfusions.

POSTOPERATIVE MANAGEMENT

The postoperative evaluation of anemia begins with reviewing the operative report and anesthesia record for estimated blood loss and blood products administered during surgery. Not all patients require laboratory studies postoperatively. The medical consultant and surgical team should assess for ongoing blood loss including from surgical drains, and monitor for signs and symptoms of anemia.

- Monitor a postoperative hemoglobin and hematocrit if there is significant intraoperative or ongoing postoperative blood loss, the patient is symptomatic, or there is an increased risk for bleeding from surgery, especially if the patient was anemic prior to surgery.
- Monitor for and treat hemostatic abnormalities.
- Careful consideration should be given to starting or resuming medications that predispose patients to bleeding.
- Continue or initiate therapy for underlying causes of anemia.
- Limit the number of blood draws or the amount of blood drawn.
- Red blood cell transfusion remains the treatment for severe postoperative anemia.

OPTIMAL TRANSFUSION THRESHOLD

Despite many studies to define the optimal threshold at which postoperative blood transfusion should be given, a definitive threshold has yet to be established [10–15]. A recent Cochrane review concluded that a restrictive transfusion strategy (transfusion for hemoglobin <7–8 g/dL) does not impact morbidity and mortality and decreases patient exposure to RBC transfusion [15]. The decision to transfuse depends on how the patient is tolerating the degree of anemia and whether there are ongoing or anticipated blood losses.

- In the postoperative setting, studies in patients undergoing cardiac, orthopedic, and vascular surgery support a restrictive transfusion strategy [13, 15, 16]. While these data may be extrapolated to other surgical populations (e.g., general surgery, urology, gynecologic oncology), high-quality evidence for transfusion practices in these specialties is lacking.
- For patients with preexisting coronary artery disease who do not have active coronary ischemia, current data support a restrictive transfusion strategy (hemoglobin <8 g/dL) [13, 14].
- There is insufficient data to define an optimal transfusion threshold for patients with acute coronary syndrome (ACS) [10, 16]. Two small studies suggest that mortality risk may be higher when using a restrictive transfusion strategy in patients with ACS; however, the findings did not reach statistical significance. A multicenter randomized trial is underway to evaluate and determine a safe transfusion threshold in patients with anemia and acute myocardial infarction (Myocardial Ischemia and Transfusion – MINT) [17]. Outcomes data are expected in 2021.
- Recommendations for red blood cell transfusion based on hemoglobin are listed in Table 20.1.

TABLE 20.1 RECOMMENDATIONS FOR RED BLOOD CELL TRANSFUSION BASED ON HEMOGLOBIN [10–15]

Hemoglobin level	Recommendation
Hgb < 7–8 g/dL	Red blood cell transfusion is usually indicated
Hgb ≥ 8 g/dL	Red blood cell transfusion is usually not necessary. Transfusion may be considered when the hemoglobin is between 8 and 10 g/dL, and there is ongoing or anticipated blood loss or there is clinical evidence of decreased tissue perfusion and oxygenation, including active coronary ischemia

EFFECT OF RED BLOOD CELL TRANSFUSION

One unit of packed red blood cells (~300 mL) is expected to increase the hemoglobin by 1 g/dL or the hematocrit by ~3% in an average 70 kg adult patient, if there is no active bleeding. A post-transfusion hemoglobin or hematocrit can be sent as soon as 15 min following transfusion to assess for response.

RISKS OF TRANSFUSION

Red blood cell transfusions are associated with complications and costs [18–21].

- The risks of transfusion include acute and delayed hemolytic reactions, febrile nonhemolytic reactions, allergic reactions, viral hepatitis and HIV, transfusion-related acute lung injury (TRALI), sepsis due to bacterial contamination, volume overload (or transfusion-associated circulatory overload [TACO]), and hyperkalemia.
- Other possible adverse effects are less common and include potential exposure to emerging infectious agents, and immunomodulation from transfused blood that may predispose to bacterial infection [18, 19].

KEY CLINICAL PEARLS

- Routine testing for anemia is not indicated unless anemia is suspected based on the history and physical exam, significant blood loss is expected during surgery, or the patient is undergoing major surgery.
- If surgery is elective, then unexplained or severe anemia should be evaluated and treated preoperatively with particular attention to nutritional deficiencies, GI bleeding, and malignancy.

🗝 Current guidelines recommend a restrictive transfusion strategy (transfusion for hemoglobin <7–8 g/dL) for patients undergoing surgery, including patients with preexisting coronary artery disease.

REFERENCES

1. Carson JL, Duff A, Poses RM, et al. Effect of anaemia and cardiovascular disease on surgical mortality and morbidity. Lancet. 1996;348(9034):1055–60.
2. Musallam KM, Tamim HM, Richards T, et al. Preoperative anaemia and postoperative outcomes in non-cardiac surgery: a retrospective cohort study. Lancet. 2011;378(9800):1396–407.
3. Carson JL, Noveck H, Berlin JA, et al. Mortality and morbidity in patients with very low postoperative Hb levels who decline blood transfusion. Transfusion. 2002;42(7):812–8.
4. Butcher A, Richards T. Cornerstones of patient blood management in surgery. Transfus Med. 2018;28(2):150–157. 📖
5. Paone G, Likosky DS, Brewer R, et al. Transfusion of 1 and 2 units of red blood cells is associated with increased morbidity and mortality. Ann Thorac Surg. 2014;97(1):87–93.
6. Robich MP, Koch CG, Johnston DR, et al. Trends in blood utilization in United States cardiac surgical patients. Transfusion. 2015 Apr;55(4):805–14.
7. Committee on Standards and Practice Parameters, Apfelbaum JL, Connis RT, Nickinovich DG, American Society of Anesthesiologists Task Force on Preanesthesia Evaluation, Pasternak LR, Arens JF, Caplan RA, et al. Practice advisory for preanesthesia evaluation: an updated report by the American Society of Anesthesiologists Task Force on Preanesthesia Evaluation. Anesthesiology. 2012;116(3):522–38.
8. National Institute for Health and Care Excellence (NICE). Routine preoperative tests for elective surgery. NICE guideline. 5 April 2016. Available at: nice.org.uk/guidance/ng45. Accessed 4 Apr 2018.
9. Stoffel NU, Cercamondi CI, Brittenham G, et al. Iron absorption from oral iron supplements given on consecutive versus alternate days and as single morning doses versus twice-daily split dosing in iron-depleted women: two open-label, randomised controlled trials. Lancet Haematol. 2017;4(11):e524–33.
10. Hébert PC, Wells G, Blajchman MA, et al. A multicenter, randomized, controlled clinical trial of transfusion requirements in critical care. Transfusion requirements in critical care investigators, Canadian Critical Care Trials Group. N Engl J Med. 1999 Feb 11;340(6):409–17.
11. American Society of Anesthesiologists Task Force on Perioperative Blood Management. Practice guidelines for perioperative blood management: an updated report by the American Society of Anesthesiologists Task Force on perioperative blood management. Anesthesiology. 2015;122(2):241–75.
12. Hajjar LA, Vincent JL, Galas FR, et al. Transfusion requirements after cardiac surgery: the TRACS randomized controlled trial. JAMA. 2010;304(14):1559–67.
13. Carson JL, Terrin ML, Noveck H, Sanders DW, Chaitman BR, Rhoads GG, et al. FOCUS investigators. Liberal or restrictive transfusion in high-risk patients after hip surgery. N Engl J Med. 2011;365:2453–62.
14. Carson JL, Grossman BJ, Kleinman S, et al. Red blood cell transfusion: a clinical practice guideline from the AABB. Ann Intern Med. 2012;157(1):49–58. 📖
15. Carson JL, Stanworth SJ, et al. Transfusion thresholds and other strategies for guiding allogeneic red blood cell transfusion (review). Cochrane Database Syst Rev. 2016;10:CD002042. 📖
16. Mazer CD, Whitlock RP, Fergusson DA, et al. Restrictive of Liberal red-cell transfusion for cardiac surgery. N Engl J Med. 2017;377:2133–44.
17. ClinicalTrials.gov. National Library of Medicine (US). 2000 Feb 29. Myocardial Ischemia and Transfusion (MINT). Identifier NCT02981407. Accessed 5 Apr 2018. Available from: https://clinicaltrials.gov/ct2/show/NCT02981407.
18. Goodnough LT, Brecher ME, Kanter MH, et al. Transfusion medicine. First of two parts—blood transfusion. N Engl J Med. 1999;340(6):438–47.
19. Klein HG, Spahn DR, Carson JL. Red blood cell transfusion in clinical practice. Lancet. 2007;370(9585):415–26.
20. Amin M, Fergusson D, Wilson K, et al. The societal unit cost of allogenic red blood cells and red blood cell transfusion in Canada. Transfusion. 2004;44(10):1479–86.
21. Varney SJ, Guest JF. The annual cost of blood transfusions in the UK. Transfus Med. 2003;13(4):205–18.

Chapter 21
Jehovah's Witnesses

Ronald Huang

BACKGROUND

Informed consent must be obtained prior to blood transfusion. Patients may decline transfusions for many reasons. The most common reason for declining transfusion is a religious objection among Jehovah's Witnesses. Caring for Jehovah's Witnesses may present a unique challenge to providers around the time of surgery when blood loss can be expected. However, with proper planning and management, most surgeries can be performed safely with outcomes comparable to patients who accept transfusions [1–3].

PREOPERATIVE EVALUATION

DOCUMENT THE PATIENT'S WISHES

The first step in caring for a Jehovah's Witness perioperatively is to establish which products and procedures are acceptable to the patient (see Table 21.1). In general, Jehovah's Witnesses adhere to the following practices and beliefs:

- Jehovah's Witnesses do not accept whole blood or any of the four "primary components" of blood: Red blood cells, platelets, plasma (fresh frozen plasma), and white blood cells.
- Jehovah's Witnesses believe that blood should not be taken out of the body and stored for any length of time, and do not accept the practice of preoperative autologous blood donation (PAD).
- Whether or not to accept "minor fractions" of the primary components or procedures using autologous blood other than PAD is a personal decision for Jehovah's Witnesses (see Table 21.1).

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_21

TABLE 21.1 JEHOVAH'S WITNESSES' POSITION ON MEDICAL THERAPY

Generally Unacceptable
Whole Blood
Primary components of whole blood
Red blood cells
Platelets
Plasma (fresh frozen plasma)
White blood cells
Preoperative autologous blood collection and storage for later infusion
Personal decision (potentially acceptable)
Minor fractions
Albumin (and medications that contain albumin such as epoetin)
Cryoprecipitate
Prothrombin complex concentrates
Fibrinogen
Single factor concentrates
Fibrin sealant
Thrombin sealants
Immunoglobulins
Interferons
Interleukins
Procedures using autologous blood when the blood remains in a closed circuit with the patient
Hemodialysis
Cardiopulmonary bypass
Extracorporeal membrane oxygenation
Apheresis
Cell salvage
Acute normovolemic hemodilution
Tagged RBC and WBC scans
Platelet gel with autologous platelet-rich plasma
Epidural blood patch
Organ or bone marrow transplantation or donation
Hemoglobin-based oxygen carriers

TABLE 21.1 (CONTINUED)

Generally acceptable
Procedural interventions to limit blood loss
Hemostatic surgical instruments
Minimally invasive surgery
Endoscopic procedures
Interventional radiology procedures
Anesthetic techniques to limit blood loss including deliberate hypotension and patient positioning
Limited phlebotomy
Nonblood volume expanders
Normal saline
Lactated Ringer's
Non-albumin colloids
Pharmacologic agents that do not contain blood components or fractions
Iron, folate, B12
Darbopoetin
Tranexamic acid
Aminocaproic acid
Desmopressin
Recombinant factor VII
Nonbiologic topical hemostatic agents

Jehovah's Witnesses carry a Durable Power of Attorney card that describes their preferences regarding whole blood, "primary components," and autologous blood donation. These cards typically do not contain details about minor fractions or procedures using a patient's own blood which may be relevant for the patient's planned procedure. Therefore, it is important to review the patient's wishes in detail using an institutional blood refusal form and enter that information into the electronic medical record. This documentation is ideally performed well in advance of surgery for elective procedures.

When discussing a patient's preferences around transfusion practices, providers should respect their autonomy and maintain confidentiality. While most Jehovah's Witnesses adhere to the practices described above, providers should not assume that is the case with every individual. Many Jehovah's Witnesses prefer to involve family or members of their congregation when discussing these issues with providers, but care should be taken to ensure that the patient's wishes are their own.

PERIOPERATIVE MANAGEMENT

OVERVIEW

Many of the principles for managing patients who decline blood transfusions are the same principles used to reduce the need for blood transfusions in all patients as part of a patient blood management strategy [4–6]. Table 21.2 provides an overview of the key steps in caring for Jehovah's Witnesses perioperatively.

- Most surgeries with a low-risk or intermediate-risk for clinically significant anticipated blood loss can be performed safely by reviewing and documenting the patient's preferences, screening for and treating anemia, evaluating for bleeding disorders, and appropriately managing antiplatelet and anticoagulant medications.
- Management strategies such as erythropoiesis-stimulating agents, prohemostatic agents, and blood conservation procedures are typically reserved for surgeries with a high-risk of clinically significant blood loss.

If there are questions about whether perioperative care can be safely provided for patients who decline blood transfusion, clinicians should consider referral to another hospital or provider that is familiar with managing these issues. The Society for the

TABLE 21.2 PERIOPERATIVE MANAGEMENT OF JEHOVAH'S WITNESSES

Category	Preoperative	Intraoperative	Postoperative
Patient support	Review and document patient preferences Consider alternative treatment plan or referral to a bloodless center if needed Provide Jehovah's Witness Hospital Liaison Committee contact information to the patient	Awareness of patient preferences through communication and alerts	Awareness of patient preferences through communication and alerts Involve Jehovah's Witness Hospital Liaison Committee

TABLE 21.2 (CONTINUED)

Category	Preoperative	Intraoperative	Postoperative
Surgery and anesthesia	Review surgical plan and consider a less invasive or staged procedure to limit blood loss if applicable	Meticulous surgical hemostasis Anesthetic techniques to limit blood loss Blood conservation procedures (cell salvage, acute normovolemic hemodilution)	Closely monitor and treat surgical complications promptly
Anemia	Evaluate for and treat anemia to a goal Hgb as determined by the expected blood loss of surgery and patient comorbidities	Maximize physiologic tolerance of anemia with O_2, fluids, and vasopressors	Limit frequency and amount of phlebotomy Maximize physiologic tolerance of anemia Support hematopoiesis with iron, B12, folate, ESAs
Hemostasis	Identify and treat bleeding disorders Review and stop antiplatelet and anticoagulants appropriately	Prohemostatic medications or minor fractions if acceptable to patient	Identify and treat bleeding disorders Exercise caution when starting antiplatelet and anticoagulants

The Jehovah's Witness Hospital Liaison Committee is an international network made up of local members. Liaisons provide pastoral care and practical assistance to Jehovah's Witnesses. To obtain the Jehovah's Witness Hospital Liaison Committee contact information, providers may contact spiritual care at their hospital or go to https://www.jw.org/en/medical-library/hospital-liaison-committee-hlc-contacts/ to contact Hospital Information Services in their country

Advancement of Blood Management (SABM), which is not affiliated with Jehovah's Witnesses, maintains a list of hospitals in the USA with patient blood management programs: https://www.sabm.org/patient-blood-management-programs.

ERYTHROPOIESIS-STIMULATING AGENTS

Recombinant human erythropoietin (epoetin alfa) is FDA approved to reduce the need for blood transfusions in patients undergoing elective, noncardiac, nonvascular surgery [7]. The benefit of epoetin alfa must be weighed against the potential risks of this therapy including myocardial infarction (MI), stroke, deep vein thrombosis (DVT), and tumor progression. For this reason, the use of epoetin alfa perioperatively is generally limited to patients who decline blood transfusions when the estimated blood loss from surgery would put the patient at increased risk.

- Depending on the timing of surgery, epoetin alfa may be given as 300 U/kg per day beginning 10 days before surgery, on the day of surgery, and for 4 days after surgery. Alternatively, it can be given as 600 U/kg once weekly 21, 14, and 7 days prior to surgery, and on the day of surgery. A CBC should be monitored weekly after initiating epoetin alfa.
- Evaluate the iron status in all patients before administering epoetin alfa. Replace iron if ferritin <100 ng/mL or if transferrin saturation < 20%, although various cutoffs are used. Even if iron stores are adequate, oral iron (usually with B12 and folate) is typically given perioperatively to patients in whom blood transfusion is not an option.
- Due to increased risk of DVT with epoetin alfa, DVT prophylaxis is recommended perioperatively.
- Jehovah's Witnesses should be made aware that epoetin alfa contains albumin since albumin is considered a minor fraction.

BLOOD CONSERVATION PROCEDURES

There are a variety of intraoperative procedures that collect a patient's blood for later infusion to decrease the use of transfusions. These are typically reserved for surgeries with high risk of clinically significant blood loss and should be performed by experienced providers.

- Preoperative autologous blood donation is a procedure in which a patient's blood is collected preoperatively, stored, and then later infused. This practice is unacceptable to Jehovah's Witnesses because the blood is stored separately from the patient.

- Acute normovolemic hemodilution (ANH) is a procedure in which a patient's blood is collected immediately preoperatively and replaced with crystalloid or colloid. Less blood is lost during the surgery because it is less concentrated. The collected blood is typically transfused at the end of surgery. ANH may be acceptable to Jehovah's Witnesses because it can be set up so that the patient's blood remains in a closed circuit with the patient.
- Red blood cell salvage is a procedure in which the blood lost during the surgery is suctioned, processed, and later transfused. Like ANH, cell salvage may be acceptable to Jehovah's Witnesses because it can be set up so that the blood remains in a closed circuit with the patient.
- In addition to the concept of a closed circuit, some Jehovah's Witnesses may differentiate between procedures where their blood is running continuously (cardiopulmonary bypass, dialysis) or not (ANH, cell salvage). Some Jehovah's Witnesses may determine that procedures in which their blood is not running continuously to be unacceptable.

PROHEMOSTATIC AGENTS

Medications may be used to promote hemostasis and prevent clinically significant blood loss. While Jehovah's Witnesses may not accept minor fractions that can be used to correct coagulopathies, the following medications are generally acceptable to Jehovah's Witnesses.

- Antifibrinolytic agents (tranexamic acid, ε-aminocaproic acid) inhibit the activation of plasminogen to plasmin which impairs the degradation of fibrin clots. Tranexamic acid has been shown to reduce blood transfusion in surgery without an increased risk of thrombosis [8]. Tranexamic acid is administered during surgery and postoperatively to reduce blood loss. The typical dose for tranexamic acid is 1000 mg IV or PO every 6 hours.
- Recombinant Factor VIIa (rFVIIa) is approved for use in patients with hemophilia A and B who have inhibitors to factors VIII and IX, respectively, but has been used off-label in patients without hemophilia undergoing surgery. Treatment with rFVIIa reduces blood loss perioperatively but due to the high cost and thrombotic risk, the use of rFVIIa is limited to situations in which there is life-threatening bleeding due to a coagulopathy that is not responsive to conventional treatments or when conventional treatments are not an option (e.g.,

Jehovah's Witnesses) [9, 10]. In this scenario, the initial dose of rFVIIa is 90 mcg/kg.

- Desmopressin increases levels of factor VIII and von Willebrand factor and can be used to manage bleeding in the setting of platelet dysfunction, such as patients who are uremic (see Chap. 22).

HEMOGLOBIN-BASED OXYGEN CARRIERS

Hemoglobin-based oxygen carriers (HBOCs) are either human or bovine hemoglobin that are purified and then chemically modified to increase their stability. They were once thought to be a promising solution to the problems associated with red blood cell transfusions. However, as a result of a meta-analysis showing an increased risk of death and MI when compared with controls, HBOCs are not approved for use by the FDA in the USA [11]. Only one product (HBOC-201 [Hemopure], a bovine-derived HBOC produced by HBO2 Therapeutics) can be obtained in the USA through the FDA's expanded access ("compassionate use") protocol for life-threatening anemia when allogeneic blood transfusion is not an option. If clinically indicated, a provider would need to take the following steps to use HBOCs:

- Contact the manufacturer. HBO2 Therapeutics can be contacted at (781)373-1835.
- Obtain an emergency investigational new drug (eIND) number by contacting the FDA emergency line at (866)300-4374.
- Obtain emergency Institutional Review Board (IRB) approval from the institution where the product will be used.
- Obtain informed consent from the patient or their representative.
- The manufacturer will supply the product and provide further guidance on usage and monitoring. In the case of Hemopure, consensus usage guidelines are available for review from South Africa where it has been approved to treat surgical anemia since 2001 [12].
- If the product is used, further information about the patient's course will need to be supplied to the FDA.

Another bovine-derived HBOC called SANGUINATE (a bovine-derived HBOC produced by Prolong Pharmaceuticals) is in clinical development but is no longer available through the protocol described above.

KEY CLINICAL PEARLS

- Jehovah's Witnesses generally do not accept whole blood, red blood cells, platelets, plasma (fresh frozen plasma), white blood cells, and preoperative autologous donation.
- Whether or not to accept "minor fractions" or other procedures using autologous blood is a personal decision for Jehovah's Witnesses.
- Review the patient's wishes with an institutional blood refusal form and enter that information into the electronic medical record well in advance of surgery for elective surgery.

REFERENCES

1. Pattakos G, Koch CG, Brizzio ME, et al. Outcome of patients who refuse transfusion after cardiac surgery: a natural experiment with severe blood conservation. Arch Intern Med. 2012;172(15):1154–60.
2. Jassar AS, Ford PA, Haber HL, et al. Cardiac surgery in Jehovah's Witness patients: ten-year experience. Ann Thorac Surg. 2012;93(1):19–25.
3. Frank SM, Wick EC, Dezern AE, et al. Risk-adjusted clinical outcomes in patients enrolled in a bloodless program. Transfusion. 2014;54(10 Pt 2):2668–77.
4. Scharman CD, Burger D, Shatzel JJ, Kim E, DeLoughery TG. Treatment of individuals who cannot receive blood products for religious or other reasons. Am J Hematol. 2017;92(12):1370–1381.
5. Resar LM, Wick EC, Almasri TN, et al. Bloodless medicine: current strategies and emerging treatment paradigms. Transfusion. 2016;56(10):2637–47.
6. Lawson T, Ralph C. Perioperative Jehovah's Witnesses: a review. Br J Anaesth. 2015;115(5):676–87.
7. Procrit (Epoetin alfa) [package insert]. https://www.accessdata.fda.gov/drugsatfda_docs/label/2008/103234s5196pi.pdf.
8. Ker K, Edwards P, Perel P, Shakur H, Roberts I. Effect of tranexamic acid on surgical bleeding: systematic review and cumulative meta-analysis. BMJ. 2012;344:e3054.
9. Simpson E, Lin Y, Stanworth S, Birchall J, Doree C, Hyde C. Recombinant factor VIIa for the prevention and treatment of bleeding in patients without haemophilia. Cochrane Database Syst Rev. 2012;14(3):CD005011.
10. Ranucci M, Isgrò G, Soro G, Conti D, De Toffol B. Efficacy and safety of recombinant activated factor vii in major surgical procedures: systematic review and meta-analysis of randomized clinical trials. Arch Surg. 2008;143(3):296–304; discussion 304.
11. Natanson C, Kern SJ, Lurie P, et al. Cell-free hemoglobin-based blood substitutes and risk of myocardial infarction and death: a meta-analysis. JAMA. 2008;299(19):2304–12.
12. Mer M, Hodgson E, Wallis L, et al. Hemoglobin glutamer-250 (bovine) in South Africa: consensus usage guidelines from clinician experts who have treated patients. Transfusion. 2016;56(10):2631–6.

Chapter 22
Thrombocytopenia

Anna Fahy Hagan and Scott Hagan

BACKGROUND

Thrombocytopenia, defined as a platelet count <150,000/μL [1], is a common hematologic abnormality encountered during perioperative testing. Severe thrombocytopenia and platelet dysfunction may increase the bleeding risk of surgery. This chapter focuses on perioperative thrombocytopenia. See Chap. 23 for the preoperative assessment of hemostatic disorders, and the management of von Willebrand disease, hemophilia, vitamin K deficiency, and acquired coagulopathy.

PREOPERATIVE EVALUATION

HISTORY AND PHYSICAL EXAM

History and physical exam can help to identify patients with thrombocytopenia or suggest a cause for patients with known thrombocytopenia. The signs and symptoms of thrombocytopenia are unlikely to be present unless the patient has a platelet count below 50,000/μL. Patients with low platelet counts may describe bleeding at various sites: Cutaneous (petechiae, purpura), gastrointestinal (melena, hematochezia), genitourinary (hematuria, menorrhagia), and mucosal (gingival, epistaxis).

For patients with suspected thrombocytopenia or unexplained thrombocytopenia, it is important to take a detailed history to determine the cause. Specific patient factors to review include [1]:

- Past medical history of liver disease, hematologic or rheumatologic disorders
- Recent exposures or infections
- Recent medications

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_22

- Heavy alcohol use
- Family history of thrombocytopenia

Physical exam (e.g., splenomegaly or sequelae of cirrhosis) may also suggest an underlying cause of the thrombocytopenia.

TESTING

Routine testing of platelet count or function is not recommended. Evaluation of platelet count preoperatively is indicated for patients whose history and physical exam suggest thrombocytopenia and is reasonable for surgeries with a moderate-risk or high-risk for bleeding or for surgeries in which neuraxial anesthesia is planned [2].

Patients who are found to be thrombocytopenic preoperatively may require further evaluation depending on the surgery, severity of thrombocytopenia, and possible causes of the patient's thrombocytopenia. At a minimum, repeating the CBC with a peripheral blood smear is a helpful first step. Further testing depends on the suspected cause of the thrombocytopenia. Ultimately patients may need to be referred to hematology for further evaluation.

If platelet dysfunction is suspected based on history and physical exam in the setting of an adequate platelet count and a cause is not readily apparent, a test of platelet function should be ordered (e.g., platelet function analyzer or thromboelastography [TEG]).

THROMBOCYTOPENIA AND BLEEDING RISK

The surgical bleeding risk in patients with thrombocytopenia strongly depends on other factors including whether a disorder of coagulation is also present, the etiology of thrombocytopenia, a personal history of excessive bleeding, whether platelet function is also affected, and the surgical procedure. There is no convincing evidence of increased perioperative bleeding risk for patients with a platelet count above 50,000/μL (or 100,000/μL for neurosurgical procedures).

PERIOPERATIVE MANAGEMENT

THROMBOCYTOPENIA

For most patients with thrombocytopenia, elective and emergent surgical procedures can be performed safely using platelet transfusions to prevent bleeding or to hasten hemostasis during active bleeding. The evidence for specific platelet transfusion thresholds in surgical patients is poor. Recommendations for platelet transfusion are listed in Table 22.1.

TABLE 22.1 RECOMMENDATIONS FOR PLATELET TRANSFUSION [3, 4]

Platelet count	Recommendation
Plt < 10,000/μL	Platelet transfusion is indicated for prophylaxis against spontaneous bleeding
Plt < 20,000/μL	Platelet transfusion is indicated for prophylaxis prior to central venous catheter placement
Plt < 50,000/μL	Platelet transfusion is indicated for major, elective non-neuraxial surgery, for patients with active non-neuraxial bleeding, or for prophylaxis prior to lumbar puncture
Plt < 100,000/μL	Platelet transfusion is indicated for prophylaxis for neuraxial surgery or for patients with active neuraxial bleeding

EFFECT OF PLATELET TRANSFUSIONS

Platelet transfusions are either pooled (random donor) platelets or apheresis (single donor) platelets. A unit of platelets (50–60 mL) is prepared from platelets that have been separated from a unit of whole blood. Generally, 5 or 6 units of platelets from separate donors are combined into pooled platelets for transfusion. A unit of apheresis platelets (150–300 mL) is collected from a single donor.

- In patients without ongoing active platelet consumption, one apheresis unit, or 4–6 units of pooled platelets, should raise the platelet count by approximately 40,000/μL [5]. A post-transfusion platelet count should be sent to assess for response and can be sent as soon as 10–60 min after the transfusion. The platelet count will gradually fall to pre-transfusion levels after 2–3 days.

PLATELET DYSFUNCTION

Besides platelet transfusions, it is important to avoid platelet dysfunction to prevent bleeding complications in patients with thrombocytopenia. Platelet dysfunction is most commonly due to medications but may also be due to other conditions such as uremia.

- Medications that interfere with platelet function (e.g., NSAIDs, aspirin, clopidogrel) should be reviewed and managed accordingly perioperatively.
- Platelet dysfunction due to uremia is managed with dialysis, desmopressin (0.3 mcg/kg over 30 min) [6] and raising hemoglobin to 8–10 g/dL (which may improve platelet function through hemodynamic effects and increased RBC release of adenosine diphosphate) [7–9].

IMMUNE THROMBOCYTOPENIA

Immune thrombocytopenia (ITP) is characterized by platelet destruction from platelet autoantibodies. The prevalence of ITP in adults is estimated to be approximately 10–20 per 100,000 persons [10, 11]. Consultation with a hematologist is advised to guide perioperative management of patients with ITP.

- For elective procedures, patients with ITP are treated preoperatively with intravenous immunoglobulin (IVIG) 1 g/kg for 1–2 days and/or steroids (dexamethasone 40 mg daily for 4 days or prednisone 1 mg/kg for 1–2 weeks with a taper) before surgery to increase the platelet count to adequate levels such that transfusion is not needed [12].
- IVIG and high-dose steroids can also be used for emergent procedures.
- Platelet transfusions are reserved for emergent surgeries or life-threatening bleeding since they are generally less effective in patients with ITP.
- Newer therapies for patients with chronic ITP in nonsurgical settings include rituximab and thrombopoietin mimetics (romiplostim and eltrombopag), but their role in the perioperative setting is not yet established [10, 11].

POSTOPERATIVE THROMBOCYTOPENIA

Postoperative thrombocytopenia can be due to a number of causes (see Table 22.2) and can often be multifactorial [13]. As different etiologies require specific management, identifying the cause of thrombocytopenia is important to prevent morbidity. The degree and timing of the decrease in platelet count can be important clues for determining the etiology of thrombocytopenia. If thrombocytopenia is identified postoperatively, initial work-up to determine the etiology depends on clinical suspicion and may include:

- Reviewing medications
- Peripheral blood smear
- Repeating CBC
- Coagulation profile (PT/INR, PTT), fibrinogen, D-dimer
- ELISA (antibody) testing for heparin-induced thrombocytopenia (HIT)
- Infectious work-up (e.g., urine or blood cultures, CXR, additional imaging)
- Other tests (e.g., HIV, HCV, abdominal imaging) depend on whether chronic thrombocytopenia is suspected

Although the management of postoperative thrombocytopenia depends on the underlying cause, some of which are listed in

TABLE 22.2 COMMON ETIOLOGIES OF POSTOPERATIVE THROMBOCYTOPENIA

Etiology	Description	Management
Pseudo-thrombocytopenia	Lab artifact due to EDTA in blood collection tube Clumping present on smear	Redraw platelet count in tube containing citrate instead of EDTA
Consumption	Seen in larger blood loss surgeries Occurs immediately after surgery	Returns toward normal within 2–3 days
Dilution of platelets after transfusion	Occurs soon after transfusion. Severity proportional to the volume of blood administered	Platelet count usually returns to normal within 3–5 days after blood transfusion
Thrombocytopenia due to infection	Associated with both viral and bacterial infections	Treat infection
Drug-induced immune thrombocytopenia	Common medications include penicillin-class drugs, vancomycin, digoxin, thiazides, trimethoprim/sulfamethoxazole. Platelet count can be <20,000 μL	Discontinue offending medication
Heparin-induced thrombocytopenia (HIT) type I	Due to the direct effect of heparin Thrombocytopenia occurs 1–2 days after heparin and nadir is >100,000/μL	Continue heparin and monitor
Heparin-induced thrombocytopenia (HIT) type II	Immune (antibody)-mediated process Thrombocytopenia occurs 5–10 days after heparin and nadir is 30–70,000/μL. Associated with thrombosis Calculate 4 Ts score to determine whether to test with ELISA (antibody) and treat [14]	Stop heparin products Start a non-heparin anticoagulant Assess for thrombosis

(continued)

TABLE 22.2 (CONTINUED)

Etiology	Description	Management
Disseminated intravascular coagulation (DIC)	Associated with sepsis, trauma, or malignancy If postoperative, often occurs immediately after surgery	Treat underlying cause If bleeding, transfuse FFP, cryoprecipitate, or platelets as needed
Exacerbation of chronic thrombocytopenia	Causes of chronic thrombocytopenia include chronic infection (HIV, HCV), hematologic disorder (e.g., malignancy, ITP), chronic treatment (chemotherapy), rheumatologic disease (e.g., SLE), and cirrhosis	Depends on the cause of chronic thrombocytopenia

Table 22.2, some general measures can be taken for all patients with postoperative thrombocytopenia. Those include supporting patients with transfusion if indicated and avoiding causes of platelet dysfunction.

KEY CLINICAL PEARLS

- Platelet transfusion thresholds vary greatly depending on clinical context but a threshold of 50,000/μL is adequate for most surgeries unless it is a neuraxial surgery.
- Postoperative thrombocytopenia is often multifactorial, and the initial evaluation should include the following at a minimum: Assessing the timing and severity of thrombocytopenia, reviewing recent medications, and a repeat CBC with a peripheral smear.

REFERENCES

1. Gauer RL, Braun MM. Thrombocytopenia. Am Fam Physician. 2012;85(6):612–22.
2. Feely MA, et al. Preoperative testing before noncardiac surgery: guidelines and recommendations. Am Fam Physician. 2013;87(6):414–8.
3. American Society of Anesthesiologists Task Force on Perioperative Blood Management. Practice guidelines for perioperative blood management: an updated report by the American Society of Anesthesiologists Task Force on perioperative blood management. Anesthesiology. 2015;122(2):241–75.

4. Kaufman RM, Djulbegovic B, Gernsheimer T, et al. Platelet transfusion: a clinical practice guideline from the AABB. Ann Intern Med. 2015;162(3):205–13.
5. Mccullough J. Overview of platelet transfusion. Semin Hematol. 2010;47(3):235–42.
6. Mannucci PM, Remuzzi G, Pusineri F, et al. Deamino-8-D-arginine vasopressin shortens the bleeding time in uremia. N Engl J Med. 1983;308(1):8–12.
7. Liumbruno GM, Bennardello F, Lattanzio A, et al. Recommendations for the transfusion management of patients in the peri-operative period. I. the pre-operative period. Blood Transfus. 2011;9(1):19–40.
8. Mannucci PM, Tripodi A. Hemostatic defects in liver and renal dysfunction. Hematology Am Soc Hematol Educ Program. 2012;2012:168–73.
9. Palevsky PM. Perioperative management of patients with chronic kidney disease or ESRD. Best Pract Res Clin Anaesthesiol. 2004;18(1):129–44.
10. Lakshmanan S, Cuker A. Contemporary management of primary immune thrombocytopenia in adults. J Thromb Haemost. 2012;10(10):1988–98.
11. Neunert C, Lim W, Crowther M, Cohen A, Solberg L Jr, Crowther MA. The American Society of Hematology 2011 evidence-based practice guideline for immune thrombocytopenia. Blood. 2011;117(16):4190–207.
12. Mithoowani S, Gregory-Miller K, Goy J, et al. High-dose dexamethasone compared with prednisone for previously untreated primary immune thrombocytopenia: a systematic review and meta-analysis. Lancet Haematol. 2016;3(10):e489.
13. Chang JC. Review: postoperative thrombocytopenia: with etiologic, diagnostic, and therapeutic consideration. Am J Med Sci. 1996;311(2):96–105.
14. Cuker A, Gimotty PA, Crowther MA, Warkentin TE. Predictive value of the 4Ts scoring system for heparin-induced thrombocytopenia: a systematic review and meta-analysis. Blood. 2012;120(20):4160–7.

Chapter 23
Disorders of Hemostasis

Mala M. Sanchez and Paul B. Cornia

BACKGROUND

Assessing the risk of perioperative bleeding is a fundamental component of the preoperative evaluation. Early recognition and proper perioperative management of hemostatic disorders may prevent, or at least reduce the risk of, perioperative bleeding. This chapter focuses on the preoperative assessment of hemostatic disorders, and the management of von Willebrand disease, hemophilia, vitamin K deficiency, and acquired coagulopathies. See Chap. 22 for evaluation and management of platelet disorders.

PREOPERATIVE EVALUATION

HISTORY AND PHYSICAL EXAM

A preoperative hemostatic history is appropriate for all patients, regardless of the planned procedure [1–3]. Specific information to elicit from the patient includes:

- A personal history of abnormal bleeding, such as excessive bleeding associated with childbirth, menses, minor trauma, dental procedures, or surgery; bruising that occurs spontaneously or with minimal trauma [1]; and bleeding that required a blood transfusion
- Family history of bleeding disorders
- Past medical history of hepatic, renal, or hematologic disease
- Current medication use including aspirin, nonsteroidal anti-inflammatory drugs, antiplatelet medications, anticoagulants, and vitamins, supplements, or herbal preparations

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_23

Although many patients will not have abnormal exam findings, a preoperative physical exam supports the hemostatic history. Physical exam may:

- Suggest the presence of an undiagnosed hemostatic disorder (e.g., petechiae, purpura, ecchymoses)
- Demonstrate chronic findings of hemostatic disorders (e.g., joint deformity and muscle atrophy in hemophilia, although with early diagnosis and treatment, such findings are increasingly rare)
- Reveal signs of chronic conditions that result in hemostatic abnormalities (e.g., jaundice, ascites, and spider telangiectasias observed in cirrhosis; or pallor, lymphadenopathy, and splenomegaly observed in a variety of hematologic disorders)

TESTING

Routine preoperative laboratory testing, including platelet count, prothrombin time (PT/INR), and partial thromboplastin time (PTT), is generally not indicated in patients with a normal hemostatic history [1–4]. Numerous observational studies have demonstrated that an abnormal preoperative PT/INR and/or PTT alone or a bleeding time do not predict an increased perioperative bleeding risk [2, 5]. Preoperative testing is directed by the patient's history and exam and the procedural bleeding risk (see Table 23.1):

- For low-risk procedures and a reassuring history and exam, no further testing is required.
- For high-risk procedures, and to a lesser degree for moderate-risk procedures, a platelet count, PT/INR, and PTT may be considered in addition to history and exam [1, 6].
- Regardless of the procedure, a platelet count, PT/INR, and PTT are appropriate initial testing for patients with a suspected disorder of hemostasis.
- Consider obtaining a platelet count, PT/INR, and PTT if a patient cannot provide a history [3].

Depending on the results of initial testing, additional specialized testing or evaluation may be required. For prolonged PT/INR and/or PTT, the first step is to repeat testing. If repeat testing confirms the abnormal test and a cause is not readily apparent (see Table 23.2), then a referral to hematology for further evaluation is appropriate. Additional testing may include a mixing study to determine if the abnormality is due to factor deficiency (abnormality corrects with mixing) or a factor inhibitor (abnormality does not correct with mixing), lupus anticoagulants, DIC panel, thrombin time, or specific factor levels.

TABLE 23.1 RISK OF BLEEDING WITH SURGICAL OR INVASIVE PROCEDURES

Risk	Type of procedure	Examples
Low	Nonvital organs involved, exposed surgical site, limited dissection, percutaneous access	Lymph node biopsy, dental extraction, cataract extraction, most cutaneous surgery, laparoscopic procedures, coronary angiography
Moderate	Vital organs involved, deep or extensive dissection	Laparotomy, thoracotomy, mastectomy, major orthopedic surgery, pacemaker insertion
High	Bleeding likely to compromise surgical result, bleeding complications frequent	Neurosurgery, ophthalmic surgery, cardiopulmonary bypass, prostatectomy, bladder surgery, major vascular surgery, renal biopsy, bowel polypectomy

Reprinted with permission from [6]

TABLE 23.2 CAUSES OF ABNORMAL COAGULATION STUDIES [7]

PT/INR	PTT	Causes
Prolonged	Normal	Warfarin Vitamin K deficiency Liver disease Extrinsic factor deficiency or inhibitors
Normal	Prolonged	Heparin Von Willebrand disease Intrinsic factor deficiency or inhibitors Antiphospholipid syndrome
Prolonged	Prolonged	Direct oral anticoagulants (DOACs) Disseminated intravascular coagulation (DIC) Common pathway factor deficiency or inhibitors

If the history and physical exam are suggestive of a bleeding disorder but PT/INR and PTT are normal, platelet disorders (see Chap. 22) and von Willebrand disease should be considered, as well as referral to a hematologist.

PERIOPERATIVE MANAGEMENT

VON WILLEBRAND DISEASE

Von Willebrand disease (VWD) is the most common inherited bleeding disorder. The prevalence of VWD may be as high as 1% of the general population, but clinically significant VWD is much less common [8]. Von Willebrand factor (VWF) mediates the adhesion of platelets to damaged endothelium, and binds and stabilizes factor VIII. Von Willebrand disease (VWD) is caused by either a deficiency or dysfunction of VWF, which may also result in low factor VIII levels. There are 3 types of VWD [9]:

- Type 1 (mild) and 3 (severe) VWD represent a quantitative deficiency of VWF.
- Type 2 VWD represents a group of four subtypes that are characterized by dysfunctional VWF (qualitative disorder).

Clinical manifestations vary based on the VWD type, but typically include mucocutaneous and gastrointestinal bleeding. Bleeding typical of a coagulation defect (i.e., hemarthrosis, large ecchymoses) can be seen in Type 3 VWD and in some Type 2 subtypes. If a diagnosis of VWD is suspected, initial laboratory testing in addition to platelet count and PT/INR and PTT should include VWF antigen, VWF activity (e.g., ristocetin cofactor activity), and factor VIII activity levels. Platelet count, PT/INR, and PTT are typically normal, though PTT may be prolonged if factor VIII levels are low. Referral to a hematologist for more specialized testing and treatment is recommended if any studies are abnormal.

Surgical prophylaxis for patients with VWD involves either desmopressin (DDAVP), factor VIII/VWF concentrates, antifibrinolytic therapy (e.g., tranexamic acid), or some combination of the three. Consultation with a hematologist is recommended, as the treatment and monitoring may vary considerably depending on the VWD type.

- Desmopressin transiently increases VWF and factor VIII levels and is most effective for Type I VWD. It is typically reserved for low bleeding risk surgery. Patients should receive a test dose to establish responsiveness. The recommended IV dose is 0.3 μg/kg slowly infused 30 minutes prior to surgery. It can be administered every 12–24 hours if needed [8, 9]. Tachyphylaxis is common so factor VIII activity and VWF activity levels should be monitored if multiple doses are used. The main risks associated with desmopressin are hyponatremia and fluid overload. If repeat dosing is needed, water intake should be limited to 1,500 mL over the 24 hours following administration and serum sodium monitored [9].

- Factor VIII/VWF concentrates are recommended for surgical prophylaxis in the following situations: Patients with Type 3 VWD; patients with Type 2 VWD with an inadequate response to a DDAVP challenge; patients who have or are prone to developing volume overload or hyponatremia with desmopressin; and for any patient with VWD undergoing high bleeding risk surgery. For high bleeding risk surgery, VWF activity levels should be maintained >100 IU/dL during surgery and up to 36 hours after, then >50 IU/dL for a total of 7–10 days as needed. Dosing generally ranges from 50 to 60 IU/kg with repeated doses every 12–24 hours to maintain appropriate levels [8, 9].

ACQUIRED DISORDERS OF COAGULATION

Acquired disorders of coagulation including liver disease, vitamin K deficiency (see below), and anticoagulants are common. Perioperative management of patients with liver disease and anticoagulants are discussed in Chaps. 17 and 26, respectively.

VITAMIN K DEFICIENCY

In the appropriate clinical context (inadequate dietary intake or TPN, alcohol dependence, antibiotics, disease of malabsorption, liver disease), suspect vitamin K deficiency when an elevated PT/INR corrects with 1:1 mixing study. If the clinical suspicion is high, a 1:1 mixing study is not necessary and patients may be given vitamin K for both diagnosis and management.

- For elective surgeries, oral vitamin K (5–10 mg daily for 3 days) is recommended with repeat PT/INR prior to surgery.
- For more urgent or emergent surgeries, intravenous vitamin K (1–2.5 mg IV once) is usually sufficient, but correction with fresh frozen plasma (FFP) may be necessary.

EFFECT OF FRESH FROZEN PLASMA TRANSFUSIONS

One unit of FFP is the plasma collected from a unit of whole blood or apheresis plasma. It contains all coagulation factors in normal or mildly reduced concentrations. The volume of one unit of FFP is roughly 200–300 mL [10].

- FFP transfusion may be used to correct preoperative coagulopathy (e.g., INR > 2), bleeding due to multiple factor deficiencies (e.g., cirrhosis, DIC), as part of a massive transfusion protocol to prevent dilutional coagulopathy, or for urgent warfarin reversal in the setting of serious bleeding when prothrombin complex concentrates are not available. In rare

instances, FFP may be used in emergent situations to manage factor deficiencies when specific factor replacement is not available [11].

- FFP transfusion may not be appropriate for a mildly elevated INR (e.g., INR < 2) as mild elevations are not predictive of increased bleeding and FFP does not significantly change INRs in this range [12].
- The recommended dose of FFP is 10–15 mL/kg. Since one unit of FFP is ~ 250 mL, 3–5 units of FFP are generally necessary for therapeutic effect when indicated [10]. A post-transfusion PT/INR and/or PTT may be measured 15–30 minutes after transfusion to assess the response.

HEMOPHILIA

Inherited factor deficiencies are relatively uncommon, especially when compared with acquired coagulopathies. Hemophilias are the most common of the inherited factor deficiencies. Hemophilia A (factor VIII deficiency) and hemophilia B (factor IX deficiency) together have an estimated incidence of 1:10,000 male births, with Hemophilia A making up ~80% of the cases [13]. Although some patients with mild factor deficiency may be diagnosed in adulthood, most patients with hemophilia are diagnosed as children and are managed by a hematologist. However, a negative family history does not rule out hemophilia with approximately one-third of cases due to de novo mutations [13]. Female carriers of hemophilia A or B may have bleeding symptoms, although usually less severe than in males. Patients with hemophilia undergoing surgery should be managed in consultation with a comprehensive hemophilia treatment center.

- Develop a specific plan with the patient's hematologist for the entire perioperative period which may include additional infusions or monitoring after discharge.
- The dose of factor replacement for surgical prophylaxis depends on the severity of hemophilia, the type of surgery, patient's response to replacement in the past, and the presence of an inhibitor.
- In general, preoperative normalization of factor activity levels with factor replacement is recommended for patients undergoing major surgery [13].
- Perioperative monitoring of factor levels with factor replacement is necessary.

KEY CLINICAL PEARLS

- Obtaining a preoperative PT/INR, PTT, and platelet count is indicated when the history and/or exam are suggestive of a bleeding disorder.
- If history and exam suggest a bleeding disorder but PT/INR and PTT are unrevealing, consider platelet disorders or von Willebrand disease.
- Desmopressin for bleeding prophylaxis is only appropriate in patients with type 1 or type 2 von Willebrand disease when the bleeding risk from surgery is low and they have established a safe response to desmopressin.

ACKNOWLEDGMENTS

Robert E. Richard, MD, PhD
Director of Hematology, VA Puget Sound Health Care System
Associate Professor of Medicine, Division of Hematology, University of Washington

REFERENCES

1. Rapaport SI. Preoperative hemostatic evaluation: which tests, if any? Blood. 1983;61(2):229–31.
2. Chee YL, Crawford JC, Watson HG, et al. Guidelines on the assessment of bleeding risk prior to surgery or invasive procedures. British Committee for Standards in Haematology. Br J Haematol. 2008;140(5):496–504.
3. Bonhomme F, Ajzenberg N, Schved JF, et al. Pre-interventional hemostatic assessment. Guidelines from the French Society of Anaesthesia and Intensive Care. Eur J Anaesthesiol. 2013;30:142–62.
4. Weil IA, Seicean S, Neuhauser D, et al. Use and utility of hemostatic screening in adults undergoing elective, non-cardiac surgery. PLoS One. 2015;10(12):e0139139.
5. Lind SE. The bleeding time does not predict surgical bleeding. Blood. 1991;77(12):2547–52.
6. Jaffer IH, Reding MT, Key NS, et al. Hematologic problems in the surgical patient: bleeding and thrombosis. In: Hoffman R, Benz EJ, Silberstein LE, al e, editors. Hematology: basic principles and practice. 7th ed. Philadelphia: Elsevier; 2018. p. 2304.
7. Kruse-Jarres R, Singleton TC, Leissinger CA. Identification and basic management of bleeding disorders in adults. J Am Board Fam Med. 2014;27(4):549–64.
8. Castaman G, Linari S. Diagnosis and treatment of von Willebrand disease and rare bleeding disorders. J Clin Med. 2017;6(4):E45.
9. Leebek FWG, Eikenboom JCJ. Von Willebrand's disease. N Engl J Med. 2016;375:2067–80.
10. Arya RC, Wander GS, Gupta P. Blood component therapy: which, when and how much. J Anaesthsiol Clin Pharmacol. 2011;27(2):2954–62.
11. American Society of Anesthesiologists Task Force on Perioperative Blood Management. Practice guidelines for perioperative blood management: an updated report by the American Society of Anesthesiologists Task Force on perioperative blood management. Anesthesiology. 2015;122(2):241–75.
12. Szczepiorkowski ZM, Dunbar NM. Transfusion guidelines: when to transfuse. Hematology Am Soc Hematol Educ Program. 2013;2013:638–44.
13. Srivastava A, Brewer AK, Mauser-Bunschoten EP, et al. Guidelines for the management of hemophilia. Hemophilia. 2013;19:e1–e47.

Chapter 24
Venous Thromboembolic Disease

Meghaan Hawes

BACKGROUND

Venous thromboembolism (VTE) is a known potential complication of surgery. Roughly one-third of VTE-related deaths annually occur after surgery, making symptomatic VTE a common and preventable cause of death in the perioperative population [1]. VTE is also a significant cause of morbidity. Studies have demonstrated that without prophylaxis, deep vein thrombosis (DVT) occurs in 15–40% of general surgery patients and 40–60% of orthopedic surgery patients [2]. Evidence-based guidelines have been published for VTE prevention, management of patients currently receiving anticoagulation for DVT or pulmonary embolism (PE) in the perioperative period, and treatment of VTE [2–5].

PREOPERATIVE EVALUATION

PATIENTS WITHOUT KNOWN VTE

Risk for VTE in surgical patients is determined by patient-related predisposing factors and the specific type of surgery.

- Patient factors that increase risk for perioperative VTE include malignancy, hereditary thrombophilias (see Chap. 25), pregnancy, recent sepsis, and medications such as hormone replacement and oral contraceptives.
- Surgical factors that increase risk for perioperative VTE include the type of surgical procedure (abdominal, gynecologic, spine, and lower extremity surgery); prolonged immobility; and length of postoperative hospitalization [2].

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_24

The Caprini risk assessment model is a tool that can be used to help risk stratify surgical patients for postoperative VTE based on their anticipated type of surgery and medical history [6]. Table 24.1 outlines the various patient and surgical characteristics that have been found to contribute to VTE risk in this model.

PATIENTS RECEIVING ANTICOAGULATION FOR PRIOR VTE

Recommendations differ regarding the perioperative management of patients who are receiving anticoagulation for a prior VTE. The perioperative consultant should consider the following:

- In general, the closer in proximity to the venous thromboembolic event, the higher the risk of a recurrent event in the perioperative period.
- Purely elective procedures should be avoided within the first month following a VTE, and should be discouraged within the first 3 months.
- If it is determined that surgery should proceed while a patient is still receiving treatment for VTE, it is important to balance the risk of VTE while off anticoagulation with the risk of bleeding with stopping and starting anticoagulation perioperatively.

Vitamin K Antagonists (Warfarin)

All decisions about warfarin management must be individualized for a patient's particular risk of both VTE and surgical bleeding (see Table 24.2) [2, 7, 8]. Bridging therapy should be considered for patients taking warfarin who are at high risk of VTE to minimize the time off anticoagulation therapy during the perioperative period. A bridging protocol for patients on warfarin is available in Chap. 26 if it is determined bridging therapy is indicated.

Direct Oral Anticoagulants

Direct oral anticoagulants (DOACs), which include the direct thrombin inhibitor dabigatran and direct factor Xa inhibitors rivaroxiban, apixaban, and edoxaban, are approved for the treatment of acute VTE in patients without cancer [3]. The same principles of when to avoid or delay surgery after a recent VTE for patients taking warfarin apply to those patients taking DOACs (see Table 24.2). However, because of their predictable half-life, patients taking a DOAC for a prior VTE do not need to be bridged perioperatively. When to stop and restart DOACs depends on a patient's renal function and the bleeding risk of surgery. See Chap.

TABLE 24.1 CAPRINI RISK ASSESSMENT MODEL [5, 6]

1 point	2 points	3 points	5 points
Age 41–60 years	Age 61–74 years	Age 75 years or older	Stroke (<1 month)
Acute myocardial infarction	Central venous access	Family history of VTE	Elective arthroplasty
Swollen legs	Arthroscopic surgery	History of VTE	Hip, pelvis, or leg fracture
Congestive heart failure (<1 month)	Major open surgery (>45 min)	Heparin-induced thrombocytopenia (HIT)	Acute spinal cord injury (<1 month)
Varicose veins	Malignancy	Factor V Leiden	
Medical patient at bed rest	Laparoscopic surgery (>45 min)	Prothrombin 20210A	
BMI>25 kg/m^2	Confined to bed (>72 hours)	Lupus anticoagulant	
History of inflammatory bowel disease	Immobilizing plaster cast	Anticardiolipin antibodies	
Minor surgery		Elevated serum homocysteine	
Sepsis (<1 month)		Other congenital or acquired thrombophilia	
Abnormal pulmonary function			
Serious lung disease, including pneumonia (<1 month)			
Oral contraceptives or hormone replacement therapy			
Pregnancy or postpartum			
History of unexpected or recurrent spontaneous abortion			

Very low risk = 0 (<0.5% VTE risk in the absence of prophylaxis), low risk = 1–2 (1.5%), moderate risk = 3–4 (3%), high risk = 5 or more (6%)

TABLE 24.2 MANAGEMENT OF PATIENTS WITH PRIOR VTE TAKING WARFARIN IN THE PERIOPERATIVE PERIOD [3–5]

Time of VTE prior to surgery	Risk of recurrent VTE after stopping anticoagulation	Management	
		Pre-op	Post-op
Within 1 month	Approaches 50% if stopped prior to 1 month	*Avoid surgery* Bridge from warfarin with IV heparin or LMWH Consider IVC filter	Bridge with IV heparin or LMWH once surgically acceptable
1–3 months prior	Risk decreases sharply after 1 month At 1 month≈8% At 3 months≈4%	Delay surgery if possible Bridge from warfarin with IV heparin or LMWH	Bridge with IV heparin or LMWH once surgically acceptable
>3 months prior	3 months of anticoagulation is a reasonable amount of time prior to surgery	May proceed with surgery Bridge from warfarin with IV heparin or LMWH if severe thrombophilia present Consider bridging for patients with a VTE within the past 3–12 months, recurrent VTE, or active malignancy	Consider bridge with IV heparin or LMWH once surgically acceptable if a patient had an indication to bridge preoperatively

LDUH low-dose unfractionated heparin, *LMWH* low-molecular-weight heparin

Post-operatively, if a patient is hospitalized and not receiving bridge therapy, (i.e., therapeutic anticoagulation), then prophylaxis-dose LDUH or LMWH should be given until therapeutic anticoagulation can be safely resumed

26 for more information about when to stop and restart DOACs perioperatively.

Inferior Vena Cava (IVC) Filters

The function of an IVC filter is to provide a mechanical interruption in the vena cava to prevent major pulmonary embolism. Guidelines recommend against IVC filter placement in patients who can receive anticoagulation [3]. Acceptable indications for IVC filters include:

- Acute proximal DVT or PE with an absolute contraindication to therapeutic anticoagulation or an unacceptably high bleeding risk [3, 9]
- Acute VTE within 3–4 weeks of surgery who will require perioperative interruption of therapeutic anticoagulation, and anticoagulation treatment will be held for at least 12 hours postoperatively [7, 10]
- Hemodynamic instability or large PE and poor baseline cardiopulmonary reserve, such that another embolic event would be poorly tolerated even if able to receive anticoagulation [10, 11]

Potentially retrievable IVC filters should be considered when the decision to place an IVC filter has been made and the contraindication to anticoagulation is likely to be temporary (e.g., less than 2 weeks). Filters should be removed in a timely manner to minimize adverse events and increase the success of retrieving the filter, generally by 3 months [12]. A time course and plan for possible retrieval should always be discussed with the proceduralist at the time the IVC is placed.

Prophylactic placement of IVC filters is more controversial, and practice varies widely. In trauma patients, prophylactic IVC filter placement does not appear to have a mortality benefit and is associated with complications, including increased rates of DVT [13].

PERIOPERATIVE MANAGEMENT

The main concerns for perioperative management are prevention of VTE in all patients, resumption of anticoagulation in those patients who are chronically receiving it, and diagnosis and treatment of new postoperative VTE.

VTE PROPHYLAXIS FOR ALL SURGICAL PATIENTS

VTE prophylaxis recommendations are shown in Table 24.3. The suggested types of prophylaxis for each type of surgery are based on the 2012 ACCP guidelines [4, 5], which do not make specific dose recommendations for all methods of pharmacologic prophylaxis. Be aware that decisions regarding timing and method of VTE prophylaxis are usually at the discretion of the surgeon with consideration of the risk of surgical bleeding. Dose-related questions in special situations, especially in patients at the extremes of body weight or those with chronic kidney disease, should be discussed with a clinical pharma-

TABLE 24.3 RECOMMENDED VTE PROPHYLAXIS [3–5]

Type of surgery	First line	Second line	Notes
Orthopedic surgery			
Hip replacement (THA), knee replacement (TKA), hip fracture surgery (HFS)	LMWH (enoxaparin 30 mg SC Q12 hours or dalteparin 5000 U SC once daily)	THA and TKA only: Dabigatran 110 mg PO 1–4 hours post-op then 220 mg PO daily, rivaroxiban 10 mg PO daily, or apixaban 2.5 mg PO BID THA, TKA, HFS: LDUH, fondaparinux 2.5 mg SC daily, vitamin K antagonist (VKA) with goal INR 2–3, aspirin 81 mg–160 mg daily, IPC	Minimum treatment duration is 10–14 days, although recommendations favor extending for up to 35 days postoperatively ACCP guidelines suggest LMWH in preference to the other options Consider IPC in addition to pharmacologic agent while hospitalized If increased bleeding risk, then use IPC only or no prophylaxis
Knee arthroscopy	No prophylaxis if no history of VTE		

TABLE 24.3 (CONTINUED)

Type of surgery	First line	Second line	Notes
General surgery, abdomen/pelvis surgery			
Very low risk <0.5% (e.g., ambulatory same-day surgery)	Early ambulation		
Low risk ~1.5% (e.g., certain laparoscopic procedures, more minor abdominal, gynecologic, urologic procedures)	IPC		
Moderate risk ~3% (e.g., major abdominal, nonmalignant gynecologic, thoracic, cardiac surgery)	LMWH, LDUH	IPC	Use IPC if high risk for major bleeding or if consequences of bleeding would be particularly severe
High risk ~6% (e.g., abdominal/ gynecologic malignancy surgery, bariatric (see below for bariatric specifics)	LMWH, LDUH +/– IPC	IPC, low-dose aspirin 160 mg daily, or fondaparinux	Extend duration if abdominal/pelvic cancer surgery Use IPC if high risk for major bleeding or if consequences of bleeding would be particularly severe. If bleeding risk diminishes, add back pharmacologic prophylaxis

(continued)

TABLE 24.3 (CONTINUED)

Type of surgery	First line	Second line	Notes
Bariatric	LMWH high-dose prophylaxis (e.g., enoxaparin 40 mg SC Q12 hours) for BMI > 40 +/–IPC	LDUH +/–IPC	Consult with clinical pharmacist for weight-based dosing. Consider higher doses of LDUH if LDUH is chosen
Cardiac surgery	IPC		If prolonged hospital course due to non-hemorrhagic complications, then add LDUH or LMWH
Thoracic surgery	Moderate risk of VTE: LDUH, LMWH Can add IPC if high risk of VTE	Moderate risk of VTE: IPC	If high risk of bleeding, use IPC
Craniotomy	IPC		If high risk of VTE, add pharmacologic prophylaxis once bleeding risk is acceptable
Spinal surgery	IPC	LMWH, LDUH	If high risk for VTE, add pharmacologic prophylaxis once bleeding risk is acceptable
Major trauma	LDUH, LMWH, or IPC		IVC filter not recommended

LDUH low-dose unfractionated heparin, dosing usually 5,000 U SC Q8 hours or Q12 hours
IPC intermittent pneumatic compression
LMWH low-molecular-weight heparin, e.g., enoxaparin 40 mg SC once daily unless otherwise noted

cist. In general, the current guidelines favor individualized assessment when selecting VTE prophylaxis, taking into account both patient risks and surgical risks of VTE and bleeding [5].

VTE Prophyalxis for Neuraxial Procedures and Nerve Catheter Placement

The use of neuraxial anesthesia and potential for neuraxial bleeding complicates perioperative VTE prophylaxis administration [14]. Generally, the use of low dose unfractionated heparin (LDUH) is preferred if a neuraxial procedure or nerve catheter is planned for surgery, although low-molecular-weight heparin (LMWH) can be considered if dosing is carefully coordinated with catheter placement and removal. Recently updated guidelines for the management of VTE prophylaxis with neuraxial anesthesia are summarized in Table 24.4.

SURGICAL PATIENTS WITH PRIOR VTE REQUIRING ANTICOAGULATION

Therapeutic anticoagulation should only be resumed after discussion with the patient's surgeon with regard to timing and bleeding risk.

- Until therapeutic dose anticoagulation has been resumed postoperatively, prophylactic dose pharmacologic VTE prophylaxis should be considered if the bleeding risk is acceptable.
- Once therapeutic anticoagulation can be resumed, patients taking warfarin may need to be bridged with IV unfractionated heparin (UFH) or LMWH while waiting for the INR to become therapeutic (see Table 24.2). The timing of warfarin reinitiation depends on the assessment of bleeding risk. ACCP guidelines recommend resuming warfarin approximately 12–24 hours after surgery if there is adequate hemostasis [8].
- For patients who are taking therapeutic dose LMWH or direct oral anticoagulants (DOACs), bridging is not required after surgery. Once therapeutic anticoagulation can safely be resumed postoperatively, patients may start taking their therapeutic dose LMWH or DOAC. For patients on DOACs who are at high risk of VTE and are unable to take their DOAC because they cannot take oral medications, then IV UFH or LMWH may be used until the patient is able to resume their DOAC.

TABLE 24.4 MANAGEMENT OF VTE PROPHYLAXIS FOR NEURAXIAL AND PERIPHERAL NERVE CATHETERS [14]

VTE Prophylaxis Medication	Prior to neuraxial or nerve catheter placement	While neuraxial or nerve catheter is in place	After neuraxial or nerve catheter removal
Low-dose unfractionated heparin (heparin 5,000 U SC Q8 or 12 hours)	Discontinue LDUH 4–6 hours before procedure	Can be administered. Discontinue 4–6 hours before removal.	May be resumed 1 hour after catheter removal
Higher dose unfractionated heparin (heparin 7500 U SC Q8 hours)	Discontinue 12 hours before procedure	Risks and benefits of administering higher dose UFH with nerve catheter in place should be individually assessed.	May be resumed 4 hours after catheter removal
Daily LMWH (enoxaparin 40 mg SC daily or dalteparin 5,000 U SC daily)	Discontinue 12 hours before procedure In patient with renal insufficiency, LMWH should be discontinued >12 hours before procedure	First dose may be administered 12 hours after the procedure, and the second dose should be 24 hours after the initial dose. Discontinue 12 hours before removal.	May be resumed 4 hours after catheter removal
Twice daily LMWH (enoxaparin 30 mg or 40 mg SC Q12 hours)	Discontinue 12 hours before procedure In patient with renal insufficiency, LMWH should be discontinued >12 hours before procedure	Given increased spinal hematoma risk associated with this regimen, twice daily LMWH should not be administered with nerve catheter in place.	May be resumed 4 hours after catheter removal

TABLE 24.4 (CONTINUED)

VTE Prophylaxis Medication	Prior to neuraxial or nerve catheter placement	While neuraxial or nerve catheter is in place	After neuraxial or nerve catheter removal
Prophylactic dose fondaparinux (2.5 mg SC daily)	Fondaparinux carries increased risk of spinal hematoma and should generally be avoided with neuraxial procedures or nerve catheter placement unless neuraxial intervention can be performed under conditions similar to clinical trials (e.g., single needle pass, use of atraumatic needles, avoidance of indwelling catheters)		

ACUTE POSTOPERATIVE VTE

Despite best efforts, postoperative VTE still occurs. Patients may present with acute hypoxia, dyspnea, tachycardia, or limb edema. Keep in mind that patients in the postoperative state may have other explanations for symptoms of VTE, and having a high clinical suspicion remains vital so that VTE is not missed. Screening in asymptomatic patients is not recommended. Diagnostic testing for suspected postoperative VTE is shown in Table 24.5.

Immediate Management

Immediate management of postoperative VTE consists of stabilization of the patient. Severity of the VTE and risk of bleeding must be assessed first. Thrombolytics are indicated for unstable patients with massive PE [3, 15]. Contraindications to thrombolytics include intracranial neoplasm, history of intracranial hemorrhage or hemorrhagic stroke, and internal bleeding within 6 months. Due to bleeding risk, this option must always be discussed with the surgeon. Systemic thrombolytic therapy is recommended over catheter-directed thrombolysis for PE with hypotension [3]. For patients with proximal DVT or with PE who are hemodynamically stable, treat with therapeutic dose anticoagulation as soon as possible (see Table 24.6). It is critical to discuss bleeding risk with the surgery team.

TABLE 24.5 DIAGNOSTIC TESTING FOR SUSPECTED POSTOPERATIVE VTE

Test	Notes
Chest CT, PE protocol	Requires 18 gauge antecubital IV, power injectable PICC or power injectable ports to deliver an adequately timed contrast bolus for the study to be properly interpreted Uses IV contrast—use caution in patients with kidney disease
V/Q scan	Consider if contraindication to CT, e.g., chronic kidney disease or severe allergy May be difficult to interpret in patients with underlying lung disease
Lower extremity duplex	Use if suspected DVT, or if suspected PE and unable to perform chest CT or V/Q scan A negative lower extremity duplex does not rule out PE
D-dimer	Not used—generally not useful in postoperative patients, who may have elevated values due to other reasons, and in whom low values would not preclude further evaluation for VTE

TABLE 24.6 STRATEGIES FOR MANAGEMENT OF POSTOPERATIVE VTE [3]

Bleeding risk	Management of DVT/PE
Anticoagulation unacceptable	IVC filter until able to anticoagulate Consider potentially retrievable IVC filter Give prophylactic dose unfractionated heparin or LMWH if possible
Anticoagulation acceptable High bleeding risk	IV UFH Consider using "no-bolus" protocol
Anticoagulation acceptable Low bleeding risk	IV UFH or LMWH (therapeutic dose) if plan is to treat with warfarin, dabigatran, edoxaban, or LMWH Consider apixaban or rivaroxiban, which do not require initial IV UFH or LMWH, in non-cancer patients (use caution in patients with renal insufficiency or morbid obesity)

Choice of Anticoagulation

Similar to VTE prophylaxis, several anticoagulation medications are approved for the treatment of VTE, and guidelines recommend considering an individual's co-morbidities when selecting treatment [3, 16].

- Both IV UFH and LMWH can be used for the initial treatment of acute VTE. IV UFH may be advantageous postoperatively because of its short half-life if bleeding risk is high. Guidelines recommend the use of LWMH if acute VTE is associated with malignancy [3].
- If warfarin is chosen for long-term management of VTE, IV UFH or LMWH should be administered with warfarin until the INR is ≥2.0 for at least 24–48 hours (i.e., usually need to give additional heparin after the first INR is in target range).
- Fondaparinux has also been approved for the treatment of acute VTE as a bridge to warfarin, although it is not approved for subacute or long-term management [16].
- Dabigatran, rivaroxaban, apixaban, and edoxaban are recommended over vitamin K antagonist (warfarin) for the treatment of acute VTE in non-cancer patients [3]. Caution should be used in patients with renal insufficiency or morbid obesity, and a patient's medication list should be reviewed for potential drug interactions with all DOACs [3, 17].
- Dabigatran or edoxaban require initial treatment with a parenteral anticoagulant (IV UFH or LMWH) for 5–10 days before they can be started for long-term anticoagulation as monotherapy.
- Apixaban and rivaroxiban can be started immediately for acute VTE treatment and do not require initial use of LMWH or IV UFH. Dosing for apixaban and rivaroxaban, unlike dabigatran and edoxaban, is adjusted 1 or 3 weeks after starting therapy to complete treatment. Initial apixaban dosing is 10 mg twice daily for 1 week, then 5 mg twice daily for the duration of treatment. Rivaroxiban is prescribed 15 mg twice a day for 3 weeks, then 20 mg daily [17].

Long-Term Management

The duration of anticoagulation depends on whether the VTE was provoked by reversible risk factors, whether the VTE is recurrent, and the bleeding risk of anticoagulation.

- For most patients with postoperative VTE, the recommended duration of therapy for their first VTE is 3 months if there was a reversible, transient risk factor (e.g., recent surgery, immobilization) [3, 16].
- The duration of anticoagulation for patients with recurrent provoked VTE is less clear. If the bleeding risk is low, indefinite anticoagulation should be considered. A patient's bleeding risk

should be re-evaluated periodically to determine whether they should remain on indefinite anticoagulation.

- For patients who have a postoperative VTE but their risk factor(s) are not reversible (e.g., malignancy), the duration of anticoagulation is also unclear. The decision to continue anticoagulation beyond 3 months should be made on an individual basis based on risks and benefits of long-term anticoagulation.

Subsegmental Pulmonary Embolism

Subsegmental pulmonary embolism (SSPE) refers to a peripheral PE confined to the subsegmental pulmonary arteries. Following improvements in CT pulmonary angiography, they account for greater than 10% of all newly diagnosed PEs [3]. To date, there have been no randomized trials specifically investigating anticoagulation of SSPE, and retrospective studies have demonstrated varying results about the risk of progressive or recurrent VTE after SSPE [18, 19].

- If a patient diagnosed with an SSPE is felt to be low risk for recurrent or progressive VTE and does not have a concomitant lower extremity proximal DVT, guidelines recommend clinical surveillance over anticoagulation [3]. If clinical surveillance is chosen over anticoagulation, lower extremity DVT and DVTs in other high-risk locations (e.g., upper extremities with central venous catheters) should be excluded by duplex ultrasound. Clinical surveillance may be an appealing strategy for patients with high bleeding risk in the perioperative period.
- For patients who are felt to be high risk for recurrent VTE (hospitalized or reduced mobility, active cancer, or no reversible risk factor identified) and in whom a diagnosis of an SSPE is likely to be correct based on imaging characteristics, guidelines suggest anticoagulation over surveillance. A low cardiopulmonary reserve or severe symptoms attributed to the SSPE also favor anticoagulation.

Isolated Distal DVT

Isolated distal DVT, defined as a DVT confined to the veins distal to the popliteal vein (e.g., anterior tibial, posterior tibial, soleus, gastrocnemius), is another category of VTE in which clinical surveillance may be an option for management [3]. Studies demonstrate approximately 15% of isolated distal DVTs extend into the popliteal vein when untreated, so patients require either surveillance or anticoagulation [20].

- Guidelines recommend that patients diagnosed with an isolated distal DVT who are relatively asymptomatic and without risk factors for progression of VTE should be managed with serial duplex ultrasound imaging for 2 weeks (e.g., at 1 week and at 2 weeks) to monitor for VTE extension rather than initiating anticoagulation [3]. Anticoagulation should be considered if serial imaging demonstrates an extension of distal DVT into proximal deep veins.
- Guidelines favor anticoagulation over clinical surveillance with serial imaging if a patient has severe symptoms associated with an isolated distal DVT or is high risk for proximal extension (e.g., large thrombus size, history of VTE, active cancer, no reversible provoking factor, positive D-dimer without an alternative reason, inpatient status) [3].

Central Line-Associated DVT

For upper extremity and catheter-associated DVT, current recommendations favor treating them the same as proximal lower extremity DVT or PE [16]. Patients diagnosed with an acute upper extremity DVT associated with a central line should be treated as follows [16]:

- Do not remove the catheter if it is still functional and there is an ongoing need for central access.
- If the catheter is removed, treat for at least 3 months of anticoagulation therapy.
- If the catheter is not removed, continue anticoagulation for at least 3 months and as long as the catheter remains in place, if beyond 3 months.

KEY CLINICAL PEARLS

- 🗝 Collaboration with surgical and pharmacy colleagues is imperative for safe and effective anticoagulation treatment around the time of surgery.
- 🗝 IVC filters are not recommended for patients who can receive anticoagulation.
- 🗝 Direct oral anticoagulants are approved as first-line therapy for postoperative VTE in non-cancer patients.

ACKNOWLEDGMENTS

Elizabeth Kaplan, M.D. Assistant Professor, Division of General Internal Medicine, Department of Medicine, University of Washington

REFERENCES

1. Horlander KT, Mannino DM, Leeper KV. Pulmonary embolism mortality in the United States, 1979–1998: an analysis using multiple-cause mortality data. Arch Intern Med. 2003;163(14):1711–7.
2. Geerts WH, Pineo GF, Heit JA, Bergqvist D, Lassen MR, Colwell CW, Ray JG. Prevention of venous thromboembolism: the seventh ACCP conference on antithrombotic and thrombolytic therapy. Chest. 2004;126(3 Suppl):338S.
3. Kearon C, Akl EA, Ornelas J, et al. Antithrombotic therapy for VTE disease: CHEST guideline and expert panel report. Chest. 2016; 149(2):315–52.
4. Falck-Ytter Y, Francis CW, Johanson NA Curley C, Dahl OE, Schulman S, et al. Prevention of VTE in orthopedic surgery patients. Antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. Chest. 2012;141(2 Suppl):e278S–325.
5. Gould MK, Garcia DA, Wren SM, Karanicolas PJ, Arcelus JI, Heit JA, et al. Prevention of VTE in nonorthopedic surgical patients: antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. Chest. 2012;141:e227S–7.
6. Bahl V, Hu HM, Henke PK, Wakefield TW, Campbell DA, Caprini JA. A validation study of a retrospective venous thromboembolism risk scoring method. Ann Surg. 2010;251(2):344–50.
7. Kearon C, Hirsh J. Management of anticoagulation before and after elective surgery. N Engl J Med. 1997;336:1506–11.
8. Douketis JD, Spyropoulos AC, Spencer FA, Mayr M, Jaffer AK, Eckman MH, et al. Perioperative management of antithrombotic therapy: antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. Chest. 2012;141(2. Suppl):e326S–50.
9. Haut ER, Garcia LJ, Shihab HM, Brotman DJ, Stevens KA, Sharma R, Chelladurai Y, Akande TO, Shermock KM, Kebede S, Segal JB, Singh S. The effectiveness of prophylactic inferior vena cava filters in trauma patients: a systematic review and meta-analysis. JAMA Surg. 2014;149(2):194–202.
10. Bergqvist D. The role of vena caval interruption in patients with venous thromboembolism. Prog Cardiovasc Dis. 1994;37:25–37.
11. Stein PD, Matta F. Vena cava filters in unstable elderly patients with acute pulmonary embolism. Am J Med. 2014;127(3):222–5.
12. Mismetti P, Rivron-Guillot K, Quenet S, et al. A prospective long-term study of 220 patients with a retrievable vena cava filter for secondary prevention of venous thromboembolism. Chest. 2007;131:223–9.
13. Hemmila MR, Osborne NH, Henke PK, et al. Prophylactic inferior vena cava filter placement does not result in a survival benefit for trauma patients. Ann Surg. 2015;262(4):577–85.
14. Horlocker TT, Vandermeuelen E, Kopp SL, Gogarten W, Leffert L, Benzon HT. Regional anesthesia in the patient receiving antithrombotic or thrombolytic therapy: American Society of Regional Anesthesia and Pain Medicine evidence-based guidelines. Reg Anesth Pain Med. 2018;43:263–309.
15. Jaff MR, McMurtry S, Archer SL, et al. Management of massive and submassive pulmonary embolism, iliofemoral deep vein thrombosis, and chronic thromboembolic pulmonary hypertension: a scientific statement from the American Heart Association. Circulation. 2011;123:1788–830.
16. Kearon C, Aki EA, Comerota AJ, Prandoni P, Bounameaux H, Goldhaber SZ, et al. Antithrombotic therapy for VTE disease. Antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. Chest. 2012;141:e419S–4.
17. Eriksson BI, Quinlan DJ, and JW Eikelboom. Novel Oral factor Xa and thrombin inhibitors in the management of thromboembolism. Annu Rev Med. 2011;62:1, 41–57.
18. Stein PD, Goodman LR, Hull RD, Dalen JE, Matta F. Diagnosis and management of isolated subsegmental pulmonary embolism: review and assessment of the options. Clin Appl Thromb Hemost. 2012;18(1):20–6.
19. Den Exter PL, van Es J, Klok FA, et al. Risk profile and clinical outcome of symptomatic subsegmental acute pulmonary embolism. Blood. 2013;122(7):1144–9.
20. Masuda EM, Kistner RL, Musikasinthorn C, Liquido F, Geling O, He Q. The controversy of managing calf vein thrombosis. J Vasc Surg. 2012;55(2):550–61.

Chapter 25
Inherited Thrombophilias

Scott Hagan and Anna Fahy Hagan

BACKGROUND

Inherited thrombophilias are increasingly diagnosed in the general population and are associated with excess risk of venous thromboembolism (VTE) [1]. Though testing for these conditions preoperatively is not indicated, it is important for clinicians to understand how inherited thrombophilias affect perioperative decisions regarding VTE prophylaxis, chronic anticoagulation management, and treatment of acute VTE.

PREOPERATIVE EVALUATION

Refer to Table 25.1 for a general overview of the most common inherited thrombophilias [2]. This chapter will not review acquired hypercoagulable states, including antiphospholipid syndrome, but perioperative management principles for acquired hypercoagulable states are similar. The focus of this chapter is inherited thrombophilias.

Factor V Leiden (FVL) mutation and prothrombin gene mutation (PGM) constitute 50–60% of inherited thrombophilia cases, with the remainder of the cases due to deficiencies in antithrombin, and proteins C and S. Inherited thrombophilias likely increase the risk of postoperative VTE compared to the general population, but the extent of this risk is uncertain and varies by condition [3]. Some previous guidelines have distinguished weak (also referred to as non-severe) from strong (also referred to as severe) thrombophilias based on the relative risk of thrombosis, with PGM and FVL

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_25

TABLE 25.1 OVERVIEW OF INHERITED THROMBOPHILIAS

Etiology	Prevalence	Relative initial VTE risk	Relative recurrent VTE risk
Strong (also referred to as severe) Thrombophilias			
Homozygous FVL mutation	0.2%	13	1.8
Compound FVL/PGM heterozygotes	0.1%	3	2.7
Protein C deficiency	0.4%	10	1.8
Protein S deficiency	0.4%	10	1.0
Antithrombin III deficiency	0.02%	20	2.6
PGM homozygote	<0.1%	11	Unknown
Weak (also referred to as non-severe) thrombophilias			
Heterozygous FVL	5%	4	1.5
PGM heterozygote	2%	3	1.5

Reprinted and adapted with permission from [2]
FVL Factor V Leiden, *PGM* prothrombin gene mutation

heterozygotes considered weak, and the remaining thrombophilias considered strong (see Table 25.1). The impact of these labels on clinical decision-making, perioperative or otherwise, is unclear [2].

HISTORY

Key features of a patient's history that increase the risk of inherited thrombophilias are [1]:

- Strong, early family history of VTE (>1 first degree relative with VTE prior to age 50)
- Personal history of unprovoked or weakly provoked VTE at a young age (prior to age 50)
- VTE in an unusual location (e.g., splanchnic or cerebral veins)
- Recurrent VTE, especially at a young age (prior to age 50)

For patients with a reported or known inherited thrombophilia, important information to obtain preoperatively includes:

- Prior testing
- Thrombosis history
- Anticoagulation history
- Perioperative anticoagulation or thromboprophylaxis management plan from the patient's hematologist if applicable

TESTING

Inherited thrombophilia screening is not indicated prior to surgery even for patients who may be at higher risk based on history; and patients with known inherited thrombophilias do not need repeat confirmatory testing. Assessing the postoperative VTE risk based on the patient's medical history is generally sufficient to inform the perioperative management decisions regarding thromboprophylaxis or anticoagulation management.

PERIOPERATIVE MANAGEMENT

VTE PROPHYLAXIS FOR PATIENTS WITH KNOWN THROMBOPHILIA NOT ON CHRONIC ANTICOAGULATION

According to the Caprini risk assessment model (see Chap. 24), all patients with thrombophilias are at least moderate risk (Caprini score 3–4) for perioperative VTE, and thus merit pharmacologic thromboprophylaxis, usually with low-molecular-weight heparin (LWMH) or low-dose unfractionated heparin (LDUH), if bleeding risk is acceptably low**.** Further, most patients with thrombophilias undergoing surgery will have a high risk of VTE (Caprini score of 5 or more) and should receive both pharmacologic and mechanical prophylaxes with intermittent pneumatic compression devices and/or elastic stockings [4]. Patients with thrombophilias who have a high bleeding risk, regardless of risk of VTE, should use mechanical prophylaxis initially and pharmacologic prophylaxis should be started once the bleeding risk diminishes.

PATIENTS WITH KNOWN THROMBOPHILIA ON CHRONIC ANTICOAGULATION

In patients who are chronically anticoagulated on warfarin due to a history of VTE and known thrombophilia, there is scant evidence to guide the decision of whether to bridge the patient in the periprocedural setting [5]. Guidelines on perioperative bridging divide patients with known inherited thrombophilia into moderate and high risk categories primarily by distinguishing weak and strong thrombophilias [6].

- Moderate risk (bridging not generally necessary): Weak thrombophilia with a history of VTE more than 3 months ago who lack additional risk factors (such as variables in the Caprini risk assessment model) for postoperative VTE.
- High risk (bridging recommended): Strong thrombophilia with history of VTE, or a weak thrombophilia with history of VTE less than 3 months ago.

Patients with thrombophilia taking either LMWH or direct oral anticoagulants (DOACs) for anticoagulation do not need to be bridged. See Chap. 26 for more information on how to bridge patients on warfarin and to manage other anticoagulants perioperatively.

MANAGEMENT OF ACUTE POSTOPERATIVE VTE IN PATIENTS WITH KNOWN THROMBOPHILIA

Acute provoked VTE in the postoperative setting in patients with known thrombophilia should be managed the same as the general population (see Chap. 24). In a large registry which prospectively screened patients with VTE for thrombophilias and monitored for recurrence, the risk of recurrence did not differ between those with or without a hereditary thrombophilia [7]. Therapeutic anticoagulation is recommended for 3–6 months for a first time acute provoked VTE in patients with thrombophilias [8, 9].

For patients with known thrombophilia who have a recurrent VTE following surgery, the recommended duration of anticoagulation is unclear and should be individualized to the patient's preferences and their bleeding risk. In general, indefinite anticoagulation is recommended for patients with recurrent VTE and low bleeding risk, regardless of a diagnosis of thrombophilia [8]. If a patient with thrombophilia who is already on anticoagulation develops a VTE while they are on their anticoagulation, hematology should be consulted to help decide whether to change the intensity or type of anticoagulation.

TESTING FOR THROMBOPHILIA AFTER POSTOPERATIVE VTE

For patients with a first episode of VTE in the setting of a significant surgery, thrombophilia testing is never indicated. Further, both acute thrombosis and anticoagulation are known to interfere with the diagnostic accuracy of several common tests for thrombophilia [9]. If testing is pursued or the patient has additional risk factors for thrombophilia, it should be done at least 3 months after the diagnosis of acute thrombus, when the patient is off anticoagulation, specifically off vitamin K antagonists for at least 2 weeks, heparin for at least 24 hours, and DOACs for 2–3 days.

KEY CLINICAL PEARLS

- Do not perform thrombophilia testing preoperatively for screening and for hospitalized patients with an acute thrombosis.
- Patients with inherited thrombophilias should receive at least pharmacologic prophylaxis for VTE following surgery.

REFERENCES

1. Connors JM. Thrombophilia testing and venous thrombosis. N Engl J Med. 2017;377(23):2298.
2. Stevens SM, Woller SC, Bauer KA, et al. Guidance for the evaluation and treatment of hereditary and acquired thrombophilia. J Thromb Thrombolysis. 2016;41(1):154–64.
3. Wu O, Robertson L, Twaddle S, et al. Screening for thrombophilia in high-risk situations: systematic review and cost-effectiveness analysis. The Thrombosis: Risk and Economic Assessment of Thrombophilia Screening (TREATS) study. Health Technol Assess. 2006;10(11):1–110.
4. Caprini JA. Risk assessment as a guide for the prevention of the many faces of venous thromboembolism. Am J Surg. 2010;199(1 Suppl):S3–10.
5. Wiszniewski A, Szopiński P, Ratajczak J, Bilski R, Bykowska K. Perioperative bridging therapy with low molecular weight heparin for patients with inherited thrombophilia and antiphospholipid syndrome on long-term acenokumarol therapy. Blood Coagul Fibrinolysis. 2011;22(1):34–9.
6. Douketis JD, Spyropoulos AC, Spencer FA, et al. Perioperative management of antithrombotic therapy: antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. Chest. 2012;141(2. Suppl):e326S–50S.
7. Coppens M, Reijnders JH, Middeldorp S, et al. Testing for inherited thrombophilia does not reduce the recurrence of venous thrombosis. J Thromb Haemost. 2008;6(9):1474–7.
8. De Stefano V, Rossi E, Za T, Leone G. Prophylaxis and treatment of venous thromboembolism in individuals with inherited thrombophilia. Semin Thromb Hemost. 2006 Nov;32(8):767–80.
9. Moll S. Thrombophilia: clinical-practical aspects. J Thromb Thrombolysis. 2015;39(3):367–78.

Chapter 26
Chronic Anticoagulation

Maya Narayanan

BACKGROUND

Patients receiving chronic anticoagulation often require interruption of treatment perioperatively. It remains challenging to balance both the risk of thromboembolic events off anticoagulation and the risk of surgical bleeding on anticoagulation. The decision to interrupt anticoagulation is dependent on several factors including the patient's underlying condition requiring anticoagulation, the type of surgery, and the type of anticoagulant. For further discussion about perioperative management of patients receiving anticoagulation for atrial fibrillation and venous thromboembolic disease, please see Chaps. 9 and 24, respectively.

PREOPERATIVE EVALUATION

When assessing a patient who is chronically anticoagulated, it is important to consider and document the following:

- Specific indication for anticoagulation
- Anticoagulant in use and any recent dose adjustments
- Evaluation of medications including antiplatelet agents and other medications which may interact with the anticoagulant
- History of bleeding complications or additional risk factors that predispose the patient to bleeding such as renal or liver disease
- Renal function (glomerular filtration rate) and complete blood count
- Type of surgery
- Potential need for nerve/neuraxial catheter for anesthesia/analgesia perioperatively

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_26

For patients on warfarin, in addition to the above, the following should be documented:

- Whether bridging was recommended in the past
- Plan developed with the patient's anticoagulation clinic
- Recent prothrombin time/international normalized ratio (PT/INR)

PERIOPERATIVE MANAGEMENT

RISK STRATIFICATION TO DECIDE WHETHER TO BRIDGE PATIENTS TAKING WARFARIN

In general, patients who are taking warfarin and are high risk for thrombus formation should be bridged, and those who are low risk should not be bridged [1, 2]. For patients at intermediate risk of thrombus formation, the decision to bridge should be based on surgery-related factors and the individual patient's condition (see Table 26.1).

HOW TO BRIDGE PATIENTS TAKING WARFARIN

Patients on warfarin, who are deemed to have a high enough risk for thromboembolism to need bridging, should be monitored closely by their anticoagulation clinic as they transition off warfarin. Low-molecular-weight heparin (LMWH) is usually used for bridging, but if the patient's renal function prohibits use of LMWH, intravenous unfractionated heparin (IV UFH) can be used.

- In general, hold warfarin for 5 days prior to surgery to allow INR reversal [1]. Warfarin may need to be held longer if a patient's INR is supratherapeutic.
- Start LMWH or IV UFH 3 days prior to surgery, or when the INR is below the lower limit of therapeutic range (INR <2 or < 2.5 depending on the indication for anticoagulation).
- Hold LMWH for 24 hours pre-procedure. If IV UFH is used to bridge, then it should be discontinued 6 hours pre-procedure.

Postoperatively, warfarin can be reinitiated within 12–24 hours if the patient is able to take oral medications and hemostasis has been achieved [2]. Bridging with LMWH or IV UFH can be reinitiated 24 hours after surgery for patients with low post-procedural bleeding risk and between 48 and 72 hours after surgery for patients with moderate to high post-procedural bleeding risk. LMWH or IV UFH can be discontinued when the INR reaches the lower limit of therapeutic range. Consider delaying reinitiation of therapeutic antico-

TABLE 26.1 RISK STRATIFICATION AND RECOMMENDATIONS FOR BRIDGING

	Indication for anticoagulant therapy		
Risk category	**Venous thromboembolism (VTE)**	**Atrial fibrillation (AF)**	**Mechanical heart valve (MHV)**
High Risk *Use bridging*	VTE within 3 months History of VTE or recurrent VTE in the setting of severe thrombophilia (protein C or S deficiency, antithrombin deficiency, antiphospholipid antibodies, or homozygous factor V Leiden)	CHA_2DS_2-VASc score of ≥ 7 Prior stroke/TIA or systemic embolism within 3 months *Do not bridge if major bleed/ intracranial hemorrhage < 3 months ago*	Any mitral or tricuspid valve prosthesis Older (caged-ball or tilting disc) aortic valve prosthesis Bileaflet aortic valve prosthesis and any additional risk factor for stroke or thromboembolism (atrial fibrillation, prior stroke/TIA, known hypercoagulable condition, LV dysfunction)
Intermediate Risk *Bridging decision based upon individual- and surgery-related factors*	VTE > 3 months but < 12 months Recurrent VTE Active cancer	CHA_2DS_2-VASc score of 5–6 Prior stroke/TIA or systemic embolism > 3 months ago *Do not bridge if major bleed/ intracranial hemorrhage < 3 months ago, platelet dysfunction including aspirin use, or prior bleeding from previous bridging*	
Low Risk *No bridging*	Single VTE > 12 months ago and no additional risk factors	CHA_2DS_2-VASc score of 1–4 and no prior stroke/TIA or systemic embolism	Bileaflet aortic valve prosthesis without atrial fibrillation or other risk factors for stroke or thromboembolism

Reprinted and adapted with permission from [3]

agulation with warfarin, LMWH or IV UFH if there is concern about hemostasis, the patient has additional risk factors for bleeding, or if the surgery is located at a site where bleeding would be catastrophic, e.g., intracranial.

DIRECT ORAL ANTICOAGULANTS AND LOW-MOLECULAR-WEIGHT HEPARIN

In general, patients taking direct oral anticoagulants (DOACs) or low-molecular-weight heparin (LMWH) do not need to be bridged due to the predictable half-life of these medications [2]. When to discontinue DOACs prior to surgery is dependent on the patient's glomerular filtration rate (GFR) and bleeding risk of the surgery (see Table 26.2). LMWH should be held for 24 hours pre-procedure.

DOACs and LMWH can be reinitiated within 24 hours after surgery for patients with low post-procedural bleeding risk and between 48 and 72 hours after surgery for patients with moderate to high post-procedural bleeding risk as long as hemostasis has been achieved [2]. If there is a concern for bleeding, then IV UFH can be used initially and the patient can later be transitioned to a DOAC or LMWH once hemostasis is achieved. Similar to warfarin, the urgency to restart therapeutic anticoagulation with DOACs or LMWH depends on the bleeding risk and risk of thromboembolism.

MINOR PROCEDURES

Many minor procedures may be performed while on therapeutic anticoagulation (warfarin, DOAC, or LMWH) due to lower bleeding risk and the ability to use local control measures to obtain hemostasis [2, 4]. Examples of low bleeding risk procedures include:

- Minor dental surgery
- Minor dermatologic surgery
- Cataract surgery
- Endoscopy without biopsy

One should always discuss the anticoagulation plan with the surgeon or provider performing the procedure. For patients on warfarin, an INR should be checked to ensure that the patient's anticoagulation is not supratherapeutic.

STRATEGIES FOR REVERSAL OF COMMON ANTICOAGULANTS

Many anticoagulants can be reversed if there is an indication for emergent surgery. Ideally though, if it is safe to delay surgery, then it is best to wait until the anticoagulant has been eliminated from the body [5]. In general, for anticoagulants other than warfarin, reversal should be undertaken with guidance from pharmacy and hematology. Please see Table 26.3 for further details.

TABLE 26.2 WHEN TO DISCONTINUE DIRECT ORAL ANTICOAGULANT PRIOR TO PROCEDURE

	Dabigatran					Apixaban, edoxaban, rivaroxaban		
CrCl (mL/min)	≥80	50–79	30–49	15–29	<15	≥30	15–29	<15
Low procedural bleeding risk (hours)	≥24	≥36	≥48	≥72	No data. Consider measuring dilute thrombin time (dTT) and/or withholding for ≥96 hours.	≥24 hours	≥36 hours	No data. Consider measuring agent-specific anti-Xa level and /or withholding ≥48 hours.
Uncertain, intermediate, or high procedural bleeding risk (hours)	≥48	≥72	≥96	≥120	No data. Consider measuring dTT.	≥48 hours	No data. Consider measuring agent-specific anti-Xa level and/or withholding ≥72.	

Reprinted and adapted with permission from [2]

TABLE 26.3 ANTICOAGULANT REVERSAL STRATEGIES

Category	Drug activity measurement	Options for reversal
Oral direct factor Xa inhibitors (apixaban, edoxaban, rivaroxaban)	Agent specific anti-factor Xa activity	Hold medication Administer activated charcoal if ingested within the last 2 hours Antifibrinolytic (e.g., tranexamic acid, aminocaproic acid) Consider prothrombin complex concentrate (PCC) for life-threatening bleeding Consider andexanet alfa, if available
Oral direct thrombin inhibitors (dabigatran)	Plasma-diluted thrombin time (dTT)	Hold medication Administer activated charcoal if ingested within the last 2 hours Antifibrinolytic (e.g., tranexamic acid, aminocaproic acid) Consider idarucizumab for life-threatening bleeding If idarucizumab is unavailable, consider PCC for life-threatening bleeding Consider hemodialysis for patient patients with reduced renal function
Parenteral direct thrombin inhibitors (argatroban, bivalirudin)	Plasma-diluted thrombin time (dTT)	Turn off infusion
Parenteral unfractionated heparin	Partial thromboplastin time (PTT) or anti-factor Xa activity	Turn off infusion Consider protamine for full neutralization

TABLE 26.3 (CONTINUED)

Category	Drug activity measurement	Options for reversal
Subcutaneous low-molecular-weight heparin (dalteparin, enoxaparin)	Anti-factor Xa activity	Hold medication Consider protamine for partial neutralization
Subcutaneous factor Xa inhibitor (fondaparinux)	Anti-factor Xa activity	Hold medication
Oral vitamin K antagonist (warfarin)	Protime/ international normalized ratio (PT/INR)	Hold warfarin Consider oral vitamin K 2.5 mg or IV vitamin K 1 mg (Note: IV vitamin K has faster onset of action but has a boxed warning as it can cause anaphylaxis) Consider fresh frozen plasma (FFP) for fast onset reversal (Note: Due to the short half-life, vitamin K should also be administered or FFP may have to be re-dosed)

Reprinted and adapted with permission from [3]
Options for reversal are in addition to supportive care with transfusions

ANTICOAGULATION MANAGEMENT FOR NEURAXIAL PROCEDURES AND NERVE CATHETER PLACEMENT

With few exceptions, full systemic anticoagulation should not be administered during a neuraxial procedure or while a nerve catheter is in place. For the guidance of when to stop and restart specific anticoagulants prior to and after neuraxial procedures/nerve catheter placement, please refer to the American Society of Regional Anesthesia guidelines, 4th edition [6].

KEY CLINICAL PEARLS

- The type of surgery, underlying medical condition, and type of anticoagulation determine when/if an anticoagulant should be stopped before surgery and restarted after surgery.
- For patients on warfarin, only those who are at high risk of thromboembolism require bridging.
- Reverse anticoagulants only for truly emergent surgeries; otherwise, wait until the anticoagulant has been metabolized.

REFERENCES

1. Douketis JD, Spyropoulos AC, Spencer FA, et al. Perioperative management of antithrombotic therapy: antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. Chest. 2012;141:e326S–50S.
2. Doherty JU, Gluckman TJ, Hucker WJ, et al. 2017 ACC expert consensus decision pathway for periprocedural management of anticoagulation in patients with nonvalvular atrial fibrillation: A report of the American College of Cardiology clinical expert consensus document task force. JACC. 2017;69(7):871–898.
3. UW Medicine Pharmacy Services, Anticoagulation Services. http://depts.washington.edu/anticoag. Accessed Apr 2018.
4. Beyer-Westendorf J, Gelbricht V, Forster K, et al. Peri-interventional management of novel oral anticoagulants in daily care: results from the prospective Dresden NOAC registry. Eurp Heart J. 2014;35:1888–96.
5. Dubois V, Dincq AS, Douxfils J, et al. Perioperative management of patients on direct oral anticoagulants. Thrombosis J. 2017;15:1–17.
6. Horlocker TT, Vandermeuelen E. Kopp Sandra, et al. regional anesthesia in the patient receiving antithrombotic or thrombolytic therapy: American Society of Regional Anesthesia and Pain Medicine evidenced-based guidelines (fourth edition). Reg Anesth Pain Med. 2018;43(3):263–309.

Chapter 27
Sickle Cell Disease

Shobha W. Stack and Oyebimpe O. Adesina

BACKGROUND

Sickle cell disease (SCD) comprises a group of hemoglobin disorders that include homozygous sickle cell anemia (HbSS) and compound heterozygote states such as HbS-β thalassemia, HbSC, and many other abnormal hemoglobin variants. SCD has varying degrees of disease severity, which approximates the degree of HbS present in their red blood cells. HbSS and HbS-β^0 thalassemia are clinically indistinguishable, and the most severe phenotypes. Individuals with HbSC and HbS-β^+ thalassemia typically have a less severe phenotype. Surgery poses unique health challenges to individuals with SCD, but early recognition and treatment of disease-related comorbidities can significantly reduce these perioperative complications.

PREOPERATIVE EVALUATION

Sickle cell disease often manifests with organ dysfunction that can negatively impact perioperative management, e.g., 4–18% of people with SCD have chronic kidney disease [1], approximately 30% report near daily chronic pain [2], and 6–11% have pulmonary hypertension [3]. Prior to surgery, review the following history and testing to identify SCD-related comorbidities that will require perioperative management.

- Determine if vaccination history is up to date.
- Determine history of chronic pain and associated analgesic regimen [4].

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_27

- Screen for sequelae or comorbidities of sickle disease that can increase surgical risk, e.g., stroke, infections, avascular necrosis, leg ulcers, pulmonary hypertension, renal insufficiency, and priapism [1].
- Perform pulmonary function tests (PFT) and a 6-min walk test if not done in the past year. If the PFT and 6-min walk tests are abnormal, a transthoracic echocardiogram can be used to screen for pulmonary hypertension.
- Confirm that anesthesia knows of the patient's comorbidities that could increase cardiopulmonary stress, e.g., pulmonary hypertension, sleep apnea, and history of acute chest syndrome.
- Determine the patient's baseline hemoglobin level and any history of transfusion reactions, as people with SCD may receive intermittent or long-term (in predetermined intervals) red blood cell (RBC) transfusions. If the patient has a history of alloimmunization, then alert the blood bank as it may require additional time to prepare phenotypically matched RBCs.

PERIOPERATIVE MANAGEMENT

PREOPERATIVE MANAGEMENT

For surgical procedures involving general anesthesia, the patient should be admitted to the hospital 1–2 days prior to surgery for preoperative optimization. The focus of preoperative management is the patient's hematologic status. Optimizing hemoglobin levels, as described below, can decrease postoperative complications, e.g., acute vaso-occlusive pain episodes (VOEs) and acute chest syndrome [5].

Two days prior to surgery:

- Check hemoglobin, reticulocyte count, and quantitative hemoglobin S (Hb S) to determine transfusion needs.
- Send a type and cross to prepare for perioperative RBC transfusions as needed.
- Transfuse RBCs to increase hemoglobin levels to ≥10 g/dL using leukocyte-reduced and antigen-matched blood products [1, 6].
- For patients with HbSS who have a hemoglobin level >8.5 g/dL without transfusion, are on chronic hydroxyurea, or are undergoing high-risk surgery, consult hematology to advise on the

appropriate transfusion method (i.e., simple, partial exchange, full exchange) [1].
- For patients with HbSC or HbS-β^+ thalassemia, who typically have higher baseline hemoglobin levels, consult hematology to determine if exchange transfusion is indicated to achieve quantitative HbS levels less than 30% [1].
- Continue outpatient medications (e.g., hydroxyurea and folic acid) until NPO for surgery.

One day prior to surgery:
- Check post-transfusion hemoglobin (goal hemoglobin ≥ 10 g/dL).
- Check serum magnesium level (goal magnesium ≥ 2.2 mg/dL) and replete as needed.
- When the patient is NPO, start 1/2 NS at a maintenance rate until they are able to take oral fluids again. Avoid isotonic fluids (e.g., NS or LR) as these have been associated with increased risk of VOEs [7].
- Start incentive spirometry hourly while awake to reduce risk of acute chest syndrome [8].
- Confirm operative plan and suitability for postoperative transfer of the patient to the surgical service.
- Confirm with blood bank that phenotypically matched blood is available for surgery.
- Confirm postoperative pain management plan with pain service.

INTRAOPERATIVE MANAGEMENT

The general principles of intraoperative management include maintaining normothermia and euvolemia, avoiding hypoxia and acidosis, and providing adequate pain relief [9].
- Confirm that preoperative antibiotics were given.
- Maintain oxygen SaO_2 > 98%, PaO_2 > 95 mmHg.
- Abrupt changes in body temperature can trigger VOEs, so keep the patient's temperature > 37°C throughout the procedure. Avoid the use of ice packs and use warmed IV fluids intraoperatively.
- Use IV fluids judiciously as SCD patients are at increased risk of volume overload, which could lead to pulmonary edema.
- Continue to use 1/2 NS, avoiding NS and LR [7].
- Prolonged tourniquet use for limb surgery may trigger VOEs, so ensure minimal inflation time, maintain adequate hydration, and keep the patient mildly hyperventilated [9].

POSTOPERATIVE MANAGEMENT

Approximately, 19% of postoperative patients with SCD experience disease-related complications depending on the type of surgery [10]. The focus of the postoperative phase in SCD should be adequate pain management, avoiding factors that can trigger VOEs, and returning the patient to their previous state of health.

- Monitor for signs of SCD-related complications (stroke, acute coronary syndrome, VOEs, and acute chest syndrome).
- Consult hematology if the patient develops acute sickle cell complications: Vaso-occlusive pain crises, acute chest syndrome, deep vein thrombosis, pulmonary embolism, pulmonary hypertension, priapism, or stroke.
- Consider a hematology consult if the patient has a prior history of any of the complications listed above, or a history of avascular necrosis or leg ulcers. The latter two complications are associated with chronic sickle cell pain, which may complicate postoperative pain management.
- The optimal postoperative hemoglobin level in sickle cell patients has not been sufficiently studied to give a recommendation that is different from the thresholds used for the general population.
- Avoid fluid overload.
- Continue to use hypotonic fluids (e.g., 1/2 NS) until the patient is able to take sufficient fluids by mouth [7].
- Consider keeping serum magnesium levels at the upper limit of normal (2.2–2.4 mg/dL) [11].
- Avoid abrupt temperature changes, including hypothermia, e.g., avoid using ice packs.
- Continue with incentive spirometry hourly while awake in the postoperative period [8].
- Many people with SCD are on long-term opioid analgesia for chronic SCD pain and may have increased opioid tolerance. Consult the pain service for optimization of pain management, while avoiding oversedation, in the immediate postoperative period.
- SCD patients are at increased risk of deep venous thrombosis and pulmonary embolism [12, 13]. Implement early mobilization and DVT prophylaxis with mechanical devices, as well as prophylactic anticoagulation as soon as it is acceptable to the surgical team, preferably within 24 hours.
- Continue outpatient medication regimen for sickle cell disease, e.g., hydroxyurea and folic acid.

KEY CLINICAL PEARLS

- Prior to surgery, transfuse RBCs to increase hemoglobin levels to ≥10 g/dL using leukocyte-reduced and antigen-matched blood products to decrease the risk of postoperative complications.
- Avoid isotonic fluids (e.g., NS or LR) as these have been associated with increased risk of VOEs.
- To avoid postoperative complications, maintain normothermia and euvolemia, avoid hypoxia and acidosis, and provide adequate pain relief.
- Avoid oversedation with narcotic analgesia while noting that people with SCD chronic pain may have an increased opioid tolerance.

REFERENCES

1. Yawn BP, Buchanan GR, Afenyi-Annan AN, et al. Management of sickle cell disease summary of the 2014 evidence-based report by expert panel members. JAMA. 2014;312(10):1033–48.
2. Smith WR, Penberthy LT, Bovbjerg VE, McClish DK, Roberts JD, Dahman B, Aisiku IP, Levenson JL, Roseff SD. Daily assessment of pain in adults with sickle cell disease. Ann Intern Med. 2008;148:94–101.
3. Hayes MM, Vedamurthy A, George G, Dweik R, Klings ES, Machado RF, Gladwin MT, Wilson KC, Thomson CC. Pulmonary hypertension in sickle cell disease. Ann Am Thorac Soc. 2014;11(9):1488–9.
4. Dampier C, Palermo TM, Darbari DS, Hassell K, Smith W, Zempsky W. AAPT diagnostic criteria for chronic sickle cell disease pain. J Pain. 2017;18(5):490–8.
5. Howard J, Malfroy M, Llewelyn C, Choo L, Hodge R, Johnson T, Purohit S, Rees DC, Tillyer L, Walker I, Fijnvandraat K, Kirby-Allen M, Spackman E, Davies SC, Williamson LM. The Transfusion Alternatives Preoperatively in Sickle Cell Disease (TAPS) study: a randomised, controlled, multicentre clinical trial. Lancet. 2013;381(9870):930–8.
6. Howard J, Malfroy M, Llewelyn C, Choo L, Hodge R, Johnson T, Purohit S, Rees DC, Tillyer L, Walker I, Fijnvandraat K, Kirby-Allen M, Spackman E, Davies SC, Williamson LM. The Transfusion Alternatives Preoperatively in Sickle Cell Disease (TAPS) study: a randomised, controlled, multicentre clinical trial. Lancet. 2013;381(9870):930–8.
7. Carden MA, Fay M, Sakurai Y, McFarland B, Blanche S, DiPrete C, Joiner CH, Sulchek T, Lam WA. Normal saline is associated with increased sickle red cell stiffness and prolonged transit times in a microfluidic model of the capillary system. Microcirculation. 2017;24(5):1–5.
8. Bellet PS, Kalinyak KA, Shukla R, Gelfand MJ, Rucknagel DL. Incentive spirometry to prevent acute pulmonary complications in sickle cell diseases. N Engl J Med. 1995;333(11):699–703.
9. Paradowski K. Pathophysiology and perioperative management of sickle cell disease. J Perioper Pract. 2015;25(6):101–4.
10. Koshy M, Weiner SJ, Miller ST, Sleeper LA, Vichinsky E, Brown AK, et al. Surgery and anesthesia in sickle cell disease. Cooperative study of sickle cell diseases. Blood. 1995;86(10):3676–84.
11. Than NN, Soe HHK, Palaniappan SK, Abas AB, De Franceschi L. Magnesium for treating sickle cell disease. Cochrane Database Syst Rev. 2017;14(4):CD011358.
12. Wun T, Brunson A. Sickle cell disease: an inherited thrombophilia. Hematology Am Soc Hematol Educ Program. 2016;2016(1):640–7.
13. Naik RP, Streiff MB, Lanzkron S. Sickle cell disease and venous thromboembolism: what the anticoagulation expert needs to know. J Thromb Thrombolysis. 2013;35(3):352–8.

Chapter 28
Cerebrovascular Disease

Anna L. Golob

BACKGROUND

Stroke is an uncommon but feared complication of surgery. The observed stroke rate is 0.3–3.5% in general surgery patients, varying by age and other comorbidities [1]. Approximately one-third of postoperative strokes are embolic [2, 3]. A history of cerebrovascular disease is a risk factor for perioperative cerebrovascular and cardiovascular complications.

PREOPERATIVE EVALUATION

RISK STRATIFICATION: GENERAL CONSIDERATIONS

Prior stroke is a major risk factor for perioperative stroke events. One retrospective surgical series of patients with a history of previous stroke found a 2.9% incidence of postoperative stroke [4]. A case–control study found that history of previous stroke was the most significant risk factor for postoperative stroke [5].

Timing of surgery in relation to stroke event is also important. A Danish national cohort study of patients having surgery after ischemic stroke found an odds ratio for major adverse cardiovascular events (MACE) of 14.2 for patients with stroke less than 3 months prior to surgery, 4.8 for stroke event within 3–6 months of surgery, 3.0 with stroke event within 6–12 months of surgery, and 2.5 for stroke event more than 12 months before surgery. Similarly, 30-day postoperative mortality was highest for those with a stroke event within 3 months of surgery and seemed to level off for those with a stroke event 9 or more months prior to surgery although this remained

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_28

elevated compared to patients with no stroke history [6]. In light of this data, neurologists now often recommend delaying elective surgery for 9 or more months after an ischemic stroke event, though there are no consensus guidelines and individual patient characteristics must be considered.

Other potential risk factors for perioperative stroke include age (not independent, but as a marker of other cardiovascular disease), female gender, hypertension, diabetes, creatinine >2, smoking, chronic obstructive pulmonary disease, peripheral vascular disease, left ventricular ejection fraction <40%, coronary artery disease, heart failure, symptomatic carotid stenosis, and patent foramen ovale [2, 7]. A more recently recognized risk factor is migraine, which was found to be associated with an increased risk of perioperative stroke (odds ratio 1.75) compared to patients without migraine history in a prospective hospital registry study. Migraine with aura had an even higher risk of stroke with an odds ratio of 2.61 [8].

Medical consultants often evaluate patients who have had a recent cerebrovascular event being considered for surgery:

- Recommendations to delay elective surgery following a cerebrovascular accident (CVA) or transient ischemic attack (TIA) have varied widely, from 2 weeks to 9 or more months [1, 6].
- Perioperative stroke risk may level off around 9–12 months after an ischemic stroke event but remains elevated compared to patients with no stroke history.
- Discussion with the patient's neurologist regarding risk factor optimization and timing of surgery is recommended given lack of consensus guidelines.
- Each case should be individually evaluated with regard to the type and urgency of the surgery, the patient's comorbidities, and the extent to which the TIA/CVA symptoms are stable, have been fully evaluated, and intervened upon if appropriate (e.g., carotid endarterectomy [CEA] for recurrent TIA/ CVA due to a carotid lesion).
- Patients whose stroke risk factors have been maximally treated and who do not have ongoing symptoms are likely to be lower risk; as are those whose TIA/CVA event is 9 or more months preceding surgery.

PHYSICAL EXAMINATION

General cardiovascular examination and neurologic examination is indicated preoperatively for patients at risk for perioperative stroke [9]. If a carotid bruit is detected, the patient should be questioned for signs, symptoms, or history of TIA/CVA. Patients with truly

asymptomatic, incidentally found carotid bruits do not require further workup prior to surgery:

- There is a poor correlation between asymptomatic bruits and significant carotid disease [10].
- Patients with known mild-to-moderate carotid stenosis have an overall low risk of perioperative stroke.
- A prospective study of 735 patients (excluding those with active symptoms) undergoing elective abdominal, cardiothoracic, breast, and extremity surgery failed to show a significant perioperative risk associated with asymptomatic carotid bruit on routine preoperative physical examination [11].

Indications for a carotid duplex in patients with a carotid bruit include:

- Symptomatic patients
- History of TIA/CVA
- Asymptomatic patients planned for coronary artery bypass grafting (CABG) given evidence for improved outcomes with combined CABG/CEA in patients found to have severe carotid stenosis [11]

PERIOPERATIVE MANAGEMENT

STROKE PREVENTION

There are no good data to support specific management strategies. We advise optimizing cardiovascular risk factors as possible, including blood pressure control, restarting medications such as aspirin and statin, and restarting anticoagulation when surgically acceptable with regard to bleeding risk. If the patient is anticoagulated due to high baseline stroke risk or prior CVA, consider bridging with unfractionated or low-molecular-weight heparin in the perioperative period (see Chap. 26 for details on anticoagulation management) [12]. Vigilance in detecting new-onset atrial fibrillation may reduce embolic disease.

POSTOPERATIVE STROKE

When a postoperative stroke does occur, it may be associated with mortality as high as 26%, although estimates vary [3]. Management should proceed in the same way as a stroke not associated with a procedure. However, important considerations are the following [12]:

- Identify possible embolic sources.
- Work closely with the surgical team, should anticoagulation be indicated.

- Thrombolytics can be difficult to use because recent surgery is generally a contraindication; consider neurointerventional procedures in lieu of thrombolytics.
- "Permissive hypertension" may be difficult in certain vascular or plastic surgery procedures, and discussion with the surgery and neurology teams is essential. Hypotension should be avoided.
- Achieving normoglycemia, normal oxygenation, and preventing fever remain important.
- Hyponatremia may be more difficult to avoid in the postoperative setting secondary to third spacing.

KEY CLINICAL PEARLS

- A history of cerebrovascular disease (CVD) is the most important risk factor for postoperative stroke.
- Perioperative stroke risk may level off around 9–12 months after an ischemic stroke event but remains elevated compared to patients with no stroke history.
- It is important to optimize CVD risk factors and treat specific causes of stroke before a patient undergoes elective surgery.
- Truly asymptomatic carotid bruits do not require further evaluation or treatment before surgery.
- Postoperative stroke management must be coordinated with the surgical team, e.g., the use of thrombolytics or anticoagulants may be contraindicated and permissive hypertension may be limited by the type of surgical procedure.

ACKNOWLEDGMENTS

Christopher J. Wong, MD, Associate Professor, Division of General Internal Medicine, Department of Medicine, University of Washington.

REFERENCES

1. Bell R, Merli G. Perioperative assessment and management of the surgical patient with neurologic problems. In: Merli G, Weitz H, editors. Medical management of the surgical patient. Philadelphia: W. B. Saunders; 1998. p. 283.
2. Selim M. Perioperative stroke. N Engl J Med. 2007;356:706–13.
3. Parikh S, Cohen J. Perioperative stroke after general surgical procedures. N Y State J Med. 1993;93:162–5.
4. Landercasper J, Merz BJ, Cogbill TH, et al. Perioperative stroke risk in 173 consecutive patients with a past history of stroke. Arch Surg. 1990;125:986–9.
5. Limburg M, Wijdicks EF, Li H. Ischemic stroke after surgical procedures: clinical features, neuroimaging, and risk factors. Neurology. 1998;50:895–901.

6. Jorgensen ME, Torp-Pedersen C, Gislason GH, et al. Time elapsed after ischemic stroke and risk of adverse cardiovascular events and mortality following elective noncardiac surgery. JAMA. 2014;312(3):269–77.
7. Ng PY, Ng AK, Subramaniam B, et al. Association of preoperatively diagnosed foramen ovale with perioperative ischemic stroke. JAMA. 2018;319(5):452–62.
8. Timm FP, Houle TT, Grabitz SD, et al. Migraine and risk of perioperative ischemic stroke and hospital readmission: hospital based registry study. BMJ. 2017;10:356.
9. Fleisher LA, Beckman JA, Brown KA, et al. ACC/AHA 2007 guidelines on perioperative cardiovascularevaluation and care for noncardiac surgery: a report of the American College of Cardiology/American Heart Association task force on practice guidelines. Circulation. 2007;116:e418–500.
10. Ropper AH, Wechsler LR, Wilson LS. Carotid bruit and the risk of stroke in elective surgery. N Engl J Med. 1982;307(22):1388–90.
11. Hines GL, Scott WC, Schubach SL, et al. Prophylactic carotid endarterectomy in patients with high-grade carotid stenosis undergoing coronary bypass: does it decrease the incidence of perioperative stroke? Ann Vasc Surg. 1998;12:23.
12. Szeder V, Torbey MT. Prevention and treatment of perioperative stroke. Neurologist. 2008;14(1):30–6.

Chapter 29
Epilepsy and Seizure Disorders

Sandra Demars and Tyler Lee

BACKGROUND

Patients with epilepsy undergo surgery and experience perioperative complications at higher rates than patients without epilepsy [1, 2]. Therefore, these patients require close attention and vigilant management by the medical consultant. Perioperative seizures are rare in patients without epilepsy, except in the setting of cranial and cardiac surgery, and may indicate the presence of a toxic-metabolic disturbance that will require identification and management by the medical consultant.

PREOPERATIVE EVALUATION

Medical consultants should identify preoperatively the patients at risk for seizures in the perioperative period with a complete medical and social history. It is also important to identify any baseline neurologic deficits with a thorough examination.

PATIENT-SPECIFIC RISK FACTORS FOR SEIZURE

- Known seizure disorder or current epilepsy treatment, including use of antiepileptic drugs (AEDs) or presence of vagus nerve or responsive neural stimulator
- Intracranial brain tumors: Meningioma, glioma, metastases, etc.
- Acute presentation or history of stroke, hemorrhage, traumatic brain injury, or central nervous system infections
- Electrolyte abnormalities, hypoglycemia

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_29

- Infection
- Substance abuse
- Neurodegenerative disease, such as Alzheimer's dementia

SURGERY-SPECIFIC RISK FACTORS FOR SEIZURE

- Craniotomy [3, 4]
- Higher doses of intraoperative tranexamic acid (most common in cardiac surgery) [5, 6]
- Very high doses of certain penicillins and cephalosporins

SPECIAL CONSIDERATIONS FOR PATIENTS WITH EPILEPSY

Patients with epilepsy and seizure disorders are at high risk for perioperative complications. Two retrospective studies estimated the risk of perioperative seizures to be between 2% and 6% in patients with preexisting seizure disorders [7, 8]. Type of anesthesia or surgery was not associated with increased clinical seizure risk; however, the study that addressed type of surgery did not include craniotomy and did not specifically quantify the number of cardiac surgery patients [7, 8]. When perioperative seizures do occur, they tend to have the same semiology as patient's typical preoperative seizures [7]. Important information to consider during the preoperative evaluation from patients with preexisting seizure disorders include the following:

- Seizure type
- Seizure frequency
- Date of most recent seizure
- Most recent AED level
- If obtaining therapeutic AED levels has been challenging, the level should be rechecked and, if necessary, AED dose adjustment considered
- It is usually not necessary to perform routine imaging or electroencephalography (EEG)

Perioperative circumstances associated with increased risk of perioperative seizures in patients with preexisting seizure disorders include the following [1, 2, 7]:

- Younger age
- Preoperative use of multiple AEDs
- Shorter time between last seizure and surgery
- More frequent seizures at baseline
- Unstable or subtherapeutic AED level
- Sleep deprivation
- Stress
- Electrolyte disturbances

- Disruptions in patient's usual AED dosing schedule, either because of prolonged intraoperative times or the inability to take enteral medications perioperatively. Patients need to be instructed not to miss any of their AED doses prior to surgery
- Medications that affect seizure threshold or interact with patient's AEDs can also increase the risk of perioperative seizure

In addition to seizures, patients with a preexisting seizure disorder are at increased risk of multiple other complications. The overall complication rate for patients with epilepsy is 20.6% vs. 9.8% in patients without epilepsy (Odds Ratio [OR]: 2.69 for those with epilepsy compared to those without) [2]. There was no difference in 30-day mortality. Patients with epilepsy are at greater risk of the following additional individual complications [2]:

- Stroke (OR: 3.15)
- Pneumonia (OR: 2.54)
- Sepsis (OR: 2.03)
- Acute renal failure (OR: 1.61)
- Postoperative bleeding (OR: 1.14)
- Deep wound infection (OR: 1.31)
- ICU usage (30% in patients with epilepsy vs. 13.5% in those without)
- Higher in-hospital medical expenditures (110–151% of the expenses for those without)
- Longer hospital stay (17.8 days in patient with epilepsy vs. 10.4 days in those without)

It is unclear why these patients have increased rates of complications. Previous studies have demonstrated increased risk of stroke in patients with epilepsy, and at least one study suggested that this risk may be associated with the use of AEDs [2]. However, a likely cause of this increased risk in some patients is the underlying neurological condition causing their epilepsy. Preoperative counseling regarding these risks is advised.

PERIOPERATIVE MANAGEMENT

Seizure prevention in the general population should include close attention to electrolytes as well as monitoring for infection or other postoperative complications.

PREVENTION IN PATIENTS WITH EPILEPSY

Patients with epilepsy who are already on antiepileptic therapy need to be maintained on their antiepileptics perioperatively. Important perioperative management principles for AEDs include the following:

- Patients should take their antiepileptic medications the morning of surgery and restart them as soon as possible after surgery.
- If enteral medications are not possible, intravenous alternatives should be started postoperatively [1]. Intravenous formulations are available for phenytoin, valproic acid, levetiracetam, phenobarbital, and lacosamide.
- If there is no intravenous substitution available (examples are carbamazepine and lamotrigine), there are two alternatives: One option is to give the daily dose just before surgery, and then given an extra loading dose when resuming oral medication if patient's last dose was >36 hours ago. The second alternative is to treat with low-dose benzodiazepine rectally or by continuous intravenous infusion while the patient is unable to take enteral medications. Lorazepam, which has a longer half-life, is preferred over diazepam. The extra loading dose of the original drug would then still be given when oral medication is resumed if it has been >36 hours since patient's last dose [9]. Consultation with the patient's neurologist should be considered.
- Unfortunately, there is limited research regarding equivalence of oral and parenteral formulas. There is no assurance that an alternative medication will be as effective or as well tolerated as a patient's usual antiepileptic medications, so consultation with both neurology and pharmacy is recommended if a patient's AED does not have an alternative IV formulation [9].

PREVENTION IN PATIENTS UNDERGOING BRAIN SURGERY

Patients undergoing brain surgery for various conditions are at higher risk of perioperative seizures; however, there is much debate in the literature about the use of prophylactic antiepileptic therapy. A recent systemic review of perioperative seizure prophylaxis for supratentorial tumor resection showed no significant reduction in the incidence of seizures in those that received prophylactic AEDs compared to controls [3]. A recent Cochrane review of AED prophylaxis for postcraniotomy seizures failed to find consistent evidence that preventative AED therapy is effective in reducing postoperative seizures, although ultimately concluded that the current evidence base is

limited [4]. Even though it is conceivable that prophylactic AEDs might reduce the risk of immediate postoperative seizures in some patients, there is no evidence whatsoever that it reduces the chance of developing chronic epilepsy. Although most neurosurgeons administer prophylactic AEDs, more research is needed in this area [1, 3, 4].

PREVENTION IN PATIENTS WITH SUBSTANCE ABUSE

Patients with substance abuse, particularly alcohol, barbiturate, or benzodiazepine dependence, are at risk of withdrawal seizures in the perioperative period. Alcohol withdrawal seizures are typically generalized tonic–clonic convulsions and occur within 48 hours of patient's last drink. The timing of seizures from barbiturate or benzodiazepine withdrawal is more variable and dependent on the half-life of the abused substance. Prophylaxis is initiated if patients have a history of withdrawal seizures and have continued to abuse the same amount of the drug or have clinical evidence of a withdrawal syndrome. Benzodiazepines are utilized for both alcohol withdrawal seizure prophylaxis and treatment of the withdrawal syndrome. Benzodiazepines and barbiturates are used for prophylaxis and treatment of withdrawal seizures from those agents. There are no firm guidelines regarding when to initiate scheduled withdrawal prophylactic replacement therapy, and thus this decision relies on the clinical judgement of the medical consultant.

TREATMENT

If a patient without epilepsy develops a perioperative seizure, the most common cause is a metabolic disorder [1]. However, a broad differential diagnosis should be considered and the workup directed based on clinical suspicion. For instance, hyponatremia is more common following a transurethral procedure, hypocalcemia after thyroid/parathyroid surgery, and hypomagnesemia in transplant patients on calcineurin inhibitors [1]. Neurology consultation may be warranted if etiology is unclear. In addition to acutely treating the seizure with antiepileptic medication (benzodiazepine is the usual first line medication), workup as outlined below should be considered to identify the etiology.

- POCT glucose
- CMP, magnesium, and phosphorous
- CBC, Lactate, UA, CXR, and wound evaluation (to screen for sepsis)
- Toxicology screen; depending on the timing of the seizure, consider intoxication or withdrawal from alcohol or drugs (especially benzodiazepines or barbiturates)

- Consider CT head if there is concern for stroke
- Consider adverse effect from surgery if patient is post-craniotomy or cardiac surgery

In patients with epilepsy, especially relatively poorly controlled epilepsy, perioperative seizures are typically a consequence of their underlying seizure disorder, rather than a symptom of another abnormality. However, these patients should still be evaluated for a toxic-metabolic etiology, and for infection or stroke if consistent with the clinical scenario. Patient's AED dosing and schedule should be reviewed, and AED levels checked. Patients' other medications should also be reviewed for those, such as meperidine and carbapenem, which may lower the seizure threshold.

KEY CLINICAL PEARLS

- Perioperative seizures in patients without a preexisting seizure disorder are uncommon and are most often due to a metabolic etiology.
- Patient with epilepsy is at a much greater risk of perioperative complications including, but not limited to, seizures.
- The risk of perioperative seizures in patients with epilepsy is dependent on their baseline seizure control.
- Management of patient's AED medication therapy can be tricky perioperatively, especially when patients are unable to take enteral medications. Due to lack of equivalence among various AEDs, consultation with neurology and pharmacy may be needed to identify alternative therapy regimens.
- Benzodiazepines are a useful rescue intervention for prolonged or repetitive seizures, and for prophylaxis during periods when patients with epilepsy cannot receive their usual AEDs.

ACKNOWLEDGMENTS

John W. Miller, M.D., Ph.D., Professor, Departments of Neurology and Neurological Surgery, University of Washington.

REFERENCES

1. Dhallu MS, Baliomi A, Biyyam M, Chillmuri S. Perioperative management of neurological conditions. Health Serv Insights. 2017;10:1–8.
2. Chang CC, Hu CJ, Lam F et al. Postoperative adverse outcomes in surgical patients with epilepsy: a population-based study. Epilepsia. 2012;53(6):987–94.

3. Chandra V, Rock AK, Opalak C, Stary JM, Sima AP, Carr M, Vega RA, Braddus WC. A systematic review of perioperative seizure prophylaxis during brain tumor resection: the case for a multicenter randomized clinical trial. Neurosurg Focus. 2017;43(5):E18.
4. Weston J, Greenhalgh J, Marson AG. Antiepileptic drugs as prophylaxis for post-craniotomy seizures (Review). Cochrane Database Syst Rev. 2015;(3):CD007286. https://doi.org/10.1002/14651858.CD007286.pub3.
5. Takagi H, Ando T, Umemoto T. All-Literature Investigation of Cardiovascular Evidence (ALICE) group. Seizures associated with tranexamic acid for cardiac surgery: a meta-analysis or randomized and non-randomized studies. J Cardiovasc Surg. 2017;58(4):633–41.
6. Zhang L, Zou X. Tranexamic acid-associated seizures: a meta-analysis. Seizure. 2016;36:70–3.
7. Niesen AD, Jacob AK, Aho LE, et al. Perioperative seizures in patients with a history of a seizure disorder. Anesth Analg. 2010;111(3):729–35.
8. Benish SM, Cascino GD, Warner ME, et al. Effect of general anesthesia in patients with epilepsy: a population-based study. Epilepsy Behav. 2010;17:87–9.
9. Wichards WSW, Schobben AFAM, Leijten FSS. Perioperative substitution of anti-epileptic drugs. J Neurol. 2013;260:2865–75.

Chapter 30
Parkinson's Disease

Mehraneh Khalighi, Elizabeth Kaplan, and Hojoong Kim

BACKGROUND

Parkinson's disease (PD) is the second leading neurodegenerative disease affecting approximately one million people with 60,000 new cases diagnosed yearly in the United States of America (USA) [1]. It is estimated that about 16–45% of PD patients present to an emergency room once a year and 7–28% are hospitalized yearly [2]. According to the Centers for Disease control and Prevention (CDC), PD is the fourteenth leading cause of death in the USA [3]. Worldwide, it is estimated that 6.2 million people suffer from the condition with a projected increase to 12.9 million by 2040 [4]. Patients with PD are at increased risk for perioperative complications [5]. In a prospective study of perioperative complications, patients with PD were at significantly higher risk for all serious complications after correcting for other risk factors in a multivariate analysis (odds ratio 8.14, confidence interval (CI) 1.76–37.67) [6]. Patients are generally thought to be at increased risk because of difficulty with mobility, swallowing, and decreased pulmonary reserve made worse if they miss medication doses in the perioperative period. These patients are also at increased risk for gastric dysmotility, orthostatic hypotension, delirium, and falls. There is no broad consensus statement or treatment guidelines for the perioperative approach to this disease. However, many perioperative complications of PD can potentially be reduced by minimizing interruptions in PD medications [7].

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_30

PREOPERATIVE EVALUATION

PD HISTORY

The relevant PD history for perioperative care can be divided into three sections: Medication history, motor, and nonmotor symptoms of PD.

Medication History

Establishing the exact dosing and timing of the patient's PD medications is critical. This is especially important if they are on levodopa, since the half-life is only 90 minutes (immediate release) and the patient may require levodopa dosing every 2–3 hours to function. Additionally, levodopa should be administered 1 hour before or 1–2 hours after meals to optimize medication absorption. Patients may also have dyskinesias, hyperkinetic movements resembling chorea due to excessive dopamine activation. Severe dyskinesias can interfere with surgeries under local anesthesia. On–off fluctuations can occur in some patients, resulting in a transition from mobility to immobility over a short period [8].

Motor Symptoms

The four classic motor symptoms of PD can be remembered by the mnemonic "TRAP" which stands for tremor, rigidity, akinesia, and postural/gait instability. Manifestations of these motor symptoms can complicate the perioperative period. Dysphagia is a complication that can worsen if the PD medications are not given on time or are reduced. Bradykinesia may also interfere with transfers, participation with rehabilitation, and even communications in the form of hypophonia (soft voice) [9]. PD patients are at significantly higher risk of falling in the postoperative period when compared to non-PD patients (18% vs. 4%) [10].

Nonmotor Symptoms

In the acute setting, attention should be paid to the following nonmotor symptoms of PD [11]. Autonomic dysfunction, in particular orthostatic hypotension, can pose significant challenges in the perioperative period. Screening for cognitive impairment and risk of delirium and psychosis should be undertaken. Sleep disturbances are also common and can include restless legs and a unique parasomnia, rapid eye movement (REM) sleep behavior disorder.

PD-SPECIFIC RISK CONCERNS

Pulmonary Risk Assessment

Patients with PD are prone to several abnormalities of pulmonary function related to rigidity and bradykinesia of the respiratory and pharyngeal muscles, which increase the risk of perioperative hypoxia and development of pneumonia. Pulmonary function testing of PD patients shows a restrictive type picture related to the underlying respiratory muscle rigidity and weakness. While it is important to be aware that patients may be at increased risk for perioperative pulmonary complications, it is not necessary to routinely obtain pulmonary function tests (PFTs) before surgery. Aggressive pulmonary hygiene and treatment with levodopa improve respiratory function in many patients [12].

Parkinsonism Hyperpyrexia Syndrome

Parkinsonism hyperpyrexia syndrome (PHS) is a life-threatening complication due to abrupt cessation or decrease in dopaminergic agents especially levodopa. Similar to neuroleptic malignant syndrome, symptoms of PHS are fevers, altered mental status, autonomic dysfunction, rigidity, and tremors, which typically develop 18 hours to 7 days after abruptly stopping or reducing dopaminergic medications. Patients with advanced age, more severe disease, and on higher doses of medications are at highest risk for developing PHS. Most common complications of PHS are aspiration pneumonia or respiratory failure, venous thromboembolism, rhabdomyolysis with acute kidney injury, seizures, and disseminated intravascular coagulation. The overall incidence of PHS is rare (4%) but prognosis is poor with 4% mortality in treated and up to 20% mortality in untreated patients [13].

PREOPERATIVE MANAGEMENT

MEDICATION MANAGEMENT

Consultation with the patient's outpatient neurologist about perioperative medication management is recommended. Some general considerations include:

- Attempt to keep the timing of the patient's Parkinson's medication regimen the same as the outpatient regimen [7]. Patients may be very sensitive to the exact timing of their doses of some medications, especially carbidopa/levodopa.

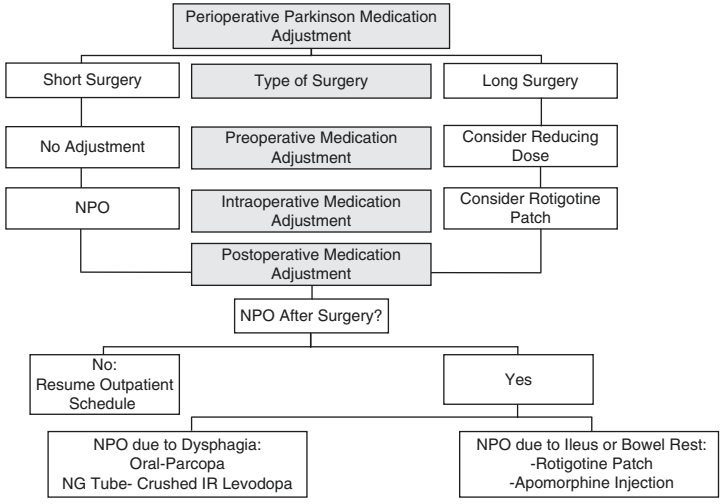

Fig. 30.1 Perioperative management of Parkinson medication

- For patients scheduled for long surgical procedures or procedures with anticipated prolonged postoperative nil per os (NPO) status, consult with patient's neurologist whether the daily dose should be titrated down prior to surgery to avoid PHS (see Fig. 30.1) [14].
- Be mindful of side effects and potential interactions of Parkinson's medications with typical perioperative medications (anesthetics, antiemetics, and pain medications) [15].
- It is also good practice to consult with a pharmacist about potential drug interactions of new medications with patient's Parkinson's medications.
- Table 30.1 summarizes the different PD medication classes and adverse effects important to consider in the perioperative period.

Dopamine Precursor: Carbidopa/Levodopa (Rytary ®, Sinemet®), Oral Disintegrating (Parcopa®)

- Carbidopa/Levodopa comes in many forms—immediate release (IR), controlled release (CR), oral disintegrating (Parcopa®), and capsules (Rytary®).
- IR can be crushed and administered in nasogastric (NG) or percutaneous endoscopic gastrostomy (PEG) tubes. CR should not be crushed.

TABLE 30.1 MEDICATIONS FOR PARKINSON'S DISEASE

Medication	Main side effects	Perioperative considerations
Dopamine precursors *carbidopa/ levodopa*	Nausea, vomiting, orthostatic hypotension, dyskinesia, hallucinations	Abrupt discontinuation of the immediate release (IR) formulation may precipitate PHS Dyskinesias can interfere with surgeries under local anesthesia
Dopamine agonists *Pramipexole* *Ropinirole* *Rotigotine* *Apomorphine*	Compulsive behaviors, hallucinations, sleepiness, lower extremity edema	Rotigotine patch and apomorphine injections are available for intraoperative use and NPO status Continue perioperatively if able
Anticholinergics *Benztropine* *Trihexyphenidyl*	Anticholinergic, postoperative delirium in the elderly	Hold on morning of surgery and restart postoperatively after recovery Associated with confusion, especially in the elderly
MAO-B inhibitors *Rasagiline* *Selegiline* *Safinamide*	Dizziness, insomnia	Long half-life and numerous drug interactions precipitating serotonin syndrome or labile blood pressures Prefer to discontinue 2–3 weeks before elective surgery but some providers continue without interruption. Consult local anesthesia team
COMT inhibitors *Entacapone* *Tolcapone*	Diarrhea, orange urine/sweat, hepatotoxicity for tolcapone	May increase the effect of epinephrine and norepinephrine Continue perioperatively if able

- When converting CR to IR, multiply dose by 0.7.
- Half-life of IR is only 90 minutes. Abrupt discontinuation for a prolonged period may rarely precipitate PHS.
- Surgical procedures should be scheduled early in the morning to avoid prolonged NPO status.

- Patients should be allowed to take scheduled medication doses while waiting for surgery to minimize medication interruptions and decrease risk of PD crisis.
- Common side effects are nausea/vomiting, hallucinations at higher doses, and dyskinesias.

Dopamine Agonists: Apomorphine (Apokyn®), Pramipexole (Mirapex®), Ropinirole (Requip®), and Rotigotine Patch (Neupro®)

- These drugs can be given perioperatively without interruption but use with caution in the elderly as they can cause confusion and hallucinations.
- Rotigotine patch and Apomorphine injections are options for intraoperative administration of PD medications and NPO status.

Anticholinergics: Benztropine (Cogentin®) and Trihexyphenidyl (Artane®)

- These agents are used less commonly in PD because of their limited efficacy and their anticholinergic side effects.
- They are usually held on the morning of surgery and restarted postoperatively after recover because of potential exacerbation of postoperative delirium especially in the elderly.

MAO B Inhibitors: Rasagiline (Azilect®), Safinamide (Xadago®), and Selegiline (Eldepryl®)

- Selective inhibitors of monoamine oxidase (MAO) type B
- There are numerous drug interactions (at any dose), especially with certain opioid narcotics such as meperidine and antidepressants like fluoxetine.
- At higher doses, interactions with sympathomimetic drugs and all narcotic analgesics are possible. Interactions can include labile blood pressures and serotonin syndrome [15].
- For elective procedures, recommendations for preoperative management of MAO B inhibitors vary among providers and institutions. While some providers discontinue these medications 2–3 weeks before the surgery to avoid potential dangerous drug–drug interactions, others continue MAO B inhibitors without interruption in the perioperative period.
- Discuss perioperative management of MAO B inhibitors with the local anesthesia team.
- Monitor for signs of dangerous interactions such as serotonin syndrome when MAO B inhibitors are continued perioperatively [7].

Catechol-O-Methyl Transferase (COMT) Inhibitors: Entacapone (Comtan®) and Tolcapone (Tasmar®)

- These agents may increase the effect of epinephrine and norepinephrine.
- Can be continued safely without interruption perioperatively.
- May precipitate dyskinesia, hallucinations, confusion, and orthostatic hypotension. Tolcapone is used infrequently due to rare but serious hepatotoxicity [15].

INTRAOPERATIVE MANAGEMENT

INTRAOPERATIVE MEDICATION MANAGEMENT

- For patients undergoing surgeries lasting greater >12 hours, consider starting a rotigotine transdermal patch to reduce chance of PHS (see Fig. 30.1) with the help of the patient's neurologist [16].
- Anesthetics: Propofol is the anesthesia of choice. Inhaled anesthetics such as halothane should be avoided in patients taking levodopa due to increased cardiac sensitivity to catecholamines [17].
- Anti-emetics: Avoid dopamine blocking agents such as metoclopramide and prochlorperazine as these can worsen PD symptoms.

DEEP BRAIN STIMULATOR (DBS)

Patients with DBS require special considerations that require coordination with other providers.

DBS and Cautery

The DBS generator may need to be turned off for the procedure based on the type of surgery. It is recommended to turn off the DBS and use bipolar cautery [18]. If bipolar cautery is not available, monopolar electrocautery can be used if the DBS is turned off and the grounding pads are placed away from the DBS battery.

DBS and MRI (Magnetic Resonance Imaging)

The manufacturer and model of DBS generator will determine the MRI compatibility for the patient [19]. Some are only MRI head compatible where others are full body. In most cases, the DBS will need to be turned off before the MRI is performed.

Miscellaneous Considerations

Patients with DBS should not have any type of diathermy treatments (e.g., ultrasound) anywhere on body as this can cause irreversible tissue damage [19]. In patients requiring emergent cardioversion, it is recommended to place the electrodes at least 1 inch (2.5 cm) away from the generator (located in the left or right upper chest). While repeated shocks have not been shown to cause injury, the DBS may need to be reprogrammed [20].

POSTOPERATIVE MONITORING AND PREVENTION OF COMPLICATIONS

POSTOPERATIVE PD MEDICATION MANAGEMENT

Resumption of PD medications postoperatively is dependent on patient's NPO status and the type of surgical procedure performed.

- For patients who have no swallow restrictions and do not have any gastrointestinal contraindications, resume their outpatient medication regimen without interruption as soon as possible.
- Aggressive bowel care and early mobilization can prevent postoperative ileus and constipation and allow for reliable gastrointestinal absorption of medications.

PD patients after surgery may remain NPO for different reasons that will determine the medication regimen postoperatively (Fig. 30.1).

- For patients who are NPO due to dysphagia and do not have any gastrointestinal contraindications such as ileus or bowel rest, crushed carbidopa/levodopa IR can be administered through an NG tube. Carbidopa/levodopa CR should not be crushed.
- When administering through an NG tube, patient's diet order may need to be changed from continuous feeds to bolus or night-time feeds to avoid food interaction with the levodopa—the best time to administer levodopa is 1 hour before or after meals to avoid any reduction in levodopa absorption.
- An alternative to feeding tube route would be Parcopa®, an oral disintegrating formulation of levodopa. Discuss with patient's neurologist if this is a consideration.
- For patients who are NPO due to gastrointestinal contraindications such as ileus or bowel rest, then parenteral routes must be given.

- Rotigotine patch is an option for patients not requiring high doses of PD medications. The maximum Food and Drug Administration (FDA)-approved dose is 8 mg/24 hours. Consult with neurology about converting levodopa equivalent dose to rotigotine.
- Apomorphine injection is another option for those requiring higher doses of PD medications. Premedication with the antinausea medication, trimethobenzamide (Tigan®) is recommended.

DELIRIUM PREVENTION

Postoperative delirium, confusion, and hallucinations are more common in PD patients especially with underlying infection or metabolic derangement. Medication interaction is another major etiology of postoperative psychiatric problems.

- Avoid typical and most atypical antipsychotic medications such as haloperidol, risperidone, olanzapine, aripiprazole, and ziprasidone that are dopamine antagonists and can worsen parkinsonism symptoms.
- Preferred antipsychotic agents are clozapine and quetiapine. Pimavanserin (Nuplazid®) is an FDA-approved medication for PD psychosis that does not block dopamine receptors or worsen motor symptoms.
- PD patients seem to be more sensitive to benzodiazepines and can develop confusion, sedation, and paradoxical agitation. Use these agents with caution and at low doses if necessary [21].
- If above work up is negative or psychosis persists despite adequate treatment of underlying etiologies, consider reducing PD medications. In some cases, stopping certain classes of PD medications may improve delirium.
- Medication classes that are most prone to cause confusion and hallucinations are anticholinergics, dopamine agonists, and amantadine [15].
- See Chap. 53 for other general measures designed to minimize the risk of delirium.

POSTOPERATIVE PAIN MANAGEMENT

Pain in the postoperative period needs to be carefully assessed to specifically distinguish between pain from rigidity of PD and surgical site pain, which are managed differently.

- PD pain related to rigidity should be treated with appropriate adjustment to dopaminergic treatment.
- Reserve low-dose opioid narcotics for surgical site pain management.

- Opioids with Selective Serotonin Reuptake Inhibitor (SSRI) activity such as meperidine, methadone, tramadol, propoxyphene, dextromethorphan, and fentanyl should be avoided especially in those patients taking MAO-B inhibitors because of increased risk for agitation, rigidity, diaphoresis, hyperpyrexia, and serotonin syndrome [6].
- MAO-B inhibitors slow down hepatic metabolism of opioid narcotics and increase the risk of narcotic overdose.
- Opioids without SSRI activity such as oxycodone, hydromorphone, hydrocodone, and morphine can be used safely at low doses when needed.
- Low-dose morphine can reduce dyskinesia but at higher doses can worsen akinesia in PD patients.
- When appropriate, use regional analgesia techniques or nonnarcotic pain medications to minimize opioid use.

POSTOPERATIVE NAUSEA MANAGEMENT

- Avoid dopamine D2 antagonist antiemetics such as metoclopramide, prochlorperazine, and promethazine, which increase the risk of extrapyramidal side effects in PD patients [6, 21].
- Ondansetron, a serotonin 5-HT_3 receptor antagonist, or trimethobenzamide (Tigan®) is preferably used in PD patients but can lower blood pressures and exacerbate autonomic dysregulation.

FALL PREVENTION

PD patients are at significantly increased risk for postoperative falls. In addition to gait abnormalities, PD patients are at risk for developing orthostatic hypotension as part of their disease process and as a side effect of medications.

- It is important to maintain adequate hydration in the perioperative period to avoid orthostatic hypotension and decrease the risk of falls.
- Early and continued involvement of physical and occupational therapy during hospitalization has shown to improve mobility and help with recovery [21].
- Order fall precautions.

POSTOPERATIVE PULMONARY MANAGEMENT

Postoperative aspiration or pneumonia related to pharyngeal muscle weakness or altered mental status is a common complication in PD patients.

- Early and continued inpatient involvement of speech therapy can identify swallowing dysfunction and modify diet consistency as appropriate.

- Restarting PD medications as soon as possible after surgery can help with reducing risk of aspiration.
- Encourage general measures to improve pulmonary hygiene: Incentive spirometry, elevating the head of the bed, and early mobilization.
- Aspiration precautions.

KEY CLINICAL PEARLS

- PD is a complex neurodegenerative disorder associated with increased perioperative complications.
- PHS is a rare but potentially life-threatening complication due to abrupt cessation or decrease in dopaminergic agents especially Levodopa. Recognize fevers, altered mental status, autonomic dysfunction, rigidity, and tremors after discontinuation of PD medications as signs of PHS.
- Adhere to patient's routine outpatient PD medication schedule and minimize interruptions as much as possible. Consulting with neurology can assist with more complex medication management.
- If patient is unable to take medications by mouth due to dysphagia, consider NG tube administration of crushed IR levodopa or oral disintegrating formulation of levodopa. For patients requiring parenteral routes, rotigotine patch and apomorphine injections are options.
- When prescribing new medications, especially opioid pain medications, antiemetics and antipsychotic medications, ensure there are no serious interactions with patient's PD medication regimen.

REFERENCES

1. parkinson.org, Parkinson's foundation understanding parkinson's causes and statistics. 2018. http://www.parkinson.org/Understanding-Parkinsons/Causes-and-Statistics/Statistics. Accessed June 16.
2. Gerlach OH, Winogrodzka A, Weber WE. Clinical problems in the hospitalized Parkinson's disease patient: systematic review. Mov Disord. 2011;26:197–208.
3. Hoyert DL, Xu J. Deaths: preliminary data for 2011. Natl Vital Stat Rep. 2012;61:1–51.
4. Dorsey ER, Bloem BR. The Parkinson pandemic-a call to action. JAMA Neurol. 2018;75:9–10.
5. Brennan KA, Genever RW. Managing Parkinson's disease during surgery. BMJ. 2010;341:c5718.
6. Reilly DF, McNeely MJ, Doerner D, Greenberg DL, Staiger TO, Geist MJ, Vedovatti PA, Coffey JE, Mora MW, Johnson TR, Guray ED, Van Norman GA, Fihn SD. Self-reported exercise tolerance and the risk of serious perioperative complications. Arch Intern Med. 1999;159:2185–92.
7. Fox A, Aseeri M, Delayed administration and contraindicated drugs place hospitalized Parkinson's disease patients at risk, Institute for Safe Medication Practices. https://www.ismp.org/resources/delayed-administration-and-contraindicated-drugs-place-hospitalized-parkinsons-disease. Accessed 16 June 2018.

8. Mariscal A, Hernández Medrano I, Alonso Canovas A, Lobo E, Loinaz C, Vela L, Garcia-Ruiz Espiga P, Martinez Castrillo JC. Perioperative management of Parkinson's disease. Neurologia. 2012;27:46–50.
9. Lees AJ, Hardy J, Revesz T. Parkinson's disease. Lancet. 2009;373:2055–66.
10. Quinn R, How should Parkinson's disease be managed perioperatively?, The Hospitalist. https://www.the-hospitalist.org/hospitalist/article/124294/how-should-parkinsons-disease-be-managed-perioperatively. Accessed 1 Dec 2011.
11. Mueller MC, Juptner U, Wuellner U, Wirz S, Turler A, Hirner A, Standop J. Parkinson's disease influences the perioperative risk profile in surgery. Langenbecks Arch Surg. 2009;394:511–5.
12. Zesiewicz TA, Sullivan KL, Arnulf I, Chaudhuri KR, Morgan JC, Gronseth GS, Miyasaki J, Iverson DJ, Weiner WJ, Quality Standards Subcommittee of the American Academy of Neurology. Practice parameter: treatment of nonmotor symptoms of Parkinson disease: report of the Quality Standards Subcommittee of the American Academy of Neurology. Neurology. 2010;74:924–31.
13. Newman EJ, Grosset DG, Kennedy PG. The parkinsonism-hyperpyrexia syndrome. Neurocrit Care. 2009;10:136–40.
14. Fujii T, Nakabayashi T, Hashimoto S, Kuwano H. Successful perioperative management of patients with Parkinson's disease following gastrointestinal surgery: report of three cases. Surg Today. 2009;39:807–10.
15. Julius A, Longfellow K. Movement disorders: a brief guide in medication management. Med Clin North Am. 2016;100:733–61.
16. Wullner U, Kassubek J, Odin P, Schwarz M, Naumann M, Hack HJ, Boroojerdi B, Reichmann H, Group NS. Transdermal rotigotine for the perioperative management of Parkinson's disease. J Neural Transm (Vienna). 2010;117:855–9.
17. Burton DA, Nicholson G, Hall GM. Anaesthesia in elderly patients with neurodegenerative disorders: special considerations. Drugs Aging. 2004;21:229–42.
18. Meyring K, Zehnder A, Schmid RA, Kocher GJ. Thoracic surgery in patients with an implanted neurostimulator device. Interact Cardiovasc Thorac Surg. 2017;25:667–8.
19. Medtronic.com, Medtronic® DBS™ Therapy implanted neurostimulators - information for prescribers. http://manuals.medtronic.com/manuals/main/en_US/manual/therapy?therapy=DBS+for+Parkinsons. Accessed 17 June 2018.
20. Tavernier R, Fonteyne W, Vandewalle V, de Sutter J, Gevaert S. Use of an implantable cardioverter defibrillator in a patient with two implanted neurostimulators for severe Parkinson's disease. Pacing Clin Electrophysiol. 2000;23:1057–9.
21. Katus L, Shtilbans A. Perioperative management of patients with Parkinson's disease. Am J Med. 2014;127:275–80.

Chapter 31
Spinal Cord Injury

Pallavi Arora

BACKGROUND

Spinal cord injury (SCI) includes traumatic and nontraumatic injuries. Studies have shown that the incidence and prevalence of traumatic SCI in the USA is higher than that in the rest of the world. In 2012, the estimated incidence was 54 cases per million [1]. Trend analyses suggest that average age at the time of injury is increasing, as is the proportion of cervical injuries and injuries due to falls [2]. Incidence and prevalence of nontraumatic spinal cord injury is unknown, but it is estimated to be three to four times that of traumatic SCI [3]. SCI causes changes in systemic physiology that can predispose to complications during the perioperative period. Moreover, chronic complications of SCI and dysfunction often result in need for urologic, orthopedic, and plastic surgical intervention. Additionally, atypical presentations of acute conditions below the level of SCI lesion may lead to need for emergency surgery requiring perioperative management [4]. The increasing percentage of SCI in the elderly (age over 60) has resulted in a population of SCI patients with several preexisting comorbid major medical conditions that require management in the perioperative period.

For the purposes of this chapter, spinal cord injury will refer to chronic traumatic spinal cord injury that is several weeks after injury.

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_31

PREOPERATIVE EVALUATION

Perform a thorough medical history and physical exam with special consideration to a variety of systems.

RISK OF CARDIOVASCULAR MORTALITY AND MORBIDITY

SCI patients have a greater prevalence of coronary artery disease (CAD) risk factors such as obesity, metabolic syndrome, and diabetes than the general population. This is primarily due to lower daily energy expenditure from lack of motor function. As a result, these patients have higher morbidity and mortality from CAD and this morbidity tends to occur at a younger age than in the general population [5]. In addition, diagnosis of CAD in patients with SCI is often complicated by absence of anginal symptoms due to lack of physical exertion, as well as atypical symptoms due to alteration in pain perception. Thus, these patients frequently have missed (silent CAD) or delayed diagnoses [6].

- Careful review of cardiovascular disease risk factors and adequacy of their control should be done during preoperative evaluation of all SCI patients.
- Pharmacologic stress testing can be considered for further risk stratification of high risk patients given poor functional baseline and higher prevalence of silent CAD.

Arterial blood pressure tends to be lower in patients with SCI because of decreased sympathetic nervous system activity below the level of lesion and loss of normal vascular tone.

- It is important to make note of the baseline blood pressure and heart rate of a SCI patient.

History of autonomic dysreflexia (AD) is another important consideration in cardiovascular morbidity of SCI patients. AD is a result of loss of coordination of autonomic response above and below the level of SCI. An uninhibited sympathetic response to noxious stimuli below the level of SCI leads to diffuse vasoconstriction and hypertension. Compensatory parasympathetic responses are activated above the level of the lesion producing bradycardia and vasodilation [7]. This is seen in 50–70% of chronic SCI patients having higher lesions (usually above the level of T6). AD can trigger cardiovascular reactions such as severe bradycardia or tachycardia, hypertensive emergency, left ventricular failure, myocardial ischemia, or arrhythmias intra or postoperatively [8].

- Make note of the history of AD and its common triggers when evaluating a patient preoperatively.

RISK OF PULMONARY MORBIDITY

Respiratory mechanics can be affected in patients with SCI through multiple mechanisms [4]. Alteration in lung volumes from paralysis of diaphragmatic and accessory muscles as well as spasticity/decreased compliance of intercostal muscles results in restrictive ventilatory defects (decreased forced expiratory volume at 1 second, usually 55% of predicted, and decreased forced vital capacity).

- Note the level and completeness of the spinal cord injury to get a sense of extent of involvement of respiratory muscles.
- Remember that standardized pulmonary function testing is often not possible in patients with SCI.

Ineffective cough is associated with risk of atelectasis, poor mobilization of secretions, and aspiration pneumonia. Increased bronchial hyperreactivity is seen in some patients with SCI due to unopposed parasympathetic impulses to the lungs and airways [9]. Increased incidence and prevalence of obstructive sleep apnea (OSA) is seen in SCI patients.

- Gather information about the past history of respiratory compromise, pneumonia, aspiration, sleep apnea, etc., in the perioperative period.
- Consider checking a baseline arterial blood gas (ABG) if concerned about chronic CO_2 retention/hypoventilation.
- Screen for obstructive and central sleep apnea.

HISTORY OF PRESSURE ULCERS

SCI patients are prone to pressure ulcers from immobility and unrelieved pressure, poor nutritional status, and neurogenic skin with altered blood flow [4].

- Perform a thorough skin evaluation, and assess and optimize nutritional status preoperatively.

SPASTICITY AND CHRONIC PAIN SYNDROMES

Spasticity and chronic pain syndromes are common in SCI patients. Frequently they have both neurogenic and nociceptive components from the primary injury and the ensuing disability [10]. These patients are frequently on complex medication regimens for pain.

- Make note of the preoperative pain regimen and touch base with a pain specialist as indicated for recommendations regarding postoperative pain management.
- Be vigilant about the regimen of anti-spasticity medications as stopping suddenly in the perioperative period may precipitate withdrawal or seizures.
- Patients with baclofen pumps may require consultation with rehabilitation medicine colleagues for assistance with management perioperatively.

PERIOPERATIVE MANAGEMENT

Perioperative management needs to pay particular attention to the monitoring and prevention of complications.

ORTHOSTATIC HYPOTENSION

Baseline blood pressure is lower in patients with SCI (especially cervical SCI) due to decreased vascular tone. It is important to maintain adequate hydration and replenish perioperative blood loss as these patients lack compensatory mechanisms to deal with volume depletion.

- Encourage gradual position changes and use of compression stockings in the postoperative period.

AUTONOMIC DYSREFLEXIA

Autonomic dysreflexia (AD) can be a medical emergency. Common symptoms are headache, severe hypertension that may be asymptomatic or malignant with intracranial hemorrhage, seizures, and myocardial infarction. Bradycardia can also occur and may progress to cardiac arrest [8]. There should be careful monitoring and avoidance of triggers common in the perioperative period (urinary retention, bladder irritation, constipation, and infection) to prevent occurrence of AD.

Management of AD in the postoperative period might include the following actions while also communicating closely with the surgical team about risks and benefits in relation to the surgery [8]:

- Sit the patient up to lower blood pressure by increasing venous pooling in lower extremities
- Remove tight-fitting garments
- Search for and relief of potential triggers of AD (bladder obstruction, fecal impaction, etc.)
- Use of short acting medications like Nitropaste or IV Hydralazine for blood pressure control if above measures do not work
- ICU monitoring for severe persistent hypertension, hypertensive emergency, and severe bradycardia

RESPIRATORY COMPLICATIONS IN SCI

Studies specifically addressing effective interventions to decrease postoperative pulmonary morbidity in patients with SCI are lacking; thus, it is necessary to extrapolate perioperative management from what is known about the management of respiratory complications

in chronic SCI patients. SCI patients are predisposed to atelectasis, poor secretion management, pneumonia, hypoxic and hypercarbic failure from hypoventilation, and sleep disordered breathing. These issues are exacerbated in the perioperative period due to medications used during anesthesia and postoperatively for pain control.

Management of respiratory complications is often based on the level of spinal injury [4, 11].

- Patients with lesions above C3 are ventilator dependent and are managed postoperatively in ICU or high dependency units.
- Lesions between C3 and C5 result in a variable degree of paralysis of diaphragmatic and accessory muscles. These patients will likely need close monitoring of airway and respiratory status in a high dependency setting in the immediate postoperative period.
- Patients with lesions between C6 and C8 will likely have adequate inspiratory function and may only require intermittent noninvasive ventilatory support in the postoperative period with close monitoring of respiratory status. They are more likely to have a weak cough and trouble with secretions. Consider aggressive postoperative chest physiotherapy, cough assistance with abdominal compressions (quad cough), and bronchial hygiene protocols with frequent suctioning.
- While patients with lesions at or below T1 have little ventilatory compromise, they are still prone to complications from a weak cough and poor secretion management due to paralysis of abdominal wall muscles requiring monitoring and supportive management of their respiratory status.
- Be vigilant for desaturations and hypercarbic failure from sleep disordered breathing and provide continuous postiive airway pressure (CPAP) support as indicated.

GASTROINTESTINAL COMPLICATIONS

Gastric emptying and bowel motility may be delayed in patients with SCI predisposing them to bowel distension, constipation, and fecal impaction. This can be exacerbated by analgesics and anesthetic medications used perioperatively. Gastrointestinal complications may also precipitate autonomic dysreflexia.

- Closely monitor bowel function postoperatively and continue preoperative bowel regimen (such as bulking agents and digital rectal stimulation) with additional use of stimulant laxatives/suppositories and enemas as needed to keep bowel function regular perioperatively [12].

NEUROGENIC BLADDER

Most patients with SCI require pharmacologic and nonpharmacologic (indwelling catheters, intermittent self-catheterization) assistance for bladder evacuation [4].

These interventions should be continued perioperatively without intervention. Be vigilant for urinary retention, UTIs, and renal insufficiency in postoperative period.

PRESSURE ULCER PREVENTION

Pressure ulcer prevention should be carried out postoperatively with use of specialty mattresses, nursing care, and optimizing nutritional intake as these can be a source of infection and autonomic dysreflexia postoperatively.

PAIN MANAGEMENT IN SCI PATIENTS

Pain management in SCI patients can be challenging. These patients may be tolerant or have a higher threshold for various pain medications and may benefit from consultation with an acute pain specialist. Providers should also be vigilant for atypical presentations of uncontrolled pain as well as atypical withdrawal symptoms. Additionally, uncontrolled pain may precipitate AD.

- Continue preoperative pain medications without interruption in perioperative period.
- Consider consultation with a pain management specialist for pain control in postoperative period.

KEY CLINICAL PEARLS

- SCI patients have a greater prevalence of CAD risk factors and CAD that may be asymptomatic.
- Autonomic dysreflexia is devastating intraoperative/postoperative complication. Providers should prevent triggers of AD and manage AD aggressively of it occurs.
- Respiratory mechanics can be affected in patients with SCI through multiple mechanisms predisposing to hypoventilation, OSA, impaired secretion clearance, atelectasis, and pneumonia.
- Pressure ulcer prevention and management of neurogenic bowel and bladder are important aspects of perioperative care of SCI patients.
- Pain management remains challenging in postoperative period requiring assistance from pain specialists.

ACKNOWLEDGMENTS

Margaret Jones MD MPH, Acting Assistant Professor, Rehabilitation Medicine, Harborview Medical Center, University of Washington.

REFERENCES

1. Jain NB, et al. Traumatic spinal cord injury in the United States, 1993–2012. JAMA. 2015;313:2236.
2. Devivo M. Epidemiology of traumatic spinal cord injury: trends and future implications. Spinal Cord. 2012;50:365.
3. McDonald JW. Spinal cord injury, seminar. Lancet. 2002;359(9304):417–25.
4. Petsas A, et al. Perioperative management of patients with a chronic spinal cord injury. BJA Education. 2015;15(3):123–30.
5. Myers J, et al. Cardiovascular disease in spinal cord injury: an overview of prevalence, risk, evaluation, and management. Am J Phys Med Rehabil. 2007;86:142.
6. Bauman WA, et al. Cardiac stress testing with thallium-201 imaging reveals silent ischemia in individuals with paraplegia. Arch Phys Med Rehabil. 1994;75:946–50.
7. Karlsson AK. Autonomic dysreflexia. Spinal Cord. 1999;37:383.
8. Bycroft J, et al. Autonomic dysreflexia: a medical emergency. Postgrad Med J. 2005;81:232.
9. Schilero GJ, et al. Assessment of airway caliber and bronchodilator responsiveness in subjects with spinal cord injury. Chest. 2005;127:149.
10. Hadjipavlou G, et al. Spinal cord injury and pain. BJA Education. 2016;16:264–8.
11. Brown R, et al. Respiratory dysfunction and management in spinal cord injury. Respir Care. 2006;51:853–68.
12. Krassioukov A, et al. Neurogenic bowel management after spinal cord injury: a systematic review of the evidence. Spinal Cord. 2010;48:718.

Chapter 32
Pulmonary Risk Assessment and Management

Tyler J. Albert and Paul B. Cornia

BACKGROUND

Postoperative pulmonary complications (PPCs) include atelectasis, bronchospasm, tracheobronchitis, pneumonia, pulmonary embolus, exacerbation of underlying lung disease, acute respiratory distress syndrome (ARDS), and respiratory failure. The reported incidence of PPCs is estimated to be 3–6% of patients undergoing general anesthesia [1, 2]. Preoperative cardiovascular risk stratification typically receives greater attention, but PPCs are more common and costly than cardiovascular complications and are associated with substantial perioperative morbidity and mortality [3, 4]. Thus, physicians must be vigilant for PPC risk factors, as well as opportunities to modify them. Both patient-related and procedure-related factors contribute to PPCs [1].

Asthma, chronic obstructive pulmonary disease (COPD), obstructive sleep apnea (OSA), obesity hypoventilation syndrome (OHS), and pulmonary hypertension are discussed separately (see Chaps. 33, 34, and 35).

PREOPERATIVE EVALUATION

PREOPERATIVE RISK FACTOR ASSESSMENT

The preoperative evaluation of all patients undergoing major surgery should include an assessment of risk factors for pulmonary complications (see Table 32.1).

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_32

TABLE 32.1 RISK FACTORS FOR PULMONARY COMPLICATIONS [2]

Patient-related factors	*Procedure-related factors*
COPD	Duration of surgery (>3 hours)
Age > 60	Surgery type: aortic aneurysm repair, abdominal (particularly upper), thoracic, neuro, head and neck, vascular
ASA class ≥II	
Functional dependence	
CHF	Emergent surgery
Weight loss	General anesthesia
Delirium	Perioperative transfusion
Alcohol use	*Laboratory tests*
Cigarette use	Albumin < 3.5 g/dL
Abnormal findings on lung exam	BUN level > 21 mg/dL
	Abnormal findings on chest radiography

COPD chronic obstructive pulmonary disease, *ASA* American Society of Anesthesiologists, *CHF* congestive heart failure, *BUN* blood urea nitrogen

- The American Society of Anesthesiologists' (ASA) physical status classification defines the overall health of a patient. ASA class ≥II (mild systemic disease) has consistently been shown to be a strong predictor of PPCs [1, 2].
- Other important patient-related risk factors for PPCs include age (>60 years), functional dependence, COPD, heart failure, and tobacco use [1, 2].
- Surgical site is the most important risk factor for PPC; the closer the incision is to the diaphragm, the higher the risk for PPC, with aortic, thoracic, and upper abdominal surgeries conferring the highest risk. Postoperative diaphragmatic dysfunction is thought to play a key role. Prolonged duration of surgery also increases the risk for PPC.
- Hypoalbuminemia is a strong predictor of PPCs. Whether or not perioperative nutritional supplementation to correct hypoalbuminemia improves outcomes is uncertain [1, 2, 5, 6].
- While severe or uncontrolled asthma is a risk factor for PPCs, well-controlled asthma is not [1, 2, 7–9].

PREOPERATIVE PULMONARY TESTING

We do not routinely order a preoperative chest X-ray or pulmonary function tests; rather, we reserve these tests for clinical indications such as uninvestigated pulmonary symptoms or abnormal physical exam findings (see Table 32.2).

- Consider echocardiography in patients with suspected heart failure as a cause of dyspnea.

TABLE 32.2 PREOPERATIVE PULMONARY DIAGNOSTIC TESTS

Chest X-ray	Routine pre-op chest X-ray is *not* recommended May consider for patients with known cardiopulmonary disease and patients >50 years of age who are undergoing upper abdominal, thoracic, and abdominal aortic aneurysm surgery [5]
Pulmonary function tests (PFTs; spirometry)	Routine PFTs *not* recommended (may be indicated for specific surgeries, such as lung resection, but we typically defer to the surgeon) Consider for patients with clinically suspected but undiagnosed obstructive or restrictive lung disease Assess COPD by symptoms and exam

RISK PREDICTION TOOLS

Several risk prediction tools are available [6, 10, 11], although none is uniformly recommended for preoperative risk assessment. We prefer the ARISCAT (Canet) Risk index because it is user-friendly and stratifies patients as low, intermediate, or high risk for any PPC. Importantly, the definition of PPC includes both major (respiratory failure, pneumonia) and minor (atelectasis, bronchospasm) types [10].

PERIOPERATIVE MANAGEMENT

PREOPERATIVE RECOMMENDATIONS

Generally, outpatient pulmonary medications are continued perioperatively, including both oral (such as leukotriene inhibitors and corticosteroids) and inhaled (such as inhaled beta-agonists, anticholinergics, and steroids) medications. Although evidence is lacking, we typically hold theophylline beginning the day prior to surgery given the narrow therapeutic window and risk for cardiac arrhythmias.

- Patients on long-term oral steroids may require perioperative supplemental "stress" dose steroids (see Chap. 14).
- Advise smoking cessation. A meta-analysis concluded that the existing evidence does not support an increased risk of complications due to stopping smoking prior to surgery; the benefits of stopping smoking were greater the longer the duration of smoking cessation prior to surgery [12].
- For patients who are at high risk for PPCs, we emphasize the importance and technique for deep breathing exercises and incentive spirometry at preoperative visits [13].

POSTOPERATIVE PULMONARY CARE

To prevent atelectasis and thus prevent PPCs, a variety of lung expansion maneuvers are available (e.g., incentive spirometry, deep breathing exercises, continuous or intermittent positive airway pressure). The American College of Physicians recommends some type of lung expansion manuever for patients undergoing major abdominal surgery [5], although the data is inconclusive [13, 14]. Because it is simple, inexpensive, and not labor intensive, we recommend deep breathing exercises and incentive spirometry to patients who are able to comply.

- Nasogastric tubes to decrease aspiration risk should not be routinely used and are generally deferred to the surgical team [5, 8].
- Consider nocturnal oximetry in patients at high risk for hypoxemia (e.g., OSA, OHS).

KEY CLINICAL PEARLS

- Advanced age, ASA class, functional dependence, COPD, and CHF are the strongest patient-related risk factors for PPCs.
- Surgical site and duration of surgery are key procedure-related risk factors for PPC, with aortic, thoracic, and upper abdominal surgeries conferring the highest risk.
- Routine spirometry and chest imaging are not recommended.

REFERENCES

1. Yang CK, Teng A, Lee DY, Rose K. Pulmonary complications after major abdominal surgery: National Surgical Quality Improvement Program Analysis. J Surg Res. 2015;198(2):441–9.
2. Smetana GW, Lawrence VA, Cornell JE. American College of Physicians. Preoperative pulmonary risk stratification for noncardiothoracic surgery: systematic review for the American College of Physicians. Ann Intern Med. 2006;144(8):581.
3. Dimick JB, Chen SL, Taheri PA, et al. Hospital costs associated with surgical complications: a report from the private-sector National Surgical Quality Improvement Program. J Am Coll Surg. 2014;199(4):531.
4. Shander A, Fleisher LA, Barie PS, et al. Clinical and economic burden of postoperative pulmonary complications: patient safety summit on definition, risk reducing interventions, and preventive strategies. Crit Care Med. 2011;39(9):2163–72.
5. Qaseem A, Snow V, Fitterman N, et al. Risk assessment for and strategies to reduce perioperative pulmonary complications for patients undergoing noncardiothoracic surgery: a guideline from the American College of Physicians. Ann Intern Med. 2006;144:575–80.
6. Arozullah AM, Daley J, Henderson WG, et al. Multifactorial risk index for predicting postoperative respiratory failure in men after major noncardiac surgery. Ann Surg. 2000;232(2):242–53.
7. Hong CM, Galvagno SM. Patients with chronic pulmonary disease. Med Clin N Am. 2013;97:1095–107.

8. Bapoje SR, Whitaker JF, Schulz T, et al. Preoperative evaluation of the patient with pulmonary disease. Chest. 2007;132:1637–45.
9. Numata T, Nakayama K, Fugii S, et al. Risk factors of postoperative pulmonary complications in patients with asthma and COPD. BMC Pulm Med. 2018;18:4.
10. Canet J, Gallart L, Gomar C, et al. Prediction of postoperative pulmonary complications in a population-based surgical cohort. Anesthesiology. 2010;133:1338–50.
11. Gupta H, Gupta P, Fang X, et al. Development and validation of a risk calculator predicting postoperative respiratory failure. Chest. 2011;140(5):1207–2015.
12. Mills E, Eyawo O, Lockhart I, et al. Smoking cessation reduces postoperative complications: a systematic review and meta-analysis. Am J Med. 2011;124:144–54.
13. Boden I, Skinner EH, Browning L, et al. Preoperative physiotherapy for the prevention of respiratory complications after upper abdominal surgery: pragmatic, double blinded, multicenter randomized controlled trial. BMJ. 2018;360:j5916.
14. Tyson AF, Kendig CE, Mabedi C, et al. The effect of incentive spirometry on postoperative pulmonary function following laparotomy. JAMA Surg. 2015;150(3):229–36.

Chapter 33
Asthma/COPD

Eric Mar

BACKGROUND

Patients with chronic obstructive pulmonary disease (COPD) and asthma deserve special attention given the impact of postoperative pulmonary complications (PPCs) in this population. From the National Surgical Quality Improvement Program database, COPD (present in 4.82% of the population) was associated with significant increases in risks of postoperative pneumonia, respiratory failure, prolonged hospitalization, and myocardial infarction [1]. For well-controlled asthma, the risk of PPCs is quite low [2], although still important clinically given small risks of perioperative bronchospasm related to anesthesia [3]. In general, a detailed history and examination is enough for perioperative evaluation of most patients with stable COPD or asthma. Additional testing should be reserved for special situations, including suspected undiagnosed disease and acute exacerbations.

PREOPERATIVE EVALUATION

A careful respiratory history and exam determines the need for additional preoperative evaluation. Attention should be given to baseline exercise tolerance, recent declines in exertional capacity, triggers for COPD/asthma exacerbations, symptoms/signs of acute exacerbations, and any history of oral steroid requirement. See Fig. 33.1 for a preoperative evaluation algorithm in COPD/asthma. The exam should include a baseline pulse oximetry. There is no absolute prohibitive pulmonary function that precludes surgery [4], but there is a

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_33

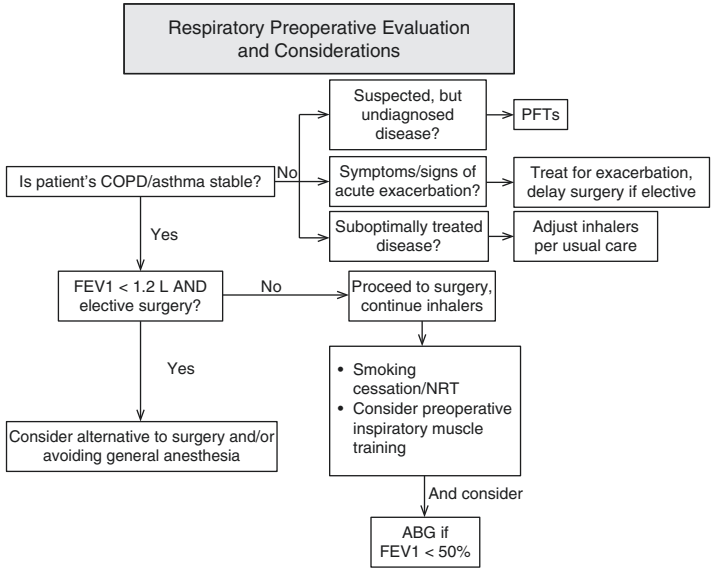

Fig. 33.1 Respiratory preoperative evaluation and considerations

correlation between worsening FEV1 function and increasing risk of PPCs [5]. Many of these risks appear to be consequences of the surgery and anesthesia itself. As such, it is prudent to be cautious with purely elective surgeries in patients with FEV1 <1.2 L, especially if the surgery entails prolonged anesthesia (>3 hours).

A patient with well-controlled disease rarely requires additional workup. However, for the following specific situations, consider the following:

- Pulmonary function testing in patients suspected of having COPD or asthma but without prior diagnosis [6].
- Arterial blood gas in patients with FEV1 <50% of predicted value and concerns for hypercarbia, especially if surgery is anticipated to be >3 hours [7].
- Routine chest imaging is not advised in stable COPD/asthma disease [8]. Do consider if there are concerns for an exacerbation or concomitant infection.
- For patients on oral corticosteroids, consider checking baseline fasting glucose if no recent readings.

PREOPERATIVE MANAGEMENT

Preoperative management consists of addressing poorly controlled disease, confirming the patient is not in an acute exacerbation, and encouraging smoking cessation.

- For stable disease, continue patient's home regimen perioperatively, with an exception to theophylline. While rarely used, theophylline has a narrow therapeutic window and a potential for arrhythmias; recommend discussion with a pulmonologist.
- For patients with poorly controlled COPD, consider intensification of inhaler regimen as per usual care.
- If an acute exacerbation is suspected, consider delaying elective surgeries until recovered.
- For patients with oral steroid dependence, consider perioperative stress dose steroids (see Chap. 14).
- No special modifications are required for patients taking an oral beta blocker.
- Encourage smoking cessation as this can improve the postoperative course for certain surgeries [9]. Offer nicotine replacement therapy or alternative pharmacological methods if indicated. Tobacco cessation is clearly beneficial even outside of surgery. This can be a good opportunity to start long-term cessation.
- Preoperative inspiratory muscle training (deep breathing exercises or self-administered incentive spirometry) requires time and patient investment, but may reduce postoperative complications [10, 11].

PERIOPERATIVE MANAGEMENT

Continue all home regimen inhalers postoperatively. Consider scheduled nebulizers with short acting medications like albuterol and ipratropium in patients with COPD. Ipratropium can replace the longer acting tiotropium for patients taking that at baseline. Consider as needed inhalers for patients with mild disease not already on treatment.

- In the postoperative state, if there is a concern about proper administration of metered dose inhalers, delivery via nebulizer or through the ventilator circuit can be considered.

- Pain control requires special attention due to the balance of under treatment (tachypnea and breath stacking) and over treatment (respiratory depression and airway protection).
- Epidural analgesia may reduce postoperative complications [12].
- If opioids are required, careful titration is recommended along with continuous pulse oximetry monitoring. Attempt to wean as soon as possible.
- Recommend aggressive pulmonary toilet and lung expansion maneuvers such as incentive spirometry (not specific to patients with obstructive lung disease). Lung expansion strategies can also include noninvasive positive pressure ventilation for patients unable to participate in incentive spirometry, although care should be taken to minimize barotrauma in this population that may be at risk for bullous disease and pneumothoraces.
- For postoperative exacerbations, discuss corticosteroid use with surgical team given risks of delayed wound healing and hyperglycemia.

KEY CLINICAL PEARLS

- Preoperative chest radiography is generally unnecessary in stable COPD/asthma.
- Consider delaying elective surgeries during acute exacerbations and altogether in patients with very low FEV1.
- Continue all inhalers up to and after surgery.

ACKNOWLEDGMENTS

John H. Choe, MD, MPH. Department of Medicine, Division of General Internal Medicine, University of Washington.

REFERENCES

1. Gupta H, Ramanan B, Gupta P, et al. Impact of COPD on postoperative outcomes: results from a national database. Chest. 2013;43(6):1599–606.
2. Kabalin C, Yarnold P, Grammer C. Low complication rate of corticosteroid-treated asthmatics undergoing surgical procedures. Arch Intern Med. 1995;155:1379–84.
3. Woods B, Sladen R. Perioperative considerations for the patient with asthma and bronchospasm. Br J Anaesth. 2009;103:i57–65.
4. Kroenke K, et al. Operative risk in patients with severe obstructive pulmonary disease. Arch Intern Med. 1992;152(5):967–71.
5. Shin B, Lee H, Kang D. Airflow limitation severity and post-operative pulmonary complications following extra-pulmonary surgery in COPD patients. Respirology. 2017;22:935–41.

6. Qaseem A, Snow V, Fitterman N, et al. Risk assessment for and strategies to reduce perioperative pulmonary complications for patients undergoing noncardiothoracic surgery: a guideline from the American College of Physicians. Ann Intern Med. 2006;144:575–80.
7. Milledge J, Nunn J. Criteria of fitness for anaesthesia in patients with chronic obstructive lung disease. Br Med J. 1975;3(5985):670.
8. Smetana G, Lawrence V, Cornell J. Preoperative pulmonary risk stratification for noncardiothoracic surgery: a systematic review for the American College of Physicians. Ann Intern Med. 2006;144:581–95.
9. Guan Z, Lv Y, Liu J, et al. Smoking cessation can reduce the incidence of postoperative hypoxemia after on-pump coronary artery bypass grafting surgery. J Cardiothorac Vasc Anesth. 2016;30(6):1545.
10. Valkenet K, van de Port I, Dronkers J. The effects of preoperative exercise therapy on postoperative outcome: a systematic review. Clin Rehabil. 2011;25(2):99–111.
11. Boden I, Skinner E, Browning L, et al. Preoperative physiotherapy for the prevention of respiratory complications after upper abdominal surgery: pragmatic, double blinded, multicenter randomized controlled trial. BMJ. 2018;360:j5916.
12. Van Lier F, van der Geest P, Hoeks S, et al. Epidural analgesia is associated with improved health outcomes of surgical patients with chronic obstructive pulmonary disease. Anesthesiology. 2011;115(2):315–21.

Chapter 34
Obstructive Sleep Apnea and Obesity Hypoventilation Syndrome

Ken He and Brian Palen

BACKGROUND

PREVALENCE OF OSA AND OHS

Obstructive sleep apnea (OSA) results in repeated partial or complete collapse of the airway during sleep. Historically, the prevalence of moderate to severe OSA based on longitudinal cohort studies was 9% in men and 4% in women [1]. Contemporary data of the same cohort showed increased prevalence of sleep-disordered breathing to 13% in men and 6% in women [2] with even higher prevalence reported in another recent population-based study [3]. These findings are attributed to increasing prevalence of obesity, the aging population, as well as changes to respiratory event scoring and diagnostic criteria of sleep apnea. Moreover, approximately 90% of individuals with moderate to severe OSA are undiagnosed [4]. In the adult surgical population, prospective studies have shown prevalence of moderate to severe OSA at 35% in patients at risk for OSA evaluated for elective surgery [5] and up to 73% in obese patients tested prior to bariatric surgery [6].

Obesity hypoventilation syndrome (OHS) is defined as body mass index (BMI) ≥30 kg/m^2 and arterial P_{CO2} >45 mm Hg in the absence of alternate causes of hypoventilation. OSA is not a prerequisite for diagnosis, though commonly co-occurs, with 17% of patients with OSA meeting OHS criteria. Prevalence of OHS in the general population is estimated to be 0.6%, but may be falsely low due to underdiagnosis [7].

IMPACT ON PERIOPERATIVE OUTCOMES

Patients with OSA are at increased risk of perioperative complications that include cardiac events (cardiac arrest, myocardial infarction, arrhythmia, and heart failure), pulmonary events (hypoxemia, acute

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_34

respiratory failure, reintubation, and pneumonia), and resource utilization (prolonged mechanical ventilation, intensive care utilization, length of stay, and health-care costs) [8–10].

OHS predisposes to perioperative complications owing to restrictive pulmonary physiology with resultant increased burden of hypoxemia and hypercapnia. Comparing those with OHS to OSA alone, adverse perioperative outcomes are higher for patients with OHS with respect to all above-mentioned categories [11]. Perioperative sleep deprivation, excessive intravenous fluid administration, perioperative body positioning, and sedatives, namely, opioids, may propagate or exacerbate existing OSA and OHS.

BEST PRACTICES AND CHALLENGES

The Society of Anesthesia and Sleep Medicine recently put forth guidelines on preoperative screening and assessment of adults with OSA [12]. Notably, most of the recommendations are based on expert consensus, as robust data remain limited. Furthermore, numerous knowledge gaps persist on best perioperative care practices in the identification of those at risk of complications, optimal timing of OSA and OHS treatment, and interventions to mitigate adverse events, along with intensity and duration of postoperative monitoring [13]. We summarize best practices for the perioperative medicine consultant based on available evidence and clinical experience. Actionable items should be modified based on existing facility protocols, available resources, patient comorbidities, type of surgery, mode of anesthesia, and degree of exposure to sedatives.

PREOPERATIVE EVALUATION

Several comparable OSA screening tools are available including STOP-Bang Questionnaire, P-SAP Score, Berlin Questionnaire, and ASA Checklist. STOP-Bang is the most validated tool in perioperative patients [12]. Modification of the STOP-Bang score and inclusion of additional parameters can increase specificity for moderate to severe OSA and screen for OHS [14, 15].

OSA SCREENING

- Focused history to include nighttime symptoms (snoring, awakening with gasping or choking, witnessed apneas, and frequent awakenings) and daytime symptoms (nonrestorative sleep, fatigue, and sleepiness).

TABLE 34.1 UPDATED STOP-BANG QUESTIONAIRE [14]

Updated STOP-Bang Questionnaire
S = Snoring. Do you snore loudly (loud enough to be heard through closed doors or your bed-partner elbows you for snoring at night)? T = Tired. Do you often feel tired, fatigued, or sleepy during the daytime? O = Observed. Has anyone observed you stop breathing or choking/gasping during your sleep? P = Pressure. Do you have or are you being treated for high blood pressure? B = BMI > 35 kg/m2 A = Age > 50 N = Neck circumference (measured around Adams apple) > 17 in/43 cm (male) or > 16 in/41 cm (female) G = Gender (male)
Scoring
High risk for OSA: Yes to ≥5 questions or ≥2 questions + (male or BMI >35 kg/m^2 or neck circumference >40 cm) Intermediate risk for OSA: Yes to 3–4 questions Low risk for OSA: Yes to <3 questions

- Focused physical of the head and neck (crowded airway, modified Mallampati Class III or IV, enlarged inferior turbinates, and retrognathia (abnormal posterior positioning of the jaw)).
- Use of the STOP-Bang screening tool (see Table 34.1) [14]. Consider high risk of any severity OSA when STOP-Bang score ≥3. Consider high risk of moderate to severe OSA when either: STOP-Bang score ≥5 or STOP-Bang score ≥2 + (male gender or BMI >35 kg/m^2 or neck >40 cm).

OHS SCREENING

- Focused history to include heart failure and pulmonary hypertension symptoms.
- Focused physical exam of cardiopulmonary system (elevated jugular venous pulse, rales, loud P2, parasternal heave, S3, and lower extremity edema).
- Consider OHS in obese patients if STOP-Bang score ≥3 with either: Ambient air SpO_2 <90% and serum bicarbonate ≥28 mEq/L [15] or BMI >45 and serum bicarbonate ≥28 mEq/L.

DIAGNOSTIC TESTING AND RECOMMENDATIONS

Refer patients identified at risk for OSA or OHS for sleep study.

- Home sleep apnea testing may be offered for uncomplicated patients at high risk for moderate to severe OSA [16].
- In-lab polysomnography is recommended for patients with medical complexity including cardiopulmonary and cerebrovascular comorbidities [16].
- We recommend all patients at risk for OHS have in-lab polysomnography with CO_2 monitoring.

Evaluate for presence of daytime hypoventilation in patients identified at risk for OHS.

- Obtain arterial blood gas (P_{CO2} > 45 mm Hg).
- May substitute with capnography (end-tidal CO_2 > 45 mm Hg).
- In patients with awake ambient air SpO_2 <90% and/or meeting criteria for hypoventilation, consider echocardiogram and pulmonary function testing (see Chap. 10 for more information on pulmonary hypertension).

The decision to delay surgery for diagnosis and treatment of OSA should be at the discretion of the surgical care team with consideration to facility policy, patient comorbidities, and surgical need and risk. The 2016 Society of Anesthesia and Sleep Medicine guidelines cite a paucity of clear supportive data and recommend against delaying or canceling surgery except in patients with abnormalities of ventilation/gas exchange demonstrated by hypoventilation, severe pulmonary hypertension, or resting hypoxemia in the absence of known disease [12].

PERIOPERATIVE MANAGEMENT

Positive airway pressure (PAP) is the mainstay of treatment for OSA and OHS. The two main categories of PAP include continuous positive airway pressure (CPAP) and noninvasive ventilation with the most common modality being bi-level positive airway pressure (BPAP) [17]. BPAP provides an expiratory positive airway pressure (EPAP) sufficient to maintain airway patency akin to CPAP, and an inspiratory positive airway pressure (IPAP) to augment ventilation. The difference between IPAP and EPAP is the pressure support window, which directly correlates to tidal volume. Recent generations of devices are capable of autoPAP (APAP) that auto-regulate delivered airway pressure based on flow detection algorithms. OSA is typically treated with CPAP, but

some patients may prefer BPAP as it is perceived to be more comfortable. BPAP is typically used for hypoventilation disorders such as OHS, but CPAP may be adequate for some patients [18]. Sleep study results, patient preference, and sleep or pulmonary specialist can help guide PAP modality selection. Alternative therapies to PAP such as mandibular repositioning devices may be used in patients with uncomplicated OSA.

PREOPERATIVE MANAGEMENT

Alert the anesthesia and surgical team to known or suspected OSA or OHS and consider locoregional anesthesia whenever possible. For patients with known OSA or OHS, the following are recommended:

- Obtain and document therapy adherence, PAP settings, and oxygen bleed-in (if any).
- Optimize adherence and effective PAP settings through sleep medicine provider.
- Counsel patients to bring their own equipment (includes non-PAP therapy).
- Counsel patients to continue PAP or non-PAP therapy in the preoperative period.
- Use facility equipment if clinically indicated and available.

POSTOPERATIVE MANAGEMENT

There is no specific recommendation on duration or intensity of monitoring; however, the following should be considered.

- Continuous pulse oximetry until sedation has resolved, opioid dose is reduced, and patient remains stable.
- CO_2 monitoring such as arterial blood gas and/or capnography (if available) in patients at risk for hypoventilation.
- Telemetry for patients with baseline or higher risk of cardiovascular disease.
- Intensive care monitoring after high risk procedure (e.g., head and neck, cardiac, thoracic, or abdominal surgery).

Non-PAP interventions should be implemented as much as appropriate in all patients with known or suspected OSA or OHS.

- Minimize use of opioids, benzodiazepines, and muscle relaxants.
- Optimize pain control with acetaminophen, NSAIDs, and other non-opioid approaches.
- Elevate head of bed (≥30° or as much as tolerated) and avoid the supine sleep position.
- Limit intravenous fluids (rostral redistribution of interstitial fluids when supine may worsen OSA).

- Avoid over-diuresis in patients with volume overload (metabolic alkalosis may worsen respiratory acidosis in OHS).
- If supplemental oxygen is utilized in patients with OHS, maintain SpO_2 around 90% to avoid blunting respiratory drive.
- Continue home non-PAP therapies such as a mandibular repositioning device.

For patients with established OSA or OHS, initiate PAP at known prescribed settings during sleep. At-risk patients without diagnosis of OSA or OHS, preemptive use of PAP is not recommended due to lack of consistent evidence of benefit, and should be reserved for the following scenarios.

- Initiate CPAP (consider APAP set to 5–20 cm H_2O) if observed apneas result in hypoxia or cardiovascular compromise (e.g., symptomatic bradycardia).
- Initiate BPAP (consider 12/6 cm H_2O) if there is evidence of CO_2 retention and adjust pressure support window to optimize tidal volume and ventilation.
- Mask choice should focus on patient tolerance and achieving a good seal; available mask styles may include nasal pillows, nasal, and oronasal.

ADDITIONAL PERIOPERATIVE CONSIDERATIONS

PAP use after certain surgical procedures warrants special attention. Avoid PAP after procedures of the head and neck (e.g., transsphenoidal surgery, tympanoplasty, and ophthalmologic procedures) due to risk of pneumocephalus and disrupting wound healing. Resumption of PAP after 6 weeks postoperative is generally acceptable, but should be discussed with the surgical team. PAP is typically considered safe to use post bariatric surgery and does not disrupt gastrointestinal anastomotic sutures [19, 20].

Contraindications and precautions to PAP therapy include:

- Impending respiratory failure.
- Cardiac or hemodynamic instability.
- Unable to manage oral secretions, vomiting, or aspiration risk.
- Head or neck wounds that preclude mask use.
- Facial or skull fractures (risk of pneumocephalus and subcutaneous emphysema).
- Altered mental status.
- Unstable or expanding pneumothorax (risk of worsening).
- Use of a nonvented face mask with home PAP (nonventilator) equipment does not allow purging of CO_2 (verify the face mask has built in exhalation ports to allow venting).

Recommend involving respiratory therapy, pulmonary, or sleep medicine as needed for additional guidance if the patient has difficulty tolerating PAP or mask fit issues. Refer patients demonstrating perioperative OSA or OHS findings without prior diagnosis for outpatient sleep evaluation.

KEY CLINICAL PEARLS

- Use the modified STOP-Bang score to increase specificity for moderate to severe OSA and additional parameters (pulse oximetry and serum bicarbonate) to increase detection of OHS.
- Avoid over-diuresis and excessive supplemental oxygen in patients with known or risk of OHS.
- Preemptive PAP therapy is not indicated in patients without established diagnosis of OSA or OHS.
- Nonvented masks are not compatible with home PAP devices and can lead to CO_2 accumulation.
- Avoid routine PAP use after head and neck surgery; discuss with the surgical team on when it is safe to resume.

REFERENCES

1. Young T, Palta M, Dempsey J, et al. The occurrence of sleep-disordered breathing among middle-aged adults. N Engl J Med. 1993;328(17):1230–5.
2. Peppard PE, Young T, Barnet JH, et al. Increased prevalence of sleep-disordered breathing in adults. Am J Epidemiol. 2013;177(9):1006–14.
3. Heinzer R, Vat S, Marques-Vidal P, et al. Prevalence of sleep-disordered breathing in the general population: the HypnoLaus study. Lancet Respir Med. 2015;3(4):310–8.
4. Chen X, Wang R, Zee P, et al. Racial/ethnic differences in sleep disturbances: the Multi-Ethnic Study of Atherosclerosis (MESA). Sleep. 2015;38(6):877–88.
5. Finkel KJ, Searleman AC, Tymkew H, et al. Prevalence of undiagnosed obstructive sleep apnea among adult surgical patients in an academic medical center. Sleep Med. 2009;10(7):753–8.
6. Reed K, Pengo MF, Steier J. Screening for sleep-disordered breathing in a bariatric population. J Thorac Dis. 2016;8(2):268–75.
7. Balachandran JS, Masa JF, Mokhlesi B. Obesity hypoventilation syndrome epidemiology and diagnosis. Sleep Med Clin. 2014;9(3):341–7.
8. Opperer M, Cozowicz C, Bugada D, et al. Does obstructive sleep apnea influence perioperative outcome? A qualitative systematic review for the Society of Anesthesia and Sleep Medicine Task Force on preoperative preparation of patients with sleep-disordered breathing. Anesth Analg. 2016;122(5):1321–34.
9. Memtsoudis SG, Stundner O, Rasul R, et al. The impact of sleep apnea on postoperative utilization of resources and adverse outcomes. Anesth Analg. 2014;118(2):407–18.
10. Memtsoudis S, Liu SS, Ma Y, et al. Perioperative pulmonary outcomes in patients with sleep apnea after noncardiac surgery. Anesth Analg. 2011;112(1):113–21.
11. Kaw R, Bhateja P, Paz Y Mar H, et al. Postoperative complications in patients with unrecognized obesity hypoventilation syndrome undergoing elective noncardiac surgery. Chest. 2016;149(1):84–91.

12. Chung F, Memtsoudis SG, Ramachandran SK, et al. Society of Anesthesia and Sleep Medicine guidelines on preoperative screening and assessment of adult patients with obstructive sleep apnea. Anesth Analg. 2016;123(2):452–73.
13. Ayas NT, Laratta CR, Coleman JM, et al. Knowledge gaps in the perioperative management of adults with obstructive sleep apnea and obesity hypoventilation syndrome. An official American Thoracic Society workshop report. Ann Am Thorac Soc. 2018;15(2):117–26.
14. Nagappa M, Wong J, Singh M, Wong DT, Chung F. An update on the various practical applications of the STOP-Bang questionnaire in anesthesia, surgery, and perioperative medicine. Curr Opin Anaesthesiol. 2017;30(1):118–25.
15. Raveendran R, Wong J, Singh M, Wong DT, Chung F. Obesity hypoventilation syndrome, sleep apnea, overlap syndrome: perioperative management to prevent complications. Curr Opin Anaesthesiol. 2017;30(1):146–55.
16. Kapur VK, Auckley DH, Chowdhuri S, et al. Clinical practice guideline for diagnostic testing for adult obstructive sleep apnea: an American Academy of Sleep Medicine clinical practice guideline. J Clin Sleep Med. 2017;13(3):479–504.
17. Hillman DR, Jungquist CR, Auckley D. Perioperative implementation of noninvasive positive airway pressure therapies. Respir Care. 2018;63(4):479–87.
18. Kushida CA, Littner MR, Hirshkowitz M, et al. Practice parameters for the use of continuous and bilevel positive airway pressure devices to treat adult patients with sleep-related breathing disorders. Sleep. 2006;29(3):375–80.
19. de Raaff CAL, Kalff MC, Coblijn UK, et al. Influence of continuous positive airway pressure on postoperative leakage in bariatric surgery. Surg Obes Relat Dis. 2018;14(2):186–90.
20. Tong S, Gower J, Morgan A, Gadbois K, Wisbach G. Noninvasive positive pressure ventilation in the immediate post-bariatric surgery care of patients with obstructive sleep apnea: a systematic review. Surg Obes Relat Dis. 2017;13(7):1227–33.

Chapter 35
Pulmonary Hypertension

Brian S. Porter

BACKGROUND

Pulmonary hypertension (PH) confers increased risk of perioperative morbidity and mortality for patients undergoing noncardiac surgery. Surgery in patients with PH can result in hypoxia, hypercapnia, or volume shifts leading to increased pulmonary pressures and acute right ventricular failure, myocardial infarction, or arrhythmias including sudden cardiac death. The specific perioperative risk attributable to PH has not been well studied, but observational studies suggest major adverse cardiac event rates may be as high as 40% [1].

Management of patients with pulmonary hypertension undergoing cardiac surgery is a complex subject, which is outside the scope of this chapter. Consultation with a cardiac anesthesiologist is recommended in such cases.

PREOPERATIVE EVALUATION

DEFINITIONS AND ETIOLOGY OF PULMONARY HYPERTENSION

Pulmonary hypertension (PH) is formally defined as mean pulmonary artery pressure (PAP) ≥25 mm Hg at rest. The gold standard to establish this diagnosis is right heart catheterization. However, echocardiography provides reasonably accurate estimates of pulmonary artery systolic pressure (PASP) in most cases. Generally, PASP >40 mm Hg as determined by echo corresponds to mean PAP >25.

PH may be caused by any of a number of different diseases, and these various etiologies are generally organized using World Health Organization (WHO) criteria. Mild PH due to left heart failure (WHO Group 2) is quite common. This disease entity is clinically distinct

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_35

TABLE 35.1 WHO CLASSIFICATION FOR PULMONARY HYPERTENSION

WHO Group	Definition	Specific underlying disease processes
Group 1	Pulmonary arterial hypertension	Idiopathic PAH Familial PAH Connective tissue disease HIV Liver disease Toxins (e.g., Fen-Phen)
Group 2	PH secondary to left heart disease	Diastolic left heart failure Systolic left heart failure Valvular left heart failure
Group 3	PH secondary to primary lung disease	Obstructive sleep apnea COPD Obesity-hypoventilation
Group 4	Chronic thromboembolic PH	Chronic pulmonary thromboemboli
Group 5	PH due to other diseases	Sarcoidosis Histiocytosis Thyroid diseases Polycythemia vera

and should be differentiated from other causes of PH (WHO Groups 1, 3, 4, and 5) which affect the pulmonary arterial vasculature specifically, thereby increasing pulmonary vascular resistance without affecting the left heart. The WHO classification scheme is summarized in Table 35.1 [2, 3]. Pulmonary hypertension often occurs in association with chronic right heart failure (cor pulmonale), but can be found in isolation, particularly in mild cases.

There are no strict definitions of severity with respect to pulmonary hypertension. As a rule of thumb, mean PAP in the 25–40 mm Hg range can be considered mild, the 40–60 mm Hg range can be considered moderate, and mean PAP 60 mm Hg and above can be considered severe.

RISK ASSESSMENT OF PATIENTS WITH PULMONARY HYPERTENSION

Prospective identification of patients at high risk of poor surgical outcomes is difficult due to a paucity of published data. Published guidelines for the preoperative management and assessment of PH patients rely exclusively on expert opinion [1]. It is unknown whether surgical risk in PH patients is affected by the underlying etiology of disease [4]. Therefore, it is recommended that the medical consultant integrate the patient's functional capacity, the underlying mechanism of PH, the degree to which PAP is elevated, and specific risk factors described below

to create an overall subjective risk assessment. A recent echocardiogram (within 6–12 months) is generally necessary as part of this evaluation. For the purposes of preoperative planning, PA catheterization is generally unnecessary except in the setting of incongruent clinical data, newly diagnosed disease, or inadequate echocardiographic assessment.

Generally, patients with asymptomatic PH and with no exercise limitation have minimal additional surgical risk beyond the usual baseline as established by the Revised Cardiac Risk Index or other such risk assessment tools. However, patients with poor functional capacity (e.g., NYHA Functional Class III/IV) or severely elevated PAP (e.g., mean PAP > 60) are known to have worse surgical outcomes [5–8]. In addition, the presence of certain patient- or procedural-specific risk factors can independently increase perioperative risk including:

- Decompensated cirrhosis [7, 9]
- Pregnancy [10]
- History of pulmonary embolism [5]
- Planned thoracic surgery or orthopedic surgery [5]
- Emergency surgery [8, 11]

Assuming surgery is not emergent, preoperative consultation with a pulmonary hypertension specialist may be beneficial in any of these higher risk situations. Performing surgery in a center with PH expertise may also be recommended. Table 35.2 summarizes the decision-making involved in these higher risk clinical scenarios.

TABLE 35.2 RISK ESTIMATION AND MANAGEMENT OF PULMONARY HYPERTENSION

Risk factor	Estimated risk	Recommendation
NYHA Functional Class 3 or 4	High	Consider referral to PH specialist for risk assessment
Severe PH (i.e., mean PAP > 60)	High	Consider referral to PH specialist for risk assessment
PH due to WHO Group 1	Unknown	Consider referral to PH specialist for optimization of pulmonary vasodilators
Presence of other specific risk factor (decompensated cirrhosis, pregnancy, history of pulmonary embolism, emergency surgery, and planned thoracic or orthopedic surgery)	High	Consider referral to PH specialist for risk assessment

PERIOPERATIVE MANAGEMENT

PREOPERATIVE PLANNING

As a general rule, emergency surgery should be avoided in patients with PH. Otherwise, the pulmonary hemodynamics, any concomitant heart failure, and all contributing underlying disease states should be optimized to the extent possible prior to surgery. Such optimization naturally requires knowledge of underlying pathophysiology. For example, patients with WHO Group 2 PH should be appropriately treated for their left heart failure prior to surgery. Additionally, in the common scenario in which the PH is associated with right heart failure, the patient should be euvolemic before proceeding to the operating room (OR).

Other strategies may be considered on a case-by-case basis to reduce morbidity or mortality in PH patients:

- Use open rather than laparoscopic surgery. Minimally invasive surgery tends to increase anesthesia time and increases the risk of hypercarbia leading to worsening pulmonary hemodynamics [6].
- Use regional anesthesia rather than general anesthesia [8, 12].
- Split longer complex cases into shorter, lower risk procedures [6, 8].

PERIOPERATIVE MEDICATION MANAGEMENT

Patients taking pulmonary vascular medication, including PDE5 inhibitors (e.g., sildenafil), endothelin receptor antagonists (e.g., bosentan), or prostaglandins (e.g., epoprostenol), for chronic PH should be continued on these medications throughout the preoperative and perioperative period without interruption unless there is a clear reason not to do so [1]. In particular, abrupt discontinuation of prostaglandin therapy may have disastrous hemodynamic consequences and should be avoided. Patients who are receiving treatment to control the underlying cause of the PH should continue this treatment through the perioperative period unless otherwise surgically contraindicated (e.g., bronchodilators for chronic obstructive pulmonary disease (COPD)).

POSTOPERATIVE CARE

High risk patients should receive initial postoperative care in an intensive care unit (ICU) setting, possibly with invasive cardiac monitoring [5]. Lower risk patients may be safely managed on a traditional surgical ward, or even in a same day discharge scenario. For all patients, attention to the following principles may reduce postoperative risk:

- Optimize volume status. PH patients generally have concomitant heart failure and tend to be particularly sensitive to volume overload, which can produce serious complications if not corrected rapidly. Careful attention to vital signs, inputs/outputs (I/O) data, weight, and jugular venous pressure is needed, and aggressive diuresis should be used when volume overload is detected [13].
- Minimize hypoxia. Hypoxia is common in hospitalized patients due to atelectasis, central nervous system (CNS) depression, or other factors, and this can be dangerous in PH. Consider the use of continuous pulse oximetry for high risk individuals [14].
- Control pain. Maintaining excellent analgesia postoperatively can help avoid dangerous increases in pulmonary pressure due to painful stimuli [12]. However, narcotics may cause respiratory depression leading to hypoxia and pulmonary vasoconstriction, so they should be used judiciously. Also, while nonsteroidal anti-inflammatory drugs do not affect the respiratory center, they do cause volume retention and systemic hypertension that may exacerbate PH or heart failure. Local anesthetics or nonpharmacologic strategies may be preferred.
- Monitor for and treat any atrial tachyarrhythmias that develop. Such arrhythmias have been associated with right ventricular failure and death [15].

KEY CLINICAL PEARLS

- Management of PH patients undergoing noncardiac surgery should be guided by knowledge of the underlying pathophysiology and optimization of contributing illnesses such as left heart failure or primary lung disease.
- Poor functional capacity, severely elevated pulmonary pressures, and emergency surgery are associated with worse outcomes, and consultation with a PH specialist is recommended in such high risk situations.
- Meticulous postprocedural control of volume, pain, and oxygenation may reduce perioperative complication rates.

REFERENCES

1. Fleisher LA, Fleischmann KE, Auerbach AD, et al. 2014 ACC/AHA Guideline on Perioperative Cardiovascular Evaluation and management of patients undergoing noncardiac surgery. J Am Coll Cardiol. 2014;64(22):e77–137.
2. McLaughlin VV, McGoon MD. Pulmonary arterial hypertension. Circulation. 2006;114(13):1417–31.

3. Simonneau G, Galiè N, Rubin L, et al. Clinical classification of pulmonary hypertension. J Am Coll Cardiol. 2004;43:5–12.
4. Kaw R, Pasupuleti V, Deshpande A, et al. Pulmonary hypertension: an important predictor of outcomes in patients undergoing non-cardiac surgery. Respir Med. 2011;105(4):619–24.
5. Ramakrishna G, Sprung J, Ravi BS, et al. Impact of pulmonary hypertension on the outcomes of noncardiac surgery: predictors of perioperative morbidity and mortality. J Am Coll Cardiol. 2005;45(10):1691–9.
6. Lai HC, Lai HC, Wang KY, et al. Severe pulmonary hypertension complicates postoperative outcome of non-cardiac surgery. Br J Anaesth. 2007;99(2):184–90.
7. Krowka MJ, Plevak DJ, Findlay JY, et al. Pulmonary hemodynamics and perioperative cardiopulmonary-related mortality in patients with portopulmonary hypertension undergoing liver transplantation. Liver Transpl. 2000;6(4):443–50.
8. Price LC, Montani D, Jaïs X, et al. Noncardiothoracic nonobstetric surgery in mild-to-moderate pulmonary hypertension. Eur Respir J. 2010;35(6):1294–302.
9. Collisson EA, Nourmand H, Fraiman MH, et al. Retrospective analysis of the results of liver transplantation for adults with severe hepatopulmonary syndrome. Liver Transpl. 2002;8(10):925–31.
10. Jones AM, Howitt G. Eisenmenger syndrome in pregnancy. Br Med J. 1965;1(5451):1627–31.
11. Memtsoudis SG, Ma T, Chiu YL, et al. Perioperative mortality in patients with pulmonary hypertension undergoing major joint replacement. Anesth Analg. 2010;111(5):1110–6.
12. Minai OA, Yared J, Kaw R, et al. Perioperative risk and management in patients with pulmonary hypertension. Chest. 2013;144(1):329–40.
13. Rodriguez R, Pearl RG. Pulmonary hypertension and major surgery. Anesth Analg. 1998;87(4):812–5.
14. Minai O, Budev MM. Treating pulmonary arterial hypertension: cautious hope in a deadly disease. Cleve Clin J Med. 2007;74(11):789–806.
15. Pilkington SA, Taboada D, Martinez G. Pulmonary hypertension and its management in patients undergoing non-cardiac surgery. Anaesthesia. 2015;70(1):56–70.

Chapter 36
Extrapulmonary Respiratory Diseases

Joshua O. Benditt

BACKGROUND

Restrictive lung diseases (RLDs) are disease processes which limit expansion of the respiratory system resulting in a reduction in lung volumes when measured by pulmonary function tests (PFTs) [1]. Diseases that result in restriction can be divided into two large categories: (1) Intrinsic pulmonary diseases where there is an increase in lung elastic recoil due to scarring or infiltrative processes and (2) extrapulmonary diseases that affect the respiratory muscles or chest wall and prevent full expansion of the lungs. The natural history and perioperative management of the two categories are quite different and therefore extrapulmonary restrictive lung diseases will be discussed in a separate chapter (see Chap. 37).

EXTRAPULMONARY DISEASES CAUSING RESTRICTION

Diseases that cause respiratory muscle weakness, significant skeletal deformity or scarring of the pleural space can result in reduced lung volumes due an inability to expand the chest wall and therefore the lungs. Although the lungs themselves may be normal, volumes measured by pulmonary function testing such as vital capacity and total lung capacity will be lower than predicted [2]. Examples of such diseases can be seen in Table 36.1.

Extrapulmonary causes of restriction can result in physiologic abnormalities that include hypercarbia and acidosis due to hypoventilation, hypoxemia associated with hypercarbia and/or atelectasis, and impaired secretion management due to weak cough function. These physiologic abnormalities can lead to perioperative complications including: (1) Hypoxemic and particularly hypercarbic respiratory failure that can lead to failed extubation and/or reintubation and

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_36

TABLE 36.1 EXAMPLES OF EXTRAPULMONARY DISEASES CAUSING RESTRICTION

Examples of extrapulmonary diseases causing restriction
Muscular dystrophies
Myasthenia gravis
Amyotrophic lateral sclerosis
Spinal cord injury
Severe scoliosis or kyphoscoliosis
Paralyzed diaphragm(s)
Fibrothorax

(2) pneumonia due to atelectasis and cough insufficiency. Fortunately, both of these complications can be mitigated with the use of noninvasive ventilation support and cough support with mechanical insufflation–exsufflation (MI-E or CoughAssist™) [3].

PREOPERATIVE EVALUATION

Evidence-based recommendations for some disease entities causing of extrapulmonary restriction are available [4].

- As with all patients with pulmonary disease, evaluation should include a detailed history of functional status and other risk factors for postoperative pulmonary complications [5].
- PFTs including spirometry, maximal inspiratory, and maximal expiratory pressure and peak cough expiratory flow should be measured to assess severity of restriction and inspiratory muscle and cough weakness.
- Lung imaging is not required preoperatively.
- Assessment for symptoms of sleep-disordered breathing (e.g., morning headache, daytime hypersomnolence, and frequent nocturnal awakenings) and cough insufficiency (weak cough with inability to raise secretions) should be sought as they are associated with increased risk of postoperative respiratory complications.
- Measurement of arterial blood gas preoperative or end-tidal carbon dioxide level ($ETCO_2$).
- If sleep symptoms are present or $ETCO_2$ or $PaCO_2$ is elevated referral to sleep medicine or pulmonologist, a sleep study, and/or initiation of noninvasive ventilation (NPPV) preoperative is strongly suggested [4]. In addition, arrangement should be made for immediate postoperative care in a monitored setting

(intensive care unit (ICU) or step-down unit) with availability of NPPV and MI-E at bedside.
- For patients where medications are being used for treatment (e.g., myasthenia gravis), a consultation with a subject expert (neurology) should be sought [6].
- If cardiomyopathy is present as it is in many muscular dystrophies, preoperative consultation with cardiology is recommended [4].

These patients should be considered at high pulmonary risk for anesthesia [4]. Anesthetic agents for specific diseases particularly muscular dystrophies should be carefully chosen.
- Succinylcholine as a paralytic agent is contraindicated as are some inhaled anesthetic agents (due to malignant hyperthermia risk).
- Due to jaw muscle spasticity, some patients may have high-risk airway for intubation.

PERIOPERATIVE MANAGEMENT

Immediate postoperative care most often should occur in a monitored setting (ICU or step-down unit) with availability of NPPV and MI-E at bedside.
- Extubation to NPPV with respiratory therapist at the bedside should strongly be considered [4].
- The consultant should be aware that general anesthesia and immobility can increase underlying muscle weakness [7].
- Postoperative management should focus on preventing atelectasis, pulmonary edema, and postoperative pneumonia. Frequent as needed use of the MI-E to aid in secretion management is strongly recommended.
- NPPV at night and during the day as needed can help prevent atelectasis and reduce work of breathing if patient uses at baseline or $ETCO_2$ or $PaCO_2$ elevated postoperative.
- As with all pulmonary diseases, maintenance of adequate nutrition and selective use of nasogastric decompression after abdominal surgery are important in preventing complications [8].
- If swallowing abnormalities are found preoperatively, a formal swallow evaluation should occur prior to oral feeding.
- For certain medication-responsive diseases (e.g., M gravis) where perioperative adjustment of medications (e.g., steroids) may be needed, expert consultation with a neurologist is recommended.

KEY CLINICAL PEARLS

- Patients with extrapulmonary restrictive are at high risk of respiratory complications following surgery including hypercarbic and hypoxemic respiratory failure and pneumonia.
- Mechanical devices to support ventilation (noninvasive ventilation) and cough (mechanical insufflation–exsufflation) can be very helpful following surgical procedures in these individuals.
- Prearrangement of postoperative care in a monitored setting is suggested for those with anything more than mild extrapulmonary restrictive lung disease.

REFERENCES

1. Scarlata S, Costanzo L, Giua R, Pedone C, Incalzi RA. Diagnosis and prognostic value of restrictive ventilatory disorders in the elderly: a systematic review of the literature. Exp Gerontol. 2012;47(4):281–9. https://doi.org/10.1016/j.exger.2012.02.001.
2. Benditt JO, Boitano LJ. Pulmonary issues in patients with chronic neuromuscular disease. Am J Respir Crit Care Med. 2013;187(10):1046–55. https://doi.org/10.1164/rccm.201210-1804CI.
3. Bach JR, Sinquee DM, Saporito LR, Botticello AL. Efficacy of mechanical insufflation-exsufflation in extubating unweanable subjects with restrictive pulmonary disorders. Respir Care. 2015;60(4):477–83. https://doi.org/10.4187/respcare.03584.
4. Birnkrant DJ, Panitch HB, Benditt JO, Boitano LJ, Carter ER, Cwik VA, Finder JD, Iannaccone ST, Jacobson LE, Kohn GL, Motoyama EK, Moxley RT, Schroth MK, Sharma GD, Sussman MD. American College of Chest Physicians consensus statement on the respiratory and related management of patients with Duchenne muscular dystrophy undergoing anesthesia or sedation. Chest. 2007;132(6):1977–86. https://doi.org/10.1378/chest.07-0458.
5. Dronkers JJ, Chorus AMJ, van Meeteren NLU, Hopman-Rock M. The association of preoperative physical fitness and physical activity with outcome after scheduled major abdominal surgery. Anaesthesia. 2013;68(1):67–73. https://doi.org/10.1111/anae.12066.
6. Blichfeldt-Lauridsen L, Hansen BD. Anesthesia and myasthenia gravis. Acta Anaesthesiol Scand. 2012;56:17–22. https://doi.org/10.1111/j.1399-6576.2011.02558.x.
7. Dhallu MS, Baiomi A, Biyyam M, Chilimuri S. Perioperative management of neurological conditions. Health Serv Insights. 2017;10:1–8. https://doi.org/10.1177/1178632917711942.
8. Qaseem A, Snow V, Fitterman N, et al. Risk assessment for and strategies to reduce perioperative pulmonary complications for patients undergoing noncardiothoracic surgery: a guideline from the American College of Physicians. Ann Intern Med. 2006;144(8):575–80. https://doi.org/10.7326/0003-4819-144-8-200604180-00008.

Chapter 37
Intrinsic Lung Diseases

Joshua O. Benditt

BACKGROUND

Restrictive lung diseases (RLDs) are disease processes which limit expansion of the respiratory system resulting in a reduction in lung volumes when measured by pulmonary function tests (PFTs) [1, 2]. Diseases that result in restriction can be divided into two large categories: (1) Intrinsic lung diseases where there is an increase in lung elastic recoil due to scarring or infiltrative processes and (2) extrapulmonary diseases that affect the respiratory muscles or chest wall and prevent full expansion of the lungs. The natural history and perioperative management of the two categories are quite different and therefore extrapulmonary restrictive lung diseases will be discussed more fully in a separate chapter (Chap. 36). Although intrinsic restrictive lung diseases can occur acutely (e.g., acute pulmonary edema), this chapter will focus on conditions that are more chronic in nature and would be expected to be present at the time of evaluation for surgery or at the time of surgery.

INTRINSIC PULMONARY DISEASES CAUSING RESTRICTION

There are many diseases that can result in scarring or infiltration of the lung parenchyma increasing lung elastic recoil and low lung volumes (see Table 37.1).

Intrinsic lung diseases can cause physiologic abnormalities that include abnormalities in gas exchange leading to hypoxemia, decreased lung compliance that can increase work of breathing at baseline and, on in some cases, pulmonary artery hypertension that can worsen hypoxemia and stress the heart can also sometimes be seen in patients with parenchymal restrictive lung disease. These physiologic abnormalities can lead to several increased perioperative

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_37

TABLE 37.1 EXAMPLES OF CHRONIC INTRINSIC LUNG DISEASES CAUSING RESTRICTION

Chronic intrinsic lung diseases causing restriction
Fibrosis associated with connective tissue diseases
Sarcoidosis
Idiopathic pulmonary fibrosis
Drug-related pulmonary fibrosis
Radiation-induced pulmonary fibrosis
Lung resection
Hypersensitivity pneumonitis or other granulomatous diseases

risks including: (1) Increased risk of hypoxemia during intubation and anesthesia, (2) increased risk of lung infection due to distorted lung anatomy or immunosuppressing medications used in treating the underlying associated diseases, and (3) increased risk of ventilator induced lung injury or barotrauma associated with high ventilator inflation pressures [3].

PREOPERATIVE EVALUATION

Currently, there are no evidence-based recommendations for patients with intrinsic pulmonary causes of restriction. As with all patients with pulmonary disease, evaluation should include a detailed history of functional status and other risk factors for postoperative pulmonary complications [4].

- If intrinsic lung disease is suspected but not previously diagnosed, obtain PFTs including spirometry, plethysmograph measured lung volumes, and lung diffusion for carbon monoxide (D_LCO).
- If intrinsic lung disease is suspect on pulmonary function test (PFT) evaluation, chest x-ray (CXR) and/or computerized tomographic (CT) scan should be obtained.
- If previously undiagnosed intrinsic lung disease is identified, pulmonary consult is recommended prior to surgery.
- If intrinsic lung disease is previously established, chest imaging is not needed.
- Strongly consider measurement of arterial blood gas preoperatively [5].
- Review of immunosuppressing medications (i.e., steroids) used to treat underlying conditions such as rheumatoid

arthritis with appropriate dosing or adjustments during the surgical period with expert consultative help as needed.

- For patients with diagnosed intrinsic lung disease, prearrangement for immediate postoperative care in a monitored setting (intensive care unit (ICU) or step-down unit) should be considered unless disease is mild.
- These patients should be considered at high pulmonary risk for anesthesia and careful preoperative discussion with anesthesia prior to surgery should be undertaken.

PERIOPERATIVE MANAGEMENT

Similar to the preoperative evaluation of intrinsic RLD, currently, there are no evidence-based guidelines for the postoperative management of RLD. Recommendations are based on the underlying etiology of disease and a pulmonary consult is warranted in patients with severe respiratory compromise.

- Management should focus on preventing atelectasis, pulmonary edema, postoperative pneumonia, and muscle weakness as these can worsen underlying restrictive deficit [6].
- Lung expansion techniques may prevent atelectasis and are recommended by the American College of Physicians (ACP). Data suggest they are superior to no prophylaxis in preventing postoperative pulmonary complications in all patients undergoing abdominal surgery, although no modality of expansion showed clear superiority [6].
- As with all pulmonary diseases, maintenance of adequate nutrition and selective use of nasogastric decompression after abdominal surgery are important in preventing complications [6, 7].

KEY CLINICAL PEARLS

- Restrictive intrinsic lung diseases increase the risk of postoperative hypoxemia and respiratory failure.
- Chest imaging and pulmonary function tests should be obtained in all patients suspected of having restrictive intrinsic lung disease.
- Continuous monitoring postoperative in a step-down or ICU setting should be considered for patients with moderate or severe restrictive intrinsic lung disease.

REFERENCES

1. Scarlata S, Costanzo L, Giua R, Pedone C, Incalzi RA. Diagnosis and prognostic value of restrictive ventilatory disorders in the elderly: a systematic review of the literature. Exp Gerontol. 2012;47(4):281–9. https://doi.org/10.1016/j.exger.2012.02.001.
2. Pellegrino R, Viegi G, Brusasco V, et al. Interpretative strategies for lung function tests. Eur Respir J. 2005;26(5):948–68. https://doi.org/10.1183/09031936.05.00035205.
3. Choi SM, et al. Postoperative pulmonary complications after surgery in patients with interstitial lung disease. Respiration. 2014;87(4):287–93. https://doi.org/10.1159/000357046.
4. Dronkers JJ, Chorus AMJ, van Meeteren NLU, Hopman-Rock M. The association of preoperative physical fitness and physical activity with outcome after scheduled major abdominal surgery. Anaesthesia. 2013;68(1):67–73. https://doi.org/10.1111/anae.12066.
5. Simić D, Ladjević N, Milenović M, Bogićević A, Strajina V, Janković R. Preoperative preparation of patients with infectious and restrictive respiratory diseases as comorbidities. Acta Chir Iugosl. 2011;58(2):63–9.
6. Qaseem A, Snow V, Fitterman N, et al. Risk assessment for and strategies to reduce perioperative pulmonary complications for patients undergoing noncardiothoracic surgery: a guideline from the American College of Physicians. Ann Intern Med. 2006;144(8):575–80. https://doi.org/10.7326/0003-4819-144-8-200604180-00008.
7. Diaz-Fuentes G, Hashmi HR, Venkatram S. Perioperative evaluation of patients with pulmonary conditions undergoing non-cardiothoracic surgery. Health Serv Insights. 2016;9(Suppl 1):9–23. eCollection 2016.

Chapter 38
Chronic Kidney Disease

Maya Narayanan and Sabeena Setia

BACKGROUND

A total of 30 million US adults (15% of the population) are estimated to have chronic kidney disease (CKD) and 48% of individuals with severely reduced renal function and 96% of individuals with mildly reduced renal function are not aware of their kidney disease [1]. Patients with CKD are at increased risk of perioperative morbidity and mortality even when adjusting for comorbid conditions such as hypertension and diabetes [2]. The major cause of morbidity in CKD patients is cardiovascular disease but other causes of morbidity include fluid and electrolyte disturbances, increased bleeding risk, and poor blood pressure control [3]. Nonetheless, patients with CKD can safely undergo surgery with appropriate medical management.

PREOPERATIVE EVALUATION

A complete renal history should be obtained for patients with chronic kidney disease, including disease etiology, onset, severity (e.g., CKD stage) history of renal transplant, and past renal complications (e.g., history of acute on chronic kidney injury). Additionally, the patient's cardiovascular status should be considered due to the high prevalence of coronary disease and heart failure in this population.

Baseline creatinine and electrolytes should be documented or obtained for patients with chronic kidney disease. For patients without known CKD but with risk factors, such as hypertension and diabetes, it is reasonable to screen for CKD prior to moderate or high-risk surgeries by obtaining baseline creatinine and electrolytes. There is no evidence to screen asymptomatic individuals without CKD risk factors [4].

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_38

PERIOPERATIVE MANAGEMENT

CONTRAST-INDUCED NEPHROPATHY

Patients with CKD are at increased risk for contrast-induced kidney injury. A meta-analysis of prospective controlled trials revealed inconclusive results [5], but a recent large randomized control trial of high-risk renal patients undergoing angiography showed no difference in outcomes (death, need for dialysis, or persistent decline in kidney function at 90 days) between those that received NAC versus placebo [6]. Intravenous (IV) hydration both before and after contrast is likely beneficial if the patient can tolerate volume expansion. Both isotonic sodium bicarbonate and isotonic normal saline are effective but isotonic bicarbonate must be compounded and is usually more expensive. The same randomized control trial compared outcomes in high-risk renal patients receiving IV sodium bicarbonate versus IV sodium chloride and found no difference [6].

When a Study or Procedure Requiring Contrast Is Proposed

- Consider the necessity of the procedure and alternative imaging options (ultrasound, noncontrast CT scan, or MRI without gadolinium).
- Iso-osmolar or low osmolar-iodinated contrast agents are preferred over high osmolar-iodinated contrast; discuss options with the radiologist.
- If using normal saline to hydrate, give 1 mL/kg/hour for 6–12 hours preprocedure, intraprocedure, and for 6–12 hours postprocedure [5].

FLUID AND ELECTROLYTES

Patients who are above their dry weight are at risk of pulmonary edema and poorly controlled hypertension; those who are under their dry weight are at risk of hypotension in the postoperative setting. Common electrolyte derangements include hyperkalemia and metabolic acidosis—monitor and treat in the pre- and postoperative setting to reduce the risk of ventricular arrhythmia. See Chap. 55 for further discussion of common electrolyte abnormalities.

MEDICATIONS

CKD affects renal drug elimination, drug absorption, drug distribution, and non-renal clearance [3]. Creatinine clearance (CrCl) is normally >100 mL/min. Most commonly used medications require dosage adjustments when the CrCl falls below 50 mL/min.

Glomerular filtration rate (GFR) and/or CrCl are estimated using the Modification of Diet in Renal Disease (MDRD) study or using the Cockcroft–Gault equation. These estimates are less accurate in certain circumstances, including when patients have more or less muscle mass than average [7].

It is crucial to review the patient's preoperative medication list looking for drugs that may impair renal function postoperatively and noting which drugs may require dose adjustment if creatinine clearance changes. Key points regarding medication management in patients with CKD:

- Angiotensin-converting enzyme inhibitors (ACE-Is) and angiotensin receptor blockers (ARBs) should generally be held on the morning of surgery (see Chap. 5).
- Avoid nonsteroidal anti-inflammatory agents (NSAIDs) perioperatively.
- Useful resources to determine appropriate dosing include Micromedex® and UpToDate.
- Clinical pharmacists are helpful resources for dose adjustment recommendations depending on the medication and the patient's estimated CrCl.
- Nephrotoxic antibiotics (vancomycin, aminoglycosides, etc.) need dose adjustment and therapeutic level monitoring.
- Morphine and meperidine have metabolites that can accumulate with renal insufficiency. Hydromorphone and fentanyl are the preferred narcotic agents for patient with renal insufficiency.
- Enoxaparin clearance is impaired in renal insufficiency and dose adjustment is often necessary.

Use caution reinstituting ACE-Is and ARBs—monitor renal function and electrolytes closely in the postoperative period.

ANEMIA AND COAGULOPATHY

Loss of erythropoietin production as renal function declines often leads to significant anemia. Anemia in CKD is defined as a hemoglobin (Hb) concentration <13.0 g/dL in males and <12.0 g/dL in females [8]. In general, anemia is treated with supplemental iron (PO/IV) if serum transferrin saturation is ≤30% and ferritin is ≤500 ng/mL. Erythropoietin-stimulating agents (ESAs) can be given to treat anemia when Hb concentrations are <10.0 g/dL [8]. Discuss options to optimize an anemic patient with their nephrologist, especially if the surgery is elective and there is time for ESAs and supplemental iron to have a meaningful effect. See Chap. 20 for more on the perioperative management of anemia.

Patients with CKD demonstrate varying defects in hemostasis ranging from prothrombotic effects to dysfunctional platelets. As CKD progresses, prothrombotic effects persist; however, platelet dysfunction due to uremia increases the risk of perioperative cutaneous, mucosal, and serosal bleeding [9]. The risk of uremic bleeding can be reduced by administering desmopressin, cryoprecipitate, or transfusion of blood products. Such strategies are best carried out in consultation with a nephrologist or hematologist.

HEMODIALYSIS-DEPENDENT CHRONIC KIDNEY DISEASE (END-STAGE RENAL DISEASE)

Care for patients with end-stage renal disease (ESRD) or history of renal transplant should be coordinated with a nephrologist [11]. Obtain the following information preoperatively:

- History of vascular or peritoneal access (anatomic location, history of clotting or stenosis).
- For peritoneal dialysis (PD): the number of exchanges and dwell time—the number of exchanges can be increased the week prior to surgery in case resumption of PD is delayed postoperatively, although there are no published data to support this practice [10].
- For hemodialysis: the patient's usual dialysis days and dialysis session length—ideally hemodialysis (HD) should be done the day before surgery to minimize fluid imbalance, electrolyte, blood pressure, and uremia-related complication [11].
- The patient's "dry weight" prior to surgery, to guide management of volume status.

Postoperatively, a nephrologist should be involved in the patient's care to help with resumption of dialysis. Most ESRD patients will require a diet that is low in potassium, phosphate, and sodium.

KEY CLINICAL PEARLS

- 🗝 Note the high risk of cardiovascular disease in patients with CKD and perform a careful history and physical to assess risk for heart disease.

- Review medications daily and adjust dosages if needed if the glomerular filtration rate is changing.
- For patients on dialysis, coordinate preoperative and postoperative dialysis schedule with the patient's nephrologist—ideally patients will be dialyzed the day before their surgery.

REFERENCES

1. Center for Disease Control and Prevention. Chronic kidney disease basics. 2017. https://www.cdc.gov/kidneydisease/basics.html. Accessed Mar 2018.
2. Mathew A, Devereaux PJ, O'Hare A, et al. Chronic kidney disease and postoperative mortality: a systematic review and meta-analysis. Kidney Int. 2008;73:1069–81.
3. Krishnan M. Preoperative care of patients with kidney disease. Am Fam Physician. 2002;66(8):1472–6.
4. Fink HA, Ishani A, Taylor BC, et al. Screening for, monitoring, and treatment of chronic kidney disease stages 1 to 3: a systematic review for the U.S. Preventive Services Task Force and for an American College of Physicians Clinical Practice Guideline. Ann Intern Med. 2012;156:507–81.
5. Kshirsagar AV, Poole C, Mottl A, et al. N-acetylcysteine for the prevention of radiocontrast induced nephropathy: a meta-analysis of prospective controlled trials. J Am Soc Nephrol. 2004;15(3):761–9.
6. Weisbord SD, Gallagher M, Jneid H, et al. Outcomes after angiography with sodium bicarbonate and acetylcysteine. N Engl J Med. 2018;378:603–14.
7. Stevens LA, Coresh J, Greene T, Levey AS. Assessing kidney function—measured and estimated glomerular filtration rate. N Engl J Med. 2006;354:2473–83.
8. Kidney International. Kidney disease improving global outcomes clinical practice guideline for anemia in chronic kidney disease. http://kdigo.org/wp-content/uploads/2016/10/KDIGO-2012-Anemia-Guideline-English.pdf. 2012;2(4). Accessed Mar 2018.
9. Jalal DI, Chonchol M, Targher G. Disorders of hemostasis associated with chronic kidney disease. Semin Thromb Hemost. 2010;36(1):34–40.
10. Sanghani NS, Soundararajan R, Weavind LM, et al. Medical management of the dialysis patient undergoing surgery. UpToDate. Sept 2017. http://www.uptodate.com. Accessed Mar 2018.
11. Kanda H, Hirasaki Y, Lida T, et al. Perioperative management of patients with end-stage renal disease. J Cardiothorac Vasc Anesth. 2017;6:2251–67.

Chapter 39
Acute Kidney Injury

Yilin Zhang and Joana Lima Ferreira

BACKGROUND

Acute kidney injury (AKI) is a common postoperative complication that results in significant morbidity and mortality. The incidence of AKI after surgery ranges from 7% to 75% depending on the criteria used to define AKI and the type of surgery [1–3]. Prior criteria used to define AKI focused on the need for renal replacement therapy (RRT) and consequently underestimated the incidence of renal injury [1, 2]. The development of postoperative AKI is associated with an increased risk of progression to chronic kidney disease (CKD) (Chap. 38) [1], need for dialysis after discharge [1], risk of cardiovascular complications, including acute coronary syndromes and heart failure [3], sepsis [4, 5], and mechanical ventilation [5]. AKI is also associated with higher incidence of readmissions [6], length of stay [3, 4, 7], and increased short- and long-term mortality [1, 3–5, 7]. This increase in mortality is evident even with small increases in serum creatinine (sCr) and despite renal recovery [5]. The severity of AKI is directly proportional to the risk of adverse outcomes [2, 4, 5, 7]. Therefore, it is important for the medicine consultant to identify risk factors for postoperative AKI, take preventative measures, and mitigate injury when AKI occurs.

PREOPERATIVE EVALUATION

Several prediction models have been developed for identifying patients at risk for postoperative AKI, but there is no expert consensus to endorse the use of any one model. These risk prediction models

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_39

TABLE 39.1 PATIENT AND SURGICAL RISK FACTORS FOR POSTOPERATIVE AKI

Patient characteristics	Surgical characteristics	Other
Advanced age [4, 5, 8–11]	*Type of surgery:*	*Preoperative lab findings:*
Male sex [4, 5, 7]	Emergency surgery [4, 8, 9, 11, 12]	sCr > 1.2 mg/dL [9]
Obesity [11, 12, 13]	Major vascular surgery [8, 9, 11]	Proteinuria without CKD [1]
Higher ASA status [3]	Cardiac surgery [8, 9, 11]	Liver dysfunction [9]
Comorbidities:	Valvular surgery [8, 9, 11]	WBC > 12 or < 1.5 × 10^3 cell/mL [8, 13]
CKD [1, 11, 8]	Intraperitoneal surgery [8, 9, 11]	Hypoalbuminemia [7, 8]
DM [3, 5, 11, 8, 10]	Transplant surgery [12]	Anemia [4, 15, 14]
Cardiovascular disease (heart failure, CAD) [3, 8–10]	*Intraoperative factors:*	*Use of:*
Atrial fibrillation [3, 5]	Use of IABP [11]	Colloidal fluids [11, 12, 13]
PVD [4, 12]	Aortic cross-clamp time [11]	Diuretics [13]
Hypertension [8, 9]	Use of and time on CPB [4, 8]	NSAIDs [11]
COPD [5, 7, 8]	Blood transfusions [9, 14]	High-dose IV contrast [11]
Liver disease [5]		

ASA American Society of Anesthesiologists, *CKD* chronic kidney disease, *DM* diabetes mellitus, *CAD* coronary artery disease, *PVD* peripheral vascular disease, *COPD* chronic obstructive pulmonary disease, *IABP* intra-aortic balloon pump, *CPB* cardiopulmonary bypass, *sCr* serum Cr, *WBC* white blood cell, *NSAIDs* nonsteroidal anti-inflammatory drugs, *IV* intravenous

are not well validated, predict only AKI requiring dialysis, or have only limited applicability to specific surgical populations [8–10]. Nevertheless, it is useful for the medicine consultant to identify high-risk patients by considering surgical and patient-specific risk factors (Table 39.1).

Emergency, cardiac, major vascular, intraperitoneal, and transplant surgeries are associated with higher risk of postoperative AKI [8–11]. Patient-specific risk factors differ subtly for different surgeries. Generally, older patients with preexisting comorbidities are more prone to develop postoperative AKI [8–11]. Preoperative laboratory

findings such as anemia, hypoalbuminemia, and proteinuria also predict postoperative AKI [8, 9, 11].

Preoperative anemia is one of the few risk factors that can be modified to decrease the risk of postoperative AKI. Medicine consultants should consider working up anemia and correcting any underlying causes to reduce the need for perioperative red blood cell (RBC) transfusions (Chap. 20). Perioperative RBC transfusions may increase the risk of postoperative AKI in patients undergoing cardiac and vascular surgery [11].

PERIOPERATIVE MANAGEMENT

DEFINITION OF ACUTE KIDNEY INJURY (AKI)

Even slight changes in sCr or transient decreases in urine output (UOP) can be harbingers of renal failure and loss of function. In 2012, KDIGO (Kidney Disease: Improving Global Outcomes) proposed criteria for AKI that included absolute and relative changes in sCr and UOP (Table 39.2) [11].

PREVENTION OF POSTOPERATIVE KIDNEY INJURY

There is currently no convincing evidence to support the use of any medications to reduce the incidence of postoperative AKI. A 2013 Cochrane systematic review found that no pharmacologic

TABLE 39.2 KDIGO CRITERIA FOR AKI

KDIGO stage	Serum creatinine (sCr)	Urine output
1	Increased sCr 1.5–1.9× that is known or presumed to have occurred within the preceding 7 days *or* Increased sCr ≥ 0.3 mg/dL within 48 hours	<0.5 mL/kg/h for ≥12 hours
2	Increased sCr 2–2.9×	<0.5 mL/kg/h for ≥12 hours
3	Increased sCr 3× *or* sCr ≥ 4 mg/dL *or* Initiation of RRT *or* GFR decrease to < 35 mL/min in patients < 18 years old	<0.3 mL/kg/h for ≥24 hours *or* Anuria for ≥ 12 hours

KDIGO Kidney Disease Improving Global Outcomes, *AKI* acute kidney injury, *RRT* renal replacement therapy, *GFR* glomerular filtration rate

interventions (including dopamine, diuretics, calcium channel blockers, angiotensin-converting enzyme inhibitors (ACE-I), N-acetyl cysteine, antioxidants, erythropoietin, and select IV fluids) reliably prevented the development of renal failure in patients with or without preexisting renal failure [16]. In non-vascular surgeries, there is low-quality evidence that atrial natriuretic peptide may have some protective effect [17]. In patients undergoing cardiovascular surgery, there is conflicting evidence on the role of statins [17], though most recent meta-analyses have argued against statin use for this indication [18].

The role of different types of intravenous fluids (IVFs) has been an area of intense research. Starch-based colloid fluids have a negative effect on kidney function. Among crystalloids, there is currently insufficient evidence to suggest the use of balanced crystalloids (e.g., lactated Ringer's or Plasmalyte-A) over chloride-rich crystalloids (e.g., normal saline) in the perioperative period [19].

Since there are currently no proven medications to decrease the incidence of AKI, non-pharmacologic preventative measures and early detection are key [17]. Several novel imaging techniques (e.g., renal resistive index measured by Doppler ultrasound, contrast-enhanced ultrasound, and blood oxygenation level-dependent magnetic resonance imaging) and biomarkers (e.g., cystatin C, tissue inhibitor of metalloproteinases-2, and neutrophil gelatinase-associated lipocalin) have been proposed for earlier detection of AKI [1, 12, 17]. However, these new tools are not well validated, expensive, and not widely available. In general, we recommend the following principles to mitigate the risk of postoperative AKI:

- Maintain euvolemia based on ongoing clinical assessment – predetermined IVF rates may overshoot or undershoot actual fluid requirements [11, 12, 14].
- Avoid overzealous fluid administration as this can result in volume overload, which increases risk of postoperative AKI and is associated with increased mortality in patients with AKI [2, 3, 12, 17, 20].
- Avoid diuretics unless they are needed to treat intravascular hypervolemia or the patient is known to be diuretic dependent [11].
- Maintain cardiac output – hypotension can lead to acute tubular necrosis (ATN), a common cause of postoperative AKI. Perioperative goal-directed therapy, fluid, or vasopressor administration titrated to cardiac output decreases the risk of postoperative AKI [21]. While invasive monitoring is not available outside of the ICU, maintenance of mean arterial pressures

(MAPs) > 60–65 mmHg (or >75 mmHg in patients with chronic hypertension) is recommended [11].

- Our practice is to hold ACE-Is and angiotensin receptor blockers (ARBs) 24 hours prior to surgery unless the patient is persistently hypertensive with a systolic blood pressure > 180 mmHg (see Chap. 5). A 2017 prospective cohort study demonstrated that withholding ACE-Is/ARBs prior to major non-cardiac surgery is associated with nearly 20% relative risk reductions in both the composite outcome of death, stroke and myocardial infarction and the incidence of intraoperative hypotension [22], which is associated with higher risk of postoperative AKI. In addition, observational data suggest that older patients and patients with underlying CKD who continue ACE-Is perioperatively are at higher risk of perioperative AKI [17].
- Maintain euglycemia – tight glucose control reduces the incidence of AKI after cardiac surgery but should be weighed against risks of hypoglycemia. KDIGO Work Group recommends a target blood glucose of 110–150 mg/dL [12].
- Correct preoperative anemia and avoid unnecessary RBC transfusions – both perioperative anemia and perioperative RBC transfusions are risk factors for AKI [11, 12, 15].
- Use contrast judiciously to mitigate the risk of contrast-induced nephropathy [11].

EVALUATION OF POSTOPERATIVE ACUTE KIDNEY INJURY

Table 39.3 outlines some considerations of the etiology and workup of AKI specific to the postoperative setting. The standard approach to AKI in the medical patient is applicable (e.g., considering pre-, intra-, and post-renal etiologies), but specific attention should be paid to the patient's additional perioperative risk factors (Table 39.3). Further workup should include the following:

- Urinalysis: Muddy brown, granular, and epithelial cell casts suggest ATN, the most common cause of postoperative AKI [23]; microscopic hematuria may suggest nephrolithiasis, ureteral trauma, intrinsic renal insult, or rhabdomyolysis (if there is occult blood without red blood cells); eosinophiluria may indicate interstitial nephritis.
- Urine labs: High urinary specific gravity, low urinary sodium, and fractional excretion of sodium (FENa) < 1% support the diagnosis of a pre-renal etiology.
- Serum labs: Complete blood count, basic metabolic panel.
- Studies to consider: Bladder scan for post-void residual (in and out catheterization if bladder scan values suggest urinary

TABLE 39.3 CAUSES OF POSTOPERATIVE AKI

Causes	Evaluation
Pre-renal	
Drugs – NSAIDs, ACE inhibitors/ARBs Contrast dye Volume depletion High nasogastric tube output High drain output Intra-abdominal compartment syndrome	FENa <1% High urine specific gravity Urinalysis may show hyaline casts Bladder pressure > 20 mm H_2O
Intra-renal	
Contrast-induced AKI ATN AIN (antibiotics, NSAIDs) Antibiotic induced (aminoglycosides, vancomycin) Atheroembolism (after cardiac and vascular surgery) Rhabdomyolysis	FENa 1–2% Urinalysis ATN – muddy brown casts AIN – may see eosinophils
Post-renal	
Bladder outlet obstruction Mechanical – e.g., BPH Medication induced Ureteral obstruction – bleeding, etc. Nephrolithiasis	FENa is variable Bladder US – urinary retention Retroperitoneal US – hydronephrosis CT scan – hydronephrosis, nephrolithiasis

NSAIDs nonsteroidal anti-inflammatory drugs, *ACE* angiotensin-converting enzyme, *ARB* aldosterone receptor blockers, *FENa* fractional excretion of sodium, *ATN* acute tubular necrosis, *AIN* acute interstitial nephritis, *CK* creatine kinase, *BPH* benign prostatic hyperplasia, *US* ultrasonography, *CT* computed tomography

retention), retroperitoneal ultrasound (US) or computed tomography (CT) scan to assess for hydronephrosis and fluid collections, and bladder pressure to evaluate for intra-abdominal hypertension.

PRINCIPLES OF MANAGEMENT

Treatment and further workup are based on the working diagnosis. Nephrology consultation may be required if establishing euvolemia or relieving urinary tract obstruction does not result in improvement or if there is an indication for acute RRT (i.e., severe acidosis, volume overload compromising organ function, significant hyperkalemia, or symptomatic uremia). Key points in management include the following:

- Closely monitor UOP and place a urinary catheter if UOP is difficult to quantify. Remove the catheter as soon as possible to prevent catheter-associated infections.
- In the case of intravascular volume depletion, resuscitate with crystalloids with frequent clinical re-assessment of volume status and UOP.
- In the case of volume overload and congestive heart failure (CHF), diurese in the usual fashion. Work up for myocardial infarction if CHF is new for the patient.
- If there is obstruction that is not relieved by a urinary catheter, this usually merits rapid surgical or percutaneous intervention.

KEY CLINICAL PEARLS

- Review preoperative risk factors (e.g., older age, medical comorbidities, emergency, and major vascular surgery) and the intraoperative hemodynamic record (e.g., intraoperative hypotension, use of cardiopulmonary bypass in cardiac surgery, and blood transfusions) to identify patients at higher risk for postoperative AKI.
- Maintain euvolemia and avoid hypotension to prevent postoperative AKI.
- If obstruction is not relieved by placement of a urinary catheter, rapid surgical or percutaneous intervention should be considered.

REFERENCES

1. Hobson C, Ruchi R, Bihorac A. Perioperative acute kidney injury: risk factors and predictive strategies. Critical Care Clin. 2017;33:379–96.
2. Van Beek SC, et al. Acute kidney injury defined according to the 'Risk,' 'Injury,' 'Failure,' 'Loss,' and 'End-stage' (RIFLE) criteria after repair for ruptured abdominal aortic aneurysm. J Vasc Surg. 2014;60(5):1159–67.
3. Biteker M, et al. Incidence, risk factors, and outcomes of perioperative acute kidney injury in noncardiac and nonvascular surgery. Am J Surg. 2014;207(1):53–9.
4. Lopez-Delgado JC, et al. Influence of acute kidney injury on short- and long-term outcomes in patients undergoing cardiac surgery: risk factors and prognostic value of a modified RIFLE classification. Crit Care. 2013;17:R293.
5. Bihorac A, et al. Long-term risk of mortality and acute kidney injury during hospitalization after major surgery. Ann Surg. 2009;249(5):851–8.
6. Brown JR, et al. Impact of perioperative acute kidney injury as a severity index for thirty-day readmission after cardiac surgery. Ann Thorac Surg. 2014;97(1):111–7.
7. Kim CS, et al. Incidence, predictive factors, and clinical outcomes of acute kidney injury after gastric surgery for gastric cancer. PLoS One. 2013;8(12):e82289.
8. Huen S, Parikh RP. Predicting AKI following cardiac surgery: a systematic review. Ann Thorac Surg. 2012;93(1):337–47.

9. Wilson T, et al. Risk prediction models for acute kidney injury following major noncardiac surgery: systematic review. Nephrol Dial Transplant. 2016;31:231–40.
10. Kheterpal S, et al. Development and validation of an acute kidney injury risk index for patients undergoing general surgery: results from a national data set. Anesthesiology. 2009;110(3):505–15.
11. Goren O, Matot I. Perioperative acute kidney injury. Br J Anaesth. 2015;115(S2):ii3–14.
12. Ishag S, Thakar CV. Stratification and risk reduction of perioperative acute kidney injury. Anesthesiol Clin. 2016;34(1):89–99.
13. Hobson C, Singhania G, Bihorac A. Acute kidney injury in the surgical patient. Crit Care Clin. 2015;31:705–23.
14. Haase M, et al. Effect of mean arterial pressure, haemoglobin and blood transfusion during cardiopulmonary bypass on post-operative acute kidney injury. Nephrol Dial Transplant. 2012;27:153–60.
15. Walsh M, et al. The association between perioperative hemoglobin and acute kidney injury in patients having noncardiac surgery. Anesth Analg. 2013;117(4):924–31.
16. Zacharias M, et al. Interventions for protecting renal function in the perioperative period. Cochrane Database Syst Rev. 2013;(9):CD003590.
17. Vanmassenhove J, et al. Management of patients at risk of acute kidney injury. Lancet. 2017;389:2139–51.
18. Lewicki M, et al. HMG CoA reductase inhibitors (statins) for preventing acute kidney injury after surgical procedures requiring cardiac bypass. Cochrane Database Syst Rev. 2015;(3):CD010480.
19. Bampoe S, et al. Perioperative administration of buffered versus non-buffered crystalloid intravenous fluid to improve outcomes following adult surgical procedures. Cochrane Database Syst Rev. 2017;(9):CD004089.
20. Brienza N. Does perioperative hemodynamic optimization protect renal function in surgical patients? A meta-analytic study. Crit Care Med. 2009;37(6):2079–90.
21. Chong MA, et al. Does goal-directed haemodynamic and fluid therapy improve peri-operative outcomes?: a systematic review and meta-analysis. Eur J Anaesthesiol. 2018;35:469–83.
22. Roshanov PS, et al. Withholding versus continuing angiotensin-converting enzyme inhibitors or angiotensin II receptor blockers before noncardiac surgery: an analysis of the vascular events in noncardiac surgery patients cohort evaluation prospective cohort. Anesthesiology. 2017;126:16–27.
23. Sear JW. Kidney dysfunction in the postoperative period. Br J Anaesth. 2005;95:20–32.

Chapter 40
Rheumatoid Arthritis

Lauren Brown

BACKGROUND

Patients with rheumatoid arthritis (RA) may be at increased perioperative risk because of systemic complications of their underlying disease or treatment with immunomodulatory therapies. Targeted evaluation by the perioperative consultant to detect specific joint involvement, such as the presence of cervical spondylitis or cricoarytenoid arthritis, is crucial to avoid operative airway complications and brain stem or spinal cord injury during airway manipulation. Immunomodulatory therapy presents a unique challenge in the perioperative period. Recently published recommendations from the American College of Rheumatology and the American Association of Hip and Knee Surgeons provide guidance for medication management surrounding elective hip and knee arthroplasty, but data to guide management in non-orthopedic procedures is lacking. The risk of infection and poor wound healing must be balanced with the risk of disease flare, which may impair functional outcome. Management must be individualized, and coordinating perioperative care with the patient's rheumatologist is recommended.

PREOPERATIVE EVALUATION

GENERAL PRINCIPLES

Patients with RA should receive the same preoperative cardiovascular, pulmonary, and other risk assessments as the general population. However, certain RA patients may be at increased risk for perioperative complications because of systemic complications of their

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_40

underlying disease, medication effects, cervical spine instability, and other specific joint issues [1].

- Assess disease activity. In general, elective surgery during uncontrolled disease or active flares should be avoided.
- Evaluate for signs or symptoms of pre-existing cardiovascular disease and pulmonary complications.
- Perform additional targeted history and physical exam to identify specific joint involvement requiring additional perioperative consideration.
- Obtain detailed medication history with specific attention to current and previous steroid use and dosing schedule of biologic DMARDs, if applicable.
- Determine the level of immunosuppression to assess infection risk.

CARDIOPULMONARY EVALUATION

Patients with RA, particularly those with systemic involvement or poorly controlled disease, have nearly twofold increased risk of cardiovascular disease (CVD) as compared to the general population, equivalent to the risk of CVD for patients with diabetes mellitus [2, 3]. Risk of heart failure both in the presence and absence of coronary artery disease is also substantially increased and may occur early in disease [4]. Due to a paucity of validity evidence for disease-specific CVD risk prediction models, cardiovascular risk stratification should follow current American College of Cardiology/American Heart Association guidelines (see Chap. 6). Limited physical mobility may make assessment of cardiovascular capacity difficult; pharmacologic stress testing may be necessary in some cases for risk stratification.

Pulmonary involvement in RA is common due to the disease itself as well as to the therapies used in treatment. Pleural disease is common but usually subclinical [5]. Interstitial lung disease, bronchiectasis, and obliterative bronchiolitis can occur and, depending on severity, may impact perioperative pulmonary status. Symptoms suggestive of underlying lung disease such as unexplained dyspnea, cough, recurrent pulmonary infection, or an abnormal pulmonary exam require further investigation.

CERVICAL SPINE DISEASE

Patients with cervical spondylitis are at risk of brain stem or spinal cord injury during neck manipulation for intubation or positioning. Patients with RA may have cervical instability from atlantoaxial subluxation or impaction, or subaxial subluxation. Asymptomatic cervical spine subluxation in RA patients awaiting orthopedic surgery is common [6]. Those with longer disease duration, younger age of RA onset, and

markers of more severe disease (erosive or nodular disease, elevated inflammatory markers, or higher disease activity scores) are at greatest risk [7]. All patients with RA undergoing surgery should be screened for cervical disease by history and neurologic exam. Neutral position radiographs are insensitive and underestimate degree of subluxation [8]; obtain lateral flexion/extension cervical radiographs in any patient with neck pain or crepitus on ROM testing, radicular pain, or abnormality on exam localizing to the cervical spine. Additionally, consider screening radiographs in any patient with a diagnosis of RA > 5 years and poorly controlled disease < 5 years or those undergoing orthopedic surgery specifically for rheumatologic disease, as this alone suggests more severe disease. If plain films are abnormal, discussion with patient's rheumatologist and anesthesiologist is recommended to determine if a cervical spine MRI should be obtained and/or if specific positioning or precautions (e.g., soft or hard neck brace) should be taken. Neurosurgical or orthopedic spine consultation may be necessary.

CRICOARYTENOID ARTHRITIS

The cricoarytenoid joints assist in vocal fold mobility and may be affected in RA. Patients with cricoarytenoid involvement may experience difficult intubation and are at risk for potentially fatal upper airway obstruction due to superimposed edema from endotracheal intubation [9]. Symptoms are usually absent until significant obstruction occurs, but all patients should be screened for early symptoms, including voice hoarseness, dysphagia, odynophagia, pain with coughing or speaking, stridor, exertional dyspnea, or inspiratory difficulty. Further evaluation is required if cricoarytenoid arthritis is suspected.

HISTORY

Specific considerations in preoperative history taken for the patient with RA include the following:

- Duration of disease
- Specific joints affected
- Extra-articular manifestations of disease
- History suggestive of cervical spine disease (neck pain, radicular pain, motor weakness)
- History suggestive of cricoarytenoid arthritis (see above)
- Current functional status
- Current medications and dosing schedule of biologic DMARDs, if applicable
- Previous and current use of steroids, including pulses of steroids within the last year, even if the patient is no longer taking steroids (see Chap. 14)
- Previous experience or complications with surgery

PHYSICAL EXAM

Pay particular attention to the following parts of the preoperative physical exam for the patient with RA:

- Assessment for active synovitis that could indicate flare or uncontrolled disease
- Active and passive range of motion of cervical spine
- Neurologic exam with attention to motor weakness, sensation, hyperreflexia, or signs suggestive of cervical spine disease
- Attentive listening to voice, upper airway noises including stridor, or other signs of cricoarytenoid involvement

LABORATORY TESTING AND IMAGING

Consider the following preoperative tests:

- Complete blood count (CBC) to evaluate for leukopenia or anemia
- Basic metabolic panel (BMP) if on potentially nephrotoxic therapy
- Liver function test (LFTs) if on potentially hepatotoxic therapy (specifically, patients on methotrexate typically have LFTs Q3 months if on stable dose, 1 month after dose increases, or more often if LFTs are abnormal)
- Ambulatory pulse oximetry (SpO_2), if history of, or concern for, pulmonary complications of RA
- Lateral flexion/extension neck radiographs or MRI c-spine, if concern for cervical disease
- Inspiratory/expiratory flow-volume loop, contrast-enhanced high-resolution chest CT, or laryngoscopy, if concern for cricoarytenoid involvement

PERIOPERATIVE MANAGEMENT

Patients with RA may be at increased risk for postoperative complications. Higher rates of prosthetic joint infections [10, 11] and postoperative pneumonia [12] occur in patients with RA undergoing arthroplasty as compared to matched controls with osteoarthritis. Rheumatoid arthritis is also associated with an increased risk of venous thromboembolism (VTE) [13] in general, but population-based cohort studies do not show excess risk of VTE in hospitalized RA patients [14] or in those undergoing knee arthroplasty [15] as compared to the general population.

Patients with RA should receive routine postoperative care with special attention to the following:

- Early mobilization and involvement of physical or occupational therapy
- Attention to thromboembolism prophylaxis
- Pulmonary hygiene
- Monitoring anemia (especially if preoperative diagnosis of the same)
- Monitoring for signs of infection

MEDICATION MANAGEMENT

Primary considerations in perioperative management of immunosuppressive medications include balancing the risk of infection and poor wound healing against the risk of flare if medications are withheld, as disease flare can impair rehabilitation or adversely affect functional outcome. Guidelines from the American College of Rheumatology/American Association of Hip and Knee Surgeons (ACR/AAHKS) published in 2017 specifically address medication management in adult patients undergoing elective total hip or knee arthroplasty and are based largely on expert opinion and moderate- to low-quality evidence.

There is little to no data on which to base medication management in non-orthopedic procedures. In the absence of data, caution is advised against extrapolation of guideline recommendations to other orthopedic procedures or non-orthopedic surgery; discussion with the patient's rheumatologist for other procedures is recommended.

Specific Medication Guidelines for Elective Total Hip Arthroplasty (THA) or Total Knee Arthroplasty (TKA)

ACR/AAHKS guidelines pertinent to RA for those undergoing elective THA or TKA are summarized below [16]. Medication dosing and schedule should be confirmed with the patient's pharmacy and/or rheumatologist.

- Optimization should include tapering glucocorticoid dose to < 20 mg/day of prednisone equivalent prior to surgery.
- Continue the current daily dose of glucocorticoids rather than perioperative stress dosing as long as the steroid dose is equivalent to or less than 16 mg/day of prednisone. Note that this is for anticipated uncomplicated elective THA/TKA; for prolonged or intensive procedures, stress dosing may be appropriate (see Chap. 14).
- Continue current dose of methotrexate, leflunomide, hydroxychloroquine, and/or sulfasalazine.
- Withhold all current biologic agents prior to surgery and plan surgery at the end of the dosing cycle for that specific medication. Withhold tofacitinib for at least 7 days prior to surgery.

- Restart biologic therapy in patients for whom it was withheld when the wound shows evidence of healing (typically at least 10–14 days), all sutures/staples are removed, and there is no evidence of surgical site or non-surgical site infection.

See Figs. 40.1 and 40.2 for further information to guide medication management decisions in orthopedic and non-orthopedic procedures; we recommend discussion with patient's rheumatologist and surgeon.

Medication	Elective Orthopedic Procedures	Non-Orthopedic Procedures and Special Considerations
Methotrexate	Continue *If anticipating extensive or complicated procedure, discuss with patient's rheumatologist.	Generally acceptable to continue. Consider holding if: surgery is being done for serious infection, post-operative infection, acute kidney injury, prolonged NPO state, or age >70 years.
Leflunomide		Consider holding if large wounds anticipated. Note that the long half-life (2 weeks) may make complete discontinuation problematic.
Sulfasalazine		Generally acceptable to continue.
Hydroxychloroquine		Generally acceptable to continue.

Fig. 40.1 Perioperative considerations for conventional disease-modifying antirheumatic drugs

Medication	Elective Orthopedic Procedures	Non-Orthopedic Procedures	Special Considerations
TUMOR NECROSIS FACTOR-alpha INHIBITORS adalimumab, certolizumab, etanercept, golimumab, infliximab	Withhold all biologic agents prior to surgery and plan surgery at end of dosing cycle for that drug. For example: if medication dosed every 4 weeks, hold and schedule surgery for week 5.	No data at present to guide management for non-orthopedic surgery. Discussion with patient's rheumatologist is recommended. In general, we recommend timing elective surgery at end of dosing interval (at nadir of drug effect) rather than using half-life to estimate duration of immunosuppressant effect.	Available data on perioperative infection risk is conflicting.
ABATACEPT (Orencia®): CTLA4-IgG fusion protein			No available perioperative data.
TOCILIZUMAB (Actemra®): anti-IL6 monoclonal antibody			Post-operative inflammatory marker suppression in case-control study raises concern that signs/symptoms of surgical site infection may be masked resulting in delayed diagnosis [17].
TOFACITINIB (Xeljanz®): Janus-associated kinase inhibitor			Withhold at least 7 days prior to surgery. Little is known about duration of immunosuppressant effect. No studies in surgical patients. Indirect evidence suggests infection risk may be similar to TNF-alpha inhibitors [18].
ANAKINRA (Kineret): anti-IL1 recombinant antibody			No specific perioperative data available.
RITUXIMAB: anti-CD20 antibody			One observational study found spine surgery is associated with postoperative complications. Complication rate not found to be related to time interval since last infusion [19].

Fig. 40.2 Perioperative considerations for biologic disease-modifying antirheumatic drugs

KEY CLINICAL PEARLS

- Screen all RA patients for cervical disease with history and physical exam, which should include passive and active range of motion, strength, and reflex testing.
- Obtain patient's biologic DMARD dosing schedule, including last date received and anticipated next dose, to determine optimal timing for elective procedures.
- Restart biologic therapy in those for which it was held when the wound is healing and all sutures/staples removed (usually at least 10–14 days), provided there is no infection.

ACKNOWLEDGMENTS

Greg Gardner, MD, Professor, Division of Rheumatology, Department of Medicine, University of Washington

REFERENCES

1. Gardner G, Mandel B. Assessing and managing rheumatologic disorders. In: Jaffer A, Grant P, editors. Perioperative medicine: medical consultation and co-management. 1st ed. New Jersey: Wiley-Blackwell; 2012. p. 215–29.
2. Van Halm VP, Peters ML, Voskuyl AE, et al. Rheumatoid arthritis versus diabetes as a risk factor for cardiovascular disease: a cross-sectional study, the CARRE Investigation. Ann Rheum Dis. 2009;68:1395–400.
3. Crowson CS, Liao KP, Davis JM III, et al. Rheumatoid arthritis and cardiovascular disease. Am Heart J. 2013;166(4):622–8.
4. Mantel A, Holmqvist M, Andersson DC, et al. Association between rheumatoid arthritis and risk of ischemic and nonischemic heart failure. J Am Coll Cardiol. 2017;69(10):1275–85.
5. Balbir-Gurman A, Yigla M, Nahir AM, et al. Rheumatoid pleural effusion. Semin Arthritis Rheum. 2006;35(6):368.
6. Neva MH, Hakkinen A, Makinen H. High prevalence of asymptomatic cervical spine subluxation in patients with rheumatoid arthritis waiting for orthopedic surgery. Ann Rheum Dis. 2006;65(7):884–8.
7. Zhu S, Xu W, Luo Y, et al. Cervical spine involvement risk factors in rheumatoid arthritis: a meta-analysis. Int J Rheum Dis. 2017;20(5):541–9.
8. Kauppi M, Neva MH. Sensitivity of lateral view cervical spine radiographs taken in the neutral position in atlantoaxial subluxation in rheumatic diseases. Clin Rheumatol. 1998;17(6):511–4.
9. Bandi V, Munnur U, Braman SS. Airway problems in patients with rheumatologic disorders. Crit Care Clin. 2002;18(4):749–65.
10. Lee DK, Kim HJ, Lee DH. Infection and revision rates following primary total knee arthroplasty in patients with rheumatoid arthritis versus osteoarthritis: a meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2017;25(12):3800–7.
11. Bongartz T, Halligan CS, Osmon DR, et al. Incidence and risk factors of prosthetic joint infection after total hip or knee replacement in patients with rheumatoid arthritis. Arthritis Rheum. 2008;59(12):1713–20.
12. Jauregui JJ, Kapadia BH, Dixit A. Thirty-day complications in rheumatoid patients following knee arthroplasty. Clin Rheumatol. 2016;35(3):595–600.
13. Choi HK, Rho YJ, Zhu Y, et al. The risk of pulmonary embolism and deep vein thrombosis in rheumatoid arthritis: a UK population-based outpatient cohort study. Ann Rheum Dis. 2013;72:1182–7.

14. Holmqvist ME, Neovius M, Eriksson J, et al. Risk of venous thromboembolism in patients with rheumatoid arthritis and association with disease duration and hospitalization. JAMA. 2012;308(13):1350–6.
15. Izumi M, Migita K, Nakamura M. Risk of venous thromboembolism after total knee arthroplasty in patients with rheumatoid arthritis. J Rheumatol. 2015;42(6):928–34.
16. Goodman SM, Spring B, Guyatt G. American College of Rheumatology/American Association of Hip and Knee Surgeons guidelines for the perioperative management of antirheumatic medication in patients with rheumatic diseases undergoing elective total hip or total knee arthroplasty. Arthritis Care Res. 2017;69(8):1111–124.
17. Hirao M, Hashimoto J, Tsuboi H, et al. Laboratory and febrile features after joint surgery in patients with rheumatoid arthritis treated with tocilizumab. Ann Rheum Dis. 2009;68(5):654–7.
18. Ahadieh S, Checchio T, et al. Meta-analysis of malignancies, serious infections, and serious adverse events with tofacitinib or biologic treatment in rheumatoid arthritis clinical trials. Arthritis Rheum. 2012;Suppl63:1697.
19. Godot S, Gottenberg JE, et al. Safety of surgery after rituximab therapy in 133 patients with rheumatoid arthritis: data from the AutoImmunity and Rituximab Registry. Arthritis Care Res. 2013;65(11):1874–9.

Chapter 41
Systemic Lupus Erythematosus

Stefanie Deeds

BACKGROUND

Patients with systemic lupus erythematosus (SLE) undergoing surgery are at increased risk for perioperative complications and mortality compared to controls. SLE is a heterogeneous disease, and while many patients may have only skin and joint involvement, others will develop severe internal organ involvement with organ failure over time [1, 2]. Kidneys are the most common internal organ affected by SLE. Patients with SLE also have an increased risk of cardiovascular disease and thrombosis. In patients with antiphospholipid syndrome (APS), there is also an increased risk for developing heart valve disease and pulmonary hypertension [3–5].

Musculoskeletal damage is common in patients with active disease, with higher rates of avascular necrosis (AVN), osteoporosis, and fractures requiring orthopedic procedures [6]. Patients with SLE are typically younger than the general population at the time of arthroplasty, though the age of patients undergoing arthroplasty is increasing and shifting from causes such as AVN to comorbid osteoarthritis [6].

The SLE patient with mild disease may only have been treated with hydroxychloroquine and is at low risk of perioperative problems. The presence of multiorgan disease places patients with SLE at increased risk of perioperative complications. In SLE patients with a history of potent immune-suppressing treatment with steroids and disease-modifying antirheumatic drugs (DMARDs), an increased risk of perioperative infection is to be anticipated. They are also at high risk of thrombosis and disease flare at the time of surgery. Patients with a history of moderate to severe disease activity may be at increased risk of perioperative myocardial infarction [7], renal complications including acute renal failure [8–10], pneumonia and

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_41

sepsis [9], infections [10], pulmonary embolism (PE) and stroke [6], and mortality [7–9]. In addition, patients with APS are at increased risk of perioperative complications of thrombosis, catastrophic exacerbation, or bleeding [11]. In a systematic review, despite the increased risk of these complications, most studies report good functional outcome [6].

PREOPERATIVE EVALUATION

Patients with SLE are at increased risk of perioperative complications due to a baseline higher risk of coronary disease, multiorgan disease involvement, and use of steroids and other immunosuppressive medications [12], and thus the preoperative evaluation should focus on assessing these factors.

HISTORY

The patient interview should focus on symptom manifestations, current disease control, and medication management. It should include an assessment for typical and disease-specific risk factors for thromboembolic and cardiac diseases. The following should be assessed:

- History of cardiovascular disease and signs/symptoms of coronary artery disease (CAD) or valvular disease
- History of thromboembolic disease and signs/symptoms of thrombosis or APS
- History of renal disease, hematologic abnormalities, and prior infections
- History of Raynaud's phenomenon (this is important as perioperative protection of extremities from cold is imperative to avoid potential digital ischemia)
- Functional status
- Traditional cardiovascular and thrombotic risk factors: Tobacco use, oral contraception (OCPs), hypertension, high cholesterol
- Lupus-specific risk factors for thrombosis: Antiphospholipid antibodies (APLA) antibodies, particularly those with lupus anticoagulant or who are triple-positive, and hospitalization in the previous 6 months [9]
- Current or prior use of steroids, which increases cardiovascular disease risk
- Accurate medication reconciliation, particularly for those that increase risk of immunosuppression and cytopenia
- Whether patients are being treated for severe or not severe SLE (see Table 41.1)

TABLE 41.1 DEFINITION OF SEVERE SLE AND NON-SEVERE SLE

Severe lupus
Currently treated for severe organ manifestations, including: Hematologic disease: Hemolytic anemia, thrombocytopenia, leukopenia Vascular disease: Vasculitis including enteritis, pulmonary hemorrhage, venous thrombosis, ulceration Renal: Nephritis, end stage renal disease (ESRD) Neurologic: Neuritis, cognitive impairment, psychosis, seizure, cerebrovascular accident (CVA), neuropathy Cardiovascular and pulmonary: Myocarditis, cardiomyopathy, myocardial infarction, pneumonitis, pulmonary fibrosis, pulmonary hypertension Musculoskeletal: Myositis with muscle weakness, active synovitis Gastrointestinal: Pancreatitis, cholecystitis, hepatitis, protein-losing enteropathy, peritonitis Ophthalmic: Orbital inflammation/myositis, keratitis, posterior uveitis, scleritis, optic neuritis, anterior ischemic optic neuropathy Mucocutaneous: Scarring, skin or mucosal ulceration
Non-severe lupus
Not currently treated for manifestations of severe SLE

Definitions adapted from disease activity indices: SELENA–SLEDAI (Safety of Estrogens in Lupus Erythematosus National Assessment version of the Systemic Lupus Erythematosus Disease Activity Index) [19] and BILAG 2004 (British Isles Lupus Assessment Group) [20]

PHYSICAL EXAM AND TESTING

A careful examination should include an evaluation for cardiopulmonary disease and multiorgan involvement:

- A grade 2 murmur or greater in a patient with APS should be evaluated with a transthoracic echocardiogram, especially if the patient has symptoms that may be related to valvular disease.
- A grade 3 or greater murmur in a patient without APS should be evaluated with a transthoracic echocardiogram.
- Assess for signs of active inflammation: Hair loss, inflammatory arthritis, facial rash, signs of pulmonary hypertension on cardiac exam, lower extremity edema.

Preoperative lab testing for markers of active disease and to obtain a baseline for postoperative comparison should include the following:

- Basic metabolic panel for renal function and electrolytes, complete blood count, and coagulation panel.

- Additional tests to measure current disease activity may be considered, such as dsDNA and complement levels, if recommended in consultation with the patient's rheumatologist.
- Patients with APLA or lupus anticoagulant should undergo D-dimer testing unless already on chronic anticoagulation for a previous thrombotic event; the presence of an elevated D-dimer may suggest higher risk and these patients should have more aggressive postoperative thrombosis prevention [13].

RISK ASSESSMENT

Patients with lupus have at least twice the risk of CAD than age-matched controls [14], most notable among younger patients, and they are at increased risk of perioperative cardiovascular events [15].

- A cardiovascular risk assessment should be performed following the same principles as with other patients (see Chap. 6). If deemed high risk, additional testing should be undertaken to evaluate for cardiac disease prior to surgery.
- Patients with dyspnea on exertion or a grade 3 murmur or greater (grade 2 in patients with APS) should undergo a transthoracic echocardiogram for evaluation of valvular structural disease and for pulmonary hypertension.
- SLE patients can occasionally have interstitial lung disease and if rales are heard on examination and there is no history of cardiac disease, a high-resolution chest CT should be obtained.

PREOPERATIVE MANAGEMENT

Management of patients with SLE may be complicated by multiorgan involvement and complex medication regimens. The decision to undergo elective surgery in patients with severe SLE should be discussed with the patient's rheumatologist. Elective surgery should be postponed in patients who do not have adequate disease control [16].

PERIOPERATIVE MANAGEMENT

CARDIOVASCULAR RISK MANAGEMENT

- Hydroxychloroquine (HCQ) reduces disease activity and cardiovascular risk and should be continued in the perioperative period [12].
- Given elevated cardiovascular risk, patients on aspirin should be continued on this if there are no major surgical contraindications [12].

- For additional preoperative cardiovascular risk reduction, manage cardiovascular risk factors (such as lipids and blood pressure) according to guidelines and consider initiating HCQ [12].

ANTICOAGULATION AND THROMBOTIC RISK MANAGEMENT

- Primary prophylaxis for thrombosis in patients with SLE and known APS consists of low-dose aspirin and hydroxychloroquine [17], which should be continued.
- Patients with APS who are on anticoagulation for secondary prophylaxis should have time off anticoagulation minimized and receive bridging anticoagulation [18]. (See Chap. 26 for additional information about bridging therapy.)
- Gualtierotti et al. supports the use of bridging anticoagulation for patients with high-risk APLA (triple positivity or lupus anticoagulant) and other risk factors for thrombosis (arterial hypertension, smoking, use of oral contraception, obesity, diabetes, neoplasm) [12]. In these high-risk patients, additional input from a specialist should be sought before elective surgery.
- Patients with APLA without additional risk factors for thrombosis should use prophylactic anticoagulation for thrombosis in line with care for other patients.
- All other SLE patients should receive the same prophylactic doses of anticoagulation for deep vein thrombosis (DVT) prevention as those for non-SLE patients [18].

RHEUMATOLOGIC MEDICATION MANAGEMENT

The American College of Rheumatology published recommendations for the management of rheumatologic medications perioperatively for orthopedic surgeries [16]. Currently, there are no guidelines for medication management in non-orthopedic surgeries, but these recommendations may be able to be extrapolated to the management of patients undergoing other types of surgery in consultation with the patient's rheumatologist. Please see Figure 40.1 and 40.2 (see Chap. 40) for specific recommendations for synthetic DMARDs and biologic agents.

Though there is little data on perioperative medication management in patients with SLE, the medication management summarized below is recommended to decrease the risk of infectious complications. In severe SLE (see Table 41.1), patients are at risk of postoperative disease flares, which could be organ threatening. The risk of postoperative complications and infections must be weighed against the risk of disease flares when deciding whether or not to hold SLE medications [16].

- Patients on steroids should be tapered to a daily dose less than or equal to 20 mg/day before undergoing surgery in consultation with their rheumatologist and continued on steroids postoperatively. See Chap. 14 for discussions on indications for stress-dose steroids that are not routinely needed.
- Typically, patients with severe SLE manifestations (Table 41.1) undergoing arthroplasty should be continued on SLE-specific DMARDs (mycophenolate mofetil, azathioprine, cyclosporine, and tacrolimus) throughout the surgical period [16].
- Patients without severe disease can discontinue SLE-specific DMARDs 1 week prior to surgery except for tacrolimus, which can be continued; restart these medications 3–5 days after surgery if there are no additional wound healing or infectious complications [16].
- There is limited data supporting perioperative use of biologic agents in SLE; however, following recommendations similar for other rheumatologic conditions, biologics should be stopped prior to elective surgery and held until wounds are healed, which can be about 14 days [16].

POSTOPERATIVE MONITORING

Patients with SLE are at increased risk of infection, cardiac disease, thrombotic events, renal disease, and death. Patients with APS are at additional risk for recurrent thrombosis, bleeding, and catastrophic exacerbation after surgery. Careful monitoring is needed to evaluate for these complications, including the following:

- Anticoagulation should be managed as above.
- Patients should be monitored for signs and symptoms of hemodynamic instability and the use of stress-dose steroids should be considered on a case-by-case basis.
- Review records of intraoperative reports of hypotension and blood loss in patients who develop acute renal injury (see Chap. 39).
- In patients with Raynaud's phenomenon, hypothermia perioperatively should be limited to avoid digital ischemia.
- Surgery can be a precipitating factor of catastrophic antiphospholipid syndrome, which is the rapid onset of thrombotic microangiopathy with at least three organs involved in the presence of APLA. Consultation with a specialist is needed to evaluate and direct management in these cases, which may include heparin, steroids, intravenous immunoglobulin (IVIG), and rituximab [16].

KEY CLINICAL PEARLS

- Taper prednisone dose to a daily dose less than or equal to 20 mg/day before elective surgery in consultation with the patient's rheumatologist.
- Review disease and non-disease cardiovascular risks.
- Postpone elective surgery in patients who have signs and symptoms of active inflammation until better control is obtained.
- Avoid prolonged reversal of anticoagulation in patients with a history of thrombosis and in over-hydrating patients with a history of renal or heart disease and keep the extremities warm.
- Disease activity and severity should be considered in managing DMARDs perioperatively in consultation with the patient's rheumatologist.

ACKNOWLEDGMENTS

Gregory Gardner, M.D., F.A.C.P., Professor, Division of Rheumatology, Department of Medicine, University of Washington, Seattle, WA.

REFERENCES

1. Chambers SA, Allen E, Rahman A, Isenberg D. Damage and mortality in a group of British patients with systemic lupus erythematosus followed up for over 10 years. Rheumatology (Oxford). 2009;48(6):673–5.
2. Becker-Merok A, Nossent HC. Damage accumulation in systemic lupus erythematosus and its relation to disease activity and mortality. J Rheumatol. 2006;33:1570–7.
3. Ruiz D, Oates JC, Kamen DL. Antiphospholipid antibodies and heart valve disease in systemic lupus erythematosus. Am J Med Sci. 2018;355(3):293–8.
4. Zuily S, Regnault V, Selton-Suty C, Eschwège V, Bruntz JF, Bode-Dotto E, De Maistre E, Dotto P, Perret-Guillaume C, Lecompte T, Wahl D. Increased risk for heart valve disease associated with antiphospholipid antibodies in patients with systemic lupus erythematosus: meta-analysis of echocardiographic studies. Circulation. 2011;124(2):215–24.
5. Zuily S, Domingues V, Suty-Selton C, Eschwège V, Bertoletti L, Chaouat A, Chabot F, Regnault V, Horn EM, Erkan D, Wahl D. Antiphospholipid antibodies can identify lupus patients at risk of pulmonary hypertension: a systematic review and meta-analysis. Autoimmun Rev. 2017;16(6):576–86.
6. Kasturi S, Goodman S. Current perspectives on arthroplasty in systemic lupus erythematosus: rates, outcomes, and adverse events. Curr Rheumatol Rep. 2016;18(9):59.
7. Smilowitz NR, Katz G, Buyon JP, Clancy RM, Berger JS. Systemic lupus erythematosus and the risk of perioperative major adverse cardiovascular events. J Thromb Thrombolysis. 2018;45(1):13–7.
8. Babazade R, Yilmaz HO, Leung SM, Zimmerman NM, Turan A. Systemic lupus erythematosus is associated with increased adverse postoperative renal outcomes and mortality: a historical cohort study using administrative health data. Anesth Analg. 2017;124(4):1118–26.
9. Lin JA, Liao CC, Lee YJ, Wu CH, Huang WQ, Chen TL. Adverse outcomes after major surgery in patients with systemic lupus erythematosus: a nationwide population-based study. Ann Rheum Dis. 2014;73(9):1646–51.
10. Roberts JE, Mandl LA, Su EP, Mayman DJ, Figgie MP, Fein AW, Lee YY, Shah U, Goodman SM. Patients with systemic lupus erythematosus have increased risk of short-term adverse events after total hip arthroplasty. J Rheumatol. 2016;43(8):1498–502.

11. Erkan D, Leibowitz E, Berman J, Lockshin MD. Perioperative medical management of antiphospholipid syndrome: hospital for special surgery experience, review of literature, and recommendations. J Rheumatol. 2002;29(4):843–9.
12. Gualtierotti R, Parisi M, Ingegnoli F. Perioperative management of patients with inflammatory rheumatic diseases undergoing major orthopaedic surgery: a practical overview. Adv Ther. 2018;35(4):439–56.
13. Wu H, Birmingham DJ, Rovin B, et al. D-dimer level and the risk for thrombosis in systemic lupus erythematosus. Clin J Am Soc Nephrol. 2008;3(6):1628–36. https://doi.org/10.2215/CJN.01480308.
14. Schoenfeld SR, Kasturi S, Costenbader KH. The epidemiology of atherosclerotic cardiovascular disease among patients with SLE: a systematic review. Semin Arthritis Rheum. 2013;43(1):77–95.
15. Yazdanyar A, Wasko MC, Scalzi LV, Kraemer KL, Ward MM. Short-term perioperative all-cause mortality and cardiovascular events in women with systemic lupus erythematosus. Arthritis Care Res (Hoboken). 2013;65(6):986–91.
16. Goodman SM, Springer B, Guyatt G, Abdel MP, Dasa V, George M, et al. American College of Rheumatology/American Association of Hip and Knee Surgeons guideline for the perioperative management of antirheumatic medication in patients with rheumatic diseases undergoing elective total hip or total knee arthroplasty. Arthritis Rheumatol. 2017;69(8):1111–24.
17. Pons-Estel GJ, Andreoli L, Scanzi F, Cervera R, Tincani A. The antiphospholipid syndrome in patients with systemic lupus erythematosus. J Autoimmun. 2017;76:10–20.
18. Goodman SM, Bass AR. Perioperative medical management for patients with RA, SPA, and SLE undergoing total hip and total knee replacement: a narrative review. BMC Rheumatol. 2018;2(2):2.
19. Petri M, Kim M, Kalunian KC, Grossman J, Hahn BH, Sammaritano LR, et al. Combined oral contraceptives in women with systemic lupus erythematosus. NEJM. 2005;353(24):2550–8.
20. Isenberg DA, Rahman A, Allen E, Farewell V, Akil M, Bruce IN, et al. BILAG 2004. Development and initial validation of an updated version of the British Isles Lupus Assessment Group's disease activity index for patients with systemic lupus erythematosus. Rheumatology. 2005;44(7):902–6.

Chapter 42
Gout and Pseudogout

Elizabeth Kaplan

BACKGROUND

Surgery is a risk factor for the development of crystal arthropathy or for a flare of a preexisting crystal arthropathy [1]. Gout or pseudogout should be considered in patients with joint pain, unexplained fever, leukocytosis, or difficulty with physical therapy. It is vital not to ignore the patient's joint exam, especially in patients who are slow to mobilize or who cannot give a history. Both gout and pseudogout are in the differential diagnosis of postoperative fever and of acute arthritis. Correctly diagnosing postoperative gout or pseudogout may lead to earlier treatment of the patient and help prevent barriers to postoperative recovery.

PREOPERATIVE EVALUATION

Assess the patient for a history of gout, including frequency of flares, what joints affected in past, medication regimen (including frequency of steroid use), whether there were any previous postoperative gout attacks, and uric acid levels (if appropriate). Examine the patient for any signs of joint redness or swelling suggestive of an acute flare. If such signs are present, consider initiating workup and treat flare (if it is in fact a crystal arthropathy) prior to surgery.

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_42

PERIOPERATIVE MANAGEMENT

PREVENTION OF FLARES

Generally, continue prophylactic medications (e.g., allopurinol) up until surgery and resume these postoperatively as soon as possible. Pay attention to adequate hydration and mobilize patients as able. Be aware that some new medications may induce a gouty attack (e.g., diuretics, cyclosporine), especially in a susceptible patient with a history of gout. Mobilization can be helpful for prevention.

DIAGNOSIS OF PERIOPERATIVE FLARE

Gout should be on the differential diagnosis for acute arthritis in the postoperative setting.

For an acute arthritis in the postoperative setting, consider the following:

- Location—crystal arthropathies are often in large joints (e.g., knee, ankle) and/or in joints that were previously involved in flares [2].
- Assess clinical suspicion for septic joint—arthrocentesis is often needed and indicated to rule out infection, as well as to diagnose crystal disease [3].

DISTINGUISHING GOUT FROM PSEUDOGOUT

Pseudogout is common. It can be important to distinguish from gout to avoid unnecessary uric acid-lowering therapy for the long-term. Gout should be considered in patients with a history of gout, obesity, chronic kidney disease, or use of diuretics or calcineurin inhibitors. Flares tend to occur within 8 days after surgery [2]; however, they can occur up to 3 weeks postoperatively. Uric acid levels can vary in either direction (increased or decreased) at the time of an attack; the level should not be used to make or exclude the diagnosis. Pseudogout can also occur postoperatively. X-rays may show calcium pyrophosphate deposition, but this finding is neither specific nor sensitive for pseudogout.

- Arthrocentesis with examination of fluid for crystals remains the gold standard for diagnosis and distinguishing between gout and pseudogout.

TREATMENT OF POSTOPERATIVE GOUT OR PSEUDOGOUT

The principles of management are generally the same for both gout and pseudogout. Importantly, the typical medications used to treat acute crystal arthropathy may be relatively contraindicated in the

immediate postoperative period, so working closely with the surgery team to make the best treatment decision is important.

- Consider intra-articular injection, especially if flare is limited to one joint. This can be especially useful if the other typical oral medications cannot be used in the postoperative period.
- Nonsteroidal anti-inflammatory medications: May be contraindicated if renal failure or surgical bleeding risk [3].
- Prednisone: May be contraindicated for concerns of wound healing, hyperglycemia, and infection risk.
- Colchicine: Gastrointestinal side effects may limit the use in patients after abdominal surgery.
- Interleukin-1 inhibitors (Anakinra): May be contraindicated because of concerns about effects on wound healing; medication is expensive. Recommend involving rheumatology service if this medication is considered.

KEY CLINICAL PEARLS

- Surgery is a risk factor for the development of crystal arthropathy or for a flare of a preexisting crystal arthropathy.
- Be aware that some new medications may induce a gouty attack (e.g., diuretics, cyclosporine), especially in a susceptible patient with a history of gout.
- Typical medications used to treat acute crystal arthropathy may be relatively contraindicated in the immediate postoperative period, so working closely with the surgery team to make the best treatment decision is important.

REFERENCES

1. Craig MH, Poole GV, Hauser CJ. Postsurgical gout. Am Surg. 1995;61(1):56–9.
2. Kang EH, Lee EY, Lee YU, Song YW, Lee EB. Clinical features and risk factors of postsurgical gout. Ann Rheum Dis. 2008;67(9):1271–5.
3. Gardner G, Mandel B. Assessing and managing rheumatologic disorders. In: Jaffer A, Grant P, editors. Perioperative medicine: medical consultation and comanagement. 1st ed. New Jersey: Wiley-Blackwell; 2012. p. 222–3. 4. 207(1): p. 53–9.

Chapter 43
Decision-Making Capacity

Jessica Woan and Kara J. Mitchell

BACKGROUND

Surgeons are responsible for obtaining informed consent from patients for the procedures that they perform. Medical consultants are sometimes asked to help assess a patient's capacity (or lack thereof) to consent to evaluation and/or treatment. This occurs infrequently, since patients are presumed to possess decision-making capacity unless a clinical evaluation suggests that it is lacking [1–3]. However, clinicians frequently fail to recognize when patients lack decision-making capacity [1, 3]. Often, the decision-making capacity of patients is questioned only when one of the following "red flags" are noted:

- The decision to be made is particularly risky or complex.
- The decision that a patient has made is in conflict with what a provider has recommended [2, 3].
- The patient seems passive or "agrees to everything" with concrete/simple answers [4].

Rather than relying on the "red flags" listed above, clinicians should actively consider whether their patient has risk factors suggesting that they may lack medical decision-making capacity [2, 3]. Important risk factors include:

- Developmental delay
- Intellectual disability
- Alzheimer's disease and other forms of dementia or cognitive impairment
- Psychiatric illness (depression, bipolar disorder, schizophrenia, etc.)
- Residence in a skilled nursing facility (SNF)

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_43

- Parkinson's disease
- Hospitalization for medical illness
- Diagnosis of brain tumor or traumatic brain injury

Note, however, that a significant percentage of patients with these risk factors will possess decision-making capacity.

PREOPERATIVE EVALUATION

A PREOPERATIVE EVALUATION MAY REVEAL THAT A PATIENT HAS DEMENTIA OR IS AT RISK OF DEMENTIA. DO THESE PATIENTS ALWAYS LACK DECISION-MAKING CAPACITY?

No. Measures of cognitive function such as the Mini-Mental Status Examination (MMSE) can help you decide if a formal evaluation is needed as it correlates with decision-making capacity at high scores (>24 indicates that the patient is more likely to have capacity) and low scores (<20 indicates that the patient is less likely to have capacity). However, patients with low scores may still possess decision-making capacity, and patients with high scores may lack it. MMSE scores between 20 and 24 have no effect on the likelihood that the patient has decision-making capacity [1, 3, 5]. Having insight into one's diagnosis of dementia and presence of memory problems are positively correlated with intact decisional capacity [4].

Decision-making capacity is influenced by time and situation [1–3]. For example, a patient may lack capacity while suffering from delirium, but regain full decision-making capacity when recovered from acute illness. Of note, given the waxing and waning nature of delirium, patients may have decisional capacity during episodes of clearer mental status. Consent in these situations should attempt to include both the surrogate and the patient.

Patients may also have limited decision-making capacity, depending upon the complexity of and the risks associated with the decision to be made. For example, a patient may have the capacity to make choices regarding diet, but lack capacity to elect major surgery with the attendant morbidity and mortality risks.

During the preoperative evaluation, it is important to elicit the patient's values and preferences regarding their medical care. This is also an opportunity to identify surrogate decision-makers in advance of any potential loss of capacity in the postoperative period.

PERIOPERATIVE MANAGEMENT

HOW DO I DETERMINE IF MY PATIENT HAS DECISION-MAKING CAPACITY? [1, 3]

The provider must determine if the patient demonstrates the following four elements:

1. Understand relevant information (risks/benefits/alternatives) regarding a proposed test or a treatment as well as the consequences of no treatment
2. Appreciate the current situation and anticipated outcomes
3. Manipulate information rationally
4. Communicate a choice that is stable over time

It should be emphasized that while patients must demonstrate the ability to reason and communicate in order to make their own medical decisions, they are NOT required to make what the healthcare provider considers a "good" decision. In addition, take care to exclude the possibility of "pseudo-incapacity." Pseudo-incapacity is the inappropriate determination of incapacity due to a provider's excessive use of medical jargon or information, or a provider's use of a communication strategy that does not appreciate language barriers or allow sufficient time for discussion and questions [3]. Patient and provider risk factors for pseudo-incapacity include:

- Impairment of vision or hearing
- Native language other than the provider's language
- Low literacy and/or low health literacy
- Lack of provider training or skill in cultural literacy

WHAT TOOLS ARE AVAILABLE TO HELP ASSESS THE DECISION-MAKING CAPACITY OF PATIENTS?

If the patient does not demonstrate the aforesaid four elements of decision-making capacity, the Aid to Capacity Evaluation (ACE) is one of many available tools that can be performed within 30 minutes, has been validated against a clinical gold standard, has a reasonable level of evidence to support its use, and is available online for free: http://www.jcb.utoronto.ca/tools/ace_download.shtml [3, 6, 7].

Other advantages of this tool include the availability of free training materials, its focus on the actual decision to be made by your patient, and its facilitation of clinical documentation [2, 3, 7]. If the capacity assessment is complex, consider involving an appropriate specialty consultant or ethics committee [1–3].

WHAT SHOULD I DO IF MY PATIENT LACKS DECISION-MAKING CAPACITY?

If a patient is found to lack capacity, identify and treat any reversible contributing causes [1–3]. Potentially thought-altering medications, such as opiates or benzodiazepines, should NOT be withheld for the purposes of obtaining consent, as long as they are being administered properly and for an appropriate indication; withholding them can be construed as coercive. Moreover, pain and anxiety can actually contribute to incapacity, if left untreated. Strategies to optimize potential for improving capacity [3, 8] include:

- Address reversible causes: Pain, fever, hypoxemia, uremia, sedation, delirium, psychosis, undiagnosed depression
- Optimize potential to improve thought processing and communication: For example, evaluate medication timing and dosing in patients with Parkinson's disease
- Optimize visual/hearing impairments with assistive devices
- Speak in plain language
- Shorten or simplify information
- Use proper translation and interpretation services
- Use diagrams and other communication tools
- Engage family members and caregivers: Acknowledge that fear, anxiety, and the illness itself can affect capacity
- Obtain collateral information from friends and family: This can be helpful in determining capacity
- Use teach-back methods
- Allow sufficient time and space for discussion, questions, and decision-making
- Repeat the evaluation

WHAT IF MY PATIENT LACKS CAPACITY DESPITE ADDRESSING POTENTIALLY REVERSIBLE CONDITIONS?

What to do if incapacity is established varies by state and typically involves identification of an appropriate surrogate decision-maker or a guardian. Advance directives from the patient, if applicable, should be executed. In case of true emergency (and no appropriate directive or surrogate is available), it is generally acceptable to provide the evaluation and/or treatment to which a "reasonable person" would have consented [1]. Note that in some areas, surrogate decision-makers cannot legally give consent for certain "high-stakes" treatments, such as sterilization, amputation, or electroconvulsive therapy; in these cases, a court order may be required.

KEY CLINICAL PEARLS

- Decision-making capacity is usually presumed to be intact but incapacity is frequently missed.
- Decision-making capacity is specific to time and situation. To have intact capacity, a patient must be able to:
  - Understand relevant information (risks/benefits/alternatives) regarding a proposed test or a treatment as well as the consequences of no treatment.
  - Appreciate the current situation and anticipated outcomes.
  - Manipulate information rationally.
  - Communicate a choice that is stable over time.

ACKNOWLEDGMENTS

Suzanne B. Murray, MD; Associate Professor, Department of Psychiatry and Behavioral Sciences, University of Washington

REFERENCES

1. Applebaum PS. Assessment of patients' competence to consent to treatment. N Engl J Med. 2007;357:1834–40.
2. Etchells E, Sharpe G, Elliott C, Singer PA. Bioethics for clinicians: 3. Capacity. CMAJ. 1996;155:657–61.
3. Sessums LL, Zembrzuska H, Jackson JL. Does this patient have medical decision-making capacity? JAMA. 2011;306:420–427.
4. Merel SE, Murray SB. Decisional capacity. Scheurer D, editor,. Hosp Med Clin. 2013;2:e263–73. https://doi.org/10.1016/j.ehmc.2012.10.002.
5. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state": a practical method for grading the cognitive state of patient for the clinician. J Psychiatr Res. 1975;12:189–98.
6. Etchells E, Darzins P, Silberfeld M, et al. Assessment of patient capacity to consent to treatment. J Gen Intern Med. 1999;14(1):27–34. https://doi.org/10.1046/j.1525-1497.1999.00277.x.
7. Community tool: Aid to capacity evaluation (ACE). University of Toronto Join Centre for Bioethics. http://www.jcb.utoronto.ca/tools/ace_download.shtml. Accessed 10 Oct 2018.
8. Fields LM, Calvert JD. Informed consent procedures with cognitively impaired patients: a review of ethics and best practices. Psychiatry Clin Neurosci. 2015;69:462–71. https://doi.org/10.1111/pcn.12289.

Chapter 44
Perioperative Care of Elderly Patients

Sabeena Setia, Mehraneh Khalighi, and George Alec Rooke

BACKGROUND

The effect of aging on surgical risk is difficult to quantify. Frailty is a much more useful concept to help assess surgical risk in older patients. Frailty refers to the state of diminished physiological reserve across multiple organ systems that leads to an overall increased vulnerability to stress [1]. Comorbidities and age strongly interact to increase the rate of perioperative complications with the effect of comorbidities becoming more pronounced with increasing age. Frail individuals are less able to adapt to and recover from stressors such as acute illness or trauma and are more vulnerable to adverse health outcomes including procedural complications, falls, institutionalization, disability, and death [2, 3]. There is no "gold standard" for detecting frailty, but many different frailty screening tools have been developed to identify patients at increased risk for adverse outcomes. The American College of Surgeons and the American Geriatrics Society recommend that a frailty assessment be part of the preoperative process for older surgical patients [4].

The prevalence of frailty is difficult to assess because of lack of a standardized screening tool. Population studies estimate the prevalence of frailty in the United States to range from 4% to 16% in men and women aged 65 and older. The prevalence of frailty increases with age; 10% of those aged 65–75 years are considered frail compared to 40% of those 80 years and older [5]. In older patients with cancer, prevalence of frailty is estimated to be >40%. The number of persons aged 65 or older rose 16% from 2010 to 2016 and comprised 15.2% of the population in 2016 [6].

As the population ages, increasing numbers of frail patients are requiring surgery and other interventions. Frailty has a strong

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_44

association with adverse surgical outcomes, increased postoperative length of stay (LOS), and 30-day readmission as well as increased postoperative mortality [7, 8]. Frail patients are more likely to be discharge to a skilled nursing facility. Although there is no single frailty screening tool that is considered the "gold standard," the original frailty phenotype identified by Fried [9] provides a solid framework for robust frailty assessment and is the basis of most frailty tools currently in use. The challenge remains in how to modify frailty and what preoperative interventions may improve outcomes in this high-risk population.

PREOPERATIVE EVALUATION

Various tools have been developed to measure frailty and surgical risk. These range from single measures of function such as grip strength or Timed Up and Go (TUG), multi-domain indices such as the Edmonton score, and detailed comprehensive geriatric assessments that include measures of cognitive ability [10–12] (Table 44.1). The targeted geriatric assessment (TaGA) is a recently validated instrument to measure frailty which promises practical and efficient comprehensive screening for frailty [13]. However, the predictive value of the TaGA and its effect on surgical outcome is not known and the assessment may be cumbersome to perform. The FRAIL scale is a relatively newer tool that, although requires further study, shows promise in predicting frailty [14]. Based on the original Fried phenotype, this tool incorporates functional status, deficit accumulation, and comorbidities. It is easy to administer by nonmedical staff, can be filled out by a patient, and can measure degrees of frailty in a dose-response fashion. We recommend the FRAIL scale [15] (Table 44.2) as an easy-to-use tool that has strong validity evidence [16].

PREOPERATIVE HISTORY AND PHYSICAL EXAMINATION

In addition to the standard preoperative evaluation, attention should be given to the following issues:

- History of surgical or anesthetic complications.
- Identifying patients with likely diastolic dysfunction from echocardiography or a history of "heart failure" after surgery.
- Nutritional status: Calculate body mass index (BMI) and document unintended weight loss >10–15% within 6 months (see Chap. 19).

TABLE 44.1 TOOLS TO MEASURE FRAILTY

Method of measuring frailty	Impact of frailty on surgical outcome	Surgical population studied	Authors
Grip strength	Increased postoperative complications Increased LOS	All ages Elective major abdominal surgery	Klidjian et al. [10]
Timed Up and Go (TUG)	Increased postoperative complications and 1-year mortality	Elective colorectal and cardiac ≥65 years old	Mathias et al. [11]
7 Frailty traits: TUG ≥ 15 sec Katz score ≤ 5 Mini-Cog ≤ 3 Charlson index ≥ Hematocrit < 35% Albumin < 3.4 Falls score > 1	Increased postoperative complications, increased length of stay (LOS), higher 30-day readmission rates	Elective colorectal or cardiac surgery	Robinson et al. [12]
Edmonton frail scale Cognition General health Functional independence Social support Medication use Nutrition Mood Continence Functional performance	Postoperative complications Prolonged LOS Increased rate of institutionalization	≥70 years old Lower limb orthopedic surgery Spinal surgery Abdominal surgery Vascular surgery	Dasgupta et al. [2]
Fried criteria Weight loss Decreased grip strength (weakness) Exhaustion Low physical activity Slowed walking speed	Postoperative complications Prolonged LOS New institutionalization at discharge	≥65 years old Elective surgery (major and minor)	Makary et al. [9]

Adapted with permission from Oxford University Press on behalf of the British Geriatrics Society [1]

TABLE 44.2 FRAIL SCALE

*F*atigue	Are you fatigued? (yes = 1 point)
*R*esistance	Can you climb 1 flight of stairs? (no = 1 point)
*A*mbulation (or aerobic)	Can you walk one block or several hundred yards? (no = 1 point)
*I*llnesses	Do you have more than 5 serious illnesses[a]? (yes = 1 point)
*L*oss of weight	Have you lost more than 5% of your weight in the past year? (yes = 1 point)

Adapted with permission from Elsevier [3]
Scoring: ≥3 points = FRAIL, 1–2 points = prefrail, 0 points = not frail
[a]Illnesses: For 11 illnesses, participants are asked, "Did a doctor ever tell you that you have [illness]?" 1 = yes, 0 = no. The total illnesses (0–11) are recoded as 0–4 = 0 and 5–11 = 1. The illnesses include hypertension, diabetes, cancer (other than a minor skin cancer), chronic lung disease, heart attack, congestive heart failure, angina, asthma, arthritis, stroke, and kidney disease

- Functional capacity and performance status: Document deficits in vision, hearing, or swallowing; and document history of falls ("Have you fallen in the past year?").
- Cognitive function: If suspicious of poor baseline cognitive function, perform Mini-Cog screen (or a full cognitive assessment [e.g., MOCA or MMSE] if the patient has known cognitive dysfunction or memory impairment, to document patient's baseline status).
- Frailty: Among patients with multiple chronic diseases, consider additional quantification of functional impairment using a frailty assessment tool such as the FRAIL scale (Table 44.2).
- Identifying alcohol and substance use: Among patients 65 years or older, the prevalence of binge drinking is as high as 14.5% among men and 3.3% among women [17].
- Use of multiple psychoactive medications.
- Sleep disturbances.

PREOPERATIVE LABS AND STUDIES

- Consider screening for anemia in elderly patients, particularly those undergoing operations in which significant blood loss is expected, and in patients who have symptoms suggestive of severe anemia.
- Obtain renal function tests in all elderly patients; particularly important groups to screen include those undergoing high-risk

surgery, patients with diabetes cardiovascular disease, or those using angiotensin-converting enzyme inhibitors (ACE-I), diuretics, or nonsteroidal anti-inflammatory drugs (NSAIDs).
- Consider checking serum albumin as a marker of frailty.
- See Chap. 3 for recommendations on obtaining preoperative electrocardiogram (ECG); consider this in some patients over the age of 70, as finding a significant abnormality on ECG may influence risk assessment and will provide a baseline to help interpret changes postoperatively. Importantly, recognize that most elderly patients will have age-related ECG abnormalities that will not change perioperative management.

ORGAN SYSTEM-SPECIFIC RISKS IN THE ELDERLY

The medicine consultant should anticipate problems and complications and help outline a plan to prevent them. Specific considerations include the following:

- Increased risk of underlying coronary artery disease (CAD) including multivessel CAD; risk is greatest beyond 70 years of age.
- Decreased ability to tolerate extremes of volume status due to prevalence of diastolic dysfunction.
- Increased risk of renal drug toxicity; glomerular filtration rate (GFR) is reduced by approximately 10% per decade and should be assessed pre- and postoperatively in the elderly.
- Increased risk of delirium due to cognitive dysfunction, age, polypharmacy, poor nutrition, electrolyte abnormalities, hearing/vision impairment, depression, sleep deprivation, and multiple comorbidities.
- Increased risk of pulmonary complications, due to small airway collapse from a loss of lung tissue elasticity, increased work of breathing due to increased chest stiffness and a barrel chest, and risk of aspiration from impaired swallowing and diminished airway protective reflexes.
- Higher risk of atelectasis, hypoxia, pneumonia, respiratory failure, prolonged ventilation, silent aspiration, and pneumonia (see Chap. 32).

The stress of the proposed surgery must also be considered, especially if large fluid requirements are expected due to hemorrhage or third spacing. Recuperation time is typically longer in older patients and could represent an unacceptably high percentage of expected remaining life span. Less stressful palliative procedures may need to be considered. Remember that the goals of surgery are often different for elderly patients, where there is greater concern for preservation of function and independence rather than a focus on prolongation of life.

PERIOPERATIVE MANAGEMENT

PREOPERATIVE MANAGEMENT

Once the decision is made to proceed with surgery, efforts should be made to prevent common complications in this age group. Although frailty indices may help to identify patients at higher risk, the challenge lies in whether this risk can be modified. Comprehensive geriatric assessments (CGA) and multidisciplinary geriatric interventions implemented preoperatively have been shown to reduce complications, including delirium, pneumonia, delayed mobilization, and length of stay in various surgical populations including oncology, orthopedic, and cardiothoracic patients [18, 19].

Preoperative exercise programs ("prehabilitation") with the goal of improving strength and functional ability have also shown some benefit but need further study [20–22]. These interventions require coordination by a comprehensive care team, including geriatricians, physical therapists, and social workers – medicine consultants should explore what resources are available at their respective institutions. At a minimum, the medicine consultant should coordinate with the patient's primary care provider to discontinue nonessential medications preoperatively and prepare the patient and family for the likely postoperative rehabilitation course. Frank and open communication with the surgery team regarding the appropriateness of alternate procedures, surgery-specific risks, and expected recovery time is essential in anticipating complications. The medical consultant, the primary care physician, and the surgeon should ideally reach consensus about the necessity, expected risks, and outcomes of the proposed procedure. Ultimately, shared medical decision-making will allow the patient and physician to develop a well-informed consent process and realistic expectations around surgical interventions [23].

POSTOPERATIVE MANAGEMENT

Minimize the Risk of Delirium (See Chap. 53)

- Encourage family to stay at bedside and overnight if possible.
- Avoid anticholinergics and antihistamines.
- Avoid benzodiazepines, unless absolutely necessary or part of the patient's home regimen.
- Narcotics and sleep agents should be administered with caution.

- Minimize polypharmacy in general – see updated Beers criteria for medications that should be avoided [24].
- Ensure adequate quiet during sleep hours by clustering care as possible overnight.
- Frequent reminders for orientation.

Optimize Pain Management (See Chap. 55)

Postoperative pain increases the risk of adverse outcome in elderly patients by contributing to cardiac ischemia, tachycardia, hypertension, hypoxemia, and delirium. Pain is often undertreated in the elderly out of concern for risks associated with opiates, including delirium and constipation. In conjunction with pain management services, the medicine consultant should make specific recommendations regarding analgesia:

- Avoid meperidine.
- Consider adjunctive therapies such as acetaminophen, gabapentin, lidocaine or capsaicin patches, and local or regional anesthesia.
- Avoid NSAIDs in most cases.

Other Measures Likely to be Salutary in the Elderly

- Aggressive pulmonary toilet and aspiration precautions to prevent pulmonary complications.
- Aggressive prevention and treatment of constipation with routine stool softeners and encouraging oral hydration when possible.
- Frequent checks for signs of pulmonary congestion, especially on post-op day 2 or 3 when third space fluid is mobilized.
- Minimize the introduction of new medications to decrease risk of polypharmacy.
- Follow renal function.
- Having family members at bedside throughout patient's hospital stay.

KEY CLINICAL PEARLS

- *Patients over the age of 65 undergoing elective surgery should be screened for frailty*.
- There are multiple validated frailty instruments that can predict outcomes in the at-risk elderly patients.

- The FRAIL scale based on the Fried criteria is a very simple and useful tool to predict frailty in the surgical population
- Careful evaluation for alcohol and substance use as well as review of mental health history during preoperative evaluation can help estimate risk for delirium and other postoperative complications.

REFERENCES

1. Partridge JS, Harari D, et al. Frailty in the older surgical patient: a review. Age Ageing. 2012;41(2):142–147.
2. Dasgupta M, Rolfson DB, et al. Frailty is associated with postoperative complications in older adults with medical problems. Arch Gerontol Geriatr. 2009;48(1):78–83.
3. Morley JE, Vellas B, et al. Frailty consensus: a call to action. J Am Med Dir Assoc. 2013;14:392–7.
4. Chow WB, Rosenthal RA, et al. Optimal preoperative assessment of the geriatric surgical patient: a best practices guidelines from the American College of Surgeons National Surgical Quality Improvement Program and the American Geriatrics Society. J Am Coll Surg. 2012;215(4):453–466.
5. Collard RM, Boter H, et al. Prevalence of frailty in community-dwelling older persons: a systematic review. J Am Geriatr Soc. 2012;60(8):1487–92.
6. United States Census Bureau: quick facts United States. https://www.census.gov/quickfacts/fact/table/US.
7. Census Bureau QuickFacts. (2019). U.S. Census Bureau QuickFacts: United States. [online]. Available at: https://www.census.gov/quickfacts/fact/table/US. Accessed 11 July 2019.
8. McIsaac DI, Bryson GL, et al. Association of frailty and 1-year postoperative mortality following major elective noncardiac surgery: a population-based cohort study. JAMA Surg. 2016;151(6):538–45.
9. Makary MA, Segev DL, et al. Frailty as a predictor of surgical outcomes in older patients. J Am Coll Surg. 2010;210(6):901–8.
10. Klidjian AM, Foster KJ, et al. Relation of anthropometric and dynamometric variables to serious postoperative complications. Br Med J. 1980;281:899–901.
11. Mathias S, Nayak US, et al. Balance in elderly patients: the "get-up and go" test. Arch Phys Med Rehabil. 1986;67(6):387–9.
12. Robinson TN, Wu DS, et al. Slower walking speed forecasts increased postoperative morbidity and one-year mortality across surgical specialties. Ann Surg. 2013;258(4):582–90.
13. Aliverti M, Apolinario D, et al. Targeted geriatric assessment for fast-paced healthcare settings: development, validity, and reliability. J Am Geriatr Soc. 2018;66(4):748–54.
14. Chong E, Ho E, et al. Frailty in hospitalized older adults: comparing different frailty measures in predicting short- and long-term patient outcomes. J Am Med Dir Assoc. 2018;19(5):450–457.e3.
15. van Kan GA, Rolland Y, et al. The I.A.N.A task force on frailty assessment of older people in clinical practice. J Nutr Health Aging. 2008;12(1):29–37.
16. Kojima G. Frailty defined by FRAIL scale as a predictor of mortality: a systematic review and meta-analysis. J Am Med Dir Assoc. 2018;19(6):480–3. https://doi.org/10.1016/j.jamda.2018.04.006.
17. Blazer DG, Wu LT. The epidemiology of at-risk and binge drinking among middle-aged and elderly community adults: national survey on drug use and health. Am J Psychiatry. 2009;166(10):1162–9.
18. Dewan SK, Zheng SB, Xia SJ. Preoperative geriatric assessment: comprehensive, multidisciplinary and proactive. Eur J Intern Med. 2012;23(6):487–94.
19. Harari D, Hopper A, et al. Proactive care of older people undergoing surgery ("POPS"): designing, embedding, evaluating and funding a comprehensive geriatric assessment service for older elective surgical patients. Age Ageing. 2007;36(2):190–6.
20. Cheema FN, Abraham NS, et al. Novel approaches to perioperative assessment and intervention may improve long-term outcomes after colorectal cancer resection in older adults. Ann Surg. 2011;253(5):867–74.

21. Mayo NE, Feldman L, et al. Impact of preoperative change in physical function on postoperative recovery: argument supporting prehabilitation for colorectal surgery. Surgery. 2011;150(3):505–14.
22. Valkenet K, Van de Port IG, et al. The effects of preoperative exercise therapy on postoperative outcome: a systematic review. Clin Rehabil. 2011;25(2):99–111.
23. Alvarez-Nebreda ML, Bentov N, et al. Recommendations for preoperative management of frailty from the Society for Perioperative Assessment and Quality Improvement (SPAQI). Periop Care Oper Room Manag. 2018;10:1–9.
24. Fick D, Semla T, et al. American Geriatrics Society updated Beers criteria for potentially inappropriate medication use in older adults. J Am Geriatr Soc. 2012;60(4):616–31.

Chapter 45
Care of Transgender Individuals

Alexander Pratt and Molly Blackley Jackson

BACKGROUND

Transgender (trans) people experience many challenges in health-care settings, including difficulty accessing care and discrimination from health-care personnel [1]. Providers who care for trans individuals perioperatively can improve patient care by developing an awareness of the challenges that trans patients experience in health-care settings, knowing and using appropriate terminology, and providing appropriate recommendations regarding perioperative management for patients on hormonal therapy. Some suggestions for best practices in care are included in Table 45.1.

The term "gender identity" refers to an individual's internal sense of self as female, male, neither, both, or some other gender [2]. "Gender identity" may or may not reflect the biological sex assigned at birth. The term "transgender" is used to describe individuals whose gender identity is incongruent with the gender typically associated with their biological sex.

- A transgender woman (or transwoman) was assigned male sex at birth but identifies as a woman.
- A transgender man (or transman) was assigned female sex at birth but identifies as a man.
- Some individuals have a gender identity that is not the traditional binary of male and female, encompasses both, or may change over time; these individuals may identify as gender fluid or genderqueer.
- The term "trans" encompasses all non-binary genders, or gender nonconforming identities, and will be used throughout this chapter.

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_45

TABLE 45.1 CONSIDERATIONS FOR HEALTH-CARE PROVIDERS: CARING FOR TRANSGENDER PEOPLE

Learn if your medical record has a location for name, gender identity, and pronouns. Err on the side of respect and double check with your patient
When addressing any patient for the first time, respectfully ask your patient how they prefer to be addressed (e.g., *"What name and pronouns do you use?"*). Make sure your other staff members are also aware
Until you know your patient's name and pronouns, use gender-neutral terminology, such as *"We are ready for you in room 3" (instead of "Miss, we are ready for you in room 3")*
When taking a medical history, recognize that trans people (like all people) can have any sexual orientation (heterosexual, gay, bisexual, etc.). Do not assume the gender of your patient's partner(s)
Recognize that many trans individuals lack trust in the health-care system; build trust by demonstrating humility and a commitment to your patient and their health. Apologize if you make a mistake of terminology or otherwise

BASICS OF HORMONE THERAPY FOR TRANSGENDER PEOPLE

Sex hormone therapy for transgender women (if used) includes antiandrogen agents and exogenous estrogen agents. Antiandrogens suppress the effects of testosterone and its effects on masculine human features, such as facial hair growth. Typical antiandrogens include spironolactone, finasteride, and cyproterone acetate; these inhibit secretion of testosterone and its action at testosterone receptors. Should a transwoman elect to have gonadectomy, antiandrogens may be discontinued. Estrogen therapy both suppresses endogenous androgen secretion and causes body changes such as breast growth and muscle/fat redistribution. Typical regimens include transdermal estrogen, oral formulations (17-beta estradiol or conjugated estrogens), or parenteral estrogen (estradiol valerate or cypionate). Oral ethinyl estradiol should no longer be used as it is associated with a prohibitively increased risk of cardiovascular death and venous thromboembolism (VTE).

Sex hormone therapy for transgender men consists of exogenous testosterone, which suppresses estrogen's effects leading to body changes associated with masculinity. Testosterone comes in many available

preparations, including depot injections, cutaneous gels, buccal tablets, or parenteral therapy. Transmen may elect to have oopherectomy or hysterectomy – this does not necessarily affect their testosterone therapy, though after oophorectomy continuing testosterone has the benefit of preventing osteoporosis and maintaining virilization.

All trans people are subject to unique adverse effects of hormone therapy and require routine monitoring for hormone levels and the presence of side effects. For the purposes of this chapter, we will focus on adverse effects that meaningfully affect perioperative management.

PREOPERATIVE EVALUATION

- Several studies have shown an association between both estrogen- and testosterone-based therapy and changes in biochemical markers associated with the development of cardiovascular disease or related conditions, but there is a paucity of high-quality evidence suggesting a direct link between hormone therapy and cardiovascular disease [3–8].
- Trans patients on hormone therapy should therefore receive usual care for preoperative cardiac evaluation, including a careful history and exam for signs or symptoms of cardiovascular disease, but no additional preoperative testing (such as laboratory evaluation, EKG, or other imaging) is recommended based on the use of hormone therapy alone.

PERIOPERATIVE MANAGEMENT

TRANSGENDER WOMEN RECEIVING ESTROGEN THERAPY

Estrogen therapy is strongly associated with venous thrombosis [9]. The theoretical mechanism of action is an acquired resistance to activated protein C that leads to a disruption in normal functioning of serum coagulation factors [9, 10]. This effect is synergistic with other pro-thrombotic factors such as smoking, immobility, and the presence of inherited hypercoagulability. Rigorous, large-cohort randomized clinical trials done on women receiving oral contraceptive pills (OCPs) and postmenopausal hormone replacement therapy (HRT) have shown a definitive link between exogenous estrogen use and the risk of VTE [10–12].

- Expert opinion suggests discontinuation of estrogen therapy 2–4 weeks prior to any major surgery, including sexual reassignment surgery (SRS). It should not be resumed until full mobilization, which is usually at least 3 weeks from surgery [8, 9].
- Transwomen that remain on hormone therapy at the time of surgery should receive usual VTE prophylaxis (typically with low-molecular-weight heparin or unfractionated heparin at prophylactic doses) during hospitalization or while less mobile, and providers should remain vigilant for VTE given the increased risk in these individuals.

TRANSGENDER MEN RECEIVING TESTOSTERONE THERAPY

- There are potential risks that may affect surgical candidacy in patients receiving exogenous testosterone therapy (polycythemia, increased coronary disease risk), but no data to suggest those on testosterone require any additional perioperative evaluation.
- Transgender men do not need to stop testosterone therapy perioperatively.

KEY CLINICAL PEARLS

- Trans people experience discrimination and face challenges accessing health care, and many health-care providers are not knowledgeable or experienced in caring for trans people. Perioperative providers can improve care by educating themselves about the challenges that trans patients experience in health-care settings, engaging with transgender patients with respect, and learning and using preferred names and pronouns.
- Trans patients receiving hormone therapy with known or intermediate-high risk of cardiovascular disease should receive perioperative risk assessment and workup similar to non-transgender patients at similar risk.
- Expert opinion suggests that estrogen therapy should be discontinued 2–4 weeks prior to any major surgery and should not be resumed until full mobilization.
- Transgender individuals who take testosterone therapy do not need to stop this medication perioperatively.

ACKNOWLEDGEMENTS

Jennifer Wright, MD, Associate Professor, Department of Medicine, University of Washington School of Medicine
Tyra Fainstad, MD, Clinical Instructor, Department of Medicine, University of Washington School of Medicine
Kamala Jain, MD, Clinical Associate Professor, Department of Medicine, University of Washington School of Medicine

REFERENCES

1. Jaffee KD, Shires DA, Stroumsa D. Discrimination and delayed health care among transgender women and men: implications for improving medical education and health care delivery. Med Care. 2016;54(11):1010–6.
2. The National LGBT Health Education Center. www.lgbthealtheducation.org.
3. Wierckx K, et al. Long-term evaluation of cross-sex hormone treatment in transsexual persons. J Sex Med. 2012;9:2641–51.
4. Canonico M, et al. Hormone replacement therapy and risk of venous thromboembolism in postmenopausal women: systematic review an meta-analysis. BMJ. 2008;336:1227.
5. Gooren L, et al. Long-term treatment of transsexuals with cross-sex hormones: extensive personal experience. J Clin Endocrinol Metabol. 2008;93(1):19–25.
6. Elamin M, et al. Effect of sex steroid use on cardiovascular risk in transsexual individuals: a systematic review and meta-analyses. Clin Endocrinol. 2010;72:1–10.
7. Maraka S, et al. Sex steroids and cardiovascular outcomes in transgender individuals: a systematic review and meta-analysis. J Clin Endocrinol Metab. 2017;102(11):3914–23.
8. Asscheman H, et al. A long-term follow-up study of mortality in transsexuals receiving treatment with cross-sex hormones. Eur J Endocrinol. 2011;164(4):635–42.
9. Asscheman H, et al. Venous thromboembolism as a complication of cross-sex hormone treatment of male-to-female transsexual subjects: a review. Andrologia. 2014;46:791–79.
10. Lidegaard O, et al. Risk of venous thromboembolism from use of oral contraceptives containing different progestogens and estrogen doses: Danish cohort study, 2001-9. BMJ. 2011;343:d6423.
11. Canonico, et al. Hormone replacement therapy and risk of venous thromboembolism in postmenopausal women: systematic review and meta-analysis. BMJ. 2008;336:1227.
12. Seim LA, Irizarry-Alvarado JM. Perioperative management of female hormone medications. Curr Clin Pharmacol. 2017;26:188–93.

Chapter 46
Solid Organ Transplant

Christopher J. Wong

BACKGROUND

The solid organ transplant recipient presents a unique challenge to the perioperative medicine consultant. Solid organ transplant recipients are living longer, increasing in number, and frequently undergo surgery that is unrelated to their transplant [1]. Concerns for perioperative complications in this patient population include the development of graft dysfunction as well as the potential for infectious complications due to immunosuppression. The data supporting these risks is varied. For example, in abdominal solid organ transplant recipients (liver, kidney, pancreas) undergoing cardiac surgery, smaller case series and case-control studies showed varying outcomes, while a larger study of 3535 patients demonstrated increased in-hospital mortality and incidence of acute renal failure, but no increase in infection [2]. One small series of solid organ transplant recipients undergoing diverticular surgery showed similar risk to non-transplant patients if the procedure was elective, but higher risk if urgent [3].

PREOPERATIVE EVALUATION

While prospective data are lacking, individual operative risk likely depends on the surgical complexity, degree of immunosuppression, and graft function. A basic transplant history should be obtained by the medicine consultant (see Table 46.1). There are often organ-specific peri-operative issues that are not typically encountered by a generalist physician. For example, for heart transplant patients:

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_46

TABLE 46.1 BASIC TRANSPLANT HISTORY

Information	Example
Transplanted organ, indication, and date of transplant	*Liver transplant for hepatitis C cirrhosis 3 years ago*
Status of transplanted organ:	
Current function	*Transaminases, liver synthetic function (bilirubin, prothrombin time/International Normalized Ratio (INR), albumin), creatinine* *Last liver biopsy*
Presence of recurrent disease in the transplanted organ	*Recurrent hepatitis C successfully treated with antiviral therapy 1 year ago*
Prior episodes of rejection and increased immunosuppression	*One episode of rejection 2 years ago, treated with pulse steroids*
Function of other organs that may be affected by immunosuppressive regimen or transplanted organ dysfunction	*Chronic kidney disease from calcineurin inhibitor (tacrolimus)*

- Resting heart rates are often high because of absent vagal stimulation. However, the heart rate may further increase in response to rejection, inflammation, infection, and other stresses.
- Allograft vasculopathy, a form of coronary artery disease in heart transplant recipients, is a common complication. Allograft vasculopathy does not often present with angina because of the transplanted heart's denervation; the transplant cardiologist typically monitors for this via routine cardiac catheterization or stress testing. It is best to consult with the transplant team prior to moderate- to high-risk surgical procedures and to be aware postoperatively that myocardial ischemia may not present with typical chest pain.

Lung transplant–specific evaluations include:

- Preoperative assessment of lung function by history, exam, and spirometry.
- Symptoms of dyspnea or cough, or decrease in spirometry, should be evaluated prior to elective surgery, as they may be indicators of chronic infection or the chronic rejection syndrome bronchiolitis obliterans.

Kidney transplant–specific considerations include:

- The transplanted kidney is usually in the lower pelvis, palpable on exam. If pre-transplant therapy included renal replacement

therapy, then the patient may still have an arterio-venous fistula.
- Renal function is usually monitored by serum creatinine and urine protein monitoring. BK virus, associated with graft dysfunction, may also be monitored by the renal transplant specialist.

It is usually best to confer with the patient's transplant provider if there is any question as to how adequately prepared the patient is for surgery. Other key elements of the pre-operative evaluation include:
- Immunosuppressive regimen: Plan for perioperative management, especially if patients are expected to be allowed nothing by mouth (NPO) or require feeding tubes postoperatively. Consult with a pharmacist experienced with the care of transplant recipients.
- Corticosteroid use: Confirm the maintenance dose, ask about previous treatment with high-dose steroids for episodes of rejection, prior episodes of adrenal insufficiency with infection, or procedures.
- For higher risk surgeries or specific questions, involve the appropriate transplant/specialty service to evaluate the patient for a complete preoperative assessment, and plan for whether that specialist will need to follow the patient postoperatively.

PERIOPERATIVE MANAGEMENT

GRAFT FUNCTION

- Evaluate clinically for signs of graft dysfunction, which may include examination and laboratory monitoring (e.g., creatinine for renal transplant).
- Coordinate with the transplant specialist if there is any concern for graft dysfunction, or recommendations pertaining to the management of immunosuppression dosing and monitoring.

MEDICATION MANAGEMENT

- Consider supplemental ("stress") dose steroids when indicated (see Chap. 14).
- Continue all usual immunosuppressant medications, including on the morning of surgery.
- If the patient receives prophylactic medications against opportunistic infections, continue them.

- If NPO postoperatively, convert anti-rejection medications to IV. Table 46.2 shows general guidelines; consultation with a transplant pharmacist is recommended in most cases.
- Cyclosporine and tacrolimus have multiple drug interactions. A partial list is shown in Table 46.3. Review any new medication for possible interactions prior to starting it.

TABLE 46.2 COMMON ANTI-REJECTION MEDICATIONS: PO TO IV CONVERSION

Cyclosporine	Give 1/3 of total daily oral dose as continuous infusion over 24 hours (e.g., Usual dose of 75 mg oral 2 times daily Total dose is 150 mg 1/3 of total dose = 50 mg, can give as 2.1 mg/hours. IV infusion) Monitor levels daily Note-when converting back to oral cyclosporine, the common oral formulations Neoral® and Gengraf® are *not* equivalent to Sandimmune® and should not be substituted for one another. It is best to maintain the patient's usual formulation and consult with a transplant pharmacist
Mycophenolate	Note different PO forms: Mycophenolate mofetil (CellCept®, MMF) 500 mg = Mycophenolate sodium (Myfortic®) 360 mg IV and PO dose of CellCept generally considered equivalent
Tacrolimus (FK506)	Often not given IV due to difficulty in titrating the dose – must consult with transplant pharmacist and organ specialty service as appropriate. They may recommend using cyclosporine instead

TABLE 46.3 COMMON DRUG INTERACTIONS WITH CYCLOSPORINE AND TACROLIMUS

Increase TAC and CsA levels	Decrease TAC and CsA levels
Erythromycin	Rifampin
Azole antifungals	Phenytoin
Diltiazem	Phenobarbital
Verapamil	Carbamazepine
Metoclopramide	
Grapefruit juice	

TAC = tacrolimus, CsA = cyclosporine

- Consider monitoring immunosuppression in hospitalized patients to ensure therapeutic levels. While daily trough levels do not always need to be monitored for inpatients, patients in the postoperative setting often have conditions that may affect drug levels, including NPO status, change in renal function, and drug interactions. Consult with the transplant specialist if possible fluctuation in immunosuppressant drug levels is a concern.
- Note that healing may be impaired in immunosuppressed patients. Sirolimus (Rapamune®) may cause a higher risk of wound complications; while the surgical team should be alerted to this concern, any change in the immunosuppression regimen should be made in discussion with the prescribing transplant/specialty service.
- Non-steroidal anti-inflammatory drugs (NSAIDs) should generally be avoided in patients who are concurrently taking calcineurin inhibitors such as cyclosporine or tacrolimus, as the combination can increase renal toxicity.

INFECTION

- The immunosuppressed patient may not present with typical features of infection such as fever or leukocytosis.
- Patients who have well-functioning grafts greater than 6 months post-transplant tend to develop similar infections to patients without transplants. However, a poorly functioning graft or prior episodes of rejection are risk factors for opportunistic infections at any time [4].
- Infections may progress rapidly due to immunosuppression.
- Consultation with transplant team/infectious disease team is appropriate for the evaluation and treatment of serious or opportunistic infections. Adjustments in the antibiotic or immunosuppressant regimen may be required.

TRANSFUSION

- The use of blood products should be considered carefully. In addition to baseline risks of transfusion (see Chap. 20), transmission of unusual infections does occur and, while rare, may be underreported in solid organ transplant recipients [5]. Graft-versus-host disease (GVHD) is a rare complication that may occur in immunosuppressed hosts who receive blood products.
- If transfusion is required, leukocyte-reduced blood products are recommended to reduce the risk of transmission of cytomegalovirus (CMV) and other infections [5].

KEY CLINICAL PEARLS

- Check for interactions with immunosuppressant medications before prescribing any new medications.
- Assess graft function as part of the preoperative evaluation.
- Signs of infection may be blunted because of immunosuppression.

ACKNOWLEDGMENTS

Reena Julka, MD

REFERENCES

1. Kostopanagiotu G, Smyrniotis V, Arkadopolous N. Anesthetic and perioperative management of adult transplant recipients in nontransplant surgery. Anesth Analg. 1999;89:613–22.
2. Vargo PR, Schiltz NK, Johnston DR, Smedira NG, Moazami N, Blackstone EH, Soltesz EG. Outcomes of cardiac surgery in patients with previous solid organ transplantation (kidney, liver, and pancreas). Am J Cardiol. 2015;116(12):1932–8. https://doi.org/10.1016/j.amjcard.2015.09.036. Epub 2015 Oct 9.
3. Reshef A, Stocchi L, Kiran RP, et al. Case-matched comparison of perioperative outcomes after surgical treatment of sigmoid diverticulitis in solid organ transplant recipients versus immunocompetent patients. Color Dis. 2012;14:1546–52.
4. Pagalilauan GL, Limaye AP. Infections in transplant patients. Med Clin North Am. 2013;97(4):581–600.
5. Mezochow AK, Henry R, Blumberg EA, Kotton CN. Transfusion transmitted infections in solid organ transplantation. Am J Transplant. 2015;15(2):547–54. https://doi.org/10.1111/ajt.13006.

Chapter 47
Chronic Pain

Katherin Peperzak and Preetma Kooner

BACKGROUND

Patients with chronic pain are at risk for difficult to control postoperative pain with consequent pulmonary and cardiovascular complications, slow resolution of pain, prolonged length of stay, unplanned admission after ambulatory procedures, and chronic postsurgical pain [1, 2]. Patients on chronic opioid therapy can present a particular challenge as they tend to report higher pain scores (both resting and dynamic), and may require up to three times greater opioid or epidural dosages compared to opioid naïve patients undergoing similar procedures [2]. Careful planning and counseling preoperatively as well as a multimodal approach to acute pain management in the perioperative period can help to mitigate these risks by supporting appropriate patient expectations and reducing pain to a level that allows functional recovery.

PREOPERATIVE EVALUATION

The preoperative evaluation of chronic pain patients can be helpful to set the stage for a successful perioperative course, particularly for patients on long-term opioid therapy. In addition to gathering important information about the pain history, the provider can help manage expectations around likely pain control strategies and what constitutes successful acute pain management. Where available, consultation with a pain specialist is recommended for patients with a high risk of inadequately controlled pain such as those with opioid tolerance or history of substance use disorder [3].

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_47

KEY QUESTIONS

A complete pre-operative history can help reduce delays in good post-operative pain care while also addressing the patient's fears and anxiety related to pain management.

- What medications is the patient currently taking for pain?
- What precise dose of opioid is the patient taking and when?
- Does the patient's opioid use match what they are prescribed (as queried in state Prescription Monitoring Program or verified with their pharmacy)?
- What treatments have been successful or unsuccessful after previous procedures?
- What are the patient's expectations regarding pain management?
- Is the procedure expected to reduce pain? How likely is this?
- For patients on opioid therapy, will the surgeon be prescribing pain medication for a period of time or will the patient be following up with their chronic opioid prescriber?

PREOPERATIVE COUNSELING

Patients that have difficulty controlling pain prior to surgery are likely to have pain that is difficult to manage after surgery. In some elective cases, it may be worthwhile to postpone surgery until pain is better managed. If the patient has an untreated co-existing mood disorder or substance use disorder affecting their pain treatment, postponement may also be warranted (see Chap. 48). Assuming the patient proceeds with surgery the following counseling may be helpful:

- Emphasize that the goal of pain treatment post-operatively is to reduce pain to a tolerable enough level to facilitate recovery (e.g., able to participate in physical therapy, sleep adequately, etc.).
- Remind the patient that providers must be mindful of medication side effects and in some cases safety will limit treatment options (e.g., concern for respiratory depression with increasing opioid doses).
- Do not promise the patient a particular "pain score" or to be "pain free."
- Educate the patient about anticipated multimodal pain care: opioid and non-opioid medications, non-pharmacologic therapies, and regional/epidural anesthesia when appropriate – contact the surgical and anesthesiology teams if you are unsure of their plan.

- Consider providing information on non-pharmacologic techniques such as guided-imagery or relaxation techniques, as starting these modalities several days prior to surgery can reduce post-operative pain [3, 4].
- For patients on chronic opioid therapy, explain to the patient that they will receive instructions on how to taper opioids back to a target dose on discharge.

PREOPERATIVE MEDICATION MANAGEMENT

Although it is commonly recommended, there is not sufficient evidence to endorse reducing opioid doses prior to surgery for those on chronic therapy. Patients should continue to take their usual opioids prescription up through the morning of surgery to ensure they have met their baseline opioid requirement, especially if on high-dose long-acting products. Patients should also be instructed to take their usual non-opioid pain medications up until surgery, keeping in mind any instructions given by their surgeons regarding non-steroidal anti-inflammatory drug (NSAID) use as this class of medication may need to be held for several days (see Chap. 5).

If the patient has an intrathecal pump or spinal cord stimulator in place they should be advised to bring in any associated remote controls or chargers for the device. Additionally, verify with the patient when their intrathecal pump was last refilled to ensure they will have adequate medication to last through the hospitalization.

If the patient is on an unusual medication or medication not typically stocked at the hospital:

- The patient may wish to bring in their home supply that can then be administered by nursing per the individual hospital policy.
- Examples include certain opioid products such as tapentadol (Nucynta ©) and oxymorphone (Opana ©) or compounded oral or intranasal ketamine products.
- If the hospitalization is expected to be long, contact the hospital pharmacy to discuss whether a supply of the drug can be ordered ahead of time.
- Alternatively, counsel the patient that they may be provided with a different medication of similar potency and mechanism while hospitalized.

PERIOPERATIVE MANAGEMENT

The key to successful perioperative management of a patient with chronic pain is a multimodal approach including systemic pharmacologic management, procedural techniques, and nonpharmacologic cognitive and physical therapies, as summarized in Table 47.1.

SYSTEMIC PHARMACOLOGIC MANAGEMENT

Opioid medications are an important component of multimodal analgesia. Please refer to Chap. 56 for general considerations regarding

TABLE 47.1 COMPONENTS OF MULTIMODAL THERAPY

Systemic Pharmacologic Therapy
Opioids
NSAIDs
Acetaminophen
Gabapentin/pregabalin
IV ketamine infusion
IV lidocaine infusion
Procedural Techniques
Local anesthetic at incision
Intra-articular local anesthetic
Site-specific regional anesthesia block with local anesthetic
Epidural with local anesthetic ± opioid
Intrathecal opioid
Nonpharmacologic Cognitive Therapies
Guided-imagery
Relaxation
Hypnosis
Distraction
Music Therapy
Nonpharmacologic Physical Therapies
Transcutaneous electrical nerve stimulation (TENS)
Ice/Heat
Acupuncture
Massage
Continuous passive motion

opioid management. Special considerations for the opioid-tolerant population include:

- Standard starting doses should be tried prior to escalation; opioid-tolerant patients may ultimately require much higher doses than the typical patient.
- Long-acting opioids should be restarted at their usual dose and scheduled as the patient's baseline opioid requirement, as long as there is no concern for sedation or respiratory depression.
- Short-acting opioids or a Patient Controlled Analgesia (PCA) can be used in addition to long-acting opioids for acute pain.
- In patients on higher dose long-acting opioids who are unable to take any oral medications, a basal infusion may be considered (consultation with a pain specialist is recommended). Recall that this is NOT recommended in opioid naïve patients [5].
- Clarify with the surgical team, pain team, and primary care provider who is expected to prescribe opioids throughout recovery after discharge; often continuity providers prefer to see chronic pain patients in rapid follow-up and resume prescribing opioids.
- Make a specific plan for what opioids the patient should take from their home supply versus from any additional postoperatively prescribed opioids.

Scheduled acetaminophen and scheduled or prn NSAIDs should be considered whenever feasible. In most cases, the use of NSAIDs for up to two weeks postoperatively is reasonable [6, 7]. In addition, use of a gabapentinoid such as gabapentin or pregabalin can be advantageous. Please see Chap. 56 for details.

Intravenous ketamine and lidocaine infusions are also useful components of multimodal care for the opioid-tolerant population (although they can be used in opioid naïve patients as well). Ketamine is an NMDA antagonist. It has been shown to be analgesic, reduce opioid consumption, and prevent central sensitization in animal models. Ketamine-treated patients show better oxygen saturation and greater wakefulness. Side effects include nightmares and hallucinations; ketamine should be avoided in those with a history of psychosis, though these side effects are uncommon with typical doses used postoperatively. Ketamine can also cause tachycardia and hypertension at higher doses. It is usually run as infusion intraoperatively and continued postoperatively for patients who are opioid tolerant. In many institutions, ketamine or lidocaine may be started intraoperatively with continuation up to several days postoperatively, which typically requires the involvement of a consulting pain service. Lidocaine is particularly helpful in reducing the

duration of ileus as well as controlling post-operative pain in visceral surgeries [8]. Lidocaine should not be used in patients with known conduction block or in patients receiving continuous regional/epidural anesthesia. Lidocaine may rarely cause dizziness, seizures, and bradycardia.

PROCEDURAL TECHNIQUES

A variety of procedural techniques are used as components of multimodal pain treatment, ranging from infiltration with local anesthetic, neuraxial or regional blockade, or topical local anesthetics. Please see Chap. 56 for more details.

Patients with chronic pain are among those most challenging to manage and therefore may require more components of multimodal therapy than the typical patient. Be mindful that patients receive local anesthetics or opioids through only one route.

For example:

- If a peripheral nerve catheter is infusing local anesthetic, avoid a systemic lidocaine infusion.
- If an epidural catheter with local anesthetic and opioid is infusing, additional oral or parenteral opioids should be avoided.

Consult with a hospital pharmacist or anesthesiologist about concurrent use of topical local anesthetics with peripheral nerve/neuraxial catheter or lidocaine infusion.

NONPHARMACOLOGIC THERAPIES

Both cognitive and physical nonpharmacologic therapies should be encouraged throughout the perioperative course. Modalities such as guided-imagery, relaxation, and hypnosis may require preoperative education and training to obtain best results [3] but may also be employed without any preparation. Music and distraction techniques such as coloring books or crossword puzzles can easily be implemented postoperatively.

Among non-pharmacologic physical modalities, transcutaneous electrical nerve stimulation (TENS) has some of the best supporting evidence for efficacy. When applied around the surgical incision, patients using TENS units have significantly reduced postoperative analgesic use compared to sham TENS units [9]. TENS should typically be avoided in patients with pacemakers or implanted defibrillators. With all physical modalities including TENS, ice/heat, acupuncture, and massage caution should be taken to avoid areas of broken skin, rash, bleeding, or infection.

KEY CLINICAL PEARLS

- During preoperative visits, consider providing information on non-pharmacologic techniques such as guided-imagery or relaxation techniques.
- If the patient is on an unusual medication for pain, ask them or a family member to bring in their home supply or ask the hospital pharmacy to order the drug ahead of time.
- For patients chronically on long-acting opioids, the long-acting opioid should be restarted postoperatively at the usual dose and schedule, once there is no concern for sedation or respiratory depression.
- Routinely consider acetaminophen, NSAIDS, and gabapentin/pregabalin in addition to opioids as part of a multimodal acute pain regimen for all chronic pain patients.

ACKNOWLEDGMENTS

Dr. Christina Bockman, PharmD, Pharmacist, Department of Anesthesiology and Pain Medicine, University of Washington

REFERENCES

1. Carroll IR, Angst MS, Clark JD. Management of perioperative pain in patients chronically consuming opioids. Reg Anesth Pain Med. 2004;29(6):576–91.
2. Chapman CR, Davis J, Donaldson GW, Naylor J, Winchester D. Postoperative pain trajectories in chronic pain patients undergoing surgery: the effects of chronic opioid pharmacotherapy on acute pain. J Pain. 2011;12(12):1240–1246.
3. Chou R, et al. Management of postoperative pain: a clinical practice guideline from the American Pain Society, the American Society of Regional Anesthesia and Pain Medicine, and the American Society of Anesthesiologists' committee on regional anesthesia, executive committee, and administrative council. J Pain. 2016;17(2):131–157.
4. Tusek D, Church JM, Fazio VW. Guided imagery as a coping strategy for perioperative patients. AORN J. 1997;66(4):644–9.
5. George JA, et al. The effect of intravenous opioid patient-controlled analgesia with and without background infusion on respiratory depression: a meta-analysis. J Opioid Manag. 2010;6(1):47–54.
6. Chen MR, Dragoo JL. The effect of nonsteroidal anti-inflammatory drugs on tissue healing. Knee Surg Sports Traumatol Arthrosc. 2013;21(3):540–9.
7. Marquez-Lara A, Hutchinson ID, Nuñez F, Smith TL, Miller AN. Nonsteroidal anti-inflammatory drugs and bone-healing: a systematic review of research quality. JBJS Rev. 2016;4(3).
8. Marret E, Rolin M, Beaussier M, Bonnet F. Meta-analysis of intravenous lidocaine and postoperative recovery after abdominal surgery. Br J Surg. 2008;95(11):1331–8.
9. Bjordal JM, Johnson MI, Ljunggreen AE. Transcutaneous electrical nerve stimulation (TENS) can reduce postoperative analgesic consumption. A meta-analysis with assessment of optimal treatment parameters for postoperative pain. Eur J Pain (London, England). 2003;7(2):181–8.

Chapter 48
Substance Use Disorders

David S. Levitt and Jared W. Klein

BACKGROUND

Substance use disorders (SUDs) can be defined as dysfunction due to compulsive use of substances. Key characteristics of SUDs include cravings, loss of control, and social consequences related to substance use. SUDs are pervasive throughout society and are the leading preventable cause of mortality, contributing to approximately one-quarter of all deaths in the United States [1]. Despite such high prevalence, SUDs often go unrecognized in the perioperative setting [2].

Substance use disorders (SUDs) pose numerous risks in the perioperative setting. Preoperative smoking status is associated with increased risk of postoperative problems including wound infections and pulmonary complications [3, 4]. Excessive alcohol use increases the risk of morbidity during surgery—including cardiopulmonary complications, infections, poor wound healing, bleeding, and neurologic complications [5]. Especially in the context of the current opioid epidemic in the United States, it is important to recognize that patients with a history of tobacco, alcohol, or other drug use are particularly vulnerable to prolonged postoperative opioid use [6, 7].

Due to the stigma associated with drug use, patients with SUDs are at risk of receiving suboptimal medical care compared to the general population [8]. For this reason, as well as the many comorbidities associated with SUD, clinical and ethical dilemmas often arise when caring for this patient population [9]. Surgeries frequently present risks to patients with SUD, but undergoing a surgical intervention may also provide patients with the motivation and opportunity to spark behavior change [10].

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_48

PREOPERATIVE EVALUATION

GENERAL CONSIDERATIONS

All patients should be assessed for current and previous use of alcohol, tobacco and other drugs. As many patients with addiction have prior negative experiences with the health care system, it is crucial that clinicians use medically accurate, person-first, non-judgmental language when interacting with this patient population (Table 48.1) [11]. This allows for development of a therapeutic alliance and combats the stigma frequently experienced by patients with substance use disorders [12, 13].

Single item screening tools for other substances involve asking "How many times in the past year have you used an illegal drug or used a prescription medication for nonmedical reasons?" This test is easy to use and highly accurate for the detection of a substance use disorder in a primary care setting, but has not been validated in the perioperative setting [14]. Once a possible SUD has been identified, clinicians should gather additional history regarding substances used, routes and frequency of use, and social or health consequences of use. For any patient with a history of injection drug use, inquire about:

- History of infectious complications
- Current symptoms of infection
- Any previously placed surgical hardware or prosthetic valves
- Current or prior treatment attempts
- Prior HIV and HCV testing

For patients who are not currently receiving treatment, the perioperative setting provides an important opportunity to refer patients to appropriate resources. For patients with opioid use disorder (OUD) and alcohol use disorders (AUD), medication treatments should be initiated [15]. If a SUD is identified, clinicians should become familiar with associated withdrawal syndromes as well as the management strategies for these conditions (Table 48.2).

TABLE 48.1 PREFERRED VERSUS NON-PREFERRED TERMINOLOGY WHEN EVALUATING PATIENTS WITH SUBSTANCE USE DISORDERS

Preferred	Non-preferred
Substance use disorder	Substance abuse
Person with substance use disorder	Addict, user, IVDUer
Negative/positive urine drug test	Clean/dirty urine drug test
In recovery, in remission	Clean, sober
Treatment attempt	Treatment failure
Return to use	Relapse, slip-up

TABLE 48.2 COMMON WITHDRAWAL SYNDROMES AND WITHDRAWAL MANAGEMENT STRATEGIES

Substance	Withdrawal syndrome	Withdrawal management
Tobacco	Symptoms include dysphoria, irritability, restlessness, insomnia, and increase appetite Symptoms typically peak within 3 days and subside after several weeks	Combination nicotine replacement therapy (patch + gum/lozenge) is most effective, if permitted by surgeon Varenicline and bupropion may also be effective
Alcohol	Acute alcohol withdrawal generally starts 6–24 hours after the patient takes the last drink of alcohol Signs and symptoms include: Restlessness, agitation, anxiety, nausea, vomiting, tremor, increased blood pressure, hyperthermia, delusions, delirium, seizures.	Monitoring and benzodiazepine treatment using symptom-triggered CIWA-Ar protocols. Consider phenobarbital
Opioids	Timing depends on duration of action of opioid used Tachycardia, hypertension, hyperthermia, insomnia, enlarged pupils, diaphoresis, hyperreflexia, increased respiratory rate, abdominal cramps, nausea, vomiting, diarrhea, muscle pain, and anxiety	Treat with opioids (typically low-dose methadone for hospitalized patients) Consider consultation with a pharmacist for additional questions

(continued)

TABLE 48.2 (CONTINUED)

Substance	Withdrawal syndrome	Withdrawal management
Benzodiazepines	Timing depends on duration of action of benzodiazepine used Sleep disturbance, irritability, anxiety, panic attacks, tremors, nausea, vomiting, palpitations, headaches, and potential delirium, and seizures	Begin a slow taper based on patient's assessed use of medications, consider switching to a benzodiazepine with a longer half-life (e.g. diazepam) In some cases phenobarbital may be considered
Stimulants (cocaine, methamphetamine)	Onset generally within several hours of last use, depending on duration/ intensity of use Depression, insomnia, fatigue, anxiety, paranoia, increased appetite.	Withdrawal is usually not medically dangerous, although catecholamine depletion can affect hemodynamics Management is based on patient symptoms; for example, antihistamines can be used for insomnia and anxiety
Marijuana	Onset generally within several hours of last use, depending on duration/ intensity of use Irritability, aggression, depressed mood, restlessness, weight loss, headaches, sweating, fever, chills, sweating	Withdrawal usually does not involve medical danger and management is based on patient symptoms Evidence is limited on pharmacologic treatments for marijuana withdrawal

TOBACCO

Many surgeons defer elective operations until the patient has quit smoking for several weeks. The use of nicotine replacement therapy (NRT) to aid in smoking cessation preoperatively is controversial and there is little evidence in human studies to suggest that systemic NRT positively or negatively impacts healing or cardiovascular outcomes [16, 17]. Although one study suggested a short duration of smoking

cessation could increase perioperative pulmonary risks, subsequent studies have not borne out this concern [18–20]. Clinicians should counsel all patients who use tobacco products about cessation and, if there aren't other contraindications, prescribe varenicline or combination NRT (patch plus gum or lozenges), in consultation with the surgeon [21]. Either option is reasonable with similar efficacy rates, so ultimately it is the patient's preference regarding route that should determine the medication that is recommended.

ALCOHOL

The AUDIT-C questionnaire is a validated tool to screen for unhealthy alcohol use and higher scores are associated with increased postoperative complications [22, 23]. In heavy alcohol users (five or more drinks a day), research demonstrates that 4 weeks of preoperative abstinence decreases the risk of postoperative complications [24]. All patients with unhealthy alcohol use should be counseled about the perioperative risk and advised to cut back or stop drinking prior to surgery. Although some patients may be concerned about precipitating withdrawal during the preoperative period, the risks of withdrawal during the postoperative period are likely more worrisome. If moderate or severe alcohol use disorder (AUD) is present, medication treatment may be indicated. First-line therapy for AUD is naltrexone, an opioid antagonist that could complicate perioperative pain control. A reasonable approach would be to start naltrexone to help decrease alcohol use perioperatively, but discontinue at least 24 hours before surgery. Alternative medication options include acamprosate and disulfiram, although evidence is weaker for these agents so they should be reserved as second-line agents or when surgery is more urgent. Disulfiram should not be started while the patient is intoxicated as this could precipitate withdrawal. Additionally, patients with alcohol use disorder, particularly those with a history of withdrawal syndrome, should be advised about the need for close monitoring using Clinical Institute Withdrawal Assessment for Alcohol (CIWA) protocol as well as symptom-triggered treatment with benzodiazepines (see below). As a rule, patients should not be treated with ethanol for alcohol withdrawal.

OPIOIDS

Patients should be asked about their preoperative use of prescribed or non-prescribed opioids. It may be difficult to distinguish between patients who are physiologically dependent due to chronic opioid therapy and patients with opioid use disorders (OUDs). The key factors suggesting OUD include loss of control, compulsive use, and

TABLE 48.3 CONSIDERATIONS IN PERIOPERATIVE MANAGEMENT OF PATIENTS ON MEDICATIONS FOR ADDICTION TREATMENT

Methadone	Buprenorphine-naloxone	Extended-release naltrexone
Whenever possible, continue on outpatient dose without interruption Verify dose with outpatient treatment program Use short-acting opioids as needed for postoperative pain. Higher doses and longer duration may be needed due to tolerance If difficulty tapering short-acting opioids, consider dose increase of methadone (in coordination with outpatient treatment program)	Whenever possible, continue on outpatient dose without interruption For minor procedures, consider dose increase and more frequent dosing (e.g., BID or TID) to help with pain control For major surgeries, continue buprenorphine and use high-affinity, short-acting agents (fentanyl, hydromorphone) as needed for postoperative pain Alternatively, consider discontinuation for 24 hours preoperatively and use short-acting opioids. Higher doses and longer duration may be needed due to tolerance	Whenever possible (planned elective procedure), discontinue at least 30 days prior to surgery For urgent/emergent surgery, consider use of high-affinity, short-acting agents (fentanyl, hydromorphone). High dosages and close monitoring may be necessary Strongly consider involvement of pain medicine specialist

consequences of opioid use. All states now have prescription drug monitoring databases and it may be informative to review this information prior to surgery to identify concerning prescribing patterns or unreported use.

Patients on medications for addiction treatment (methadone, buprenorphine-naloxone, or extended-release naltrexone) pose particular challenges during perioperative management (Table 48.3). Generally, it is preferable to avoid interrupting addiction treatment whenever possible; however, final pain management decision may depend on the severity of anticipated surgical pain and the patient's stability in treatment. Clinicians should strongly consider consultation with experienced providers, such as anesthesia/pain medicine, addiction medicine, or psychiatry.

PERIOPERATIVE MANAGEMENT

TOBACCO

In the immediate postoperative setting patients who abruptly discontinue tobacco use may exhibit a range of withdrawal symptoms including irritability, insomnia, and depressed mood. Nicotine replacement therapy, if acceptable to the surgeon, may alleviate these symptoms. A combination of transdermal and transmucosal (e.g. patch and gum or lozenges) will be the most effective at alleviating symptoms and promoting longer term abstinence.

ALCOHOL

Alcohol withdrawal is a potentially life-threatening complication and should be rapidly identified and treated. Typical withdrawal signs and symptoms, such as tremor, tachycardia, and agitation, usually manifest within 24 hours of last drink or a significant reduction in consumption (Table 48.2). The cornerstone of alcohol withdrawal management involves benzodiazepine treatment protocols, which utilize the Clinical Institute Withdrawal Assessment for Alcohol, revised (CIWA-Ar) paired with symptom-triggered use of benzodiazepines [25]. Typically diazepam, lorazepam or chlordiazepoxide are used, although other agents may be considered (e.g. oxazepam may be preferred in the setting of hepatic failure due to lack of active metabolites). There is emerging data around the use of phenobarbital, either as adjunctive treatment for severe withdrawal or even as the primary agent [26].

OPIOIDS

Patients with OUD who are not engaged in outpatient treatment should be offered methadone or long acting opioids to prevent opioid withdrawal. Methadone 20–40 mg per day is a typical dose that can treat acute opioid withdrawal symptoms. When necessary, short acting opioids can also be used to treat postoperative pain, but caution should be used to avoid over-sedation or other adverse effects. Long-acting opioids (such as methadone) should be discontinued at time of discharge if the patient does not plan on continuing treatment as an outpatient; however, this can complicate postoperative pain control. Ideally, the patient will continue engaging with treatment and transitioned directly to a methadone maintenance or buprenorphine treatment program.

The postoperative setting is also a high-risk time for developing or worsening an opioid use disorder. In addition to a history of depression,

a history of any substance use disorder appears to increase the risk of prolonged opioid use, regardless of whether the patient underwent major or minor surgery [5]. Multimodal pain control (see Chaps. 47 and 56) and judicious opioid prescribing are important methods of mitigating the risk of opioid misuse and overprescribing. Whenever possible, clinicians should start with smaller quantities and follow-up frequently to reassess patients' pain control.

OTHER RECREATIONAL OR ILLICIT DRUGS

Benzodiazepines

Chronic use of benzodiazepines decreases the brain's GABAnergic activity, placing patients at risk of a life-threatening withdrawal syndrome that may involve seizures, delirium and hemodynamic instability. Similar to management of alcohol withdrawal, patients should be treated with long-acting benzodiazepines and monitored very closely. Phenobarbital may be used as an alternative if there are contraindications to benzodiazepine use or symptoms are not controlled with typical doses. In the presence of chronic, high-level use, medications used to treat withdrawal may need to be tapered over a period of weeks.

Stimulants

The acute and chronic use of stimulants such as cocaine and methamphetamine can pose significant challenges to adequate control of hemodynamics. The anesthesiology team should be notified of the use or suspicion of use of these substances. While acute stimulant intoxication can increase anesthetic requirements, long-term stimulant use can markedly decrease anesthetic requirements. This is presumably due to catecholamine depletion and can manifest as refractory hypotension [27].

Marijuana

There is mixed evidence regarding the long-term health consequences of marijuana use and hardly any studies examine the effect of marijuana use during the perioperative period. Chronic marijuana use has been associated with a well-described withdrawal syndrome. Given deposition of marijuana in adipose tissues, the timing and duration of symptoms can be somewhat unpredictable. Management of withdrawal is generally supportive and no medications are approved for the treatment of cannabis use disorders or marijuana withdrawal. There is no evidence to support the use of dronabinol for the management of patients experiencing marijuana withdrawal.

KEY CLINICAL PEARLS

- Clinicians should use medically accurate, non-judgmental language and attitudes when caring for patients with substance use disorders.
- Whenever possible, patients with substance use disorders should be connected with longitudinal treatment around the time of surgery.
- Incorporate screening for substance use disorders into the preoperative assessment, using validated tools such as the AUDIT-C for alcohol use.
- Treat opioid withdrawal with opioids (either methadone, short-acting full agonists, or buprenorphine) and use the opportunity to engage patients in addiction treatment.

ACKNOWLEDGMENTS

Dr. Ashok Reddy authored a prior version of this chapter. Dr. Avital O'Glasser and Dr. Honora Englander generously shared their comprehensive list of references with the authors.

REFERENCES

1. Bauer UE, Briss PA, Goodman RA, Bowman BA. Prevention of chronic disease in the 21st century: elimination of the leading preventable causes of premature death and disability in the USA. Lancet. 2014;384(9937):45–52.
2. Spies C, Tonnesen H, Andreasson S, Helander A, Conigrave K. Perioperative morbidity and mortality in chronic alcoholic patients. Alcohol Clin Exp Res. 2001. Suppl;25(5):164S–70S.
3. Grønkjær M, Eliasen M, Skov-Ettrup LS, et al. Preoperative smoking status and postoperative complications: a systematic review and meta-analysis. Ann Surg. 2014;259(1):52–71.
4. Sørensen LT. Wound healing and infection in surgery: the pathophysiological impact of smoking, smoking cessation, and nicotine replacement therapy: a systematic review. Ann Surg. 2012 Jun;255(6):1069–79.
5. Tonnesen H, Kehlet H. Preoperative alcoholism and postoperative mortality. Br J Surg. 1999;86(7):869–874.
6. Hedegaard H, Warner M, Miniño AM. Drug overdose deaths in the United States, 1999–2016. NCHS Data Brief, no 294. Hyattsville, MD: National Center for Health Statistics. 2017/ CDC. Wide-ranging online data for epidemiologic research (WONDER). Atlanta, GA: CDC, National Center for Health Statistics; 2016. Available at http://wonder.cdc.gov. Accessed 4/5/2018.
7. Brummett CM, Waljee FJ, Goesling J, et al. New persistent opioid use after minor and major surgical procedures in US adults. JAMA Surg. 2017;152(6):e170504.
8. Van Boekel LC, Brouwers EPM, van Weeghel J, et al. Stigma among health professionals towards patients with substance use disorders and its consequences for healthcare delivery: systematic review. Drug Alc Depend. 2013;131(1–2):23–35.
9. Geppert CM, Bogenschutz MP. Ethics in substance use disorder treatment. Psychiatr Clin North Am. 2009;32(2):283–97.
10. Velez CM, Nicolaidis C, Korthuis PT, et al. It's been an experience, a life learning experience': a qualitative study of hospitalized patients with substance use disorders. J Gen Intern Med. 2017 Mar;32(3):296–303.
11. Botticelli MP, Koh HK. Changing the language of addiction. JAMA. 2016;316(13):1361–2.

12. Kelly JF, Westerhoff CM. Does it matter how we refer to individuals with substance-related conditions? A randomized study of two commonly used terms. Int J Drug Policy. 2010 May;21(3):202–7.
13. Van Boekel LC, Brouwers EP, van Weeghel J, et al. Stigma among health professionals towards patients with substance use disorders and its consequences for healthcare delivery: systematic review. Drug Alcohol Depend 2013;131(1–2):23–35.
14. Smith PC, Schmidt SM, Allensworth-Davies D, et al. A single-question screening test for drug use in primary care. Arch Intern Med. 2010;170(13):1155–60.
15. Wakeman SE, Metlay JP, Chang Y, et al. Inpatient addiction consultation for hospitalized patients increases post-discharge abstinence and reduces addiction severity. J Gen Intern Med. 2017;32(8):909–16.
16. Nolan MB, Warner DO. Safety and efficacy of nicotine replacement therapy in the perioperative period: a narrative review. Mayo Clin Proc. 2015;90(11):1553–1561.
17. Reuther WJ, Brennan PA. Is nicotine still the bad guy? Summary of the effects of smoking on patients with head and neck cancer in the postoperative period and the uses of nicotine replacement therapy in these patients. Br J Oral Maxillofac Surg. 2014;52(2):102–5.
18. Warner MA, Offord KP, Warner ME, et al. Role of preoperative cessation of smoking and other factors in postoperative pulmonary complications: a blinded prospective study of coronary artery bypass patients. Mayo Clin Proc. 1989;64(6):609–16.
19. Myers K, Hajek P, Hinds C, et al. Stopping smoking shortly before surgery and postoperative complications: a systematic review and meta-analysis. Arch Intern Med. 2011;171(11):983–9.
20. Wong J, Lam DP, Abrishami A, et al. Short-term preoperative smoking cessation and postoperative complications: a systematic review and meta-analysis. Can J Anaesth. 2012;59(3):268–79.
21. Wong J, Abrishami A, Yang Y, et al. A perioperative smoking cessation intervention with varenicline: a double-blind, randomized, placebo-controlled trial. Anesthesiology. 2012;117(4):755–64.
22. Bradley KA, Rubinsky AD, Sun H, et al. Alcohol screening and risk of postoperative complications in male VA patients undergoing major non-cardiac surgery. J Gen Intern Med. 2011;26(2):162–9.
23. Rubinsky AD, Sun H, Blough DK, et al. AUDIT-C alcohol screening results and postoperative inpatient health care use. J Am Coll Surg. 2012;214(3):296–305.
24. Tonnesen H, Rosenberg J, Nielsen HJ, et al. Effect of preoperative abstinence on poor postoperative outcome in alcohol misusers: randomised controlled trial. BMJ. 1999;318(7194):1311–6.
25. Saitz R, Mayo-Smith MF, Roberts MS, et al. Individualized treatment for alcohol withdrawal. A randomized double-blind controlled trial. JAMA. 1994;272(7):519–23.
26. Hendey GW, Dery RA, Barnes RL, et al. A prospective, randomized, trial of phenobarbital versus benzodiazepines for acute alcohol withdrawal. Am J Emerg Med. 2011;29(4):382–5.
27. Marschall KE, Hines RL. Chapter 29: Psychiatric disease, substance abuse and drug overdose. In: Hines R, Marschall K, editors. Stoelting's anesthesia and co-existing disease. 7th ed. Philadelphia: Elsevier; 2018. p. 611–33.

Chapter 49
Postoperative Evaluation and Care

Kim O'Connor and Molly Blackley Jackson

BACKGROUND

Medicine consultants are often called upon to collaborate on the care of patients in the immediate postoperative period. Attention to medical comorbidities, operative and anesthetic course, and a thoughtful postoperative history and physical examination can help provide optimal care and reduce complications.

POST-ANESTHESIA CARE UNIT ASSESSMENT

Most patients who receive anesthesia are monitored after operative procedures in a post-anesthesia care unit (PACU), under the primary responsibility of an anesthesia service [1]. Collaborative care between surgery, anesthesia, internal medicine teams and the recovery room staff can help avert complications and enhance continuity of care. Medical consultants should consider the following elements when evaluating a patient with medical comorbidities in the PACU.

CHART REVIEW, DATA GATHERING, AND COLLABORATION

- Perioperative documentation: Review the patient's chart for medical comorbidities and any formal preoperative evaluations, if performed. Note the preoperative administration of any medications such as antibiotics, steroids, or blood pressure agents.

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_49

- Surgical documentation: Review surgical records to clarify the exact nature of the procedure, and if there were any unanticipated changes to the surgical plan or complications.
- Anesthesia records: Review duration of anesthesia, estimated blood loss (EBL), amount and type of fluids received, intraoperative hemodynamics, type and difficulty of airway management, and medications given in the operating room. This data is typically found in the anesthesia record or the operating note.
- While reviewing the documentation is helpful, oftentimes direct communication with the surgical team or anesthesiology team is optimal, especially when the operative/anesthetic course is unclear. PACU nurses, anesthesiologists, surgeons, and other care team members often have helpful information and/or questions for the medical consultant.

BEDSIDE EVALUATION

History

Assess for the following once the patient is sufficiently interactive after anesthesia:

- Chest pain and/or shortness of breath
- Presence of nausea and/or vomiting
- Level of pain, and trajectory of pain control
- Level of anxiety
- Review of self-administered medications taken on the day of surgery
- Brief review of any new symptoms prior to surgery

Exam

A focused physical exam in the recovery room can help identify early complications and establish their immediate postoperative baseline.

- Respiratory rate, oxygen saturation, and airway patency
- Temperature: Postoperative patients are often hypothermic, which increases their risk of complications. PACU nurses are usually attuned to this and will put a warming blanket or device on the patient. Hyperthermia is also associated with postoperative complications. If either hypothermia or hyperthermia is detected, communicate directly with anesthesiology for management.
- Heart rate, blood pressure, and volume status: Blood pressure can be quite labile as the effects of anesthesia are wearing off. Patients may have transient hypertension (e.g., due to pain) or

hypotension (e.g., due to volume depletion, epidural catheters). Assure pain is controlled before embarking upon aggressive blood pressure management. Shivering or tremors can also lead to spuriously elevated blood pressure readings on an automatic cuff. When in doubt, check blood pressure manually, and in both arms.

- Responsiveness and orientation
- Assessment of neuromuscular function: Consider a focused neurologic exam especially in patients with prolonged operative time, intraoperative hemodynamic instability, history of neuromuscular or neurovascular disease, or procedures that may subject patients to intraoperative stroke.
- Level of pain
- Make note of tubes, drains, lines, catheters, and dressings.
- Additional targeted exam based on medical comorbidities.

The medical consultant should be aware of common (and rare but serious) postoperative complications, which are detailed in Chap. 4.

POST-ANESTHESIA CARE UNIT – PREPARATION FOR DISCHARGE

Readiness for discharge from the PACU is generally determined by the PACU team, often involving the use of scoring systems for stability. Common items to review and act upon prior to discharge from the PACU include:

- Check the PACU and/or pending admission orders to make sure that orders are appropriate based on your knowledge of the patient's medical comorbidities.
- Medication orders should be carefully reviewed and compared with preoperative medications. Provide guidance on resuming outpatient medications when appropriate, and if changes are made from the outpatient regime provide an explanation about why the change was made and recommendations for follow up. For example, medications that impact blood pressure should be cautiously resumed with holding parameters for hypotension. Please refer to Chap. 5 for guidance on restarting outpatient medications.
- If patient is discharging to home (or elsewhere in the community), consider providing a "warm handoff" with their primary care provider, to share an update, and pass along any follow-up issues.
- If the patient's condition warrants a change in post-PACU care (e.g., requiring ICU or telemetry), make those recommendations and call the anesthesia and surgical teams directly.

DAILY POSTOPERATIVE EVALUATION

Many medical consultants follow post-surgical patients longitudinally while inpatient, providing recommendations or primary management. Common postoperative issues are discussed in greater detail throughout this handbook. The following general principles apply to all postoperative patients for daily care:

- Review interval history, examination, medication list, and labs/studies.
- Review drains, catheters, and dressings.
- What is the surgery team's plan for the day? It is often best to discuss directly with the surgery team, particularly if surgical notes are terse or unfamiliar abbreviations are used.
- Clarify current and anticipated diet orders (if NPO, can they receive oral medications?).
- Ask about side effects of pain medications, sedatives, and anti-emetics.
- Ask about anticipated and current bowel function; review bowel regimen.
- Ask about sleep quality.
- Review a standard "checklist" for prevention of complications, including
  - Venous thromboembolism (VTE) prophylaxis.
  - Lung expansion maneuvers, if indicated (if ordered, are they being practiced correctly and routinely?).
  - Delirium precautions (see Chap. 53).
  - Tubes and lines (can any be removed?).
  - Review postsurgical activity and position restrictions.
  - Recommendations for position changes, head of bed elevation, frequent turns, and early mobility.
  - If applicable, coordinate with the surgical team and nursing to optimize quality rest during recovery through bundling of nursing care, minimizing interruptions overnight.
- Focus the remainder of your evaluation on each medical problem you are asked to evaluate (or, major medical comorbidities that need attention).

NEW POSTOPERATIVE CONSULTS

For the new post-op consult, the above information still needs to be gathered. In addition, make sure of the following:

- Obtain name, service, and contact information for the referring provider and any covering providers.
- Ask for clarification on the clinical question if it is unclear.
- Give the requesting provider a time frame in which you expect to see the patient and contact that provider.
- Review the surgical procedure – were there complications? Review the EBL, duration, and method of anesthesia.
- Postoperative course to date – have there been complications? Is the recovery going as expected? You should have a general sense of the common surgical complications, length of stay, and recovery period for the procedure; keep in mind that there may be site-specific and patient-specific differences. If in doubt, ask your surgical colleagues.
- You may need to seek other information – the patient may have post-operative delirium or still be recovering from anesthesia. If you need a better history, you may need to seek out the patient's family, the surgeon, and nursing staff.
- The preoperative med list may not be accurate. You may need to double check the patient's baseline meds.

KEY CLINICAL PEARLS

- Careful review of anesthesia/operating room records for fluids, blood loss, medications administered, and hemodynamic instability as well as direct communication with surgical and anesthesia teams can be helpful for the medical consultant in providing optimal guidance.
- Medication orders should be carefully reviewed and compared with preoperative medications; medication errors are a common source of perioperative complications.
- Any new medications (or changes in existing medications) should be communicated to primary care teams upon discharge from the hospital.

REFERENCE

1. Apfelbaum JL, Silverstein JH, Chung FF, et al. Practice guidelines for postanesthetic care: an updated report by the American Society of Anesthesiologists Task Force on Postanesthetic Care. Anesthesiology. 2013;118:291.

Chapter 50
Postoperative Tachycardia

Maralyssa Bann

BACKGROUND

Tachycardia is usually defined as a ventricular rate greater than 100 beats per minute. A tachycardic patient can be asymptomatic, but findings such as hypotension, altered mental status, or other evidence of hypoperfusion could be present. The underlying rhythm may be sinus or an atrial or ventricular arrhythmia. For purposes of this text, when tachycardia is specifically caused by an underlying atrial or ventricular arrhythmia, it will be referred to as tachyarrhythmia.

Tachycardia is a frequent postoperative finding. Sinus tachycardia tends to occur most commonly (although the actual incidence is difficult to estimate), followed by atrial tachyarrhythmias, while ventricular tachyarrhythmias are relatively rare. Reported incidence of post-operative tachycardia varies widely by the underlying rhythm identified, patient population, and type of surgery, as well as the mode and length of post-operative monitoring employed. It is estimated that around 7% of patients develop new-onset arrhythmias after major non-cardiothoracic surgeries [1].

Tachycardia may reflect an appropriate physiologic response to pain, stress, or hypovolemia, though it can also be a sign of postoperative complications including infection, anemia, myocardial necrosis/infarction, or pulmonary embolism [1–4]. Importantly, the presence of tachycardia has implications for patient morbidity and mortality, though generally a concurrent medical problem is the proximate cause of death and not the tachycardia itself [2, 5]. For example, the presence of perioperative atrial tachyarrhythmia is associated with prolonged hospitalization [4], higher mortality [5], and increased long-term risk of ischemic stroke [6].

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_50

Therefore, it is important for the internal medicine consultant to consider post-operative tachycardia a potential marker of increased morbidity and mortality and to appropriately assess for and manage any underlying precipitant identified.

PREOPERATIVE EVALUATION

Since post-operative tachycardia can result from a myriad of etiologies, it is difficult to predict the risk of occurrence. There are specific risk calculators available to estimate the risk of post-operative atrial fibrillation, in particular after cardiac surgery, but they may not have stronger predictive ability than patient age alone [7]. Therefore, while attempting to predict tachycardia beforehand may not be meaningful, it is important for the medicine consultant to consider patient and surgery-specific risk factors that may lead to tachycardia.

PATIENT-SPECIFIC RISKS

The presence of co-morbidities, especially with regard to pre-existing cardiac disease, may influence the development of post-operative tachycardia and should be evaluated as part of the preoperative assessment. Post-operative atrial tachyarrhythmias are associated with older patient age, heart failure, significant valvular disease, and history of arrhythmia [2, 4, 8].

SURGERY-SPECIFIC RISKS

The following types of surgeries have been associated with higher risk of post-operative tachyarrhythmia [2, 4, 6]:

- Cardiac surgery, including coronary artery bypass grafting
- Thoracic surgery, including resection of mediastinal mass, lobectomy or pneumonectomy, esophagectomy
- Abdominal surgery
- Vascular surgery, including abdominal aortic aneurysm

For patients with a history of significant arrhythmia undergoing non-cardiac non-low risk operation, obtaining a baseline resting 12-lead electrocardiogram (ECG) is reasonable, per the 2014 American College of Cardiology and American Heart Association guidelines (Class IIa, level B) [9].

PERIOPERATIVE MANAGEMENT

PREVENTION OF ATRIAL FIBRILLATION

A Cochrane Review found evidence that prophylactic interventions such as beta-blockers, sotalol, magnesium, amiodarone, atrial pacing, and posterior pericardiectomy significantly reduce atrial fibrillation after cardiac surgery but had no significant effect on all-cause mortality [10]. Caution should be used in extrapolating these results to patients undergoing non-cardiac surgery as a subsequent Cochrane Review analysis found association between beta-blocker use and increased all-cause mortality and stroke [11].

- Prophylactic medication recommendations should be discussed with cardiothoracic surgeons for patients undergoing cardiac surgery.
- See Chap. 5 for recommendations regarding the management of beta-blockers and antiarrhythmic medications, and Chap. 9 for more on atrial fibrillation.

EVALUATION OF POSTOPERATIVE TACHYCARDIA

The first step in evaluation is to establish the stability of the patient:

- Obtain complete set of vital signs to evaluate for hypotension, hypoxia, tachypnea, fever.
- If the patient is in severe respiratory distress or obtunded, definitive airway should be established as appropriate with the patient's goals of care.
- If there is no palpable pulse, advanced cardiac life support (ACLS) protocol should be initiated.

If the patient does not meet criteria for ACLS protocol, continue assessment with the following:

- Physical exam with specific focus on evidence of hypoperfusion (strength of peripheral pulses, skin exam, mental status, neurologic exam) as well as cardiopulmonary exam (cardiac murmurs or extra heart sounds, jugular venous pressure, peripheral edema, pulmonary edema) and assessment of the surgical wound site.
- 12-lead electrocardiogram – examine the p wave morphology, QRS complex duration, and regularity of the rhythm. Table 50.1 outlines the common classification of arrhythmias using this method.

TABLE 50.1 ECG DETERMINATION OF TACHYARRHYTHMIAS

Narrow QRS Complex, Regular Rhythm
Sinus tachycardia Atrioventricular nodal reentrant tachycardia (AVNRT) Atrioventricular reentrant tachycardia (AVRT) Ectopic atrial tachycardia Atrial flutter
Narrow QRS Complex, Irregular Rhythm
Atrial fibrillation Atrial flutter Multifocal atrial tachycardia
Wide QRS Complex, Regular Rhythm
Ventricular tachycardia Supraventricular tachycardia with aberrant conduction Supraventricular tachycardia with a pacemaker Antidromic AVRT
Wide Complex, Irregular Rhythm
Polymorphic ventricular tachycardia Pre-excited atrial fibrillation Atrial fibrillation with aberrant conduction

SINUS TACHYCARDIA

Postoperative tachycardia may be an appropriate response to an inciting physiologic stressor. Table 50.2 lists common post-operative etiologies for tachycardia, using the mnemonic TACHYCARDIC. The medicine consultant should be facile in assessing for these common etiologies. In addition to the electrocardiogram, key elements include:

- Serum labs: Complete blood count, metabolic panel including magnesium level
- Medication review and reconciliation

Other studies to consider based on the clinical presentation:

- Serum lactate to evaluate for evidence of hypoperfusion
- Serum troponin to evaluate for cardiac ischemia
- Sepsis workup including blood cultures, chest imaging, urinalysis, and treatment with empiric antibiotics
- Transthoracic echocardiogram to evaluate for structural heart disease, wall motion abnormalities, or volume status
- Computed tomography angiogram (CTA) to evaluate for pulmonary embolism

TABLE 50.2 PHYSIOLOGIC STRESSORS THAT COMMONLY CAUSE POSTOPERATIVE TACHYCARDIA: TACHYCARDIC

Thrombosis (Deep Vein Thrombosis/Pulmonary Embolism)
Anemia (related to surgery, intra-operative, drains, surgical site, stress-related GI bleed, retroperitoneal or thigh bleed related to anticoagulation)
Catecholamines (post-operative stress, inflammation)
Hypokalemia/hypomagnesemia/hypoglycemia
h**Y**povolemia/dehydration
CHF/volume overload
Anxiety
Retention (urinary)
Drug or alcohol withdrawal
Infection (surgical site, sepsis)
Constipation

If no underlying physiologic stressor is identified, the presence of tachyarrhythmia may represent an uncovered electrophysiologic abnormality requiring more specialized intervention. Additional workup and management can be completed as outlined below and in Fig. 50.1.

ATRIAL TACHYARRHYTHMIAS

Atrial tachyarrhythmias include atrial fibrillation with rapid ventricular response (RVR), atrial flutter, ectopic atrial tachycardia, multifocal atrial tachycardia, and reentry tachycardias such as atrioventricular reentrant tachycardia (AVRT) and atrioventricular nodal reentrant tachycardia (AVNRT).

Management of atrial tachyarrhythmias summarized from the 2015 ACC/AHA/HRS guidelines [12]:

- Urgent synchronized cardioversion should be considered if the patient has evidence of hypoperfusion such as hypotension, flash pulmonary edema, decreased mental status, or active ischemia; cardiology consultation is strongly advised for the management of these patients.
- For atrial fibrillation and atrial flutter, if cardioversion is to be performed, the use of therapeutic anticoagulation is strongly

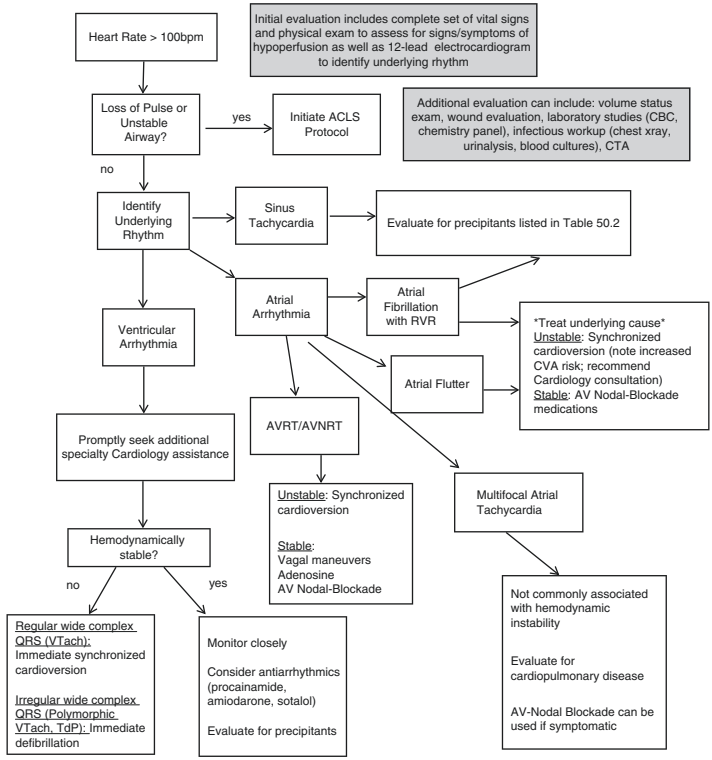

Fig. 50.1 Management of Post-Operative Tachycardia

encouraged to decrease the risk of embolic stroke, especially if the duration of the arrhythmia is longer than 48 hours. The risks and benefits of therapeutic anticoagulation in the post-operative setting require careful consideration.

- If there is no evidence of hypoperfusion, rate control can often be achieved with AV nodal blockade using beta-blockers or calcium-channel blockers (refer to chart in Chap. 9 for detailed dosing).

Special considerations:

- For AVRT/AVNRT, vagal maneuvers are recommended (Class I, Level B-R).
- For AVRT/AVNRT, adenosine is recommended for acute treatment (Class I, Level B-R) and acutely terminates AVNRT in 95% of patients.

- For multifocal atrial tachycardia, perform a thorough cardiopulmonary exam. Most instances do not result in hemodynamic collapse.
- For pre-excited atrial fibrillation, standard AV-nodal blocking medications are NOT indicated and can lead to circulatory collapse and ventricular fibrillation. Cardiology consultation is advised.

VENTRICULAR ARRHYTHMIAS

Ventricular tachyarrhythmias include monomorphic or polymorphic ventricular tachycardia and can be associated with underlying structural heart disease. Ventricular fibrillation is a non-perfusing rhythm and should be managed via ACLS protocol. Stable patients with sustained ventricular tachyarrhythmias should be monitored closely with continuous cardiac telemetry and frequent reassessment as rapid clinical deterioration can occur. Due to these risks, cardiology consultation should be obtained for the management of these patients.

Management of ventricular tachyarrhythmias summarized from the 2017 AHA/ACC/HRS Guideline [13]:

- Patients presenting with ventricular arrhythmias with hemodynamic instability should undergo direct current cardioversion (Class I, Level A).
- In patients with hemodynamically stable ventricular tachycardia, administration of intravenous procainamide can be useful to attempt to terminate ventricular tachycardia (Class IIa, Level A).
- In patients with hemodynamically stable ventricular tachycardia, administration of intravenous amiodarone or sotalol may be considered to attempt to terminate ventricular tachycardia (Class IIb, Level B-R).

KEY CLINICAL PEARLS

- Post-operative tachycardia is an important marker for potential morbidity and mortality; a careful evaluation is mandatory
- Common post-operative precipitants of tachycardia can be evaluated using the TACHYCARDIC mnemonic
- Prompt cardioversion to restore sinus rhythm is indicated for unstable tachyarrhythmias

REFERENCES

1. Walsh SR, et al. Postoperative arrhythmias in general surgical patients. Ann R Coll Surg Engl. 2007;89:91–5.
2. Goldman L. Supraventricular tachyarrhythmias in hosptialized adults after surgery: clinical correlates in patients over 40 years of age after major noncardiac surgery. Chest. 1978;73(4):450–454.
3. Sigmund AE, et al. Postoperative tachycardia: clinically meaningful or benign consequence of orthopedic surgery? Mayo Clin Proc. 2017;92(1):98–105.
4. Polanczyk CA, et al. Supraventricular arrhythmia in patients having noncardiac surgery: clinical correlates and effect on length of stay. Ann Intern Med. 1998;129:279–85.
5. Brathwaite D, Weissman C. The new onset of atrial arrhythmias following major noncardiothoracic surgery is associated with increased mortality. Chest. 1998;114(2):462–468.
6. Gialdini G, et al. Perioperative atrial fibrillation and the long-term risk of ischemic stroke. JAMA. 2014;312(6):616–622.
7. Pollack B, et al. Predicting new-onset post-coronary artery bypass graft atrial fibrillation with existing risk scores. Ann Thorac Surg. 2018;105:115–21.
8. Hashimoto K, Ilstrup DM, Schaff HV. Influence of clinical and hemodynamic variables on risk of supraventricular tachycardia after coronary artery bypass. J Thorac Cardiovasc Surg. 1991;101(1):56–65.
9. Fleisher LA, et al. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery. J Am Coll Cardiol. 2014;64(22):e77–e137.
10. Arsenault KA, et al. Interventions for preventing post-operative atrial fibrillation in patients undergoing heart surgery. Cochrane Database Syst Rev. 2013;31(1):CD003611.
11. Blessberger H, et al. Perioperative beta-blockers for preventing surgery-related mortality and morbidity. Cochrane Database Syst Rev. 2014;18(9):CD004476.
12. Page RL, et al. 2015 ACC/AHA/HRS guidelines for the management of adult patients with supraventricular tachycardia. J Am Coll Cardiol. 2016;67(13):e27–e115.
13. Al-Khatib SA, et al. 2017 AHA/ACC/HRS guideline for management of patients with ventricular arrhythmias and the prevention of sudden cardiac death: executive summary. J Am Coll Cardiol. 2017;S0735–1097(17):41305–2.

Chapter 51
Postoperative Hypoxemia

Yilin Zhang

BACKGROUND

Hypoxemia is a common and underrecognized postoperative complication that is associated with significant morbidity. Hypoxemia occurs when the arterial partial pressure of oxygen (PaO_2) falls below 80 mmHg, which typically corresponds to a peripherally measured oxygen saturation (SaO_2) of < 95%. For most patients, clinically significant hypoxemia occurs when the SaO_2 < 90% (PaO_2 < 60 mmHg). The incidence of postoperative hypoxemia ranges from 18% to 37% [1–3]. Routine vital sign checks underestimate the frequency, duration, and severity of postoperative hypoxemia, missing up to 90% of hypoxemic events [1]. Hypoxemia is associated with poor wound healing, delirium, and cardiac dysfunction [1–4].

CAUSES OF POSTOPERATIVE HYPOXEMIA

Postoperative hypoxemia is associated with a multitude of postoperative pulmonary complications (PPCs) [1, 5] and is typically caused by physiological changes that occur with anesthesia or surgery. PPCs broadly describe impairments of the respiratory system after an operation. While formal definitions of PPCs vary, they encompass disorders such as atelectasis, pulmonary embolism (PE), pneumonia, and pulmonary edema [6, 7]. Disease states that cause a low mixed venous oxygen content (e.g., low cardiac output, anemia, high fever, or sepsis) can exaggerate the hypoxemic effect of any existing PPCs [15]. Chapter 32 broadly describes a perioperative approach to

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_51

mitigating the risk of PPCs; this chapter focuses on managing hypoxemia in the post-operative patient.

In the immediate postoperative period, hypoxemia can result from perioperative changes in respiratory physiology and direct injury from mechanical ventilation [6]. The duration and severity of changes in respiratory physiology depend on the type of anesthesia and surgery [2]. General anesthesia impairs pulmonary mechanics for up to 2 weeks after surgery and reduces sputum clearance by decreasing mucociliary clearance [7]. Major surgery and anesthesia additionally blunt ventilatory responses to hypercapnia and hypoxia, an effect that can persist for weeks [2, 7]. These perioperative changes contribute to postoperative atelectasis and hypoventilation, the most common causes of transient hypoxemia in the early postoperative period [3]. Patients with preexisting pulmonary disease are at highest risk, but these physiologic changes can cause hypoxemia even in patients with healthy lungs.

Other causes of postoperative hypoxemia include bronchospasm, pleural effusions, pulmonary edema, acute respiratory distress syndrome (ARDS), transfusion-related complications, PE, pneumonia, aspiration, upper airway obstruction, and exacerbation of chronic pulmonary diseases (Table 51.1). Important points to remember include:

- Patients with preexisting reactive airway disease or smoking history are at highest risk for bronchospasm.
- Patients may develop postoperative cardiogenic pulmonary edema from overaggressive hydration (unmasking underlying diastolic dysfunction) or perioperative cardiac dysfunction [3, 9].
- Negative pressure pulmonary edema is a relatively rare cause of noncardiogenic pulmonary edema. It occurs with deep inspiration against an obstructed upper airway (e.g., laryngospasm) in the immediate postoperative period [3].
- Transfusion-associated circulatory overload (TACO) or transfusion-related acute lung injury (TRALI) typically occur within 6 hours of a transfusion [3].
- PE is a major cause of postoperative mortality with the incidence of fatal PE reported as high as 10% [10].
- Most postoperative pneumonias are polymicrobial infections [12]. Common pathogens include gram negative rods, *Pseudomonas*, *Staphylococcus aureus*, and *Streptococcus pneumoniae* [11].
- Upper airway obstruction in patients without sleep apnea may occur from airway edema, loss of pharyngeal muscle tone, or

TABLE 51.1 POSTOPERATIVE PULMONARY COMPLICATIONS

	Incidence/ Timing	Causes	Evaluation/ Management
Atelectasis	Up to 90% [19] Most common POD1–2, can persist for weeks [2]	Compression atelectasis Bronchial obstruction from mucus plugging	Chest imaging (CXR, CT) Lung expansion and airway clearance [4]
Broncho-spasm	1.8% [20] Common in the immediate and early postoperative (POD0–1) setting	Airway stimulation (aspiration, intubation) Exacerbation of RAD Medications that cause histamine release (e.g., morphine)	Short-acting β2 agonist ± anticholinergic inhalers Racemic or IV epinephrine if life-threatening
Pulmonary edema	2.4–7.6% [9, 11] Cardiogenic: Within 36 hours after surgery [9]	Cardiogenic: Overhydration, HF, TACO Noncardiogenic: NPPE, TRALI, ARDS	Chest imaging, BNP, TTE Cardiogenic: Diuresis, NIV Noncardiogenic: Supportive, LPV in ARDS
Pulmonary embolism	0.7–24% [10] Peak incidence of all VTE occur POD5–10 [10]	Orthopedic surgeries are highest risk [10] Fat or bone cement emboli can occur in orthopedic surgeries	CTPA, VQ scan Anticoagulation Supportive care in FES and bone cement emboli
Pneumonia	1.3–17.5% [11, 12, 21] Typically occurs within first 5 days after surgery [12]	Often polymicrobial Common pathogens: GNRs, *Pseudomonas*, *S. aureus*, and *S. pneumoniae* [13]	Chest imaging, cultures Antibiotics should cover hospital-acquired organisms if pneumonia develops after POD2

(continued)

TABLE 51.1 (CONTINUED)

	Incidence/ Timing	Causes	Evaluation/ Management
Aspiration	Pneumonia: 0.4% [20] More common in the immediate to early postoperative setting	Altered mental status Sedatives, opioids GI, esophageal, or neuro-bulbar abnormalities	Pneumonitis: Supportive, routine steroids and antibiotics are not recommended Pneumonia: Antibiotics
Hypo-ventilation	More common in the immediate to early postoperative setting	Residual anesthetics, opioids and anxiolytics Splinting from inadequate analgesia	Consider reversal agents for NMBs, opioids, and benzodiazepines Multimodal analgesia Bilevel ventilation
Upper airway obstruction	Immediate to early postoperative setting	Patients with undiagnosed OSA at highest risk Residual anesthetics, opioids Airway edema [8]	Consider reversal agents for NMBs, opioids, and benzodiazepines Oropharyngeal/ nasopharyngeal airway, jaw thrust maneuvers CPAP

POD postoperative day, *RAD* reactive airway disease, *HF* heart failure, *TACO* transfusion-associated circulatory overload, *NPPE* negative pressure pulmonary edema, *TRALI* transfusion-related acute lung injury, *ARDS* acute respiratory distress syndrome, *BNP* brain natriuretic peptide, *TTE* transthoracic echocardiogram, *VTE* venous thromboembolism, *CTPA* CT pulmonary angiogram, *VQ scan* ventilation-perfusion scan, *LPV* lung protective ventilation, *GNRs* gram negative rods, *FES* fat emboli syndrome, *OSA* obstructive sleep apnea, *CPAP* continuous positive airway pressure

extrinsic compression [3]. Airway edema can occur in patients who are in prone or Trendelenburg positions or receive overly aggressive resuscitation [3]. Loss of pharyngeal tone may be from persistent effects of anesthetics, neuromuscular blocking drugs (NMBs), or opioids [3]. Localized tissue edema or hematomas from head and neck surgeries can cause extrinsic airway compression [3].

- Obstructive sleep apnea (OSA), use of opioids, and residual NMBs are risk factors for aspiration [6].
- Hypoventilation may be caused by residual NMB, respiratory depressants, and restrictive physiology (from postoperative abdominal binding or abdominal distention) [3].

PERIOPERATIVE MANAGEMENT

PREVENTION OF POSTOPERATIVE HYPOXEMIA

Preventive measures include preoperative optimization of preexisting comorbidities, intraoperative minimization of surgical and anesthetic impairments on respiratory physiology, and postoperative strategies. Preoperative pulmonary optimization is further discussed in Chap. 32. Key concepts include smoking cessation and treatment of preoperative pulmonary infections or exacerbations of chronic lung disease [6]. Preoperative physiotherapy (PT) can significantly reduce PPCs, including pneumonia, after upper abdominal surgery [13]. Neuraxial or regional anesthesia, in place of general anesthesia when possible, is an important intraoperative strategy to reduce PPCs [6].

Several post-operative strategies can decrease the risk of hypoxemic PPCs:

- Lung expansion techniques – incentive spirometry, deep breathing exercises, cough assist, chest PT, and continuous positive airway pressure (CPAP) – decrease the risk of PPCs by preventing and reversing atelectasis. There are no significant differences in efficacy between different lung expansion techniques [2, 3, 6].
- Consider CPAP in patients who are unable to perform other lung expansion exercises or have diagnosed or suspected OSA [6]. CPAP use in the immediate postoperative period decreases the incidence of reintubation in patients undergoing abdominal and cardiac surgery, but not in patients undergoing lung resection [14, 15].
- Patients with diagnosed or suspected OSA should be observed with continuous pulse oximetry for at least 6 hours after ambulatory surgery [6].
- There is limited evidence on the efficacy of early ambulation alone on preventing atelectasis and PE [6]. When used as a part of a postoperative protocol that also includes lung expansion techniques, early ambulation decreases PPCs [16].

- Venous thromboembolism (VTE) prophylaxis should be started as soon as possible after surgery to decrease the risk of PE.
- Use nasogastric tubes (NGTs) selectively in patients with symptomatic abdominal distention. Avoiding routine use of NGTs after abdominal surgery shows a trend toward reducing PPCs [17].
- Postoperative neuraxial and regional analgesia decreases the risk of PPCs compared with systemic opioids, especially in patients undergoing thoracic and upper abdominal procedures [6].

EVALUATION OF POSTOPERATIVE HYPOXEMIA

Key steps in the initial evaluation:

- Determine the adequacy of oxygenation, ventilation, and work of breathing to identify patients who require urgent airway intervention.
- Correct hypoxemia while assessing for the underlying cause. A non-rebreather mask (NRB) can be used as a rescue form of oxygen delivery when a patient's oxygen needs are unknown. Persistent hypoxemia despite oxygenation with an NRB, which delivers close to 100% FiO_2, suggests that hypoxemia is from a large shunt (e.g., diffuse pulmonary edema, lobar or lung collapse, large aspiration event, a right to left intracardiac shunt).
- An initial exam includes obtaining vital signs and assessing airway patency, neurologic status, use of accessory muscles, and volume status.
- Patients with suspected upper airway obstruction from OSA or loss of pharyngeal muscle tone (e.g., from residual anesthetics or opioids) benefit from jaw thrust or CPAP [3].
- Key findings on cardiopulmonary exam that may help discern the etiology of hypoxemia: Absent breath sounds may suggest a pneumothorax; diminished breath sounds can suggest a pleural effusion or significant bronchoconstriction leading to poor air movement; wheezing is seen with bronchoreactivity or pulmonary edema (cardiac wheeze).

Patient co-morbidities, surgical procedure and approach, type of anesthesia, and intraoperative and postoperative events can narrow the differential for postoperative hypoxemia (Table 51.2). The timing of postoperative hypoxemia can provide clues to diagnosis but should not supersede clinical judgement. Upper airway obstruction, atelectasis, hypoventilation, aspiration, and pulmonary edema generally occur in the immediate to early postoperative period.

TABLE 51.2 KEY CONSIDERATIONS IN THE INITIAL EVALUATION OF THE HYPOXEMIC POST-OPERATIVE PATIENT

Patient co-morbidities	Common issues with specific types of surgeries	Perioperative factors
Chronic lung disease, reactive airway disease Cardiac disease, heart failure Renal dysfunction Liver disease Neuromuscular disorders OSA – independent risk factor for aspiration and PE [11] Obesity Chronic opiate use or opioid dependence	Neurosurgery – aspiration, PE Head and neck – airway obstruction from local edema or hematomas, neuromuscular weakness from hypocalcemia, recurrent laryngeal nerve injury Thoracic – atelectasis Abdominal – atelectasis Orthopedic – PE, FES	Volume of fluids and blood products Type of anesthesia (general or regional) Use of paralytics and reversal agents Endotracheal intubation Major operative events – ACS, aspiration events Dose and frequency of opioids, anxiolytics Other recent drugs given

PE pulmonary embolism, *FES* fat emboli syndrome, *ACS* acute coronary syndrome

Postoperative pneumonia and PE are more common after postoperative day (POD) 2–3.

Initial diagnostic evaluation may include the following:

- Chest X-ray imaging (CXR) – identifies any alveolar filling process (e.g., pulmonary edema, aspiration, pneumonia, atelectasis).
- Arterial (ABG) or venous blood gas analysis (VBG) – can identify if hypoventilation is significantly contributing to hypoxemia. An ABG confirms true hypoxemia, quantifies severity, and allows calculation of the Alveolar-arterial (A-a) gradient. A normal A-a gradient suggests that hypoxemia is completely explained by hypoventilation.
- Electrocardiogram – detects any arrhythmias or cardiac ischemia that may be contributing to new heart failure.
- B-type natriuretic peptide or troponin – helpful adjuncts in patients with suspected heart failure or cardiac ischemia.

Pursue advanced testing such as CT pulmonary angiography, or ventilation-perfusion scan if there is clinical concern for PE, for example, unexplained sinus tachycardia or hypoxemia not otherwise

explained by CXR findings. Given the high incidence of postoperative PE, we generally have a low threshold for evaluating PE in unexplained hypoxemia with concomitant tachycardia.

PRINCIPLES OF MANAGEMENT

Management of postoperative hypoxemia should focus on both treating the underlying cause (Table 51.1) and improving oxygenation and ventilation. Address any factors that may exaggerate or exacerbate existing causes of hypoxemia: Correct anemia, improve cardiac output with fluid resuscitation or vasopressor/inotropic support, and stop any unnecessary medications that blunt hypoxic vasoconstriction (e.g., amlodipine for hypertension). Patients with hypercapnic respiratory failure require ventilatory support with bag-mask, bilevel, or mechanical ventilation. Methods to improve oxygenation include conventional oxygen therapy, high flow nasal cannula (HFNC), and CPAP.

- Conventional oxygen therapy includes nasal cannula, oxygen reservoir cannula, simple face masks, venturi masks, and NRB. These forms of oxygen delivery, except for venturi masks, deliver variable FiO_2's of oxygen depending on a patient's work of breathing.
- Venturi masks deliver a fixed FiO_2 at higher flow rates. They are useful in patients with obstructive lung disease, where stable oxygen delivery is important to avoid over-oxygenation which can suppress respiratory drive [15].
- HFNC delivers humidified air at high flow rates up to 60 L/min. In a 2017 meta-analysis that included both surgical and nonsurgical patients with acute respiratory failure, HFNC decreased the need for intubation and reintubation after extubation compared to conventional oxygen therapy [18]. HFNC is not superior to noninvasive ventilation (NIV) but is often better tolerated and can be considered an alternative to NIV post-extubation [18].
- Patients who undergo head and neck surgery may not be candidates for oxygen delivery by face mask or nasal cannula because these devices can put pressure on incision sites. Face tent or blow-by systems should be used as alternatives.
- Reintubation is sometimes needed in the immediate postoperative period. If measures to improve oxygenation are not quickly effective, it is generally better not to continue to temporize.

KEY CLINICAL PEARLS

- Atelectasis, upper airway obstruction, hypoventilation, aspiration, and pulmonary edema are more common causes of hypoxemia in the immediate and early postoperative period as these are frequently related to residual anesthetic effects or intraoperative interventions. Pneumonia and pulmonary emboli are more common after POD2–3.
- Early initiation of lung expansion techniques and VTE prophylaxis are important preventative measures against PPCs.
- Postoperative pulmonary edema may result from volume overload and unmasked underlying diastolic dysfunction or can, less commonly, result from noncardiogenic causes such as transfusion reactions or negative pressure pulmonary edema.
- In patients who develop hypoxemia after head and neck surgery, evaluate for upper airway obstruction from local edema, hematomas, or from recurrent laryngeal nerve injury.

ACKNOWLEDGMENT

Chapter reviewed by Cyrus Hui, MD, Valley Anesthesia Associates, University of Washington Valley Medical Center.

REFERENCES

1. Zhuo S, et al. Postoperative hypoxemia is common and persistent: a prospective blinded observational study. Anesth Analg. 2015;121:709–15.
2. Weissman C. Pulmonary function during the perioperative period. Isr Med Assoc J. 2000;2:868–874.
3. Nicholau TK. The postanesthesia care unit. In: Miller R, editor. Miller's anesthesia. 8th ed. Philadelphia, PA: Saunders; 2016. p. 2924–46.
4. Powell JF, et al. The effects of hypoxaemia and recommendations for postoperative oxygen therapy. Anaesthesia. 1996;51:769–72.
5. Fernandez-Bustamante A, et al. Postoperative pulmonary complications, early mortality and hospital stay following noncardiothoracic surgery: a multicenter study by the perioperative research network investigators. JAMA Surg. 2017;152(2):157–66.
6. Bohman JK, Kor DJ. Advances in perioperative pulmonary protection strategies. Adv Anesth. 2014;32:89–117.
7. Miskovic A, Lumb AB. Postoperative pulmonary complications. Br J Anesth. 2017;118(3):315–34.
8. Fowler MA, Spiess MA. Postanesthesia recovery. In: Barash PG, editor. Clinical anesthesia. 7th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2013. p. 1561–9.
9. Arieff AI. Fatal postoperative pulmonary edema: pathogenesis and literature review. Chest. 1999;115:1371–7.
10. Arcelus JI, et al. Venous thromboembolism following major orthopedic surgery: what is the risk after discharge? Orthopedics. 2006;29(6):506–16.
11. Toledo C, et al. Pulmonary complications after non-cardiac surgeries: temporal patterns and risk factors. Anesthesiol Intensive Ther. 2017;49(4):245–51.
12. Montravers P, et al. Diagnostic and therapeutic management of nosocomial pneumonia in surgical patients: results of the Eole Study. Crit Care Med. 2002;30:368–75.

13. Boden I, et al. Preoperative physiotherapy for the prevention of respiratory complications after upper abdominal surgery: pragmatic, double blinded, multicentre randomised controlled trial. BMJ. 2018;360:j5916.
14. Ireland CJ, et al. Continuous positive airway pressure (CPAP) during the postoperative period for prevention of postoperative morbidity and mortality following major abdominal surgery (Review). Cochrane Database of Syst Rev. 2014;(8):CD008930.
15. Tokarczyk AJ, et al. Oxygen delivery systems, inhalation, and respiratory therapy. In: Hagberg CA, editor. Hagberg and Benumof's airway management. Philadelphia: Elsevier. 2012. p. 287–308.e3.
16. Cassidy MR, et al. I COUGH reducing postoperative pulmonary complications with a multidisciplinary patient care program. JAMA Surg. 2013;148(8):740–5.
17. Verma R, Nelson RL. Prophylactic nasogastric decompression after abdominal surgery. Cochrane Database Syst Rev. 2007;(3):CD004929.
18. Ni Y, et al. Can high-flow nasal cannula reduce the rate of endotracheal intubation in adult patients with acute respiratory failure compared with conventional oxygen therapy and noninvasive positive pressure ventilation? A systematic review and meta-analysis. Chest. 2017;151(4):764–75.
19. Duggan D, Kavanagh BP. Atelectasis in the perioperative patient. Curr Opin Anaesthesiol. 2005;102:838–54.
20. Canet J, et al. Prediction of postoperative pulmonary complications in a population-based surgical cohort. Anesthesiology. 2010;113:1338–50.
21. Edelsberg J, et al. Venous thromboembolism following major orthopedic surgery: review of epidemiology and economics. Am J Health Syst Pharm. 2001;58(2):S4–S13.

Chapter 52
Postoperative Fever

Kara J. Mitchell

BACKGROUND

Postoperative fever is common, occurring in 10–40% of surgical patients [1, 5], depending on the temperature threshold used to define fever. While most early postoperative fever is due to cytokine release and resolves spontaneously [2, 3], the possibility of infection should always be considered. The absence of fever does not rule out infection, especially with advanced age, corticosteroid or nonsteroidal anti-inflammatory use, renal replacement therapy, and other risk factors [6]. Infection may also occasionally present with hypothermia.

PREOPERATIVE EVALUATION

The preoperative history and physical examination should include assessment for signs and symptoms of occult infection that may manifest as postoperative fever. The patient should be queried regarding constitutional symptoms (fever, night sweats, etc.), cough, dyspnea, chest pain, abdominal pain, diarrhea, dysuria, skin ulceration, or rash. Any history of common or serious noninfectious causes of postoperative fever should be sought, including medication sensitivities (especially family or personal history of malignant hyperthermia) or history of hyperthyroidism, malignancy, thrombophilia, or connective tissue disease.

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_52

PERIOPERATIVE MANAGEMENT

DEFINITION OF POSTOPERATIVE FEVER

Although there is no consensus definition of fever, many use a temperature of ≥38.3 °C/101.0 °F [6]. A cutoff of 38.0 °C/100.4 °F is often used for immunocompromised patients. Pulmonary artery thermistors, and bladder, esophageal or rectal probes are invasive, but provide the most accurate approximation of core temperature. Oral thermometers and infrared ear thermometry probes are susceptible to error but more practical and generally reliable. Axillary and temporal artery estimates and chemical dot measurements are unreliable and should not be used [6].

PREVENTION OF POSTOPERATIVE INFECTION AND FEVER

After most uncomplicated surgeries, prophylactic antibiotics should be discontinued upon closure of the incision in the operating room (or at least within 24 hours), even in the presence of a drain [7, 8]. Hypersensitivity reactions to antibiotics are a leading cause of noninfectious fever—which can lead to unnecessary evaluation and treatment, and delays in hospital discharge. To reduce the risk of drug fever, stop antibiotics and other unnecessary medications.

Surgical site infections are a common cause of infectious postoperative fever. Several strategies may reduce the risk of wound infections. First, hand hygiene is a key infection prevention strategy [9]. To optimize tissue oxygen delivery to the surgical site, maintain perioperative normothermia and euvolemia, and administer increased FIO2 during surgery and for 2–6 hours after surgery [7, 8]. Blood glucose control is important for wound healing and decreasing the risk of infection; control blood glucose during the immediate postoperative period (BG < 180–200 mg/dL), both in diabetics and nondiabetics [7, 8].

Several measures can be taken to mitigate the risk of infections associated with catheters, intravenous lines, and endotracheal intubation. Assess daily (ideally with stop orders or automated decision support) for adherence to guidelines, which recommend discontinuation of catheters and tubes as soon as possible—or the use of less risky alternatives:

- Discontinue a urethral catheter within 24 hours of surgery unless there is a clear indication for it to remain in place, such as acute urinary retention, critical illness (requiring precise measurement of urine output), incontinence in the setting of

open sacral or perineal wounds, prolonged immobilization, and end-of-life care [10, 11].

- Avoid the femoral site for central venous catheters. The subclavian site is recommended over the internal jugular site to minimize infection risk, but site-specific complication risk should also be considered. If the internal jugular is used, the catheter should be placed with ultrasound guidance [12, 13].
- Implement a plan to reduce ventilator-associated pneumonia, including sedation vacations, weaning plan, and elevation of the head >30 degrees. Use noninvasive positive pressure ventilation in place of intubation, when possible [14, 15].
- Use enteral nutrition, when possible, instead of total parenteral nutrition.

Instruct patients at high risk for developing pneumonia in the use of incentive spirometry [15]. This includes anyone undergoing general anesthesia, abdominal or thoracic surgery, particularly patients who are elderly or functionally dependent. Other risk factors for pneumonia include protein–calorie malnutrition, steroid use, recent alcohol use, smoking within the past year, COPD, history of stroke with residual deficits, and impaired sensorium.

EVALUATION OF POSTOPERATIVE FEVER

The timing of the onset of fever is a major key to determining its cause (see Table 52.1). Common immediate causes of fever include cytokine release and medications. Atelectasis does not cause fever; it can, however, cause hypoxia and should still be treated [6, 16]. Important life-threatening causes of early fever that should not be missed include:

- Malignant hyperthermia
- Neuroleptic malignant syndrome
- Serotonin syndrome
- Necrotizing fasciitis
- Transfusion reaction

A brief bedside evaluation has the highest yield for determining the etiology of a fever [5]. Cultures have little utility within the first 48 hours after surgery, unless there is suspicion for antecedent infection [5, 6]. Signs that raise concern for infection include tachycardia, tachypnea, hypotension, mental status changes, and reduced urine output. These findings, however, are nonspecific and are often present in the early postoperative period as a result of bleeding third-spacing, pain, or other noninfectious cause. Fever

TABLE 52.1 CAUSES OF POSTOPERATIVE FEVER BY TIME AFTER SURGERY

Immediate (within hours)	Acute (within the first week)	Subacute (1–4 weeks out)
Trauma/cytokine release	Surgical site infection (after 48 hours)	Surgical site infection (SSI)
Environment (Bair hugger, etc.)	Pneumonia or pneumonitis	Thrombophlebitis/DVT/PE
Transfusion reaction	Urinary tract infection (CAUTI)[a]	*C. difficile*
Necrotizing skin and soft tissue infection (Clostridium, GAS, etc.)	IV catheter infection (CLABSI)	Drug reaction[b]
Adverse medication events: malignant hyperthermia, neuroleptic malignant syndrome, serotonin syndrome or other causes of drug fever Infection (influenza, aspiration), DVT/PE, or other cause acquired prior to or during surgery	Noninfectious: MI, DVT/PE, CVA/SAH, thrombophlebitis, hematoma, pancreatitis, alcohol withdrawal, gout, gut ischemia, TTP, hyperthyroidism, adrenal insufficiency, transfusion or medication reaction, retained foreign body or inflammatory reaction to implanted hardware	Nosocomial or other infections: Pneumonia, UTI, IV catheter, intra-abdominal abscess, sinusitis, otitis media, osteomyelitis, endocarditis, cholecystitis (can be acalculous), etc.[c] Neoplasia or collagen-vascular diseases

GAS Group A Streptococcus, *CAUTI* catheter-associated urinary tract infection, *CLABSI* central line-associated bloodstream infection, *MI* myocardial infarction, *DVT/PE* deep venous thrombosis/pulmonary embolism, *CVA/SAH* cerebrovascular accident/subarachnoid hemorrhage

[a]It is unusual for UTI to be the cause of fever or bacteremia in a postoperative patient, unless urinary obstruction is present or the urinary tract was instrumented or manipulated as part of the procedure [6]

[b]Implicated medications include beta-lactam antibiotics and phenytoin. Rash and/or eosinophilia are commonly absent [6]

[c]Watch for surgery-specific causes: i.e., meningitis after neurosurgery, toxic shock after nasal or vaginal packing, parotitis after oral surgery, allograft rejection after transplant surgery, fat emboli after orthopedic surgery, infected hardware or graft material, etc.

occurring after postoperative day 3, multiple days of fever, and maximum temperature of greater than or equal to 39C are predictors of infection [4].

After 48–72 hours (or sooner if there is high clinical concern for infection), important considerations include surgical site infections, pneumonia, urinary tract infections, intravascular catheter infections, and many noninfectious causes [6]. Consider ordering the following tests, using the bedside evaluation—with careful examination of the surgical site and all indwelling catheter sites—and clinical context as a guide [6]:

- Complete blood count with differential ± other blood tests, as indicated by the situation.
- Blood culture when fever is present (draw two sets peripherally; or one from central line, one peripheral).
- Urinalysis, Gram stain, urine culture. If a urinary catheter is present, remove the catheter and obtain a clean catch specimen; if unable to remove the catheter, then obtain sample from the catheter port (not the urine bag).
- Chest X-ray ± sputum gram stain and culture if pneumonia suspected.
- Seek and tap fluid collections or sterile spaces that may have become contaminated (pleural, peritoneal, joint, CSF, etc.) for cell count, chemistries, gram stain, and culture, as appropriate. Superficial wound cultures are rarely helpful.
- Directed imaging (i.e., CT or ultrasound for abdominal pain, CT pulmonary angiogram if pulmonary embolism is suspected, etc.).
- Stool for *C. difficile* if watery diarrhea (≥3 loose stools in 24 hours) is present provided the patient is not receiving laxatives.
- Some centers offer serum procalcitonin testing to differentiate bacterial infections from other causes of fever; this technique is best studied in respiratory syndromes, and should be ordered judiciously in accordance with institutional protocols and policies.

In low-risk patients, a standardized fever protocol (in which testing and/or treatment is ordered only for localizing physical examination findings or for fever>101 °F occurring >48 hours out from surgery) can limit unnecessary tests and antibiotics without increasing morbidity [17].

PRINCIPLES OF MANAGEMENT

The mainstay of management of postoperative fever is the identification and treatment of the underlying cause. Several principles should be kept in mind [6]:

- Avoid empiric antibiotics unless there is a specific indication such as neutropenic fever, hemodynamic instability, or suspicion of a high-risk diagnosis such as meningitis.
- If empiric antibiotics are given, stop or narrow these after 48 hours if the patient is stable and cultures remain sterile.
- Infected wounds and fluid collections require debridement and/or drainage.
- Aggressive pulmonary hygiene should be provided to patients with increased respiratory secretions or impaired airway clearance.
- Remain alert for noninfectious causes of fever, as per Table 52.1.
- Acetaminophen may be given for comfort (appreciating the potential for hepatotoxicity with liver disease or starvation); use aspirin and NSAIDs only with caution (increases the risk of renal failure, GI ulceration, or bleeding at the surgical site) [18].

KEY CLINICAL PEARLS

- 🗝 A brief bedside evaluation has the highest yield for determining the etiology of a fever.
- 🗝 Atelectasis in itself does not cause fever. It does, however, cause hypoxia, increases risk for pneumonia, and should be treated with lung expansion maneuvers.
- 🗝 The incidence of wound and nosocomial infections increases once the patient is out from surgery for 48 hours or more.

ACKNOWLEDGMENTS

Paul S. Pottinger, MD, DTM&H, Professor, Division of Allergy and Infectious Diseases, Department of Medicine, University of Washington

REFERENCES

1. Galicier C, Richet H. A prospective study of postoperative fever in a general surgery department. Infect Control. 1985;6(12):487–90.
2. Netea MG, Kullberg BJ, Van der Meer JW. Circulating cytokines as mediators of fever. Clin Infect Dis. 2000;31:S178–84.
3. Ward ET, et al. Cost and effectiveness of postoperative fever diagnostic evaluation in total joint arthroplasty patients. J Arthroplast. 2010;25:43–8.
4. Ashley B, Spiegel DA, Cahill P, et al. Post-operative fever in orthopaedic surgery: how effective is the 'fever workup?'. J Orthop Surg. 2017;25(3):1–9.

5. Lesperancne R, et al. Early postoperative fever and the "Routine" fever work-up: results of a prospective study. J Surg Res. 2011;171:245–50.
6. O'Grady NP, Barie PS, Bartlett JG, et al. Guidelines for evaluation of new fever in critically ill adult patients: 2008 update from the American College of Critical Care Medicine and the Infectious Diseases Society of America. Crit Care Med. 2008;36:1330–49.
7. Anderson D, Podgorny K, Berríos-Torres S, et al. Strategies to prevent surgical site infections in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol. 2014;35(S2):S66–88.
8. Berríos-Torres SI, Umscheid CA, Bratzler DW, et al. Centers for disease control and prevention guideline for the prevention of surgical site infection, 2017. JAMA Surg. 2017;152(8):784–91.
9. Ellingson K, Haas J, Aiello A, et al. Strategies to prevent healthcare-associated infections through hand hygiene. Infect Control Hosp Epidemiol. 2014;35(S2):S155–78.
10. Gould CV, Umscheid CA, Agarwal RK, et al. Guideline for prevention of catheter-associated urinary tract infections 2009. Healthcare Infection Control Practices Advisory Committee, CDC. http://www.cdc.gov/hicpac/pdf/CAUTI/CAUTIguideline2009final.pdf.
11. Lo E, Nicolle L, Coffin S, et al. Strategies to prevent catheter-associated urinary tract infections in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol. 2014;35(S2):S32–47.
12. O'Grady NP, Alexander M, Burns LA, et al. Guidelines for the prevention of intravascular catheter-related infections. CDC; 2011. http://www.cdc.gov/hicpac/pdf/guidelines/bsiguidelines-2011.pdf.
13. Marschall J, Mermel L, Fakih M, et al. Strategies to prevent central line-associated bloodstream infections in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol. 2014;35(S2):S89–S107.
14. Klompas M, Branson R, Eichenwald E, et al. Strategies to prevent ventilator-associated pneumonia in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol. 2014;35(S2):S133–54.
15. Tablan OC, Anderson LJ, Besser R, et al. Guidelines for preventing healthcare-associated pneumonia. CDC; 2003. https://www.cdc.gov/infectioncontrol/guidelines/pdf/guidelines/healthcare-associated-pneumonia.pdf
16. Mavros MN, Velmahos GC, Falagas ME. Atelectasis as a cause of postoperative fever: where is the clinical evidence? Chest. 2011;140:418–24.
17. Kendrick JE, Numnum TM, Estes JM, et al. Conservative management of postoperative fever in gynecologic patients undergoing major abdominal or vaginal operations. J Am Coll Surg. 2008;207(3):393–7.
18. Plaisance KI, Mackowiak PA. Antipyretic therapy: physiologic rationale, diagnostic implications, and clinical consequences. Arch Intern Med. 2000;160:449–56.

Chapter 53
Postoperative Delirium

Susan E. Merel, Tyler Y. M. Lee, and Andrew A. White

BACKGROUND

Delirium is a common and serious altered mental state that may develop due to a wide variety of medical conditions or drug side effects. The Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-V) defines delirium as an acute and fluctuating disorder of attention, awareness, and cognition with evidence of an underlying organic cause or causes [1]. The pathogenesis of delirium is poorly understood and most likely multifactorial. Delirium is the most common surgical complication among older adults and may occur in up to 70% of post-surgery patients [2, 3]. The incidence varies widely with both patient- and surgery-specific risk factors. Meta-analyses have produced the estimates of incidence shown in Table 53.1 [4]. Delirium is underrecognized and underdocumented, with studies suggesting that only 12–35% of cases are recognized [5]. While many clinicians assume delirium will always be transient and cognition will return to baseline quickly, symptoms often persist; a meta-analysis showed persistent delirium in 33% of patients 1 month after discharge

TABLE 53.1 ESTIMATES OF INCIDENCE OF DELIRIUM IN INPATIENTS

Type of surgery/reason for admission	Incidence of delirium
ICU care (surgical and medical patients >65-year-old) [3]	70–87%
Elective vascular surgery [1, 2]	34.5% (29–39%)
Cardiac surgery [12]	32% (0–73%)
Hip fracture [13]	21.7% (4–53%)
Elective hip or knee replacement [3]	12.1% (9–28%)
Major elective surgery [1, 2]	10% (9–17%)

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_53

and in 21% a year after discharge [6]. Perioperative delirium is associated with greater cost, longer length of stay, greater morbidity, increased likelihood of subsequent institutionalization, prolonged functional decline, development of dementia, and mortality [2].

PREOPERATIVE EVALUATION

PATIENT-SPECIFIC RISKS

Older, frail patients with multimorbidity, functional impairment, dementia, or mild cognitive impairment are at the highest risk of developing postoperative delirium. Patients with a prior history of delirium are much more likely to develop delirium again. Caregiver support is associated with lower odds of postoperative delirium [7]. Other inherent risk factors are shown in Table 53.2.

Perioperative care teams should strive to assess and document the patient's preoperative mental status for postoperative comparison. In a preoperative visit or during the first visit post-surgery, all patients over 65 or their caregivers should be asked about a history of cognitive impairment or dementia. During a preoperative visit, all elders who do not report a history of cognitive impairment or dementia should be screened with the Mini-Cog instrument [8]. The Mini-Cog combines clock drawing with a three-item recall, and poor performance of this instrument is associated with an increased incidence of postoperative delirium and a 6-month mortality [9]. Patients at high risk of delirium and their family members should be counseled about the increased risk of delirium during surgery; this should be factored into any decisions about proceeding with surgery, and the preventative measures detailed below should be implemented.

TABLE 53.2 PATIENT RISK FACTORS FOR DELIRIUM

Patient characteristics	Comorbidities	Other factors
Age > 65 Male gender Prior history of delirium	Cognitive dysfunction, especially dementia Prior stroke Depression HIV Renal or liver disease Drug, alcohol, and tobacco abuse	Vision and hearing impairment malnutrition Functional disability Preoperative psychotropic drug use

SURGERY-SPECIFIC RISKS

The duration and physiologic stressor of the surgery influence the likelihood of precipitating delirium. Patients undergoing vascular surgery may be at particularly high risk of delirium [7]. Cardiopulmonary bypass may be a surgery-specific risk factor for delirium associated with more protracted cognitive dysfunction, but studies in this area are heterogeneous [10]. Single-incision laparoscopic surgery for colon cancer may reduce the incidence of postoperative delirium compared to conventional laparoscopic surgery [11]. Total ischemic time and total time with a mean arterial pressure less than 60 were found to increase the risk of delirium in a cohort of patients undergoing lung transplant [12].

PERIOPERATIVE MANAGEMENT

PREVENTION

Prevention trials utilizing behavioral and environmental approaches implemented by a multidisciplinary team have demonstrated a reduction in delirium incidence (absolute risk reduction 5–18%) [13]. A number of studies have shown that these multicomponent interventions can reduce the risk of falls in the hospital in addition to reducing the incidence of delirium [14]. Geriatric consultation has also been shown to be helpful [13]. Reduction of psychoactive medications before, during, and after surgery (especially benzodiazepines, antihistamines, and sedative-hypnotics) and optimization of pain control are key components of both nonpharmacologic multicomponent interventions and geriatric consultation interventions.

Meta-analyses show that prophylactic antipsychotics do not reduce the incidence, duration, or severity of delirium in hospitalized patients [15, 16]. The use of prophylactic melatonin, melatonin-receptor antagonists, and anticholinesterase inhibitors has also been studied and has not been shown to prevent delirium [16]. During postoperative intensive care unit (ICU) care, use of dexmedetomidine instead of benzodiazepines for sedation has been associated with lower rates of delirium in the ICU, but it is only recommended for use for the first 24 hours of sedation and may be associated with bradycardia [17, 18].

Interventions that have been shown to decrease the incidence and/or severity of delirium fall into the following categories: Normalizing the patient's environment as much as possible, avoiding potential deliriogenic medications, and maintaining physiologic homeostasis.

TABLE 53.3 INTERVENTIONS SHOWN TO PREVENT DELIRIUM IN POSTOPERATIVE PATIENTS

Providing patient's glasses and hearing aids when appropriate
Early mobilization
Avoid volume depletion and electrolyte abnormalities
Discontinue or substitute psychoactive medications
Frequent reorientation
Maintain day/night cycle by limiting naps, opening blinds, and avoiding nighttime interruptions
Adequate pain control without oversedation
Reduction of sedation in the intensive care unit (ICU)
Regional anesthesia for pain control
Consider geriatric consultation
Use of earplugs for sleep in the ICU

Geriatric consultation has been proven effective in some studies. Regional anesthesia for pain control may be helpful and should be discussed before the surgery. Effective prevention strategies are detailed in Table 53.3.

DIAGNOSIS

When delirium is suspected, the Confusion Assessment Method (CAM) is a helpful bedside diagnostic tool and defines delirium as follows [19]:

- Acute onset and fluctuating course *and* inattention
  and either
- Disorganized thinking *or*
- Altered level of consciousness

Administering the CAM as part of a structured 3-minute diagnostic interview known as the 3D-CAM may increase sensitivity; the 3-D CAM adds specific guidelines for testing inattention and disorganized thinking and showed a sensitivity of 95% and specificity of 94% in a prospective validation study [20]. Instructions for administering the 3-D CAM are shown in Table 53.4 [2, 20]. The manifestations of hypoactive delirium are subtle and may be missed or confused with fatigue or depression; using a structured diagnostic tool is particularly important when suspecting hypoactive delirium.

Confirm the diagnosis of delirium by excluding other neurologic and psychiatric conditions. Then, focus on identifying precipitants with history, medication review, physical exam (particularly neuro-

TABLE 53.4 THE 3-D CAM DIAGNOSTIC INTERVIEW FOR DELIRIUM

Assessment	Feature 1: Acute onset and fluctuating course	Feature 2: Inattention	Feature 3: Disorganized thinking	Feature 4: Altered level of consciousness
Patient responses to direct interviewer question	Has patient felt confused, seen hallucinations, or not been oriented to place?[a]	Can patient do digit span of three digits backward, days of week or months of year backward?	Is patient oriented to year, day of week, and type of place (hospital)?	
Interviewer observation	Does patient's cognition or level of consciousness fluctuate?	Did patient seem easily distractible during the interview?	Is the patient's flow of ideas unclear, illogical, rambling, or tangential, or do they have paucity of speech?	Was the patient somnolent or hypervigilant?

Instructions: Make sure the patient is wearing his/her glasses and/or hearing aid. Each question can be stated twice; "I don't know," no response or an unintelligible response all count as incorrect. Features 1 through 3 can be scored positive by either interviewer observation or patient response to questions

[a]Can also be assessed by asking family member or healthcare provider
CAM is positive when features 1 and 2 and either 3 or 4 are positive
Adapted from Marcantonio [2] and Palihnich et al. [23]

logic and cognitive exam), and basic lab tests (complete blood count (CBC), Chem 7). Ideally, postoperative providers will refer to documentation of the patient's preoperative mental status and be aware of any patients they are caring for who have a history of dementia or cognitive impairment. When appropriate, urinalysis, electrocardiogram (ECG), chest X-ray (CXR), drug levels, or a toxin screen may confirm a suspected precipitant. Remember that the underlying cause of delirium may be multifactorial. Head computed tomography (CT) is rarely helpful in the workup for delirium, but is indicated if there is a risk factor for intracranial bleeding (e.g., history of head trauma or anticoagulant use) or evidence of new focal neurologic impairment. Lumbar puncture for cerebrospinal fluid (CSF) analysis

is usually not indicated as part of delirium evaluation in the postoperative population unless the patient has undergone neurosurgical/spinal intervention.

PRECIPITATING ETIOLOGIES

Many medications and medical conditions can contribute to the development of delirium. Use of deliriogenic medications is the most common reversible precipitating factor [2]. Among frail elderly patients, delirium is commonly a multifactorial syndrome without a clear single etiology. Although the following list is not comprehensive, consider the following common precipitants:

- *Medications*: Sedative-hypnotics, barbiturates, antidepressants, anticholinergics, opioid analgesics, antipsychotics, anticonvulsants, antihistamines, corticosteroids, fluoroquinolones (relatively rare with levofloxacin, more common with ciprofloxacin in the setting of reduced glomerular filtration test (GFR)), and anti-Parkinsonian agents
- *Acute medical conditions*: Fluid, electrolyte and metabolic abnormalities (sodium, glucose, calcium, urea), vitamin deficiency (thiamine), uncontrolled pain, hypoxemia, hypercarbia, fever, hypotension, anemia, infections (urinary tract infection (UTI), pneumonia, catheter-associated bloodstream infections), myocardial infarction, alcohol and drug withdrawal, constipation, and urinary retention
- *Iatrogenic*: Sleep cycle disruption, catheters and other "tethers" (intravenous (IV) lines, ECG leads, and restraints), lack of access to hearing aids, glasses, interpreter services, food, and water

MANAGEMENT

Delirium is often reversible if the precipitating factors are addressed, but it can take weeks to months to resolve completely and some patients never fully recover. Identifying and treating underlying causes of delirium are essential to increase the chance that the patient will recover. Simultaneously, implement environmental measures to improve the patient's orientation and reduce sensory deprivation, such as frequent orientation by staff and family, provision of the patient's glasses and hearing aids, bright light during the day and dark and quiet at night. Physical and occupational therapies should be implemented or reimplemented if they have been interrupted during the hospital stay. Continuous observation by "sitters" or family is

often necessary. Physical restraints can cause injury and should be avoided unless absolutely necessary for the patient's safety.

Antipsychotics should not be used routinely in the treatment of delirium; there is no strong evidence to suggest an effect on delirium duration, severity, or hospital or intensive care unit length of stay [11, 21]. Risks of antipsychotic treatment include extrapyramidal side effects, hypotension, arrhythmias, aspiration pneumonia, falls, and sudden cardiac death. Antipsychotics may play a limited role in the management of severe behavioral or emotional symptoms, especially hallucinations or delusions. Second-generation antipsychotics are not superior to haloperidol, except when there is concern for extrapyramidal symptoms or QTc prolongation [22]. EKG monitoring is recommended for patients receiving IV haloperidol and for patients with cardiac disease taking oral antipsychotics. Antipsychotics should generally be avoided in patients with a QTc >500, but may be considered as a palliative measure after a risk–benefit discussion with the decision maker in patients experiencing considerable suffering from their symptoms of delirium. Quetiapine is more sedating than haloperidol and can be helpful when sedation is desired, but is not available in an intravenous form. Avoid using more than one agent at a time and do not add sedating medications such as sleep aids in addition to the antipsychotics. Antipsychotics should be started at a very low dose, titrated up slowly if necessary, and stopped as soon as possible. In most cases, antipsychotics should be used for just a few days.

Given the side-effect and risk profile of these medications, families should be counseled on the risks and benefits of their use. Antipsychotics should only be used if the patient's delirium is hindering his/her recovery or he/she is suffering as a result, acknowledging that there are small but significant short-term risks and potentially increased mortality with long-term use. If antipsychotics are thought to be essential for symptom control upon discharge, a clear plan for discontinuing them should be communicated to the accepting physician. Detailed treatment recommendations are shown in Table 53.5.

Patients can often be discharged home before the delirium has fully resolved if they have appropriate caregiving support; some patients may recover more quickly in the familiar home environment. Discharging providers should always communicate the diagnosis of delirium and its precipitating factors and treatment in their discharge summary; this information can help inform prevention and treatment plans during a future hospitalization or surgery.

TABLE 53.5 TREATMENT OF DELIRIUM

Supportive care *Delirium can lead to injury or irreversible functional decline. Prevention of such sequelae includes the following steps:*	Optimize nutrition and avoid dehydration Mobilize frequently to prevent pressure ulcers and functional decline Prevent aspiration with head of bed precautions when appropriate Optimize bowel regimen Fall and wander precautions when appropriate Treat pain, hypoxia, and hypercarbia
Behavioral control *The first principle of behavioral management is to utilize environmental or social measures rather than pharmacologic or physical restraints whenever possible.*	Frequent orientation, including posting of calendar and clock Involve family and consistent providers to provide familiar context Maintain night/day cycle Provide constant observer or wander guard Consider securing or protecting vulnerable lines, drains, and wounds from harmful manipulation
Pharmacologic treatment *If behavioral interventions fail or agitated delirium is life-threatening (such as in the ICU), consider the following*:	Low-dose haloperidol (0.5–1 mg PO/IM/IV q hs to bid PRN) or quetiapine (12.5 mg po qhs to bid PRN) Recall that these are contraindicated in patients with neuroleptic malignant syndrome, prolonged QTc, or Parkinsonism Reassess behavior frequently and stop the antipsychotic medication a few days after delirium has resolved Benzodiazepines worsen confusion and sedation and should not be used

KEY CLINICAL PEARLS

- Postoperative delirium is common, leads to morbidity and mortality, can persist for months after hospitalization, and in some patients never fully resolves.
- The structured 3D-CAM interview has good sensitivity and specificity for the detection of delirium.
- The detection of delirium should trigger a search for an underlying medical cause and the treatment of that cause if possible.
- Treat delirium with supportive care and behavioral control measures.
- Antipsychotics should not be used routinely in the treatment of delirium, but do play a limited role in the control of severe behavioral or emotional symptoms.

REFERENCES

1. American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 5th ed. Arlington: American Psychiatric Association; 2013.
2. Marcantonio ER. Delirium in hospitalized older adults. New Engl J Med. 2017;377:1456–66.
3. Dyer CB, Ashton CM, Teasdale TA. Postoperative delirium. A review of 80 primary data-collection studies. Arch Intern Med. 1995;155(5):461–5.
4. Dasgupta M, Dumbrell A. Preoperative risk assessment for delirium after noncardiac surgery: a systematic review. J Am Geriatr Soc. 2006;54:1578–89.
5. Inouye SK, Westendorp RG, Sacynski JS. Delirium in elderly people. Lancet. 2014;383:911–22.
6. Cole MG, et al. Persistent delirium in older hospital patients: a systematic review of frequency and prognosis. Age Ageing. 2009;38:19–26.
7. Watt J, et al. Identifying older adults at risk of delirium following elective surgery: a systematic review and meta-analysis. J Gen Intern Med. 2018;33(4):500–9.
8. Axley MS, Schenning KJ. Preoperative cognitive and frailty screening in the geriatric surgical patient: a narrative review. Clin Ther. 2015;37:2666–75.
9. Chow WB, Rosenthal RA, Merkow RP, et al. Optimal preoperative assessment of the geriatric surgical patient: a best practices guideline from the American College of Surgeons National Surgical Quality Improvement Program and the American Geriatrics Society. J Am Coll Surg. 2012;215(4):453–66.
10. Selnes OA, Gottesman RF, Grega MA, et al. Cognitive and neurologic outcome after coronary-artery bypass surgery. N Engl J Med. 2012;366:250–7.
11. Nishizawa Y, et al. Clinical benefits of single-incision laparoscopic surgery for postoperative delirium in elderly colon cancer patients. Surg Endosc. 2018;32:1434–40.
12. Anderson BJ, et al. Incidence, risk factors, and clinical implications of post-operative delirium in lung transplant recipients. J Heart Lung Transplant. 2018;37(6):755–62.
13. The American Geriatrics Society Expert Panel on Postoperative Delirium in Older Adults. American Geriatrics Society abstracted clinical practice guideline for postoperative delirium in older adults. J Am Geriatr Soc. 2015;63:142–50.
14. Hshieh TT, Yue J. Oh E, et al. Effectiveness of multicomponent nonpharmacological delirium interventions: a meta-analysis. JAMA Intern Med. 2015;175:512–20.
15. Neufeld KJ, et al. Antipsychotic medication for prevention and treatment of delirium in hospitalized adults: a systematic review and meta-analysis. J Am Geriatr Soc. 2016;64:705–14.
16. Siddiqi N, Harrison JK, Clegg A, et al. Interventions for preventing delirium in hospitalized non-ICU patients. Cochrane Database Syst Rev. 2016;(3):CD005563.
17. Riker RR, et al. Dexmedetomidine vs midalzolam for sedation of critically ill patients. A randomized trial. JAMA. 2009;301(5):489–99.

18. Su X, et al. Dexmedetomidine for prevention of delirium in elderly patients after non-cardiac surgery: a randomized, placebo-controlled trial. Lancet. 2016;388:1893–902.
19. Inouye SK, van Dyck CH, Alessi CA, et al. Clarifying confusion: the confusion assessment method. Ann Intern Med. 1990;113:941–8.
20. Marcantonio ER, Ngo LH, O'Connor M, et al. 3D-CAM: derivation and validation of a 3-minute diagnostic interview for CAM-defined delirium: a cross-sectional diagnostic test study. Ann Intern Med. 2014;161:554–61.
21. Flaherty JH, Gonzales JP, Dong B. Antipsychotics in the treatment of delirium in older hospitalized adults: a systematic review. J Am Geriatr Soc. 2011;59:S269–76.
22. Campbell N, Boustani M, Ayub A, et al. Pharmacological management of delirium in hospitalized older adults—a systematic review. J Gen Intern Med. 2009;24(7):848–53.
23. Palihnich K, Inouye SK, Marcantonio ER. The 3D CAM training manual for research. Boston: Hospital Elder Life Program; 2014. www.hospitalelderlifeprogram.org.

Chapter 54
Postoperative Ileus

Sandra Demars

BACKGROUND

It is normal for postoperative patients to have "physiologic" arrest of gastrointestinal (GI) tract motility in response to surgical stress. Ileus, on the other hand, is a state of prolonged pathologic dysmotility beyond the expected timeframe. It is unknown why physiological postoperative GI tract dysmotility progresses to postoperative ileus (POI) in some patients. It is a multifactorial process, and several mechanisms have been identified, including autonomic nervous system dysfunction, inhibitory autonomic neural reflexes, inflammation, gastrointestinal neurohumoral peptides, fluid and electrolyte imbalance, systemic opioids, and surgical technique [1–3].

Unfortunately, there is a lack of consensus in the literature defining the "normal" expected timeframe for resumption of GI transit (ROT). Thus, the threshold distinguishing "normal" dysmotility from pathologic "prolonged" postoperative ileus (POI) is unclear. Lack of a universal definition has made it difficult to reliably and consistently estimate true POI incidence (often quoted at between 3 and 32%), identify risk factors, and reproduce and compare studies investigating preventative or therapeutic interventions [4]. POI rates are estimated at 10–25% following major abdominal surgery, and less commonly following orthopedic, urologic, and gynecologic operations [1].

An international consensus panel has defined POI as the occurrence of *two or more of the following signs and symptoms on postoperative day 4 or after* [4]:

- Nausea or vomiting
- Inability to tolerate an oral diet over the preceding 24 hours
- Absence of flatus over the preceding 24 hours

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_54

- Abdominal distention
- Radiologic confirmation

Postoperative ileus not only increases patient discomfort, dissatisfaction, and immobility, but is also associated with an increased rate of postoperative complications, length of stay (LOS), and readmission rates [1, 5, 6]. POI is the most important factor prolonging length of stay after GI surgery, increasing hospital stay duration by an average of 4–6 days thereby increasing direct health care costs by approximately $9000 per hospital stay [2, 7, 8]. The economic consequences of postoperative ileus following abdominal surgery on the US health care system are estimated to reach close to $1.5 billion annually [7]. Tolerance of solid food and passage of stool best reflects ROT and therefore should be used as the primary outcome measure in future clinical trials on POI [9].

PREOPERATIVE EVALUATION

It is difficult to predict which patients will develop POI, but the medicine consultant can anticipate that selected patients are at increased risk and should consider initiating preventative strategies. While studies use heterogenous definitions of POI, the most important risk factors for POI generally include [3, 5, 10, 11]:

Patient factors:

- Electrolyte abnormalities
- Studies have been inconsistent regarding obesity, some have found an association between POI and obesity, and some have not
- Lower preoperative albumin level

Operative factors:

- Longer operative times for abdominal or pelvic surgery
- Lower gastrointestinal surgery
- Open operative approach
- Increased intraoperative small bowel manipulation
- Bowel resection surgery

Postoperative factors:

- Greater duration of nasogastric (NG) tube use
- Delayed enteral nutrition
- Perioperative infection
- Perioperative decrease in hemoglobin or perioperative transfusion

- Greater use of systemic opiates
- Inadequate or excessive fluid resuscitation perioperatively

There has been extensive research into POI and colorectal surgery because of the high incidence in this population. Therefore, multiple risk factors unique to colorectal surgery have been identified. These are included below [1, 8, 10, 12].

Patient factors:

- Male gender
- Age > 73
- Smoking
- Peripheral vascular disease
- Respiratory comorbidity/Chronic Obstructive Pulmonary Disease
- Presence of ascites
- Diagnosis of Crohn's disease or volvulus
- Previous abdominal surgery
- Carcinomatosis

Preoperative factors:

- Preoperative chemotherapy
- Lack of mechanical bowel preparation
- Lack of oral preoperative antibiotics

Operative factors:

- Emergency surgery
- Ileocolic anastomosis
- Stoma creation
- Larger incisions

For urologic surgery, urine in the operating field, higher Clavien–Dindo score (classification scoring system of the therapy needed to correct surgical complications), advanced age, and obesity may contribute to POI [3, 13]. For gynecologic surgery, additional POI risk factors include cystotomy, lysis of adhesions, and bowel resection [14, 15].

PERIOPERATIVE MANAGEMENT

EFFECTIVE INDIVIDUAL PREVENTION STRATEGIES [1, 3]

- *Minimally invasive and minimally traumatic surgical techniques*: Laparoscopic surgery is associated with a shorter time to recovery of bowel function.
- *Epidural local anesthetic*: Mid-thoracic infusion for 2–3 days postoperatively reduces spinal inhibitory neural reflexes to the

gut thereby blunting the surgical stress response and decreasing the need for systemic opiates, and has been shown to accelerate the return of bowel function by 1–2 days. This intervention has mostly been studied with intra-abdominal surgeries including vascular, gynecologic, and urologic procedures.

- *Alvimopan* (peripherally acting mu-opioid receptor antagonist): Multiple trials have shown decreased time to first stool and tolerance of diet, as well as shortened hospital stay durations. However, due to concern for cardiovascular adverse effects, its use is currently limited to short-term use (15 doses) at hospitals registered in ENTEREG Access Support and Education (EASE) Program, and only to patients following bowel resection with primary anastomosis. The first dose is given between 30 min and 5 hours prior to surgery and then twice daily postoperatively.
- *Postoperative gum chewing*: Meta-analyses reveal shorter ROT and decreased LOS.
- *Avoidance/reduction of systemic opioids*: Opiate use increases the risk of POI; acetaminophen, nonsteroidal anti-inflammatory drugs (NSAIDs), tramadol and other non-opioid pain medications can minimize the need for opioids. NSAIDs must be used with caution due to potential gastrointestinal and renal toxicity. In addition, NSAIDs increase risk of postoperative anastomotic leak and are only safe for up to 48 hours of use in patients after colorectal surgery. Preemptive use of medications to prevent central sensitization, such as gabapentin and dexamethasone, appear to be effective in minimizing postoperative pain if initiated before surgery [16, 17].
- *Early enteral feeding*: Many studies, including two separate Cochrane reviews, have deemed early enteral feeding to be safe after abdominal and gynecologic surgeries. A recent study of patients undergoing colorectal anastomosis found significantly shorter ROT in patients who began feeding on postoperative day 1 versus feeding after complete resumption of GI transit [18].
- *Restrictive fluid management*: There is limited literature specifically looking at restrictive fluid management and POI; however, one study demonstrated shortened duration of POI, and other studies have documented harm associated with liberal fluid administration.
- *Electrolyte correction*: Many studies have demonstrated increased rate of POI with hypokalemia, hypocalcemia and hyponatremia; however, it is not clear which condition

precipitates the other (i.e., the fluid sequestration which occurs in POI may perpetuate the electrolyte changes and not the other way around) [6].

- *Daikenchuto (DKT)*: A recent meta-analysis demonstrated decreased rates of POI with perioperative administration of this traditional Japanese herbal medicine [19].
- *Postoperative coffee consumption*: One study showed earlier ROT following open colectomy with postoperative coffee consumption [20].
- *Laxative use*: Data is limited but suggest benefit with no obvious harm. One trial following hysterectomy found the scheduled use of milk of magnesia and biscolic suppositories significantly minimized time to first bowel movement [21].
- *Intravenous lidocaine*: Studies have shown improved pain control and shorter ROT; however, there are concerns about inadequate documentation of side effects and lack of consensus on infusion recommendations.
- *Intravenous magnesium*: A randomized control trial (RCT) demonstrated shorter ROT [22].

EFFECTIVE BUNDLED PREVENTION APPROACH: MULTIMODAL SURGICAL FAST TRACK/ENHANCED RECOVERY AFTER SURGERY (ERAS) PROTOCOLS

Many surgical centers utilize fast track/enhanced recovery programs for colorectal surgery, which are bundled interventions to optimize the surgical patient experience and reduce postoperative complications. The principles of these multimodal fast track/enhanced recovery programs are widely accepted [23]. ERAS protocols for colorectal surgery have clearly demonstrated shorter length of stay, cost reduction, and improved patient experience, and now a recent study found that adherence to >85% of the protocol protected patients from POI [24]. Most ERAS protocols are composed of the following interventions [3]:

- Preoperative phase: Patient information about the surgical procedure as well as the ERAS protocol, sweetened oral liquids on the morning of surgery, no bowel preparation, avoidance of routine anxiolytic premedication, reduction of preoperative fasting period to 2 hours for liquids and 6 hours for solids
- Intraoperative phase: Preference for laparoscopic approach, avoidance of bladder, gastric and abdominal drains, optimal fluid replacement based on suitable monitoring, avoidance of long-acting opioids, active measures to combat hypothermia, nausea, and vomiting

- Postoperative measures: Early mobilization, immediate postoperative removal of NGT, early enteral nutrition, multimodal analgesic program, removal of the bladder catheter on postop day 1, limitation of postoperative intravenous fluids, thromboprophylaxis, digestive stimulation with gum chewing and carbohydrate loading

EVALUATION OF PATIENT WITH SUSPECTED POI

History and Physical Examination

Patients with POI will often complain of diffuse abdominal pain/distention, nausea, emesis, inability to pass flatus or stool, or inability to tolerate a normal diet. Beware of signs suggesting bowel ischemia or perforation (fever, tachycardia, or peritoneal signs) that require emergent surgical evaluation. Alternative diagnoses should be considered including gastroparesis in patients with long standing diabetes, and small bowel obstruction (SBO) in patients with previous abdominal surgeries, areas of potential hernia formation, abdominal masses, large tumor burden, stomas, or Crohn's disease. SBO should also be considered in the case of patients with intense colicky pain or feculent emesis. Other etiologies to consider include constipation/stool impaction, acute colonic pseudo-obstruction, toxic megacolon, volvulus, anastomotic leak, intra-abdominal infection or abscess, and large bowel obstruction. Also, be mindful of other contributors to ileus such as medications or other medical conditions as discussed below.

Review the medication list for possible contributors to ileus:

- Opiates
- Anticholinergics
- Antihistamines
- Steroids
- Tricyclic antidepressants
- Calcium channel blockers
- H2 blockers

Common exam findings for POI include:

- Decreased, or absent, bowel sounds
- Abdominal distension
- Mild diffuse tenderness
- Tympany

Laboratory and Imaging Work-Up

Labs should be obtained to identify reversible factors leading to an ileus such as those listed below. Correction of the primary underlying problem should be treatment enough to resolve the ileus.

- Leukocytosis: Consider sepsis, abdominopelvic abscess, cholecystitis, appendicitis, or bowel ischemia secondary to SBO.
- Hemoglobin/hematocrit: Consider intra-abdominal or retroperitoneal bleeding if decreased; consider dehydration if elevated.
- Chemistry panel: Evaluate for electrolyte imbalances associated with ileus including hypokalemia, hypomagnesemia, hyponatremia, hypocalcemia, uremia; consider sepsis or bowel ischemia secondary to SBO in the case of metabolic acidosis.
- Elevated liver function panel: Consider gallstones or pancreatitis.
- Elevated amylase/lipase: Consider pancreatitis.

Imaging should begin with supine and upright plain abdominal radiographs ("obstruction series") to distinguish between ileus and other pathologies. Common patterns include:

- Dilated loops of bowel (>3 cm): Seen in ileus or SBO.
- Paucity of gas in the colon: Seen in ileus or SBO.
- Air-fluid levels suggest SBO, but may also be seen in ileus.
- Pneumoperitoneum: Concerning for bowel perforation or recent insufflation during laparoscopy. On supine films, look for Rigler's sign (double wall sign) which is a sign of lucency (gas) on both sides of the bowel wall. On upright films, look for free air under the diaphragm.
- Mucosal thickening (thumbprint sign): Suggests bowel inflammation; concerning for bowel ischemia.
- Large bowel dilatation (>6 cm or >9 cm at the cecum): Suggests large bowel obstruction or acute colonic pseudo-obstruction.
- Dilation of transverse colon/splenic flexure >6 cm, with alteration of normal wall contour (effacement or thumbprinting), intraluminal gas, and possibly pneumoperitoneum: Concerning for toxic megacolon.
- Dilated twisted loop of colon (coffee bean sign): Seen in volvulus.

Plain films, however, are often indeterminate. If you have clinical suspicion for a more serious problem, consider obtaining a computed tomography (CT) abdomen/pelvis with oral contrast. Abdominal CT can also often identify secondary causes of ileus, such as abscess. If diagnosis after CT is still uncertain, consider upper gastrointestinal contrast studies with water-soluble contrast.

TREATMENT OF POI

- Nil per os (NPO) except sips of clears.
- Intravenous fluid (IVF) as needed.

- Replete electrolytes as needed.
- Treat concomitant constipation with appropriate agents.
- Ambulate regularly.
- Replace gastrointestinal fluid losses with a balanced isotonic crystalloid solution (such as Ringer's Lactate or Plasma-Lyte 148) over 0.9% saline [6].
- Minimize opiates as able, and consider scheduled acetaminophen, tramadol, and judicious NSAID use (avoiding gastrointestinal and renal toxicity).
- Utilize alvimopan if available.
- Perform serial clinical evaluations and reimage for worsening or persistence.
- Do not routinely place a nasogastric (NG) tube, but if the patient has significant vomiting, distension, or pain consider inserting one and putting it on low-intermittent wall suction (after checking with the surgical team to ensure that it is safe to do so).
- If patient has not had adequate oral intake for 7 days, start parenteral nutrition [6].
- Once bowel function resumes, remove the NG tube (if present) and advance the diet as tolerated, beginning with clear liquids.

KEY CLINICAL PEARLS

- The most significant risk factors for ileus are an open surgical approach, abdominal surgery, longer operative times, increased handling of the small bowels, perioperative blood loss, duration of NGT, systemic opioids, and factors that create bowel wall edema (lower albumin levels, electrolyte abnormalities, and liberal fluid administration).
- Utilization of enhanced recovery after surgery protocols is the most successful prevention approach, as these protocols employ many strategies that have each demonstrated faster ROT times (laparoscopic approach, epidural anesthesia, early feeding, early mobilization, immediate removal of NGT after surgery, restrictive fluid management, etc.).
- It is very important to rule out obstruction and reversible factors contributing to ileus (such as infection, electrolyte abnormalities, medications) when evaluating a postoperative patient with abdominal pain, distention, nausea, emesis, and decreased flatus/stool.

ACKNOWLEDGMENTS

Lauge Sokol-Hessner, MD. Hospital Medicine Program, Division of General Medicine and Primary Care, Department of Medicine, Beth Israel Deaconess Medical Center.

REFERENCES

1. Bragg D, El-Sharkawy AM, Psaltis E, Maxwell-Armstrong CA, Lobo DN. Postoperative ileus: recent developments in pathophysiology and management. Clin Nutr. 2015;34:367–76.
2. Mattei P, Rombeau JL. Review of the pathophysiology and management of postoperative ileus. World J Surg. 2006;30:1382–91. https://doi.org/10.1007/s00268-005-0613-9. PMID: 16850151.
3. Venara A, Neunlist M, Slim K, Barbieux J, Colas PA, Hamy A, Meurette G. Postoperative ileus: pathophysiology, incidence, and prevention. J Visc Surg. 2016;153:439–46.
4. Vather R, Trivedi S, Bissett I. Defining postoperative ileus: results of a systematic review and global survey. J Gastrointest Surg. 2013;17(5):962–72.
5. Murphy MM, Tevis SE, Kennedy GD. Independent risk factors for prolonged postoperative ileus development. J Surg Res. 2016;201:279–85.
6. Vather R, Bissett I. Management of prolonged postoperative ileus: evidence-based recommendations. ANZ J Surg. 2013;83:319–24.
7. Iver S, Saunders WB, Stemkowski S. Economic burden of postoperative ileus associated with colectomy in the United States. J Manag Care Pharm. 2009;15(6):485–94.
8. Artinyan A, Nunoo-Mensah JW, Balasubramaniam S, Gauderman J, Essani R, Gonzalez-Ruiz C, Kaiser AM, Beart RW Jr. Prolonged postoperative ileus-definition, risk factors, and predictors after surgery. World J Surg. 2008;32(7):1495–500.
9. van Bree SHW, Bemelman WA, Hollmann MW, et al. Identification of clinical outcome measures for recovery of gastrointestinal motility in postoperative ileus. Ann Surg. 2014;259:708–14.
10. Vather R, Josephson R, Jaung R, Robertson J, Bissett I. Development of a risk stratification system for the occurrence of prolonged postoperative ileus after colorectal surgery: a prospective risk factor analysis. Surgery. 2015;157:764–73.
11. Ay AA, Kutun S, Ulucanlar H, Tarcan O, Demir A, Cetin A. Risk factors for postoperative ileus. J Korean Surg Soc. 2011;81:242–9.
12. Chapuis PH, Bokey L, Keshava A, Rickard MJ, Stewart P, Young CJ, et al. Risk factors for prolonged ileus after resection of colorectal cancer: an observational study of 2400 consecutive patients. Ann Surg. 2013;257:909e15.
13. Mattei A, Birkhaeuser FD, Baermann D, Warncke SH, Studer UE. To stent or not to stent perioperatively the ureteroileal anastomosis of ileal orthotopic bladder substitutes and ileal conduits? Results of a prospective randomized trial. J Urol. 2008;179(2):582–6.
14. Antosh DD, Grimes CL, Smith AL, et al. A case-control study of risk factors for ileus and bowel obstruction following benign gynecologic surgery. Int J Gynaecol Obstet. 2013;122:108.
15. Bakkum-Gamez JN, Langstraat CL, Martin JR, et al. Incidence of and risk factors for postoperative ileus in women undergoing primary staging and debulking for epithelial ovarian carcinoma. Gynecol Oncol. 2012;125:614.
16. Pandey CK, Priye S, Singh S, Singh U, Singh RB, Singh PK. Preemptive use of gabapentin significantly decreases postoperative pain and rescue analgesic requirements in laparoscopic cholecystectomy. Can J Anaesth. 2004;51(4):358.
17. Bisgaard T, Klarshov B, Kehlet H, Rosenberg J. Preoperative dexamethasone improves surgical outcomes after laparoscopic cholecystectomy: a randomized double-blind placebo-controlled trial. Ann Surg. 2003;238(5):651.
18. Nematihonar B, Salimi S, Noorian V, Samsami M. Early versus delayed (traditional) postoperative oral feeding in patients undergoing colorectal anastomosis. Adv Biomed Res. 2018;16(7):30. https://doi.org/10.4103/abr.abr_290_16. eCollection 2018.
19. Ishizuka M, Shibuya N, Nagata H, Takagi K, Iwasaki Y, Hachiya H, Aoki T, Kubota K. Perioperative administration of traditional Japenese herbal medicine *Daikenchuto* relieves postoperative ileus in patients undergoing surgery for gastrointestinal surgery for gastrointestinal cancer: a systemic review and meta-analysis. Anticancer Res. 2017;37:5967–74.

20. Muller SA, Rahbari NN, Schneider F, Warschkow R, Simon T, von Frankenberg M, Bork U, Weitz J, Schmied BM, Buchler MW. Randomized clinical trail on the effect of coffee on postoperative ileus following elective colectomy. Br J Surg. 2012;99(11):1530–8.
21. Fanning J, Yu-Brekke S. Prospective trial of aggressive postoperative bowel stimulation following radical hysterectomy. Gynecol Oncol. 1999;73(3):412–4.
22. Shariat MS, Motalebi M, Najafi A, Imani F, Etezadi F, Pourfakhr P, Khajavi MR. Magnesium can decrease postoperative physiological ileus and postoperative pain in major non laparoscopic gastrointestinal surgeries: a randomized controlled trial. Anesth Pain Med. 2013;4(1):e12750.
23. Wind J, Polle SW, Fung Kon Jin PH, Dejong CH, von Meyenfeldt MF, Ubbink DT, Gouma DJ, Bemelman WA. Systemic review of enhanced recovery programs in colonic surgery. Br J Surg. 2006;93:800–9.
24. Barbieux J, Hamy A, Talbot MF, Casa C, Mucci S, Lermite E, Venara A. Does enhanced recovery reduce postoperative ileus after colorectal surgery? J Visc Surg. 2017;154:79–85.

Chapter 55
Postoperative Electrolyte Abnormalities

Michael F. Krug

BACKGROUND

Electrolyte abnormalities are common in the hospital. Studies have estimated the incidence of hyponatremia as high as 38% among inpatients [1]. Hypokalemia and hyperkalemia are also common with incidences in one study of 13 and 7%, respectively [2]. Postoperative patients are particularly susceptible due to the perioperative use of intravenous fluids (IVF) and blood transfusions, hormonal responses to surgical stress, the loss or third spacing of body fluid, and perioperative medication use. Electrolyte abnormalities, especially if untreated, can lead to severe neurologic, cardiac, intestinal, and muscular sequelae. This chapter provides an overview of some common postoperative metabolic and electrolyte derangements.

PREOPERATIVE EVALUATION

Most patients do not need to have electrolytes checked preoperatively (see Chap. 3), but in some cases a preoperative basic metabolic panel (possibly including calcium, magnesium, and phosphate) should be checked:

- Patients with chronic kidney disease (CKD) (see Chap. 38)
- Patients taking diuretics, angiotensin converting enzyme (ACE) inhibitors, angiotensin-II receptor blockers (ARBs), aldosterone antagonists, or using nonsteroidal anti-inflammatory drugs (NSAIDs) frequently

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_55

- Patients with a history of electrolyte derangement
- Patients with recent significant malnutrition, vomiting, or diarrhea

PERIOPERATIVE MANAGEMENT

HYPONATREMIA

Common Etiologies

- Release of antidiuretic hormone (ADH; i.e., vasopressin) in response to surgical stress. This is particularly common and worrisome after neurosurgical procedures.
- Hypotonic intravenous fluid use. The use of dextrose and water solutions, 0.45% sodium chloride, or large volume infusion of modestly hypotonic balanced solutions such as lactated Ringers, can cause or contribute to hyponatremia (see Table 55.1).
- Intravasation of hypotonic fluids used for irrigation during the operation.

Management

Acute postoperative hyponatremia is most often related to ADH release and/or the use of hypotonic intravenous fluids (IVF). Be sure to discontinue hypotonic IVF in patients with hyponatremia (see Table 55.1). If chronic hyponatremia is suspected or if an alternative etiology is suspected, the typical workup includes a focused history and assessment of volume status, plasma osmolality, urine osmolality, and urine sodium.

Most mild (Na ≥ 130) postoperative hyponatremia will resolve with an oral diet and/or a switch to isotonic IVF as the ADH response to surgical stress dissipates.

TABLE 55.1 COMPOSITION OF COMMONLY USED CRYSTALLOIDS [3]

	Na+ (mmol/L)	K+ (mmol/L)	Buffer (mmol/L)
Plasma	135–145	3.5–5.3	23–30 (HCO_3^-)
0.9% Sodium chloride	154	0	0
0.45% Sodium chloride	77	0	0
Lactated Ringer's	130	4	28 (lactate)
Plasma-Lyte 148	140	5	50 (acetate)

Patients with more significant hyponatremia (Na <130) or patients with hyponatremia after brain injury/surgery require careful management. The approach to management depends on the acuity and etiology of the hyponatremia, the presence or absence of symptoms, and the patient's volume status. In general, aggressive measures such as infusion of hypertonic saline are considered if the patient has acute neurologic symptoms or if the sodium is less than 120. The rate of sodium increase should not exceed 6–8 mEq/L/24 hours regardless of duration of hyponatremia due to the risk of central pontine myelinolysis [4]. Frequent lab draws and adjustment of IVF are crucial to avoid overly rapid correction.

HYPOKALEMIA

Common Etiologies

- Gastrointestinal fluid losses due to nasogastric suction or diarrhea
- Release of aldosterone in response to surgical stress
- Mobilization of third-spaced fluids and the consequent auto-diuresis
- Medications such as potassium-wasting diuretics, laxatives, and glucocorticoids
- Hypomagnesemia

Management

Potassium can be repleted intravenously, enterally, or via a combination of both routes. Severe hypokalemia is typically treated with intravenous replacement (typically in addition to scheduled enteral replacement) and potassium values should be rechecked frequently to ensure improvement. Every 10 mEq of potassium administered should raise the serum potassium by roughly 0.1 mEq/L. Hypomagnesemia must be corrected to facilitate correction of hypokalemia.

HYPERKALEMIA

Common Etiologies

- Acute renal failure
- Medications such as trimethoprim, succinylcholine, ACE inhibitors, ARBs, aldosterone antagonists, calcineurin inhibitors
- Large volume red blood cell transfusion

Management

Patients with mild, asymptomatic hyperkalemia may improve with addressing the underlying cause. Strategies for removing potassium in cases of significant hyperkalemia include loop diuretics,

gastrointestinal potassium binders such as sodium polystyrene sulfonate, or hemodialysis. Patients with signs or symptoms of severe hyperkalemia (muscle weakness, arrhythmia, electrocardiography (ECG) changes) or who have a potassium 6.5 mEq/L or greater should receive rapid temporizing measures in addition to employing strategies for potassium removal from the body. Rapid temporizing measures include calcium to counter the cardiac membrane effects of hyperkalemia, insulin with glucose, and sodium bicarbonate for patients with concomitant acidosis.

METABOLIC ACIDOSIS

Common Etiologies

- Lactic acidosis due to intraoperative tissue hypoperfusion, sepsis, blood loss, or under-resuscitation
- Diabetic ketoacidosis
- Renal failure (acute or chronic)
- Rhabdomyolysis

Management

Metabolic acidosis is suspected when the serum bicarbonate level is low. The anion gap should be calculated and a delta-delta calculated if applicable to establish the differential for the acidosis. An arterial blood gas (ABG) should be obtained if the metabolic acidosis is severe or if a mixed picture is suspected. Additional labs including a serum lactate, urinalysis looking for ketones, and/or serum ketones can be helpful if the etiology is unclear.

Metabolic acidosis is primarily managed by addressing the underlying cause. A bicarbonate infusion can be considered in cases of severe acidosis (i.e., pH <7.1), especially in patients with concurrent acute kidney injury [5]. Lactic acidosis is managed by identifying and treating the underlying cause and trending serum lactate levels to ensure resolution. See below for management of rhabdomyolysis.

REFEEDING SYNDROME

Typical Electrolyte Abnormalities

- Hypophosphatemia
- Hypocalcemia
- Hypokalemia

As malnourished patients resume nutritional intake after surgery, they are at risk of the refeeding syndrome which is a set of often severe electrolyte deficiencies related to intracellular shift of electrolytes. The most common and worrisome feature of the refeeding syndrome is hypophosphatemia which can be severe and lead to critical cardiac, neurologic, and muscular complications.

Malnourished patients should have their electrolytes (including Mg, and Phos) checked prior to reintroducing nutrition, and deficiencies should be aggressively replete and monitored.

RHABDOMYOLYSIS

Common Electrolyte Abnormalities

- Hypovolemia
- Hypocalcemia
- Hyperkalemia
- Hyperphosphatemia
- Metabolic acidosis

Rhabdomyolysis can develop after traumatic injury, or it can develop after a surgical insult such as prolonged muscle compression, tourniquet use, or compartment syndrome. It is diagnosed when a serum creatine kinase level is at least five times the upper limit of normal. Rhabdomyolysis is treated by addressing the underlying cause, and by aggressively treating with fluid, electrolyte repletion, and careful monitoring.

COMMON INDICATIONS FOR DAILY (AT LEAST) ELECTROLYTE MONITORING [6]

- Fluid resuscitation
- Reliance on maintenance fluid or total parenteral nutrition
- Severe organ dysfunction
- Increased bodily fluid losses (nasogastric tube, high ostomy output, etc.) or insensible losses (burns, open surgical site)
- Ileus or bowel obstruction
- Traumatic or surgical neurologic insult
- Continuous bladder irrigation
- Significant volume blood transfusion
- Renal failure—acute or advanced chronic

KEY CLINICAL PEARLS

- Postoperative hyponatremia is most commonly due to release of ADH in response to surgical stress, or the use of hypotonic IVF.
- Advanced hyponatremia must be managed carefully to improve symptoms and sodium level while avoiding central pontine myelinolysis.
- Check a magnesium level in patients with advanced or refractory hypokalemia.

REFERENCES

1. Wald R, Jaber BL, Price LL, Upadhyay A, Madias NE. Impact of hospital-associated hyponatremia on selected outcomes. Arch Intern Med. 2010;170(3):294–302.
2. Nilsson E, Gasparini A, Arnlov J, Xu H, Henricksson KM, Coresh J, et al. Incidence and determinants of hyperkalemia and hypokalemia in a large healthcare system. Int J Cardiol. 2017;245:277–84.
3. Moritz ML, Ayus JC. Maintenance intravenous fluids in acutely ill patients. NEJM. 2015;373:1350–60.
4. Aldrogue H, Madias NE. Diagnosis and treatment of hyponatremia. Am J Kidney Dis. 2014;64(5):681–4.
5. Paugam JS, Futier E, Lefrant JY, Lasocki S, Lescot T, Pottecher J, et al. Sodium bicarbonate therapy for patients with severe metabolic acidemia in the intensive care unit (BICAR-ICU): a multicenter, open-label, randomized controlled, phase 3 trial. Lancet. 2018;392(10141):31.
6. Siparsky N, Sanfey H, Sterns RH, Collins KA. Overview of postoperative electrolyte abnormalities. UpToDate [Internet]. 2018; [cited 2018 May]. Available from: https://www.uptodate.com/contents/overview-of-postoperative-electrolyte-abnormalities.

Chapter 56
Acute Pain Management

Preetma Kooner and Katherin Peperzak

BACKGROUND

Pain is defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage. Acute pain has a direct cause—injury or disease—and serves a biological purpose [1]. Acute nonsurgical pain is usually limited to 1 month. Once surgical pain outlasts the usual healing time known for that specific procedure, it is often defined as chronic pain (see Chap. 47). Chronic pain no longer serves a purpose as an alarm system and often does not have a cure [2].

Acute pain treatment in the surgical setting can actually begin preoperatively and is managed intraoperatively by the anesthesiologist. The current model for the postoperative pain control is known as multimodal analgesia. The goal of multimodal analgesia is to treat pain through several modalities in order to create antinociception through multiple receptors which cascade into several known (and some yet to be elucidated) pathways in the creation of pain.

Postsurgical pain is treated to improve quality of life by reducing suffering, to optimize conditions for mobility postoperatively, and to avoid surgical complications such as pneumonia, deep vein thrombosis (DVT), and ileus. It is increasingly understood that the development of chronic pain after surgery might be partially due to undertreated acute postoperative pain [3].

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_56

PREOPERATIVE EVALUATION

RISK ASSESSMENT

It can be extremely helpful to identify patients preoperatively that are at risk of requiring more complex postoperative pain management. If these risk factors are identified early, interventions can be planned during the anesthetic and the early postoperative period to optimize a multimodal approach. Also, patients can be counseled regarding management of expectations regarding pain control after surgery.

Risk factors for difficult to control postoperative pain [4] include:

- Type of surgery: Abdominal (open), orthopedic, thoracic
- Age: Negative correlation (the younger the patient increased risk of postoperative pain)
- Psychiatric conditions (anxiety is the most common predictor of postoperative pain)
- Catastrophizing: Magnification of the level of threat caused by pain, fear or rumination about potential pain
- Preexisting pain: Not necessarily in the area of the operation
- Opioid tolerance: Patients on opioids for an extended period of time prior to surgery often require greater amounts of medication to reach therapeutic effect

Preoperative evaluation and counseling should include a comprehensive history and physical exam. Please see Chap. 47 for a guide to key questions and counseling.

PERIOPERATIVE MANAGEMENT

There are several medications, procedures, and nonpharmacological approaches to managing postoperative pain. The focus of this chapter will be medications (opioids and adjuncts) as well as inpatient procedures used in the acute postoperative period. See Chap. 47 for further discussion, in particular in the context of underlying chronic pain.

OPIOIDS

Opioids have been an intrinsic part of acute pain management since opium was cultivated in ancient Mesopotamia. In the last two decades, deaths tied to opioid use have been rising as have addiction rates. Therefore, it is crucial that perioperative practitioners understand the benefits and risks of opioid treatment. Some important aspects of opioid treatment include the following:

- Opioids are associated with respiratory depression, sedation, nausea and vomiting, constipation, and potential for addiction and abuse.
- The risk of oversedation and respiratory depression is increased with concurrent use of psychoactives, especially benzodiazepines [5].
- Patient-controlled analgesia (PCA) with an opioid is a reasonable option for those unable to tolerable oral medications or poorly controlled pain on an oral regimen.
- Basal PCA infusions should be avoided in opioid naïve adults [6].
- Oral administration is the preferred route for patients who can take oral medications.
- Long-acting opioid formulations should NOT be started for acute pain.

Opioids are most often administered intravenously (IV), intrathecally, and orally. PCAs were invented in the 1980s as a way for patients to give self-administered boluses with or without a background continuous infusion. Patient-controlled analgesia is considered the safest and most effective way to administer IV opioids. PCA nomenclature can be confusing, but the standard prescription is written as *x*/*y*/*z*: *x* = dose with one button push, *y* = number of minutes between doses, and *z* = specified 1 hour dose limit. Basal infusions are no longer recommended, due to an increased risk of adverse events without demonstrated functional benefit.

PCAs offer rapid pain relief with decreased risk of side effects, but there are noteworthy barriers to PCA use. Some teaching is required: Patients may not actually be pushing the button when they think they are, they may be afraid to push button and "overdose", or may be physically unable push the PCA button. There is the risk of inappropriate use of the PCA, which could include others pushing the button for the patient, or the patient setting timers to remind them to push the button if they fall asleep.

Once a patient is tolerating a diet, it is ideal to switch from IV to PO short-acting opioids to achieve a more even steady state of analgesia. Long-acting opioids should not be started in the postoperative period as they are difficult to safely titrate in the acute setting. Conservative conversion from IV to PO opioid dosing is recommended because of theoretical cross tolerance and expected improvement in pain in the days following the surgery. Ongoing down-titration may require the aid of a pain physician once the patient is discharged.

ADJUNCT MEDICATIONS

Multimodal analgesia is based upon the theory that there are several neurotransmitters and receptors involved in the experience of pain. The goals of utilizing nonopioids as a component of postoperative pain control include a reduction in opioid consumption as well as more balanced pain control (with fewer unwanted side effects).

Nonopioids are becoming a greater component of postoperative pain management as adjuncts in multimodal pain control. Depending on the class of drug, they can be started preoperatively, used in the OR, and/or used in the postoperative period.

Nonopioid adjuncts

- N-methyl-D-aspartate (NMDA) receptor antagonists
- Nonsteroidal anti-inflammatory drugs (NSAIDs)
- Acetaminophen
- Calcium channel blockers
- Local anesthetics
- Tricyclic antidepressants[1]
- Serotonin and norepinephrine reuptake inhibitors (SNRIs)[1]

One of the most widely used NMDA receptor antagonists is ketamine, which is particularly helpful in the opioid tolerant population (see Chap. 47).

Acetaminophen is a centrally acting medication that is available in several forms. It has been shown to augment opioid analgesia if taken scheduled. Keep the following in mind:

- Typical acetaminophen dose should range from 500 to 1000 mg PO q6hr.
- Acetaminophen doses should be reduced in those with history of Hepatitis C, liver dysfunction or cirrhosis, and the geriatric population.
- There is no clear difference in pain relief between IV and oral administration of acetaminophen.

NSAIDs work on the prostaglandin pathway to reduce systemic tissue inflammation peripherally.

- Some observational studies reveal concerns over bone healing in fractures and spinal fusion and anastomotic healing in colon surgery with NSAID use [7]—discuss with the surgical team prior to ordering.
- Caution should be used with prolonged NSAID use due to risk of GI bleed, ulceration, cardiovascular events, and renal

[1] Used more commonly in the outpatient setting for chronic pain.

dysfunction, though selective COX-2 inhibitors reduce the risk of GI events.

- Addition of a proton pump inhibitor (PPI) to NSAIDs is recommended in selected patients: Those also taking aspirin, advanced age, concomitant use of corticosteroids or anticoagulants, and history of prior gastrointestinal bleeding.

Calcium channel blockers, such as gabapentinoids, were initially designed to prevent seizures. These drugs structurally resemble gamma-aminobutyric acid (GABA), but are not active in GABA neuronal systems. They inhibit calcium channels, stabilizing neuron membranes and helping to decrease neuropathic pain.

A Cochrane review concluded that gabapentin is effective if given preoperatively as preventative analgesia or in established acute postoperative pain [8]. Higher doses of preoperative gabapentin (1200 mg per dose) are significantly more effective than lower doses. Continuing gabapentin postoperatively is more effective than a single preoperative dose because of varied absorption and the several half-lives needed to reach therapeutic effect. One reasonable approach is to give one dose of gabapentin preoperatively (generally ranging 600–1200 mg) and continue gabapentin 300 mg q8h in the postoperative period with escalation to 600 mg or 900 mg q8h if tolerated. Disadvantages to gabapentin include the lack of an IV formulation that could be given to nil per os (NPO) patients, the need for renal dosing, and commonly reported side effects including dizziness and sedation.

PROCEDURAL TECHNIQUES

Procedural techniques involve the deposition of local anesthetics and adjuncts through an injection or catheter in the region where postsurgical pain is expected. Anesthesia or pain service colleagues may place a site-specific regional block or epidural catheter, depending on type and location of surgery. Epidurals are characterized as neuraxial analgesia but differ from intrathecal analgesia as medication is delivered to the epidural space instead of into the cerebrospinal fluid.

Local anesthetics may also be used when surgeons infiltrate local anesthetic at the incision site or intra-articularly. These options will have analgesia limited to the expected duration of action of the local anesthetic. For example, injection with lidocaine 2% may provide analgesia for 1–2 hours while ropivacaine 0.5% may last 5–12 hours depending on site. Topical local anesthetics such as 4% liposomal lidocaine gel or eutectic mixtures of local anesthetics applied directly to painful areas can also be utilized, and do not require specialty care.

Epidurals

Epidurals provide anesthetic to block the sensory and motor nerves in a targeted area. This can result in pain control but at the thoracic level can result in a block of the sympathetic trunk. Sympathetic inhibition has benefits such as decreased catecholamine production and side effects such as exaggerated blood pressure response in the setting of hypovolemia. Thoracic epidurals have been shown to reduce risk of pneumonia by improved cough mechanisms, decreased risk of perioperative myocardial infarction (MI), and decreased length of postoperative ileus due to vasodilation of splanchnic vasculature [9, 10].

The volume and concentration of epidural medication impacts the spread and density of the block. If the analgesia is not as expected, testing sensation to temperature and pain over the region of interest to can help guide changes to the epidural infusion.

Along with local anesthetic, often a small amount of opioid such as fentanyl or hydromorphone can be added to the epidural. PCEA (patient-controlled epidural analgesia) allows the patient to self-bolus both local and opioid in the epidural space as a continuous infusion is running. The goal of adding an opioid is to provide analgesia at a targeted level with the aim of reducing systemic effects of opioids [11].

Limitations of epidurals depend on the level of placement. Thoracic epidurals can cause worsening hypotension in the setting of hypovolemia. Therefore, it is important to ensure that postoperative patients are appropriately volume loaded with fluids or blood products if appropriate. Epidurals are often discontinued due to hypotension; however, the subsequent improvement in blood pressure may be secondary to worsening pain. Rather than stopping it altogether, first consider decreasing the concentration and volume of the epidural infusion.

Contraindications to neuraxial include patient refusal, infection at the insertion site, coagulopathy, or evidence of increased intracranial pressure (ICP). Because of the devastating consequences of spinal hematoma, institutional guidelines are usually available for the timing and appropriateness of anticoagulation before during and after neuraxial procedures. Patients who are on chronic anticoagulation (other than aspirin) will often need to be off anticoagulation prior to the procedure and potentially during the time an epidural is in place. Standard DVT prophylaxis is most likely safe while an epidural is in place; however, it is best to confirm this based on institutional neuraxial guidelines.

Peripheral Nerve Blocks

Peripheral nerve blocks can be placed using landmarks and nerve simulation, but are usually done under ultrasound guidance. Local anesthetics and possible adjuncts such as clonidine, dexamethasone, or epinephrine can be delivered as a "single shot" or via continuous infusion with catheter placement. These blocks are not considered neuraxial procedures; however, they still carry the risk of local anesthetic toxicity, infection, and bleeding.

The potency of a nerve block will depend on whether it was used as part of the surgical anesthetic (complete motor and sensory block) or placed primarily for pain (motor sparing with partial sensory block). They are most beneficial for lower and upper extremity procedures. Often patients can be discharged with an infusion pump and the catheter still in place.

NONPHARMACOLOGIC THERAPIES

Both cognitive and physical nonpharmacologic therapies should be encouraged throughout the perioperative course. Effective techniques include guided imagery, relaxation, distraction techniques, use of TENS, ice, heat, and acupuncture among other modalities (see Chap. 47).

KEY CLINICAL PEARLS

- Avoid concurrent treatment with opioids and benzodiazepines as this increases the risk for respiratory depression.
- Opioid use should decrease during the subacute postoperative period; consider a taper plan.
- Consider adjunct treatments for patients who are already on opioids prior to surgery.
- The acute postoperative period is not the time to start new long-acting opioids.

ACKNOWLEDGMENTS

Dr. Gregory Terman MD, PhD

REFERENCES

1. Pogatzki-Zahn E, et al. Postoperative pain—from mechanisms to treatment. Pain Rep. 2017;2(2):588.
2. Grichnik KP, Ferrante FM. The difference between acute and chronic pain. Mt Sinai J Med. 1991;58(3):217–20.

3. Fletcher D, et al. Chronic postsurgical pain in Europe: an observational study. Eur J Anaesthesiol. 2015;32:725–34.
4. Ip HY, et al. Predictors of postoperative pain and analgesic consumption: a qualitative systematic review. Anesthesiology. 2009;111:657–77.
5. Sun E, Darnall B. Association between concurrent use of prescription opioids and benzodiazepines and overdose: retrospective analysis. BMJ. 2017;356:j760.
6. George JA, et al. The effect of intravenous opioid patient-controlled analgesia with and without background infusion on respiratory depression: a meta-analysis. J Opioid Manag. 2010;6(1):47–54.
7. Rushfeldt CF, Sveinbjørnsson B, Søreide K, Vonen B. Risk of anastomotic leakage with use of NSAIDs after gastrointestinal surgery. Int J Color Dis. 2011;26(12):1501–9.
8. Schmidt P, et al. Perioperative gabapentinoids: choice of agent, dose, timing, and effects on chronic postsurgical pain. Anesthesiology. 2013;119:1215–21.
9. Freise H. Risks and benefits of thoracic epidural anaesthesia. Br J Anaesth. 2011;107(6):859–68.
10. Popping DM, et al. Protective effects of epidural analgesia on pulmonary complications after abdominal and thoracic surgery: a meta-analysis. Arch Surg. 2008;143(10):990–9.
11. McLeod GA, et al. Thoracic epidural anaesthesia and analgesia. Contin Educ Anaesth Crit Care Pain. 2004;4(1):16–9.

Chapter 57
Surgical Procedures Overview

Molly Blackley Jackson, Kara J. Mitchell, Edie P. Shen, Eric Mar, and Elizabeth Kaplan

BACKGROUND

The following sections describe typical, uncomplicated postoperative courses for a variety of selected common surgeries. These briefings are presented from a medical, rather than a surgical, point of view. Our goal is to give the internist a general sense of the typical postoperative course and to highlight surgical issues that may impact medical diagnoses and treatments.

DENTAL SURGERY

Preoperative evaluation for patients with multiple medical comorbidities who are to undergo general anesthesia for dental extractions should perform a complete history and physical exam and ensure that there are no active or decompensated medical problems. Patients on warfarin typically remain on anticoagulation as long as the international normalized ratio (INR) is <3.0, and the bleeding risk is not greater than average, but it is recommended to confirm that this is acceptable with the surgical provider.

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9_57

HEAD AND NECK SURGERY

TRACHEOTOMY (NEW)

Typical length	15–30 min/typically general anesthesia (GA) can be done under local anesthesia
Blood loss pattern	Minimal
Tips	May be straightforward or complex depending on the patient's anatomy and previous operations, if any Common early complications are obstruction or displacement of the tracheostomy tube If acute airway obstruction is suspected, the inner cannula of the tracheostomy tube may be removed Also, direct suctioning through the tracheostomy tube can alleviate mucus plugging that can cause obstruction

POD 0	POD 1
Intensive care unit (ICU) or other specialized ward for airway monitoring	May be transferred to floor if doing well; usually other reasons for continued admission

HEAD AND NECK CANCER RESECTION/MICROVASCULAR FREE FLAP/LARYNGECTOMY

Typical length	8+ hours/GA
Blood loss pattern	Variable

Tips	Can be extensive operations of long duration, although fluid shifts are typically minimal given the anatomical location Most patients are in the ICU initially if a new tracheotomy is involved or a microvascular free flap is placed Free flaps are commonly harvested from the forearm, lower leg (fibula), and thigh. Flaps may also be harvested from the chest, abdomen, or back. Frequently drains are present in multiple sites Free flap patients are often started on aspirin POD#1 to optimize blood flow through flap, but reinitiation of anticoagulation may be delayed depending on the comfort of surgical team For patients undergoing resection and reconstruction of the oral cavity or pharynx, nutrition is commonly initially provided via a nasogastric tube to avoid damage to the oral cavity or pharyngeal reconstruction. If the patient is at high risk of prolonged dysphagia from the procedure, a gastrostomy tube maybe placed Laryngectomy patients are typically not permitted oral intake for a week postoperatively and are either fed through a nasogastric tube, gastrostomy tube, or potentially a tracheoesophageal catheter placed intraoperatively Communication may be difficult with patients due to alteration of anatomy Alcohol withdrawal and chronic obstructive pulmonary disease (COPD) are common given the patient population's comorbid risk factors Overall hospital stay is approximately 7 days

HEAD AND NECK DISSECTION

Typical length	2–4 h/GA
Blood loss pattern	Minimal
Tips	Can be an extensive operation of long duration, although fluid shifts are typically minimal given the anatomical location May be admitted to the floor if shorter duration of operation and no tracheostomy Hospital stay is typically 2–3 days Alcohol withdrawal and COPD are common given the patient population's comorbid risk factors

GENERAL SURGERY

GASTRIC BYPASS, LAPAROSCOPIC

Typical length	2–3.5 h/GA
Blood loss pattern	20–50 mL
Tips	Open gastric bypass surgeries are seldom electively done, but laparoscopic gastric bypass surgeries may be converted to open if there are hepatomegaly, prohibitively thick abdominal wall, adhesions, or complications that require direct visualization In diabetic patients, insulin requirements quickly decrease and oral intake will be greatly curtailed relative to baseline Insulin dosages on discharge are difficult to predict and home monitoring with early follow-up is the best strategy Often, oral antihyperglycemic medications are not resumed on discharge, but there is wide practice variation

POD 0	POD 1	POD 2
Admission to general surgical ward; sleep apnea monitoring per protocol. Encourage ambulation/IS	Start bariatric clear liquid diet and ADAT to full/pureed liquids. Start oral medications (no need to crush pills). Encourage ambulation. Urinary catheter out. PT/OT, dietician consults. Discharge in evening, if nausea/pain controlled and tolerating diet	Discharge home

SLEEVE GASTRECTOMY

Typical length	1–2 h/GA
Blood loss pattern	5–20 mL
Tips	Consider staple line leak if tachycardic or disproportionate pain

POD 0	POD 1
Admission to general surgical ward; sleep apnea monitoring per protocol. Encourage ambulation/IS	Start bariatric clears diet and ADAT to full liquids/pureed. Start oral medications (no need to crush pills). Encourage IS/ambulation. Urinary catheter removed. PT/OT consult. Dietician consult. Discharge in evening if nausea/pain controlled and tolerating liquid/pureed diet

LAPAROSCOPIC BAND (OR BAND REMOVAL)

Typical length	1 h/GA
Blood loss pattern	Minimal
Tips	Less frequently performed at many institutions May be admitted to limited stay units, started on clear liquids, rapidly advanced to full liquids and discharged on POD0-1

ESOPHAGECTOMY

Typical length	4–6 h/GA + epidural – varies by approach (open, laparoscopic, or minimally invasive)
Blood loss pattern	Variable
Tips	Can have many serious complications, including acute respiratory distress syndrome (ARDS), pericarditis, pneumothorax, pneumonia, and anastomotic leak Widened mediastinum on chest X-ray (CXR) may be due to postoperative changes, and small pneumothorax is expected given approach; check with surgery team regarding imaging changes Transhiatal approach involves an abdominal incision and a left neck incision. Proximity to heart and great vessels may cause intraoperative hypotension and arrhythmias Post-op atrial fibrillation is very common; NPO status may complicate treatment Most patients have some degree of chest or shoulder pain post-op due to the location of the surgery Some surgeons will not use BiPAP/CPAP initially after esophagectomy Do not reposition or move NG tube Medications typically need to be crushed, and thus may require changes in formulation of outpatient medications (e.g., switch from long-acting to short-acting version)

POD 0	POD 1–5	POD 5–7
ICU for some patients, depending on patient and institutional factors; may have chest tubes	Mobilize; transfer to floor when possible. Strict NPO typically for several days. Enteral feeds may be started earlier, if intraoperative feeding tube placed	UGI series. Postesophagectomy diet and/or TF. Possible discharge

PANCREATICODUODENECTOMY (WHIPPLE PROCEDURE)

Typical length	8–12 h/GA + epidural
Blood loss pattern	EBL 500–1000 mL
Tips	Usually prolonged postoperative course, initially in ICU, with prolonged return of bowel function Often J tubes are placed for enteral nutrition Increased drain output may be from thoracic duct (chylous), pancreatic, or biliary leak Some patients develop insulin-dependent DM postoperatively, depending on the extent of the pancreatic resection If a patient returns from surgery very quickly, it likely means that there was unresectable disease and no further operation was performed. Wait for the surgeon to discuss intraoperative findings Complications include line infection, pneumonia, ARDS, portal vein thrombosis, pulmonary embolism, gastroduodenal artery stump hemorrhage, and lateral cutaneous nerve injury from retractors

GYNECOLOGY AND GYNECOLOGY–ONCOLOGY SURGERY

LAPAROSCOPIC TOTAL ABDOMINAL HYSTERECTOMY-BILATERAL SALPINGO-OOPHORECTOMY (TAH-BSO): ROBOT ASSIST OR CONVENTIONAL

Typical length	1–3 h/GA
Blood loss pattern	EBL < 100 mL
Tips	An increasing percentage of hysterectomies are now done robotically For laparoscopic or robotic, patients may have shoulder pain from gas under the diaphragm, but they are able to ambulate and have earlier return of bowel function than with a TAH-BSO Some patients are discharged on the same day as surgery, but some obese patients may require an overnight ICU stay due to prolonged Trendelenburg positioning

POD 0	POD 1
Can advance diet if no nausea/vomiting post-op	Diet advanced; PO pain medications; Foley out and discharge

VAGINAL HYSTERECTOMY WITH PELVIC ORGAN PROLAPSE REPAIR (E.G., ANTERIOR AND POSTERIOR REPAIR, VAGINAL VAULT SUSPENSION, SLING FOR URINARY INCONTINENCE)

Typical length	2–3 h/GA or regional
Blood loss pattern	EBL < 200 mL
Tips	Only about 1/3 of women void adequately on POD 1 after complex vaginal repairs. 2/3 go home with a catheter

POD 0	POD 1
Advance diet if tolerated.	Diet advanced; change to PO pain medications Voiding trial done with checking of post-void residual volume

OPEN TAH-BSO

Typical length	2–4 h/GA, longer for surgeries for malignancy
Blood loss pattern	EBL 100–1000 mL, higher for surgeries for malignancy
Tips	Open TAH-BSOs are rarely done for benign conditions such as fibroids; most of these procedures are now laparoscopic and robotic surgeries In some cases, it is unknown whether a tumor is benign or malignant preoperatively These procedures tend to have earlier return of bowel function than general surgery cases that involve more of the GI tract, but later than minimally invasive procedures If done for malignancy, depending on tumor burden, this operation may be longer and involve bowel resection, lymph node dissection, and/or omentectomy, with a higher EBL and longer duration: There may be delayed return of bowel function as a result Depending on the type of hysterectomy, there may be a need for prolonged urinary catheterization If malignancy, there is increased venous thromboembolic events (VTE) risk, so VTE prophylaxis is often continued after discharge

POD 0	POD 1–2	POD 2–3
If there has been an intestinal anastomosis, then NPO until flatus; otherwise diet advanced	Diet advanced as above, Foley out, change to PO pain meds	Discharge home

OVARIAN TUMOR DEBULKING OR CYTOREDUCTION (PELVIC EXENTERATION RARELY DONE)

Typical length	7–10+ h/GA + epidural
Blood loss pattern	EBL 1000+ mL
Tips	Commonly observed in the ICU postoperatively, often in the hospital 7–14 days Expect extensive blood loss and fluid shifts requiring additional resuscitation; electrolyte abnormalities are common Patients with advanced ovarian cancer may have significant ascites Exenteration typically results in ileostomy/colostomy and urostomy May have prolonged ileus requiring parenteral nutrition. Complications include sepsis/ARDS, urinoma/ureter disruption, VTE, pelvic abscess, as well as atrial fibrillation

NEUROSURGERY

CRANIOTOMY

Typical length	3–12 h/GA
Blood loss pattern	Variable

Tips	Variable course, depending on the extent of surgery and condition necessitating surgery Initially admitted to ICU, may have ICP monitor, often still intubated First few days post-op may have labile blood pressures, hyponatremia. Neurosurgery team will often administer mannitol if ICP elevated and salt tabs for cerebral salt wasting, and order serial CT scans Watch for ICU complications such as VTE, line infections, and PNA May have a great deal of facial swelling postoperative cerebrospinal fluid (CSF) leak requires over sewing of wound due to risk of meningitis ICP monitors include external ventricular drains that measure. ICP and permit CSF drainage and "bolt-type" ICP pressure wires that measure pressure only. Prophylactic antibiotics are not indicated while in place, though they represent a small risk of ventriculitis/meningitis

VENTRICULOPERITONEAL (VP) SHUNT

Typical length	1–2 h/GA
Blood loss pattern	EBL 5–10 mL
Tips	Often admitted to ICU for frequent neuro checks for first 24 hours post-op In hospital for 1–3 days for pain control, return of bowel function Postoperative ileus can occur. Treat as usual postoperative ileus Rarely bowel/bladder injury during peritoneal exposure or catheter placement can occur. Daily abdominal exam is a useful measure Any acute neurological exam worsening after shunt placement raises suspicion for acute shunt failure (breakage of hardware or clogging of valve/catheters) Watch for ileus, surgical site infection, and spinal headache

LUMBAR DRAINS

Typical length	<1 hour, may be placed by IR or at the bedside in addition to OR
Blood loss pattern	Minimal

Tips	Risk of infection/meningitis including Gram-negative organisms due to site of placement Must be clamped before mobilizing patient so that overdrainage does not occur Overdrainage can precipitate postural headache and in extreme cases subdural hematoma intracranially or herniation syndrome. Initial management: Immediately return patient to supine position and clamp drain

ENDOVASCULAR TREATMENT FOR ANEURYSMS (COILING) AND ACUTE STROKE

Typical length	Duration varies by complexity/GA
Blood loss pattern	Minimal
Tips	Know the surgical plan—This is often a precursor to open clipping Often a 24-hours admission for hourly neuro checks then home. Watch for hypertension, new neurological findings, groin hematomas, or hypotension, which may indicate a large retroperitoneal hemorrhage from common femoral artery puncture site Radial artery access is commonly performed in lieu of femoral artery access; in such cases, check affected extremity and hand for capillary refill and signs of normal tissue perfusion Neurosurgeons may monitor for vasospasm in subarachnoid hemorrhage patients with transcranial Dopplers. Initial treatment is medical: Euvolemia, induced hypertension Refractory or severe vasospasm is treated with balloon angioplasty and/or intra-arterial vasodilator therapy in the angiography suite For diagnostic cerebral angiography, spinal angiography or neurointerventional procedures, ASA, and clopidogrel are typically NOT held preoperatively as these agents are typically needed for the procedures or healing process Usually the treating interventionalist will manage the duration and dosing of antiplatelet agents Postthrombectomy acute stroke patients often require permissive hypertension. Neurological worsening might indicate reperfusion intracerebral hemorrhage (ICH); IV tPA usage can potentiate ICH and puncture site hemorrhages

OPHTHALMOLOGIC SURGERY

CATARACT SURGERY

Typical length	1–2 hours local anesthesia or MAC
Blood loss pattern	Minimal
Tips	Typically, a same day outpatient procedure Indication for surgery dependent upon patient's ability to attend to the needs of daily living rather than any objective findings Requires preoperative H&P, although no specific additional testing has been shown to improve outcomes Antiplatelet or anticoagulation at therapeutic doses can be continued perioperatively (although should confirm with surgeon) Alpha-1 antagonists (like tamsulosin) have been associated with intraoperative floppy iris syndrome. It is important for the surgeon to be aware, but there is no perioperative benefit to discontinuing the medication as the effects of the medication can last for years Usually able to resume regular light activities by evening of surgery, with resumption of lifting >20 pounds and/or physical exertion in 2 weeks

RETINA SURGERY

Typical length	2–3 h/GA, MAC, or regional anesthetic block
Blood loss pattern	Minimal

Tips	Diabetic retinopathy can lead to proliferation of abnormal vasculature and vision loss from vitreous hemorrhage and tractional retinal detachment. This often requires a vitrectomy to remove opacities and to relieve vitreous traction, as well as provide adequate retinal ablation. It is important to note that patients with advanced disease often have significant comorbidities, including poorly managed diabetes with microvascular and macrovascular complications—comorbidities are important to note for anesthesia purposes If surgery is being performed for nonclearing vitreous hemorrhage and/or diabetic retinopathy with neovascular proliferation, it is preferable for anticoagulation to be held However, if medical indications outweigh, the procedure can be done without holding anticoagulation (should be discussed with surgeon) If intraocular gas is used during the procedure, there may be postoperative face down positioning requirements per surgeon instruction

GLAUCOMA SURGERY

Typical length	MAC or local
Blood loss pattern	Minimal
Tips	Evaluation and medical management are very similar to that of cataract surgery Even with surgical treatment of open angle glaucoma, many patients still require lifelong eye drops to control intraocular pressures. Advising ongoing adherence in this chronic disease is important Usually able to resume regular light activities by evening of surgery, with resumption of lifting >20 pounds and/or physical exertion in 2 weeks

ORTHOPEDIC SURGERY

GENERAL CONSIDERATIONS

Total knee arthroplasties (TKAs) and total hip arthroplasties (THAs) are two of the most common elective surgeries performed. It is important for the medicine consultant to be aware of the typical postoperative course after these surgeries (see below). In addition,

there are several considerations common to both of these types of surgeries:

- The use of narcotics prior to joint replacement is associated with clinical dissatisfaction after surgery. Consider minimizing narcotics to lowest tolerable dose in advance of elective surgery—See Acute Pain and Chronic Pain chapters for further reading.
- Depression can also hinder postoperative recovery—ideally, depression should be reasonably controlled preoperatively.
- Revisions of prior joint replacements typically are more complex, take longer, and have more intraoperative blood loss.
- Hypotension is common on the night of surgery (POD 0), especially if insufficient volume is given intraoperatively or if indwelling epidural catheters are used. Holding antihypertensives and giving IV fluid boluses (as tolerated by intravascular volume status) are typically sufficient to support blood pressure through this phase.
- Avoid 1/2 normal saline for IVF maintenance immediately postoperatively as this may lead to hyponatremia; rather, normal saline or lactated ringers are appropriate.
- A "cell saver" system may be used intraoperatively to filter and reinfuse drained blood.
- Patients may have drains placed, including a Hemovac drain (connected to a cylinder with springs to provide suction) or Jackson-Pratt drain (shaped like a hand grenade).
- Prophylactic antibiotics should be discontinued within 24 hours postoperatively, unless otherwise indicated; typically the surgical team is responsible for this and may lengthen the course of antibiotics based on presence of drains or intraoperative findings.
- Some centers use multimodal analgesic approaches, including long-active oral analgesics, nonsteroidal anti-inflammatory drugs (NSAIDs), and prophylactic antiemetics (see Acute and Chronic Pain chapters).
- Use caution when introducing long-acting narcotics in narcotic-naïve and older patients.
- Modality of deep vein thrombosis (DVT) prophylaxis is typically the surgeon's choice, but it is important to discuss with the surgeon if the patient's risk for DVT is higher than average.
- Know that there are differences between the American Academy of Orthopedic Surgeons (AAOS) and the Chest (ACCP) guidelines on DVT prophylaxis. Common agents are low-molecular-weight heparins, warfarin, and aspirin (in addition to TEDs and SCDs).

TOTAL KNEE ARTHROPLASTY (TKA)

Typical length	2 hours general anesthesia (GA) or regional
Blood loss pattern	Less than 100 mL during procedure but can be quite high (500–1500 mL) over first post-op day into drains (or into the knee, if no drains)
Tips	Minimally invasive total knee arthroplasty (TKA) (MIS or quad sparing) may discharge earlier Continuous passive motion (CPM) machine is sometimes used Most primary (and some revision) TKAs are weight bearing as tolerated (WBAT)

POD 0	POD 1	POD 2–3
IVF, diet advanced. Patient-controlled analgesia (PCA) and/or regional anesthesia (femoral block or catheter) and Foley. Usually able to restart PO meds	Diet advanced if not yet done. Stop IV fluids if doing well with oral intake. Knee range of motion emphasized. Out of bed and walking with PT. Foley out. Transition from PCA to PO pain meds. VTE prophylaxis	D/C to home. Extended VTE prophylaxis on discharge

TOTAL HIP ARTHROPLASTY (THA)

Typical length	2 hours general anesthesia (GA) or regional
Blood loss pattern	Around 300 mL during procedure, plus additional blood loss over first post-op day into drains
Tips	More blood loss may occur postoperatively than intraoperatively Patients will be taught "hip precautions"—avoidance of flexion/rotation, avoidance of deep flexion, and others—to minimize the likelihood of dislocation of the hip prosthesis Patients who have undergone minimally invasive approach may go home on POD1–2 Most primary (first-time) total hip arthroplasties (THAs) are WBAT, but many revision THAs will be partial or protected weight bearing Be aware of hip precautions when examining patients—they may be prohibited from crossing legs initially. Check with the orthopedic surgeon if you need to move the patient for an examination

POD 0	POD 1	POD 2–3
IVF, diet advanced. PCA and Foley. Usually able to restart PO meds	Diet advanced if not yet done. Stop IV fluids if doing well with oral intake. Remove drains and Foley catheter if possible. Consider transition to PO pain meds. VTE prophylaxis	Stop PCA, change to PO pain meds if not already done. Extended VTE prophylaxis. Discharge to skilled nursing facility for rehabilitation and therapy often required

HIP FRACTURE REPAIR

Typical length	1–3 h/GA or regional
Blood loss pattern	EBL 300 mL
Tips	Options for operative repair include intramedullary (IM) nail, dynamic hip screw, and hemi- or total arthroplasty. Preoperative evaluation should include cardiovascular risk stratification, assessment for the presence of medical factors contributing to fracture (e.g., seizure or syncope), and recommendations for perioperative medication management Surgery should not be delayed for minor medical conditions (e.g., poorly controlled hypertension without hypertensive urgency or emergency) If surgery is to be delayed, VTE prophylaxis should be encouraged, as there is risk of VTE from the fracture itself even without surgery

TOTAL SHOULDER ARTHROPLASTY (TSA)

Typical length	3 h/GA (occasionally regional)
Blood loss pattern	EBL ~150 mL

Tips	Except in high-risk patients, pharmacologic VTE prophylaxis is not used if patients are ambulating Postoperative bleeding/hemarthrosis is not uncommon. In patients who are on therapeutic anticoagulation (for atrial fibrillation, heart valve, history of VTE, others) work closely with the patient's surgeon and primary cardiologist (if applicable) to determine the best time to resume therapeutic anticoagulation. Ideally, avoid anticoagulation in the first 72 hours postoperatively unless the risk of clot is exceedingly high (e.g., mitral valve prosthesis) If an interscalene block is used, adverse effects include hypotension, bradycardia, Horner's syndrome, and phrenic nerve involvement, causing diaphragmatic paralysis, and sudden onset of pain late in the night or early morning as block wears off

POD 0	POD 1–2
Advance diet. Stop IV fluids if doing well with oral intake. PCA for initial pain control, with transition to oral medications the evening of surgery. Continuous passive motion (CPM) machine commonly used	Continued physical therapy, CPM machine. Discharge home

MAJOR SPINE SURGERY

Typical length	7–10+ h/GA
Blood loss pattern	EBL 2000–3000 mL
Tips	These are high-risk operations due to blood loss and duration EBL can reach as much as 5 L Often operations are accomplished in 2–3 stages Patients are at risk for multiple complications including venous thromboembolic events (VTE), myocardial infarction, pneumonia, disseminated intravascular coagulation, dilutional coagulopathy, posterior ischemic optic neuropathy (blindness—rare, but devastating), dural leak, cerebrospinal fluid leak, (may be difficult to detect), hematoma, secondary meningitis (can be subtle—may present with confusion, low-grade fever, headache), facial/airway edema from prone position, and ileus. In case of neurological deficits: Patients may receive high doses of steroids and MAP goal of >80 is instituted for the first 24 hours Discharge to rehab/skilled nursing facility is common Spine precautions—patients commonly require a brace

POD 0	POD 1–2	POD 3–7
ICU care until stabilized. Remain intubated for airway protection and pain control. Often require additional transfusions. Drain care	Extubate when stable; transfer to floor. VTE prophylaxis when possible, drain care	Mobilization using brace, drain care

OTHER SPINE SURGERIES

- Lumbar spine decompressions/fusions are of intermediate risk, typically involve a several-day hospital stay, and patients are admitted directly to the floor.
- Anterior C-spine decompressions often have a smaller EBL and shorter length of stay, for example, 24–48 hours.
- Microdecompressions/endoscopic decompression surgeries typically are same-day (or limited-stay) procedures.

ORTHOPEDIC TUMOR SURGERY

Typical length	4+ h/GA
Blood loss pattern	Highly variable
Tips	Complex and varied. Range from peripheral tumors to combined procedures with general surgery and urology in the pelvic and abdominal cavity Many have long duration, high EBL, and long length of stay, similar to major spine operations Tumors are often highly vascular, contributing to higher EBLs and drain output Sudden increase in drain output after pelvic surgery may be a sign of ureter disruption Surgical service may be reluctant to initiate heparin-based VTE prophylaxis due to wound drainage; discuss with primary team

UROLOGIC SURGERY/ PROCEDURES

CYSTECTOMY, RADICAL

Removal of the bladder and prostate in men; removal of the bladder, possibly uterus and ovaries, possibly anterior vaginal strip in women. Urinary diversion with ileal conduit, neobladder to the urethra, or cutaneous neobladder to the abdominal wall.

Typical length	6+ hours (varies, longer for robotic)/GA + epidural
Blood loss pattern	EBL 500–1500
Tips	Generally no per rectum (PR) meds initially Delayed postoperative ileus often occurs (and may last a week or more), even after apparent return of bowel function. High risk for VTE events, patients usually discharge with a month of low-molecular-weight heparin (LMWH) prophylaxis

POD 0	POD 1–3	POD 4–5
NPO	NPO, follow drain output; some urologists give early clears, regular diet POD 2	Bowel function usually returns

PROSTATECTOMY, RADICAL

Typical length	2–5 h/GA
Blood loss pattern	EBL 200–1000 mL
Tips	Typical length of stay is 1–2 days for robotic or open. Main issue is attention to blood loss; this is less of an issue now that many are done robotically

TRANSURETHRAL RESECTION OF PROSTATE

Typical length	1 hour or less/GA or spinal
Blood loss pattern	EBL minimal to 300
Tips	Many go home on the same day, especially if they had a greenlight laser TURP Watch for obstructing clots, problematic on continuous bladder irrigation

NEPHRECTOMY WITH INFERIOR VENA CAVA THROMBECTOMY

Typical length	4–8 h (depending on the height of the thrombus)/ GA + epidural/EBL
Blood loss pattern	Variable, often >1 L
Tips	Often require ICU care postoperatively (unless thrombus is small) Liver surgeon may assist if there is need for mobilization of the liver Thoracic surgeon may perform part of the thrombectomy via sternotomy if thrombus extends above the diaphragm Intraoperative concern for emboli from manipulation of inferior vena cava (IVC) thrombus Watch for pneumothorax, pleural effusion, hemothorax, hepatic dysfunction, sequela of intraoperative emboli from manipulation of thrombus, ileus; also, other ICU complications such as pneumonia, catheter-associated infections, and so on Often greater bowel manipulation than radical nephrectomy without thrombectomy High risk for VTE events, patients may discharge with a month of LMWH prophylaxis

OPEN NEPHRECTOMY, RADICAL

Typical length	3–4 h/GA + epidural
Blood loss pattern	300 mL
Tips	POD 1–3 advance diet when bowel function returns. Anticipate increased creatinine/renal dosing of medications Diet can usually be advanced expeditiously, if bowel is not manipulated

LAPAROSCOPIC NEPHRECTOMY

Typical length	4 h/GA
Blood loss pattern	100 mL
Tips	POD 0—Diet may be advanced In some cases, patients may be discharged on POD 1 Anticipate increased creatinine/renal dosing of medications

OPEN PARTIAL NEPHRECTOMY

Typical length	3–4 h/GA + epidural
Blood loss pattern	300 mL
Tips	POD 1–3 advance diet when bowel function returns Usually no increased creatinine or need for renal dosing of medications; look for other causes, if kidney injury develops Main issues are bleeding and urinary leak: Usually on bed rest for 24–48 hours with drain in place

LAPAROSCOPIC/ROBOTIC PARTIAL NEPHRECTOMY

Typical length	4–6 h/GA
Blood loss pattern	100 mL
Tips	POD 0—Diet may be advanced In some cases, patients may be discharged on POD 1, but usually 2–3 days for drain/Foley management and observation for bleeding Usually no increased creatinine or need for renal dosing of medications (look for other causes) Main issues are bleeding and urinary leak: Usually on bed rest for 24–48 hours with drain in place

CYSTOSCOPY, TRANSURETHRAL RESECTION OF BLADDER TUMOR (TURBT), LITHOTRIPSY

Typical length	Moderate sedation to GA, usually <1 hour
Blood loss pattern	Usually minimal
Tips	Typically, outpatient or limited-stay procedures Note that cystoscopy may have risk of increased vagal tone, bradycardia, and hypotension, despite being considered a low-risk procedure

VASCULAR SURGERY

GENERAL CONSIDERATIONS

- Continue preoperative beta blockade in the postoperative setting.
- Almost all patients undergoing vascular surgical procedures should continue aspirin perioperatively, but this should be discussed with the surgeon.
- Decisions about anticoagulants and antiplatelet agents are made based on the procedure and the patient's individualized risk of thrombotic and/or bleeding complications.
- Statins are associated with reduction in cardiovascular events and thought to play a beneficial role in atherosclerotic plaque stability and possibly rate of aneurysm degeneration. As such, most vascular surgery patients should be on a statin unless specifically contraindicated.

CAROTID ENDARTERECTOMY (CEA)

Typical length	3–4 h/GA
Blood loss pattern	150 mL
Tips	Procedure carries risk of myocardial infarction, stroke, and cranial nerve injury Postoperative blood pressure control can require IV medications as endarterectomy can alter function of the baroreceptor in the carotid sinus Needs postoperative blood pressure control and close neurologic examinations

POD 0	POD 1	POD 2
ICU	Remove urinary catheter, advance diet Transfer to floor, possible discharge home	Discharge

ABDOMINAL AORTIC ANEURYSM (AAA) REPAIR, OPEN

Typical length	6 h/GA
Blood loss pattern	EBL 400–1000 mL

Tips	Variable length of ICU stay Level of proximal aortic cross clamp predicts morbidity of the operation. Infrarenal is least stressful, suprarenal is more stressful, and supravisceral (aka supra-celiac) is most stressful Nonoliguric acute renal failure can occur with suprarenal cross-clamping of the aorta. Reviewing the operative note is helpful Other severe complications include bowel infarction and spinal cord infarct

POD 0	POD 1–3	POD 4–6
ICU; may come out of OR still intubated	Stabilize, transfer to floor	Epidural out, then urinary catheter out

AAA REPAIR, ENDOVASCULAR

Typical length	3 h/GA
Blood loss pattern	EBL 50–200 mL
Tips	Much lower level of overall physiologic stress than open repair, therefore less time in ICU and shorter overall hospital course Patients require lifelong follow-up after discharge for monitoring for stent migration or endoleak, usually CT at 1 month, then at 6–12 months, and annually thereafter (but imaging schedule may differ per surgeon) Severe complications include groin hematoma, endoleak, kidney injury from embolization or contrast, bowel ischemia, and spinal cord infarct (rare)

POD 0	POD 1
ICU. Short post-op hydration for IV contrast load, but rarely require resuscitation	Foley out in AM. Check renal function. Regular diet. Often go home

PERIPHERAL VASCULAR DISEASE (PVD) BYPASS, SUPRAINGUINAL

Typical length	4–6 h/GA
Blood loss pattern	EBL 250–1000 mL

Tips	Similar to open AAA repair, but usually reserved for healthier patients with PVD Clamp is most often below the renal arteries, so typically better tolerated than AAA repair

POD 0	POD 1–2	POD 3–5
ICU. May come out of OR intubated. Resuscitation	Stabilize, wean resuscitation by 48 hours. To floor	Resume diet. Epidural and Foley out. Walking. Discharge planning

PVD BYPASS, INFRAINGUINAL

Typical length	4–5 h/GA
Blood loss pattern	EBL 200–400 mL
Tips	Length of stay is often a function of mobility status and foot wounds/ulcerations

POD 0	POD 1
ICU for pulse checks. Do not need resuscitation	Floor. Wound care. Foley out

ACKNOWLEDGMENTS

Amit D. Bhrany, MD, Clinical Associate Professor, Department of Otolaryngology, University of Washington
Darin Davidson, MD, Departments of Hematology/Oncology and Orthopedic Surgery, University of Washington
Shu Feng, MD, Resident, Department of Ophthalmology, University of Washington
Michael F. Fialkow, MD, Associate Professor, Department of Orthopedics and Gynecology, University of Washington
John L. Gore, MD, MS, Associate Professor, Department of Urology, University of Washington
Christoph Hofstetter, MD, Associate Professor, Department of Surgery, Division of Neurological Surgery, University of Washington
Saurabh Khandelwal, MD, Associate Professor, Division of General Surgery, Department of Surgery, University of Washington
Louis J. Kim, MD, Professor, Division of Neurosurgery, Department of Surgery, University of Washington
Seth Leopold, MD, Professor, Department of Orthopedics and Sports Medicine, University of Washington
Daniel W. Lin, MD, Professor, Department of Urology, University of Washington
Frederick A. Matsen, MD, Professor, Department of Orthopedics, University of Washington
Brant Oelschlager, MD, Professor, Division of General Surgery, Department of Surgery, University of Washington
Benjamin W. Starnes, MD, Professor, Division of Vascular Surgery, Department of Surgery, University of Washington
Matthew Sweet, MD, Associate Professor, Division of Vascular Surgery, Department of Surgery, University of Washington
Renata R. Urban, MD, Associate Professor, Department of Orthopedics and Gynecology, University of Washington
Winston Warme, MD, Professor, Department of Orthopedics and Sports Medicine, University of Washington

Index

© Springer Nature Switzerland AG 2020

M. B. Jackson et al. (eds.), *The Perioperative Medicine Consult Handbook*,
https://doi.org/10.1007/978-3-030-19704-9