Christopher J. Wong
Nason P. Hamlin
Editors

The Perioperative Medicine Consult Handbook

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Dedication

We dedicate this book to Dominic F. "Dom" Reilly, MD and Diane Doerner, MD and to our patients.

Preface

Perioperative medical consultation is an exciting and evolving field of medicine. At the University of Washington Medical Center, medicine consultation as a separate endeavor began in the late 1980s with general medicine attendings taking medicine consultation calls in addition to their primary care practices. In the early 1990s, a formal Medicine Consult Service was developed, with early pioneers including Dominic Reilly, MD, and Diane Doerner, MD. Patients were seen on the inpatient wards and in the surgical clinics. By 1995, however, the Medicine Consult Service began its own small clinic in a shared space. Over the ensuing years, the Medicine Consult Service has expanded in number of staff, patients seen, and clinic size. Our focus has been on the evaluation of medically complex patients undergoing noncardiac surgery.

Collaboration and *continuity* have been hallmarks of the service:

- In November of 2003 the Medicine Consult Clinic moved into the Surgical Pavilion, in close proximity to the Pre-Anesthesia Clinic and the Surgical clinics. This location fosters close contact with the perioperative team.
- A unique feature of this service has been its continuity—the same provider who performs the preoperative evaluation also sees the patient postoperatively (see Chap 2, Styles of Medical Consultation). In the current hospitalist era, it is a way in which a general internist can still practice inpatient and outpatient medicine at the same time.

The Medicine Consult Service has always maintained its teaching mission, with housestaff and medical students rotating through the service. In addition, in the course of performing clinical consultation, we also serve as educators for the surgical residents, holding the belief that a surgeon who knows more medicine will provide better overall care.

The first edition of The Medicine Consult Handbook was published in 2006 as a resource for residents and junior faculty regarding the

science and art of perioperative medicine. As the evidence base for perioperative practice has expanded, so too has this handbook. We have attempted to provide a balanced presentation that includes education, evidence, common situations, guideline-based care, and pearls of wisdom, while not emphasizing practices that may be unique to our own institution. For the sake of point-of-care use, we have favored brevity and included references to a subset of the perioperative medicine literature, rather than creating comprehensive chapters better suited to a traditional textbook.

How to use this book: For those just starting in perioperative medicine, we recommend reading Chap 3: The Preoperative Evaluation, Chap 4: Perioperative Medication Management, Chap 6: Cardiovascular Risk Stratification, and Chap 13: Pulmonary Risk Assessment and Management as a general overview. Other topics may be reviewed as needed depending on one's practice setting and the types of patients seen.

Even with the increasing guidelines and evidence, perioperative medicine remains an art and, as always, there may be local practices that are different from those presented in this book. We fully expect the practice of perioperative medicine to continue to change and welcome your comments and feedback.

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PART I
Introduction

Chapter 1
Introduction

Kara J. Mitchell and Christopher J. Wong

Perioperative Medicine Consultation is an exciting and evolving field.

We believe that teamwork between internists, surgeons, and anesthesiologists improves patient care, especially for patients with serious or complex medical conditions. We created this handbook to provide useful information for the general medical care of a patient planning for and recovering from surgery. The information presented here is based on a combination of clinical experience, guidelines, and evidence-based medicine.

As with any handbook, the material presented is simply a guide, and is no substitute for clinical judgment and individualized patient care.

GENERAL GUIDELINES FOR PROVIDING OUTSTANDING MEDICAL CONSULTATION

PREOPERATIVE ROLE

1. Risk stratify patients prior to surgery (AVOID the term "cleared for surgery").
2. Provide recommendations to optimize a patient's condition prior to surgery.
3. Anticipate perioperative events, and suggest potential ways of mitigating the risk for medical complications of surgery (see also Chaps. 4, 6, and 13 for further details).

POSTOPERATIVE ROLE

1. Provide postoperative advice with regard to a patient's medical problems.

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2. Identify and manage medical complications of surgery that may arise (see also Chap. 36 for further details).

Medicine is medicine, whether a patient has just undergone, or is about to undergo, a surgery. Creating a differential diagnosis, weighing risks and benefits, providing timely treatment—none of these skills disappear when we see a patient in the perioperative setting.

There are, however, a few key characteristics that distinguish postoperative patients:

- Natural history: Most patients should get better if their case is uncomplicated.
- NPO status: Administration of medications may be restricted for a period of time. Medications may need to be given per rectum, sublingually, IV, transdermally, or via inhalation.
- Medication side effects: Most patients receive opiate pain medications and are at risk for opiate-related complications: delirium, decreased level of consciousness, respiratory depression, constipation, and urinary retention. Most patients have received sedation and are at risk for delirium and other complications from sedating medications.
- Lines and tubes: Patients may begin their postoperative course with more lines and tubes than medical patients, but are expected to have them removed as they recover.
- Third-spacing: Patients undergoing many types of surgery (especially abdominal surgery) have significant third-spacing of fluids and, at least initially, are intravascularly volume depleted.

For several areas of care, the medical consultant should pause before making certain recommendations (see Table 1.1).

Communication is Vital!

Surgical Team: Keep up a dialogue with the surgical team, and always call with critical recommendations. Do not wait for them to discover an important recommendation that you made on morning rounds when they make evening rounds. Know the habits of your primary surgical team—different surgeons round at different times, and surgery teams have varying compositions of house staff, attendings, ARNPs, and PAs.

Patients and Families: In general it is acceptable to discuss your recommendations with the patient and family. Be careful, however, when discussing issues specific to the surgery—these are usually best left to the surgeon. There may also be recommendations that are pending your discussion with the surgeon—it is preferable to wait until that discussion has taken place prior to speaking with the family.

TABLE 1.1 SUBJECTS FOR THE MEDICAL CONSULTANT TO REFRAIN FROM MAKING RECOMMENDATIONS ABOUT, OR TO DISCUSS WITH THE SURGEON OR ANESTHESIOLOGIST PRIOR TO TAKING ACTION

Avoid recommendations on these subjects	
Type of anesthesia or use of pulmonary artery (PA) catheters	These decisions are best left to the anesthesiologist
Per rectum (PR) meds in any surgery with bowel manipulation (including abdominal surgery, cystectomy, prostatectomy, and gynecologic surgery)	PR meds may affect the surgical site
Diet advancement with abdominal surgery	Let the surgery team advance the diet
Discuss with the surgical team before making recommendations or writing orders on these subjects	
Venous thromboembolism (VTE) chemoprophylaxis	Good to recommend, but first discuss bleeding risk with the surgery team
Anticoagulation, including antiplatelet agents	Bleeding risk needs to be discussed with the surgery team
Pain medications	Generally pain medications should be handled by a single team or service to maintain consistency
Transfusions	If a patient truly requires a transfusion, it is best to discuss with the surgery team first (see Chap. 26)
Antibiotics	The possibility of infection should be discussed with the surgical team; prophylactic antibiotics are generally discontinued within 24 h of surgery. Antibiotic use risks Clostridium difficile infection, antibiotic-associated diarrhea, antibiotic resistance, and side effects
Postoperative fever workup, especially within the first 72 h	Early postoperative fever may be due to cytokine release or other causes, and not due to infection (see Chap. 37)

Documentation

Medical Record: Documentation in the medical record is essential. You may have communicated very important recommendations verbally but if they are not in the chart, they are not official. It is best to document your recommendations immediately after seeing the patient.

Initial Consults

- Make sure that the name of the provider requesting consultation and reason for consultation is documented in the chart (e.g., "Dr. Smith has requested Medicine Consultation for advice regarding management of diabetes.").
- For format of initial consultation, see Chap. 3.
- Include your contact information.

Follow-Up Notes

- In general, a note should be completed every day in the chart.
- If you plan to follow the patient less frequently than daily, you should communicate this in the chart: "I will follow up with the patient after surgery" or "Dr. _____ will be on call this weekend, but will not plan to see the patient unless you call. Please call if questions arise. I will follow up with the patient on Monday."
- Assessments should be by diagnosis, not organ system: e.g., "Diabetes," not "Endocrine." Start with the most important *medical* diagnosis, e.g., "Atrial fibrillation," instead of "Post-op AAA repair."
- In most cases, you should also communicate with the team verbally.

"COMANAGEMENT" VERSUS "CONSULTATION"

Each hospital and service has a unique balance of comanagement versus consultation. Some services work with internal medicine physicians purely as consultants, and ask their advice as needed. In other hospitals, internists actively manage all the medical aspects of a patient's perioperative care, including performing daily assessments, being the first call for nursing staff, and writing orders. See Chap. 2 for further details.

Ultimately, the level of assistance depends on you and the primary service, and good communication is essential to define this balance.

Chapter 2
Styles of Medical Consultation

Rachel E. Thompson and Nason P. Hamlin

Medicine departments at many academic institutions have created Medicine Consult Services that provide consultative and perioperative care in the hospital. At some institutions consult services are engaged in both pre- and postoperative care, providing continuity for patients. At other institutions, solely preoperative evaluations and recommendations are provided for surgeons to incorporate into their care. In yet another model, consultations are available only postoperatively. Newer models have included comanagement agreements for certain situations, commonly with orthopedic or neurosurgical colleagues.

At the University of Washington Medical Center, where most of the complex surgery is elective, there is a consultative, teaching, and continuity model. The Medicine Consult Service is staffed by internists specializing in perioperative medicine. The patient has a comprehensive outpatient medical consultation at the request of the surgeon. The same internist who performs the outpatient consultation follows the patient daily when admitted to the hospital for surgery, serving as a consultant (not a comanager). The internist advises and teaches the surgical teams about the medical aspects of perioperative care such as diabetes management, etc. New inpatient perioperative consultations are also performed and followed by the Medicine Consult Service physicians. The continuity model minimizes handoffs and enhances satisfaction for patients, surgeons, and the medical consultant.

At Harborview Medical Center, our county hospital run by the University of Washington, we have a smaller, but growing, preoperative practice that was modeled after the University's clinic. Our larger practice at present is our inpatient consultative service. Our county hospital is a regional level 1 trauma center and thus many of the surgeries are unplanned. When surgical patients are identified as medically complex and when medical complications arise postoperatively, a medicine consultation is requested. This is a teaching service with

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medical, surgical, and anesthesia residents overseen by an internist who specializes in perioperative care.

In community hospitals, hospitalists and primary care providers often incorporate perioperative care into their daily work. This can be through caring directly for surgical patients admitted to the hospitalist service, but can also be through providing consultation and recommendations to surgical colleagues. Some hospitalist practices have a specified individual available daily for consultations; others perform both primary and consultative care within any given day. Comanagement is also entering into some community practices where a hospitalist may work on a surgical unit or with a particular surgical service. Some preoperative clinics are run by anesthesiologists or in partnership with medical practitioners.

The optimal method of medical consultation is unknown, and is likely best tailored to meet the needs of each hospital's patients and care delivery structure. It is hoped that as this field grows we will continue to develop the art and science of best perioperative care practices to improve testing strategies, avoid unnecessary cost, minimize complications, and optimize patient outcomes.

PART II

Preoperative Evaluation

Chapter 3
The Preoperative Evaluation

Molly Blackley Jackson and Christopher J. Wong

The "pre-op" remains a common and important role for the medical consultant. A good preoperative evaluation provides a baseline for the patient's preoperative state, identifies perioperative risks for the patient and surgical team, makes recommendations to help mitigate that risk, and serves as a starting point for postoperative management of a patient's medical conditions.

PRE-OP HISTORY AND PHYSICAL

The elements of the preoperative history and physical are listed in Table 3.1.

ASSESSMENT

Key Points to Determine

1. What is the surgical risk?
   The ACC/AHA guidelines categorize surgical risk into low, intermediate, and high risk, with ambulatory surgery being low risk, and major vascular surgery being high risk [1]. However, these guidelines do not list the numerous types of surgery in existence, and therefore one must use clinical judgment to estimate the surgical risk. Additionally, the ACC/AHA guidelines' surgical risk categories refer to the risk of cardiovascular complications, not overall morbidity or mortality. Factors to take into consideration include the following:
   - Duration of general anesthesia—Surgery longer than 8 h has been associated with increased risk of complications [2].
   - Emergency surgery—Generally considered higher risk.
   - Blood loss.
   - Location and possible complications—For example, abdominal surgery may be of greater risk in a patient with cirrhosis.

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TABLE 3.1 ELEMENTS OF THE PREOPERATIVE HISTORY AND PHYSICAL

Requesting physician	Usually the surgeon, sometimes a PCP or a specialist, or an anesthesiologist
Consult request for	Specific reason for consult, or question for consulting physician
Chief complaint	Include the intended surgical procedure
Date of surgery	(If known)
Primary Care Provider	
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 should be repeated in the medical pre-op HPI
Active and past medical problems	Focus on the ones for which advice has been requested (e.g., diabetes and hypertension), but be complete
Past surgical history and past surgical complications	Assess medical complications such as bleeding, clotting, infection, delirium, cardiovascular events, and respiratory problems
Drug sensitivities	Include type of reaction(s)
Medications	Include prescription, over-the-counter, and herbal preparations
Family history	Consider assessing family history of problems with anesthesia, or bleeding/clotting disorders, in addition to the standard family history
Social history	Patient's living situation and care network—especially important if there are post-op complications requiring additional support after discharge
Habits	Smoking (see Chap. 13) Alcohol (see Chap. 35) Illicit/recreational drugs

Review of systems	*Constitutional*: Fever, weight change, obesity, fatigue, night sweats *Eyes*: Vision changes or impairment *Ears/nose/mouth/throat*: Sinusitis, snoring, hearing impairment, dysphagia, epistaxis or gum bleeding *Cardiovascular*: Angina, exertional dyspnea, paroxysmal nocturnal dyspnea, orthopnea, edema, palpitations, arrhythmia, presyncope or syncope, claudication, heart murmur, arrhythmia *Respiratory*: Dyspnea, cough, wheezing, daytime somnolence, witnessed apnea *Gastrointestinal*: Abdominal pain, heartburn, reflux, dysphagia, nausea, vomiting, diarrhea, constipation, dark or bloody stools, jaundice, abdominal swelling *Genitourinary*: Urinary incontinence, retention, hesitancy, frequency, urgency, slow stream, nocturia, dysuria, hematuria, frequent UTIs *Musculoskeletal*: Joint or muscle pain/stiffness/swelling, decreased range of motion, mobility/function problems *Skin*: Rash, pruritus, striae, sensitivities (e.g. tape), skin color changes (e.g. jaundice, excess pigmentation), wound healing problems *Neurologic*: Cognitive problems, difficulty with balance or speech, frequent falls, tremor, seizures, headache, neuropathy, limb weakness, chronic pain *Psychiatric*: Depression, anxiety, psychosis, insomnia *Endocrine*: Steroid use, hot/cold intolerance, polydipsia/polyuria, orthostasis, hypoglycemia (if diabetic) *Hematologic*: History of bruising or bleeding, anemia, thromboembolic disease, lymphadenopathy *Allergic/Immunologic*: Allergies, history of difficulty breathing/wheezing after an exposure
Functional status and exercise tolerance	Independent, partially dependent, or dependent Performs own ADLs? Number of blocks able to walk at a normal pace Number of flights of stairs able to climb
Physical exam	Include comprehensive cardiovascular and pulmonary exam, and other physical examination as indicated by the patient's history

(continued)

TABLE 3.1 (CONTINUED)

Studies	There are many "standard" preoperative tests that do not need to be done routinely. In some cases, there is no consensus	
	PT, PTT	Not required unless personal or family history of bleeding diathesis Obtain PT/INR in patients taking warfarin
	ECG (ACC/AHA guidelines) [1]	Class I: Vascular surgery and ≥1 clinical risk factor[a] Intermediate risk surgery in patients with CAD, PAD, or cerebrovascular disease Class IIa: Vascular surgery and no clinical risk factors Class IIb: Intermediate risk surgery and ≥1 clinical risk factor
	Chest X-ray	As a general rule, not necessary *May* be helpful for patients ≥50 years old undergoing thoracic, upper abdominal, or AAA surgery, or who have significant cardiac or respiratory disease [3] (see Chap 13)
	Pulmonary function tests (PFTs)	Obtain only if needed to diagnose previously unknown obstructive lung disease Used in some surgery specific protocols (e.g., thoracic surgery)
	Arterial blood gas (ABG)	Obtain only if suspicion for CO_2 retention that would affect postop management

[a]Clinical risk factors: Diabetes, ischemic heart disease, history of congestive heart failure, cerebrovascular disease, chronic kidney disease

Many preoperative protocols, whether from the anesthesiologist or the surgeon, require certain preoperative tests that the medical consultant may not feel are required. The ECG and coagulation tests are common examples of tests that are often overused. Good communication between the medical consultant, patient, surgeon, and anesthesia team is essential—if the testing is required, we will often go ahead and order it so that the patient's surgery will not be cancelled, but also take the situation as an opportunity to have a dialogue with those requesting the tests

Assessment	Include: Problem list Risk assessment—cardiovascular, pulmonary, others as indicated, e.g., "2 clinical risk factors for high risk surgery." Consider using risk calculators (see cardiovascular section), but in general we recommend avoiding quoting specific percent risk, favoring instead broad language, e.g., "patient is at elevated risk for cardiovascular complications due to …"
Recommendations	Be specific (doses of drugs, etc.) and concise Include preventative measures, e.g., VTE prophylaxis, incentive spirometry, and delirium precautions See text for further discussion
Thank you	
Contact information	

2. What are the patient's risk factors?
   Cardiovascular risk is well described in the ACC/AHA guidelines. A thorough medical history will help identify patients at risk for pulmonary complications, bleeding, clotting, or increased risk of delirium. The sections in this handbook that follow are useful guides for specific conditions. Consider reading Chaps. 6 and 13 for all patients, and other sections as pertinent.
3. How urgent is the surgery?
   Often underestimated, the urgency of surgery is a critical part of the preoperative evaluation. For example, a patient with significant cardiovascular risk might reasonably undergo stress testing for a major elective procedure, but would likely forego such testing prior to a necessary, urgent surgery for cancer. In the latter case, medical management may be preferred, as a positive preoperative stress test is lesslikely to lead to coronary surgery or revascularization prior to the cancer surgery.

SUMMARIZE YOUR FINDINGS

Once these elements are known, the preoperative evaluation, including recommendations, should be summarized in a concise but thorough note.

First, state whether the patient is of acceptable risk to undergo surgery. As mentioned previously, avoid the term "clearance"—this term implies that nothing will go wrong. There may be complications with *any* surgical procedure—the key assessment is whether the anticipated benefits outweigh the risks.

Example

> "Mr. ____ presents for elective total hip arthroplasty. He is an acceptable candidate for this surgery."

You may then go on and describe risks in more detail:

> "He is at increased risk for cardiovascular complications due to clinical risk factors of diabetes and a prior TIA. However, his exercise tolerance is good and thus I do not recommend further cardiac testing prior to this intermediate risk procedure."

"He is at increased risk of pulmonary complications due to COPD and obstructive sleep apnea. COPD remains stable, and his OSA is well treated with CPAP."

"He is at risk for postoperative delirium."

RECOMMENDATIONS

Patients are sent to the internist not just for an assessment but also for recommendations. Recommendations should go beyond the ACC/AHA guidelines. Our role as a medical consultant is to provide guidance on perioperative medication management and management of chronic medical conditions, anticipate and mitigate potential perioperative complications, and recommend appropriate prophylactic measures.

Example

"Recommendations:

1. Proceed with surgery without further cardiac testing.
2. Continue his beta-blocker postoperatively. He is anticipated to be taking oral medications immediately postop, so he may be given metoprolol 50 mg PO BID, his home dose, holding if his SBP is <110 or HR <60, as often patients are relatively hypotensive initially postop.
3. VTE prophylaxis should be provided postop per the ACCP guidelines. For hip replacement these include low molecular weight heparin, fondaparinux, direct thrombin inhibitors, low dose unfractionated heparin, aspirin, or warfarin, with a preference toward low molecular weight heparin. Of these options, given our institutional formulary, I recommend dalteparin 5,000 Units subcutaneously once daily for at least 10 days.
4. His postoperative pain should be treated, but psychoactive medications should be minimized to avoid delirium.
5. Postoperative incentive spirometry.
6. Continue his usual tiotropium inhaler postop, and have albuterol nebulizers PRN. Should he develop a COPD exacerbation, I would favor corticosteroids.

7. Start a low dose insulin correction algorithm with premeal lispro postop. Restart metformin when the patient is eating and renal function has been confirmed to be acceptable.
8. Follow up with his PCP 2–4 weeks postop."

COMMUNICATE YOUR EVALUATION

The patient should be informed of your recommendations. This note should be communicated to the surgeon, the primary care provider, and any specialists as appropriate. The anesthesia team should have access to this note. State how you may be reached. Make sure you know who in your institution will be seeing the patient post-op—it may be you, the surgery team alone, or a hospitalist—and make this clear in your note for the inpatient providers.

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PART III
Medication Management

Chapter 4
Perioperative Medication Management

Anna L. Golob and Reena Julka

III

Time permitting, one should stop any medication that may prove harmful perioperatively (e.g., MAO inhibitors, anticoagulants). Medications that are necessary for the patient's health (e.g., steroids, antiarrhythmic agents, beta-blockers, transplant medications) should be continued without interruption if possible. Exercise judgment on the rest. Substitute parenteral or topical forms of medications when necessary if the patient is unable to take their medications by mouth.

PREOPERATIVE MANAGEMENT

Recommendations for preoperative medication management are shown in Table 4.1.

POSTOPERATIVE MANAGEMENT

Resume usual outpatient medications as tolerated by patient's ability to take oral pills and current and expected medical indication, with certain exceptions such as diabetes medications if the patient is not eating (see Chap. 21). Use caution with blood thinners (see Chap. 23), including NSAIDs, and diuretics.

Most cardiovascular medications should be continued postoperatively if at all possible. However, a patient's blood pressure often falls postoperatively (especially if the patient has an epidural), so WRITE HOLD PARAMETERS for all vasoactive medications. Dose reduction is frequently necessary for the first 2–3 days.

Following some surgeries, particularly those involving major manipulation of the GI tract, the administration of oral medications might be

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TABLE 4.1 PREOPERATIVE MEDICATION MANAGEMENT

Drugs to hold at least 2 weeks preoperatively	Aspirin: hold for a minimum of 1 week—consider 2 weeks for neuro/spine surgery Warning: Must evaluate whether patient has received a cardiac stent. See "Discussion" and Chap. 7 Clopidogrel (*Plavix*): hold for a minimum of 5 days Warning: Must evaluate whether patient has received a cardiac stent. See "Discussion" and Chap. 7 MAO inhibitors (See "Discussion" re: selective MAO B inhibitors used for Parkinson's e.g., selegiline, rasagiline) Oral central alpha agonists (e.g., methyldopa). See "Discussion" for clonidine Herbal medications (e.g., garlic, gingko, ginseng, ephedra, oral vitamin E) Consider holding: Oral contraceptive pills (OCPs) (see "Discussion") Selective estrogen receptor modulators (SERMS) (see "Discussion") Menopausal hormone therapy (MHT) (see "Discussion") SSRIs in orthopedic patients (see "Discussion")
Drugs to hold for 4–5 days preoperatively	NSAIDs, selective COX-2 inhibitors. Generally hold 4–5 half-lives—depending on the NSAID, this may be more or less than 4–5 days (see "Discussion"). Dipyridamole (*Persantine®*). If combined with aspirin (*Aggrenox®*), see above. Warfarin (typically hold 5 doses = 5 days); see Chap. 23 Dabigatran (typically hold 4 doses = 2 days, but varies depending on creatinine clearance and type of surgery); see Chap. 23
Drugs to hold on the morning of surgery	Oral hypoglycemic agents Prandial insulin—See Chap. 21 Non-insulin injectable hypoglycemic agents (e.g., exenatide) Niacin, gemfibrozil, cholestyramine and colestipol Stimulant medications (e.g., methylphenidate) Carbidopa–levodopa (consider tapering dose several weeks prior to surgery with assistance from neurologist) (see "Discussion") Diuretics (see "Discussion") ACE-I/ARBs (see "Discussion") Dopamine agonists used for Parkinson's Disease (e.g., bromocriptine, pramipexole, ropinirole): hold the evening before and the morning of surgery

(continued)

TABLE 4.1 (CONTINUED)

Drugs to give on the morning of surgery	Most cardiac meds (antiarrhythmics, digoxin, nitrates, beta-blockers)
	Certain antihypertensive medications (see "Discussion" on calcium channel blockers)
Meds should be taken with a small sip of water only	Pulmonary medications (e.g., inhalers, nebulizers, oral leukotriene inhibitors)
	Endocrine medications (Including steroids—may need stress dosing, see Chap. 22)
	Most GI medications (e.g., H2 blockers, PPIs)
	Most psychoactive meds (except MAOIs and stimulants); see "Discussion" on SSRIs
	Statins (if taken in the morning)
	Seizure medications
	Eye drops
	Narcotics (Coordinate with anesthesia and primary team)
	Transdermal medications
	Transplant medications (see Chap 33), immunosuppressives, and antiretrovirals (check with anesthesiology and HIV provider regarding possible drug interactions)

temporarily precluded. For essential medications, consider using alternate formulations such as intravenous, transdermal, or per rectum if available. In other cases, e.g., after gastric bypass surgery (see Chap. 32) or with PEG or NG 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.

See Table 4.2 for recommendations on restarting usual outpatient medications.

DISCUSSION

Aspirin/clopidogrel/prasugrel: In high-risk patients (e.g., those with unstable coronary syndromes or cerebrovascular disease) it may not be feasible to stop antiplatelet agents for a prolonged period preoperatively. For patients with cardiac stents, there must be a thorough evaluation and discussion regarding the risks of stopping antiplatelet therapy, as acute in-stent thrombosis may be fatal (See Chap 7). It is

TABLE 4.2 RECOMMENDATIONS FOR RESTARTING OUTPATIENT MEDICATIONS POSTOPERATIVELY

Drugs to restart as soon as possible (pending clinical status)	Beta-blockers Antiarrhythmics Statins Nebulizers and inhalers Steroids (discuss with surgical team as needed) Most psychiatric medications Seizure medications Parkinson's medications Immunosuppressives, transplant, and antiretroviral medications (discuss with surgery team as needed)
Drugs to restart carefully (pending clinical status and discussion with surgical team)	Antiplatelet agents Other anticoagulants (see Chap. 23) Antihypertensives and diuretics Oral hypoglycemic agents
Drugs to consider holding postoperatively for several weeks	Oral contraceptive pills (OCPs) Selective estrogen receptor modulators (SERMs) Menopausal hormone therapy (MHT)

best to discuss high-risk cases with the patient's cardiologist or neurologist, and the surgical team. In some instances, one or more antiplatelet agents can/should be continued perioperatively, or held for a shorter duration of time (e.g., 1 week).

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 his/her 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, then stop the oral medication. Patches are changed every 7 days.

Oral contraceptive pills (*OCPs*): Increase the risk of thrombosis, especially for high-risk procedures (e.g., hip arthroplasty). Consider stopping 4 weeks preoperatively for moderate and high-risk procedures; one must weigh the risk of VTE against the risk of undesired pregnancy.

Selective estrogen receptor modulators (*SERMs*): Increase the risk of thrombosis, especially for high-risk procedures. If the indication for SERM use is breast cancer prevention or osteoporosis, consider

stopping 4 weeks preoperatively for procedures that are moderate or high risk for VTE. If the indication for SERM use is breast cancer treatment, discuss risks/benefits of stopping with the patient's oncologist.

Menopausal hormone therapy (*MHT*): Increases the risk of thrombosis, especially for high-risk procedures. If possible, should be discontinued at least 4–6 weeks preoperatively for procedures of moderate or high risk of VTE.

SSRIs: A retrospective study from 2003 showed that exposure to serotonergic antidepressants (not necessarily selective) increased the degree of intraoperative bleeding and increased risk of blood transfusion in patients undergoing orthopedic surgery (6/26 = 23 % in serotonergic antidepressant group versus 20/494 = 4 % of nonexposed group) [1]. Interestingly, the transfusion group also had lower baseline hemoglobin values. However, a cohort study of patients receiving CABG did not show a difference in perioperative bleeding [2]. The putative mechanism for potential increased bleeding risk is effect on platelet aggregation. Based on the available evidence, one may consider recommending patients discontinue SSRIs prior to orthopedic surgery, but must weigh carefully the risk of worsening or recurrent depression. Many SSRIs if discontinued should be tapered to avoid a withdrawal syndrome.

Diuretics: Conventional practice and our recommendation is 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 [3]. When to restart diuretics after surgery should be determined based on a careful evaluation of fluid status and in close consultation with the surgical team. Many patients are intravascularly depleted postoperatively due to third spacing, poor PO intake, etc.; however, some may become hypervolemic from intraoperative resuscitation or maintenance IV fluids, especially in the setting of CHF or CKD.

ACE inhibitors (*ACE-I*) *and angiotensin receptor blockers* (*ARBs*): There is currently controversy about use of ACE-Is and ARBs perioperatively. Anecdotal experience and a number of relatively small studies have suggested that the use of ACE-Is/ARBs on the morning of surgery may lead to excessive intraoperative hypotension [4]. However, holding these agents may lead to perioperative hypertension. Our recommendation is 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 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).

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 if at all possible (use low dose IV metoprolol 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. 8 for a more detailed discussion.

Calcium channel blockers: 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.

Statins: There is some evidence that use of the HMG CoA reductase inhibitors (statins) perioperatively may reduce the risk of perioperative cardiovascular events (e.g., MI, angina, stroke). The data comes from retrospective studies and a few small prospective studies in vascular surgery patients [5, 6]. Conclusive evidence is lacking. If a patient has indications for lipid lowering therapy, consider initiating a statin prior to vascular surgery if there is sufficient time (e.g., >2 weeks) and the patient will have appropriate follow-up. If the patient is already on a statin, it should be continued preoperatively and resumed postoperatively as able.

Monoamine oxidase inhibitors: In general, these drugs should be used with caution by those with experience using them. They have many drug interactions and these interactions can cause serotonin syndrome and hypertensive crisis. For Parkinson's patients who are taking MAO-B inhibitors, the traditional practice of discontinuing these medications 2 weeks prior to surgery may not be advisable in all circumstances. While MAO-B inhibitors at higher doses are less selective and have more risk of drug interactions, many patients with Parkinson's receive lower doses, and the decision to discontinue must take into account the patient's symptoms, the surgery, and the anticipated anesthesia medications. If you are not able to stop these drugs preoperatively (e.g., emergent surgery), it is imperative to alert the anesthesiologist so that medications with higher risk (e.g., certain pressors) can be avoided. It is good practice to consult with a pharmacist about other potential drug interactions (see Chap. 27).

Carbidopa–levodopa: Management of patients receiving carbidopa–levodopa should be individualized. If the patient will be NPO postop, it

may be advisable to taper the dose slowly prior to surgery. Acute discontinuation may rarely precipitate a neuroleptic malignant like syndrome. Some authors recommend reducing the dose of carbidopa/levodopa to the lowest possible preoperatively if expected to be NPO postop, then resuming the drug postoperatively as soon as possible. It is generally recommended to take the dose the night before surgery, and in some cases on the morning of surgery. The anesthesiologist and the patient's neurologist should be consulted as needed (See Chap 27).

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.

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 [7], 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.

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PART IV
Anesthesia

Chapter 5
Anesthesia Pearls

Gail A. Van Norman

IV

WHAT ARE THE MAIN CONCERNS OF ANESTHESIOLOGISTS IN THE PERIOPERATIVE PERIOD?

The anesthesiologist fulfills several critical roles in the perioperative period apart from the actual administration of the anesthetic. The anesthesiologist functions also as a "primary care" physician for the patient's medical conditions in the operating room. Anesthesiologists have a wide range of core medical knowledge as well as broad experience in managing coexisting disease in the operating room. They also 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.

A primary focus of anesthesia practice is risk management and patient safety. In the preoperative period, some examples of issues that anesthesiologists focus on include the following:

- Relative risk of the surgery in question.
- Current medical comorbidities and whether they have been optimized.
- History or physical exam indications of any undiagnosed medical conditions that could affect anesthesia and surgery.
- What anesthetic techniques are options for surgery, and which best address the medical comorbidities of the patient while providing good surgical conditions.
- In what ways physical aspects of the surgery (positioning, site of incision, duration, need for muscle relaxation) affect anesthetic choices and monitoring patients.

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- The monitoring (including hemodynamic and neuromuscular monitoring) that is appropriate for the surgery and will impact risk in a positive way.
- Postoperative management of pain, respiratory changes, nausea, and vomiting in the postoperative period.
- Discharge issues such as how soon the patients can be discharged, where the patient will be discharged to, and in whose company.

SOME "PEARLS" TO THINK ABOUT

Evidence-based guidelines on anesthesia and surgery are extremely helpful in most cases, but are not always completely applicable, because they fail to account for local differences in surgical practice, as well as important differences among individual surgeons. Issues that can affect whether further workup of a medical condition, or other management, is needed in the perioperative period and are often overlooked include the following:

- *Positioning during surgery*. Some surgeries require sitting position (shoulder, breast, and some neurosurgery). Further cardiac or neurovascular workup may be indicated if the patient will undergo unusual positioning with adverse hemodynamic consequences.
- *Blood loss*. While surgeries can be categorized into major, minor, and minimal blood loss, this is highly dependent on the surgeon, whether the surgery is a revision of a previous one, and the surgical technique. For example, blood loss during spine surgery can range from minor (1–2 unit loss not requiring transfusion) to major/disastrous (up to or exceeding one blood volume). Consultation with an anesthesiologist may be helpful in defining these risks for the patient, based both on the surgery and the surgeon performing it.
- *Duration of surgery*. Not all surgeons work alike. One surgeon may routinely finish a lumbar laminectomy in 20 min, for example, while another takes 3 h. Duration of surgery affects anesthetic choices, risks, and perioperative planning. Discussion with the anesthesiologist may facilitate your plans, particularly in high-risk patients.
- *Device management*. All implantable cardiac electronic devices should be interrogated to determine if they either should be turned off or reprogrammed for the operating room during elective surgery. Depending on the institution, this may be done in a

preanesthesia clinic or in the preoperative holding area, by either the cardiology or the anesthesiology department (see Chap. 12).

Devastating central nervous system injuries have been reported in Parkinson's patients with deep brain stimulators, as a result of deep brain electrical injury. The patients should always bring their programmer with them to surgery, at which time these devices will be temporarily turned off. Consultation with the anesthesiologist can help determine if an exception to this general rule can be made.

- *Open vs. laparoscopic surgery*. Although laparoscopic surgery is considered less invasive, physiologic changes during laparoscopy can have serious hemodynamic consequences. Patients may be positioned in extreme upright or extreme Trendelenberg position. Insufflation of the abdomen affects right heart filling. Absorption of CO_2 leads to obligatory hypercapnia. Ventilation is impeded due to high abdominal pressures. For patients who cannot tolerate these changes, other surgical approaches might be appropriate, even if more "invasive."
- *Regional anesthesia is no safer than general anesthesia* for most procedures, with some very limited exceptions. The decision for regional vs. general anesthesia is made based primarily on patient, anesthesiologist and surgeon preference, and postoperative pain management issues. Please consult the anesthesiologist if you have questions.

WHAT ANESTHESIOLOGISTS FIND HELPFUL IN A MEDICINE CONSULT NOTE

- A list of medical comorbidities and assessment of the current status of each.
- Plans for any further workup or intervention for comorbidities.
- Plans regarding anticoagulation, including timing and meds to be discontinued, and plans for bridging therapy, if any.

Requests for anything that might be helpful to your postoperative management. For example: You might want central line access, but such access is not needed for the anesthetic per se. The anesthesiologist may be willing to place these lines or others for you while the patient is anesthetized. Please do indicate that you are requesting the line for postoperative issues, however.

STATEMENTS/ADVICE TO AVOID IN A MEDICINE CONSULT NOTE

- DO NOT advise anesthesiologists to "avoid hypoxemia and hypotension," or "watch the patient's hemodynamics" during surgery, or similar statements. Anesthesiologists specialize in understanding the hemodynamic, respiratory, and metabolic changes brought about by the surgery and anesthetic, and how to treat them.
- DO NOT instruct the anesthesiologist about what monitors to use, or make statements that a patient "must have" or "needs" such a monitor. Anesthesiologists specialize in understanding when the information from a particular monitor (e.g., PA catheter) is helpful or not. Statements advising the use of these devices create medicolegal problems when the anesthesiologist's expert opinion differs from yours. Please make any advisory statements that you feel compelled to make flexible enough to accommodate dissent. For example: "PA catheter might be useful," or "would consider PA catheter."
- DO NOT demand a specialist anesthesiologist or make statements that the patient requires them (see below for guidelines). It also creates medicolegal issues if there is disagreement with the specialist. Statements such as "will consult cardiac anesthesia" or "consider cardiac anesthesia" are much more acceptable.
- Under NO circumstances should you ever "prescribe" an anesthetic. The anesthesiologist is the specialist best qualified to determine the appropriate and safest anesthetic techniques.

WHEN SHOULD YOU THINK ABOUT CONSULTING A SUBSPECIALTY ANESTHESIOLOGIST?

- *Pain specialist*. Patient has medical comorbidities or complex pain issues that will require special techniques. Risk factors for postoperative pain management issues include sleep apnea, chronic sedative or opioid use, history of poor postoperative

pain control, history of substance abuse (including alcohol), complex surgery, or history of opioid allergies.

- *Cardiac anesthesiologist*. Procedure will involve cardiopulmonary bypass, transesophageal monitoring may be needed, patient has complex congenital heart disease (e.g., other than ASD, VSD), patient has severe pulmonary hypertension (PA systolic >55 mmHg, particularly if accompanied by RV dysfunction or dilation), pulmonary hypertension accompanied by other cardiac issues (e.g., abnormal LV function, critical coronary disease, associated valvular dysfunction), and patients with severe valvular stenosis (due to high likelihood of requiring TEE monitoring).
- *Obstetrical anesthesiologist*. Patient is undergoing a complex surgery and is pregnant.
- *Pediatrics anesthesiologist*. A patient has complex congenital heart disease, or is under 1 year old *from its full-term birth date* (e.g., for a premature infant born at 30 weeks, this would be 10 + 52 weeks old). These infants have risks of delayed apnea after anesthesia.

ANESTHESIOLOGY TERMS TO BE FAMILIAR WITH

American Society of Anesthesiologists (ASA) Class [1]:

I—Healthy
II—Mild systemic disease
III—Severe systemic disease
IV—Severe systemic disease that is a constant threat to life
V—Moribund, not expected to survive without the operation

This classification system has been shown to be predictive of perioperative complications and mortality. For example, one study showed mortality rates of 0.1, 0.7, 3.5, and 18.3 % for ASA class I, II, III, and IV, respectively [2].

Mallampati class: Refers to the accessibility of the oral airway as seen by the patient opening his or her mouth while seated. Ranges from Class I (can see back of throat, uvula, etc.) to Class IV (can only see hard palate).

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PART V
Cardiology

Chapter 6
Cardiovascular Risk Stratification

Molly Blackley Jackson

Perioperative cardiovascular complications pose serious risk to patients. A careful medical consultation before surgery can help with (1) suggesting evaluation that may change management to mitigate risk and (2) an informed discussion of the risk for patients and providers.

The algorithm shown in Fig. 6.1 is based on the ACC/AHA guidelines for perioperative cardiovascular risk stratification [1,2]. The guidelines leave some discretion to the provider and patient regarding noninvasive stress testing. We advocate following these guidelines while keeping in mind that patients are individuals and guidelines should not be interpreted as strict rules.

FUNCTIONAL CAPACITY/EXERCISE TOLERANCE

Assessment of functional capacity is critical to estimating surgical risk and to decision making regarding further evaluation. The four METs criterion has been used in numerous studies. One metabolic equivalent (MET) is defined as the oxygen uptake of sitting at rest [3] (Table 6.1).

Self-reported reduced exercise tolerance (inability to walk four blocks or climb two flights of stairs) predicts perioperative complications [4].

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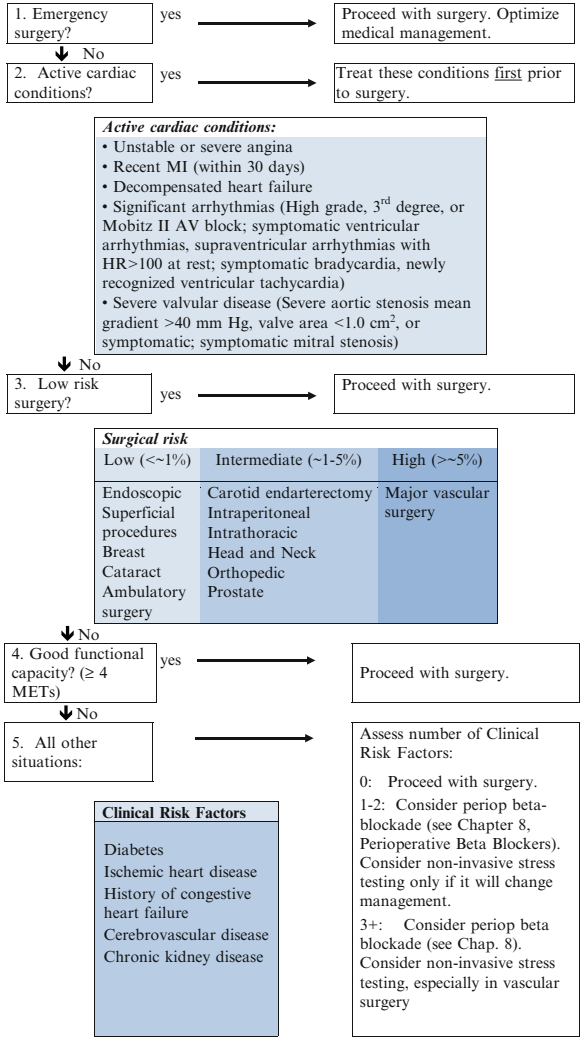

Fig. 6.1 Cardiovascular risk stratification algorithm. Adapted with permission from [1] (Figure 1)

TABLE 6.1 EXAMPLES OF ESTIMATED METABOLIC EQUIVALENTS

METs	Activity
1–3	Care of self (eating, dressing, using toilet)
4	Climbing a flight of stairs, walking up a hill, walking on level ground at 4 mph
6	Moderate recreational activity, e.g., dancing, doubles tennis, moderate cycling

Adapted with permission from [3] (Table 10)

WHAT ABOUT SURGICAL PROCEDURES THAT ARE NOT LISTED ABOVE IN FIGURE 6.1?

In general, we infer the risk based upon similarity to the procedures listed, and expected blood loss, duration of anesthesia, and anticipated fluid shifts. Surgeries within the same broad category may have a range of risk—e.g., among intraperitoneal surgeries, the laparoscopic band surgery likely has lower risk than a 6 hour, complex abdominal surgery, but there are not extensive data regarding this.

Previous ACC/AHA guidelines listed procedures of prolonged duration and cases with extensive fluid shifts or blood loss as being high risk; we believe it is still reasonable to consider these conditions as higher risk. Duration of anesthesia, especially 8 h or greater, is a risk factor for perioperative complications [4].

ESTIMATION OF CARDIAC RISK

There are several clinical tools to estimate perioperative cardiovascular risk, though none have ideal predictive performance. These tools are helpful when used in combination with a traditional medical evaluation and clinical gestalt. When documenting and discussing risk with patients, avoid quoting exact percentage estimates from these tools; rather, indicating that a patient is at low, moderate, or high risk for cardiac complications is more useful (and accurate).

NSQIP/MICA RISK CALCULATOR

The MICA risk calculator (perioperative *m*yocardial *i*nfarction or *c*ardiac *a*rrest) was created using the American College of Surgeons' 2007 National Surgical Quality Improvement Program (NSQIP) database, and evaluated over 200,000 surgical patients for perioperative cardiac complications [5]. The risk model was then validated, and the predictive performance surpassed the commonly used Revised Cardiac Risk Index (RCRI) risk calculator (below). Five major predictors for perioperative MI or cardiac arrest were determined: type of surgery, functional status, American Society of Anesthesiologists class, elevated creatinine, and advanced age. The statistics used in this risk calculator are complex, but the online calculator is fairly easy to use: http://www.surgicalriskcalculator.com/miorcardiacarrest.

REVISED CARDIAC RISK INDEX

The Revised Cardiac Risk Index is a well-known, well-validated, and easy-to-use tool [6]. Patients in the study were 50 years or older and underwent major noncardiac surgery. Note that this tool differs from ACC/AHA in what is labeled "high risk" surgery.

The incidence of major cardiac events shown in Table 6.2 is from the validation cohort. It represents an average across surgeries; there were differences among the different types of surgeries, with vascular surgery conferring a higher risk (see Lee et al. article for details).

OTHER GUIDELINES

The European Society of Cardiology (ESC) published a comprehensive set of guidelines in 2009 [7]. While generally similar to the ACC/AHA guidelines, they further delineate the risk of different types of surgery and have recommendations on preop ECG, echo, stress testing, stents, aspirin, and anticoagulation. Their algorithm favors more beta-blockade and less stress testing. They also emphasize continuing aspirin when possible. Clinical risk factors are defined more clearly to resemble the Revised Cardiac Risk Index definitions.

TABLE 6.2 REVISED CARDIAC RISK INDEX

Risk factors (1 pt for each)	# of Risk factors	Risk class	% Major cardiac complications (95% confidence interval)
■ "High-risk" surgery	0	I	0.4 (0.05–1.5)
■ Intraperitoneal	1	II	0.9 (0.3–2.1)
■ Intrathoracic	2	III	6.6 (3.9–10.3)
■ Suprainguinal vascular	3 or more	IV	11 (5.8–18.4)
■ History of myocardial ischemia (pathologic Q's, angina, nitrates, prior MI, positive stress test)			
■ History of heart failure	Major cardiac complications = MI, pulmonary edema, cardiac arrest, complete heart block		
■ History of CVA or TIA			
■ Preoperative insulin use			
■ Creatinine >2.0			

Reprinted with permission from [6]

V

NONINVASIVE CARDIAC STRESS TESTING

The ACC/AHA algorithm provides a degree of discretion regarding noninvasive stress testing. Before ordering a stress test, ask yourself: How will the results change my management? What will I do with the data? The goals of stress testing are (1) to risk stratify prior to surgery and (2) to identify patients in whom cardiology consultation, revascularization, or other means of potentially lowering cardiac risk is warranted.

DOES REVASCULARIZATION PRIOR TO SURGERY IMPROVE OUTCOMES?

It remains uncertain which patients should receive revascularization versus optimum medical management prior to surgery. Each case needs to be considered on an individual basis. The Coronary Artery Revascularization Prophylaxis (CARP) trial randomized patients undergoing elective vascular surgery who had at least 70 % stenosis in one or more coronary vessels to revascularization (PCI or CABG) versus usual care. There were no significant differences in the incidence

of postoperative mortality, MI, or stroke [8]. It remains uncertain whether other types of patients or surgeries would have a successful cardiovascular risk reduction with revascularization preop.

CHOOSING A STRESS TEST

There are several options for noninvasive cardiovascular stress testing.

Exercise Tolerance Test (ETT):

An ETT is an inexpensive, well-validated, excellent study to assess functional capacity and symptoms, hemodynamic response to exercise and recovery, and ECG evidence of ischemia. Each of these factors has independent prognostic predictive value. The Duke Treadmill Score (DTS) provides a risk score based upon exercise duration on a Standard Bruce Protocol, symptoms, and ST changes [9].

An ETT study (with ECG monitoring), coupled with myocardial perfusion imaging (MPI) OR echocardiography (ECHO), can elucidate additional high-risk features such as a large region of anterior wall ischemia and multiple regions of myocardial infarction that may change perioperative management. However, exercise testing is often not possible (e.g., patients with orthopedic limitations, vascular claudication), or not recommended (e.g., patients with large aortic aneurysms).

PHARMACOLOGIC STRESS STUDIES:

These studies are used in patients who are unable to exercise adequately. They are thought to have very good negative predictive value (if negative, likelihood of cardiac event is very low), but less good positive predictive value (if positive, still a weak predictor of perioperative cardiac complications). There are two commonly ordered pharmacologic stress studies.

Dobutamine stress ECHO:

Provides important prognostic information including LV/ RV size and function, resting wall motion abnormalities consistent with prior infarction, stress-induced wall motion abnormities suggestive of ischemia, and valvular abnormalities. A history of unstable angina, recent MI, ventricular arrhythmias, and severe hypertension are contraindications to high-dose dobutamine infusion. Beta-blockers must be held for 12–24 h prior to study. Dobutamine as a stress agent is preferred in patients with a history of severe bronchospasm (as many of the vasodilators used in MPI can induce bronchospasm).

Vasodilator (Adenosine, Regadenoson) Myocardial Perfusion Imaging (MPI):
Provides useful prognostic information including LV size and function, fixed perfusion abnormalities consistent with myocardial infarction, and reversible abnormalities consistent with ischemia. The extent, severity, and location of ischemia and infarction are likewise reported. A history of severe aortic stenosis or severe bronchospasm is a contraindication for vasodilator infusion. Vasodilator stress studies are preferred in patients with a history of arrhythmia (as high-dose dobutamine may induce arrhythmia).

WHAT CONSTITUTES A "HIGH-RISK" STRESS TEST?

ACC/AHA guidelines recommend cardiology evaluation and coronary angiography for patients with the features shown in Table 6.3 on cardiac testing, even if asymptomatic (note that this does not address the issue of *preoperative* evaluation) [1,10].

QUESTIONS TO ASK YOURSELF

1. How urgent is the surgery?
2. What is the extent of myocardium at risk?
3. Are there indications for revascularization (e.g., three-vessel or left main disease as standard indications for CABG) *regardless* of surgery?
4. What comorbidities does the patient have?

TABLE 6.3 HIGH-RISK NONINVASIVE TEST RESULTS

Resting LVEF <35%
High-risk treadmill score of ≤–11
Exercise LVEF <35 %
Stress-induced large perfusion defect (particularly if anterior)
Stress-induced moderate-size multiple perfusion defects
Large, fixed perfusion defect with LV dilatation or increased lung uptake
Stress-induced moderate-size perfusion defect with LV dilatation or increased lung uptake
Wall motion abnormality on stress echo (>2 segments) at low dose of dobutamine or at a low HR (<120 bpm)
Stress echo with extensive ischemia

Reprinted with permission from [10]

OTHER CARDIAC TESTING

Electrocardiogram. Preoperative resting 12-lead ECG is recommended by ACC/AHA guidelines in patients undergoing intermediate-risk surgery who have a history of cardiovascular disease, peripheral arterial disease, or cerebrovascular disease. In addition, ECG is recommended in any patient with at least one ACC/AHA clinical risk factor scheduled to undergo vascular surgery. Providers may consider ECG testing in patients undergoing vascular surgery with no clinical risk factors, or any patient undergoing intermediate-risk surgery with at least one clinical risk factor.

Resting echocardiography: The ACC/AHA guidelines recommend assessing LV function in patients with shortness of breath of unknown etiology (to assess cardiac function and pulmonary vascular pressures) as well as in patients with a history of heart failure and increasing dyspnea. Routine echocardiography in patients without these findings is not recommended.

EXAMPLES OF STRESS TESTS AND POTENTIAL MANAGEMENT STRATEGIES

1. A 55-year-old woman with hypertension and hyperlipidemia is diagnosed with colon cancer. She has no cardiac symptoms but her exercise tolerance is poor due to severe arthritis. A vasodilator stress MPI scan is positive for a small region of ischemia involving the inferior wall.
   Comment: This patient is undergoing a necessary surgery for cancer, and her surgery should not be delayed for a stress test result that is, although positive, low risk. Optimum management includes aggressive control of her hypertension and hyperlipidemia, and intra- and postoperative attention to pain control, blood pressure control, and signs of ischemia. Beta-blockade may be recommended based on her stress test, but if chosen, should be started well in advance of surgery (see Chap. 8). However, in practice, this patient may require an IV antihypertensive agent post-op and a beta-blocker would likely be used. Best evidence suggests that this patient did not require a stress test because she does not have any clinical risk factors.

2. A 65-year-old man, ex-smoker, with type 2 diabetes mellitus (DM) and <4 MET exercise tolerance is diagnosed with a 5.6 cm AAA. ROS was positive for exertional dyspnea. A vasodilator stress MPI scan revealed several areas of ischemia (multiple territories at risk), including a large region of severe myocardial ischemia involving the anterior wall.
   Comment: This patient is undergoing a major vascular surgery that is elective. He has a high-risk stress test, and is likely symptomatic. Surgery should be postponed and cardiology consultation should be initiated. Cath confirmed three-vessel disease with a normal left main. He meets the criteria for CABG regardless of his intended operation, and elects to have this done prior to his AAA repair. However, revascularization may not necessarily alter the perioperative outcome of his AAA repair [8].

3. A 60-year-old woman with hypertension, type 2 DM, hyperlipidemia, and COPD is to undergo partial lobectomy for non-small cell lung cancer. Her exercise tolerance is <4 METs. Her 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 a significant risk of infarction that will likely be hemodynamically significant. Consultation with cardiology including possible cardiac catheterization would be prudent. Several options exist, including the following:
   - Placement of a bare metal stent and postponing surgery for 1 month, if delay would not pose significant risk of spread of cancer.
   - CABG, single vessel, with combined partial lobectomy.
   - No intervention based on extrapolating the CARP trial results to nonvascular surgery. Optimize medical management; alert anesthesia.
   - Defer surgical intervention completely.

4. The same patient as in #3 is to undergo elective TKA for DJD.
   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.

5. A 64-year-old man develops postoperative atrial fibrillation after an elective AAA repair. Resting echo shows wall motion abnormalities. A dobutamine stress ECHO suggests a moderate-size region of mild myocardial ischemia involving the inferior lateral and anterior lateral walls. Patient is now preoperative for RLE bypass surgery for severe peripheral vascular disease, with early rest pain.

Comment: This patient's heart disease is asymptomatic and he is undergoing urgent vascular surgery. After consultation with cardiology, he is medically managed.

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Chapter 7
Ischemic Heart Disease

Molly Blackley Jackson

PREOPERATIVE EVALUATION

Careful history collection and physical exam in patients with ischemic heart disease are crucial prior to surgery. Key elements of information to gather include history of myocardial infarction, history of intracoronary stent, current symptoms, previous diagnostic workup, and current medications (Table 7.1).

- If there are symptoms of coronary disease (exertional chest pain, dyspnea, etc.), consider further cardiac evaluation and prompt consultation with a cardiologist; consider cardiac anesthesia review if surgery is urgent.
- Continue prescribed beta-blockers without interruption; consider starting beta-blocker if indicated (see Chap. 8).
- Continue statins, blood pressure control agents, and pain management pre-op.
- See Table 7.2 for current recommendations for antiplatelet therapy following cardiac stent placement [1]. Whenever possible antiplatelet therapy should not be interrupted for procedures due to risk of acute in-stent thrombosis.
- Narrow window off of antiplatelet medications if possible; discuss management with the surgeon and the patient's cardiologist—see Table 7.3 for possible strategies.

POSTOPERATIVE MANAGEMENT

- Close attention to heart rate and blood pressure control; consider telemetry monitoring.
- Resume beta-blockers at home dose, and convert to IV if necessary; hold if blood pressure or heart rate are too low.

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TABLE 7.1 HISTORY ELEMENTS FOR PREOPERATIVE PATIENTS WITH ISCHEMIC HEART DISEASE

History of MI?	Date, symptoms?
History of stent placement?	Date(s) of stent placement Why was stent placed (MI? abnormal stress test?) Bare metal or drug eluting?
Current symptoms	Angina, dyspnea (esp with exertion), edema, palpitations, presyncope or syncope? Any escalating symptoms?
Prior stress testing, cardiac catheterization, PCI, etc.?	Dates and results if known
Medication review	Obtain a careful medication list. Nitro glycerin use? Is patient taking meds as prescribed? On beta-blockers?
Who is your cardiologist?	Communicate with cardiologist, especially when patient is coming off antiplatelet therapy

TABLE 7.2 RECOMMENDED ANTIPLATELET THERAPY AFTER CARDIAC STENT PLACEMENT

Stent	***Aspirin* (once daily)**	***Clopidogrel* (once daily)**
Bare metal	162–325 mg for *at least 1 month*, then *75–162 mg indefinitely*	75 mg for *at least 1 month*, then extend to *1 year* if no bleeding
Sirolimus	162–325 mg for *at least 3 months*, then *75–162 mg indefinitely*	75 mg daily for *at least 12 months*
Paclitaxel	162–325 mg for *at least 6 months*, then *75–162 mg indefinitely*	75 mg daily for *at least 12 months*

Adapted with permission from [1]

- Follow closely for symptoms or signs of cardiac ischemia; especially be vigilant in caring for postoperative patients who are at higher risk for cardiac complications (history of ischemia, heart failure, cerebrovascular disease, diabetes, chronic kidney disease).
- In all patients at high risk for coronary ischemia (especially those who do not reliably report symptoms) and in any patient

TABLE 7.3 POTENTIAL STRATEGIES FOR PATIENTS WITH CARDIAC STENTS

Type of surgery	Example	Strategy
Purely elective	Total knee replacement	Postpone surgery for 1 year post stent placement, especially drug-eluting stents. Some orthopedic surgeons may be comfortable operating on aspirin alone
Urgent, low bleeding risk	Minor ENT procedure for cancer	Determine if the operation can be done without stopping aspirin and/or clopidogrel
Urgent, high bleeding risk	Obstructing colon cancer	Withhold antiplatelet agents in the narrowest time frame acceptable with regard to surgical bleeding risk. Aggressively manage HR, BP

with ECG changes worrisome for ischemia, check serial troponins postoperatively (~6, 12, and 24 h post-op).
- Restart antiplatelet therapy as soon as safe from a surgical perspective.

DISCUSSION

Risks and benefits of holding antiplatelet agents perioperatively in patients with CAD must be weighed with the patient's primary cardiologist, surgeon, and the patient. Evidence shows that cessation of aspirin for even 5 days or more in patients with underlying cardiac disease may substantially increase the risk of CVA and MI (especially those patients with indwelling stents) [2].

Drug-eluting stents, which are commonly used, have a moderately high incidence (1.3 %) of in-stent thrombosis when antiplatelet therapy is held, and the outcomes from this are serious (case fatality rate for in-stent thrombosis of a drug-eluting stent is 45 %) [3]. Bare metal stents have lower rates of restenosis, but demonstrate no difference in MI or mortality [4]. In some high-risk cases of coronary disease with stent placement, dual antiplatelet therapy is extended beyond 12 months. No elective procedures should be done during the first year following stent placement unless they can be performed without stopping aspirin and clopidogrel. In some cases, the surgical intervention may be performed with continuation of aspirin; discuss this with the surgeon.

Placement of stents preoperatively strictly for perioperative cardiovascular risk is not recommended; by placing a stent and subsequently withholding dual antiplatelet therapy for a procedure, *additional* risk is introduced (risk of acute in-stent thrombosis) because of the presence of the stent. For patients with a positive stress test and/or active symptoms of ischemic heart disease for whom you are considering revascularization, discuss the case with the patient's cardiologist and see the section entitled, Noninvasive Cardiac Stress Testing, in Chap. 6.

Postoperatively, patients with symptoms of ischemia or ECG changes require serial cardiac enzymes. In addition, the 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 [5]. Thus, in all patients at high risk for cardiac complications (high-risk surgery plus at least one risk factor of the Revised Cardiac Risk Index, see Chap. 6) consider checking serial troponins as part of routine postoperative care.

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Chapter 8
Perioperative Beta-Blockers

Paul B. Cornia and Christopher J. Wong

PREOPERATIVE EVALUATION

- Is the patient already on a beta-blocker? If so, then plan to continue perioperatively.
- Consider starting in vascular surgery patients with CAD. Whether any one beta-blocker is superior is not definitively known. If prophylactic beta-blockade is started, begin well in advance of surgery (≥1 week) and titrate to heart rate (60–70 bpm) while avoiding hypotension.
- See Table 8.1 for class I and IIa indications for perioperative beta-blockers [1].

POSTOPERATIVE MANAGEMENT

- Continue beta-blockers in patients receiving them preop. Watch for hypotension and bradycardia.

DISCUSSION

Our position: In light of the current data, we do not recommend starting a beta blocker routinely before surgery purely in an attempt to reduce perioperative cardiac complications. There is insufficient evidence of benefit, and ample evidence of harm. This is in line with AHA class I guidelines. Use in class IIa situations should be considered on an individual basis.

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TABLE 8.1 INDICATIONS FOR PERIOPERATIVE BETA-BLOCKERS, FROM THE ACCF/AHA GUIDELINES [1]

Class I	Continue in those already receiving them for angina, arrhythmia, and hypertension
Class IIa	Titrate to heart rate and blood pressure in the following situations: (A) Vascular surgery in patients with CAD ("probably recommended") (B) Vascular surgery in patients with multiple clinical risk factors ("reasonable") (C) Intermediate- to high-risk procedures in patients with CAD or multiple clinical risk factors ("reasonable")

Adapted with permission from [1]

Which beta-blocker to use: Most of the positive studies used bisoprolol or atenolol, and some of the negative studies used metoprolol. However, it is difficult to draw definitive conclusions given the different patient populations and dosing regimens used in the randomized trials. Dose titration, as opposed to fixed dose regimens, may be a more important factor than the specific agent used.

When to start: The POISE trial showed that a high-dose beta-blocker regimen started immediately before surgery reduces post-op cardiac events, but increases stroke and mortality [2]. A cohort study found that patients on chronic beta-blocker therapy had fewer cardiovascular events than those who only received beta-blockers post-op, but this was not a randomized trial, and the indications for starting post-op beta-blockers were unknown [3]. An analysis in vascular surgery patients suggests that benefit in a composite cardiovascular endpoint was seen if beta-blockers were started at least a week before surgery [4]. Whether this finding remains true of solely "hard" cardiovascular endpoints, or may be generalized to other populations or with different beta-blockers, is uncertain.

History: There has been an evolution in the literature regarding the use of perioperative beta-blockers.

- In 1996, a study of 200 patients with known CAD or multiple CAD risk factors found that those randomized to atenolol immediately before surgery had reduced mortality at 2 years—however there were concerns regarding the randomization,

lack of intention-to-treat analysis, and lack of early clinical outcome difference [5].

- An unblinded 1999 study randomized patients with a positive dobutamine stress echo undergoing vascular surgery to bisoprolol versus usual care, and found a decrease in death or nonfatal MI at 30 days. Notably, this was a high-risk group of patients with a placebo rate of death or nonfatal MI of 34 % [6].
- These two studies, among others, led to the increased use of perioperative beta-blockers in both high-risk patients undergoing vascular surgery, as well as patients with cardiac risk factors undergoing noncardiac surgery.
- In 2005 a retrospective cohort study examined over 600,000 patients and found that beta-blockers may cause harm in patients who were at low cardiac risk based on risk factors from the Revised Cardiac Risk Index [7]. A meta-analysis that same year was inconclusive as to whether there was any benefit to perioperative beta-blockers, but did find an increased risk of bradycardia and hypotension [8].
- ACC/AHA guidelines published the following class I indications in June 2006: Continue beta-blockers in those patients already receiving them for angina, arrhythmia, or hypertension, and for vascular surgery patients with a positive preoperative stress test. Other indications were class IIa.
- In May 2008 the POISE trial results were published [2]. Over 8,000 patients not previously on a beta-blocker with CAD, PVD, stroke, CHF within 3 years, major vascular surgery, or three of seven risk factors (intrathoracic/intraperitoneal surgery, TIA, CHF, DM, creatinine >2, age >70, emergent/urgent surgery) undergoing noncardiac surgery were randomized to a regimen of high-dose oral and/or IV metoprolol immediately before and after surgery. There was a decrease in the composite endpoint of cardiovascular death, nonfatal MI, or nonfatal cardiac arrest (5.8 % versus 6.9 %) at 30 days, driven mainly by the decrease in nonfatal MI. However, there was increased hypotension, bradycardia, stroke, and total mortality. Some argue that the dose and dose-titration regimen of beta-blocker was too aggressive. Consider however that a lower dose regimen with negative results may have been interpreted as simply not achieving adequate beta-blockade.
- In November 2008 a systematic review concluded that there was insufficient evidence to support the use of perioperative beta-blockers in patients who were not already on them for

cardiovascular indications [9]. This review's results were dominated by the POISE trial, as it had the largest number of participants by far.

- The AHA published updated guidelines in 2009 changing the vascular surgery recommendation from class I to class IIa. The other class IIa recommendations are unchanged. The class IIb recommendations remain, including patients with fewer risk factors. A class III recommendation (i.e., recommendation against) was added as follows: "Routine administration of high-dose beta-blockers in the absence of dose titration is not useful and may be harmful to patients not currently taking beta-blockers who are undergoing noncardiac surgery." [1] Therefore, the updated AHA guidelines recommend against duplicating the POISE protocol in practice, but did not otherwise significantly expand the caution in perioperative beta-blocker use.

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Chapter 9
Atrial Fibrillation

Paul B. Cornia and Christopher J. Wong

Atrial fibrillation is commonly encountered by the medical consultant, including patients with preexisting atrial fibrillation, as well as those with new onset in the perioperative period. Balancing the risk of stroke versus the risk of bleeding complications is required for the perioperative management of anticoagulation. Additionally, strategies for maintaining rate and/or rhythm control must be considered. Management options are frequently restricted by a patient's NPO status postoperatively.

PREOPERATIVE EVALUATION

The focus of the preoperative evaluation for patients with preexisting atrial fibrillation is to (1) assess rate and/or rhythm control; (2) identify patients with valvular disease or heart failure; (3) determine if prior thromboembolic events have occurred; and (4) take a thorough history of previous management plans employed when cessation of anticoagulation was required. A complete cardiovascular examination should be performed, in addition to an ECG, and review of the prior echocardiograms (Table 9.1).

Because the thromboembolic rates are similar for paroxysmal (i.e., intermittent, self-terminating) compared to persistent (i.e., lasting >7 days) and permanent (i.e., lasting >1 year without attempted cardioversion or failed cardioversion) atrial fibrillation, recommendations for anticoagulation are generally the same. Prior factors that induced atrial fibrillation episodes, including whether it occurred with previous surgical procedures, should be elicited. For patients with a history solely of perioperative atrial fibrillation who are otherwise in sinus rhythm, there is no evidence available to guide management to prevent a recurrent episode.

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TABLE 9.1 PREOPERATIVE EVALUATION OF PATIENTS WITH ATRIAL FIBRILLATION

History	Medications: Rate control, rhythm control (if applicable), anticoagulation Baseline ejection fraction (EF) Presence of valvular heart disease Prior thromboembolic events Prior management of interruptions in anticoagulant therapy (including prior use of bridge heparin therapy) Paroxysmal/persistent/permanent
Exam/studies	Cardiovascular exam Adequacy of rate control ECG Most recent echocardiogram

Preoperative management includes optimizing rate. A supraventricular arrhythmia with a heart rate >100 beats per minute at rest is considered an "Active Cardiac Condition" in the current ACC/AHA guidelines (see Chap. 6). Adequacy of rate control should be individualized. AV nodal blockers are typically continued perioperatively, and a post-op plan should be made for continuing these agents, taking into account whether or not the patient is anticipated to be NPO. Management of patients receiving antiarrhythmic medications, such as sotalol, propafenone, and amiodarone, should generally include a discussion with the patient's cardiologist (Table 9.2).

Perioperative anticoagulation requires complex decision making and a multidisciplinary approach is recommended, involving the patient, perioperative medicine consultant, anesthesiologist, and surgeon, as well as the clinicians managing the patient's anticoagulation in the outpatient setting (e.g., primary care provider, anticoagulation clinic). *A plan for perioperative anticoagulation should be developed prior to surgery whenever possible*. This plan should be discussed with the patient, preferably with written instructions, and clearly documented in the medical record. The plan should include anticipating the postoperative conditions affecting resumption of anticoagulation (see Table 9.2).

TABLE 9.2 PREOPERATIVE MANAGEMENT OF PATIENTS WITH ATRIAL FIBRILLATION

Anticoagulation management if necessary to discontinue for surgery	Aspirin: Stop aspirin for 7 days prior to surgery—consider longer for neurosurgery or spine surgery. For patients with cardiac stents, *must* discuss with the patient's cardiologist first (see Chap. 7) Warfarin (target INR 2.0–3.0): For most cases, hold 5 doses (5 days) of warfarin prior to surgery Consider holding for a longer duration (e.g., 6 doses/6 days) for elderly patients (delayed clearance), patients who have low baseline doses of warfarin, or surgical procedures with higher potential for serious bleeding complications (e.g., neurosurgery) Check INR preop For patients monitored by an anticoagulation clinic, work with that clinic's pharmacist Dabigatran (see Chap. 23) Recommended to stratify based on estimated GFR and risk of bleeding [1, 2] Standard bleeding risk: CL_{CR} >50: Hold for 24 h prior CL_{CR} 30–50: Hold for 48 h prior High bleeding risk (cardiac surgery, neurosurgery, abdominal surgery, surgery involving of major organs, and any procedure in which complete hemostasis is required, including neuraxial procedures): CL_{CR} >50: Hold for 2–4 days prior CL_{CR} 30–50: Hold for 4 days prior GFR <30: Dabigatran generally not recommended (see "Discussion" in text) Bridging therapy: High risk patients (CHADS2 score of 5-6, stroke/TIA within the past 3 months or associated rheumatic valvular heart disease): bridging recommended Moderate risk patients (CHADS2 score of 3-4): individualize based on patient and surgery-specific factors. Low risk patients (CHADS2 score of 0-2, and no prior TIA/CVA): bridging not recommended. [3] (See "Discussion" below. For details on bridging therapy, see Chap. 23

(continued)

TABLE 9.2 (CONTINUED)

	Plan for postoperative anticoagulation management. See Chap. 23 In most cases, resume anticoagulation when surgical bleeding risk is acceptable
Rate and rhythm control	In most cases, usual AV nodal blockers and rhythm control medications should be given on the morning of surgery Plan for post-op rate control—anticipate whether the patient will be NPO and require IV medications

POSTOPERATIVE MANAGEMENT

Patients with preexisting atrial fibrillation should, in general, have their rate control medications continued postoperatively. Medications may need to be converted to an IV formulation if the patient is strictly NPO. If a plan was made preoperatively regarding resumption of anticoagulation post-op, this plan should be reviewed. As previously mentioned, a perioperative anticoagulation plan should be determined preoperatively if possible. However, adjustments may be necessary depending on 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 chemoprophylaxis unless there is an absolute contraindication. Patients should be carefully monitored for embolic complications. The use of cardiac telemetry should be decided on an individual basis (Table 9.3).

NEW-ONSET POST-OP ATRIAL FIBRILLATION

- Identify precipitating causes (CHF, electrolyte imbalance, infection, infarction, alcohol withdrawal, thyroid abnormalities, anemia, hypovolemia, lung disease, valvular heart disease, pulmonary embolism, volume overload/reabsorbed third-spaced fluids, etc.).
- Assess how well the patient is tolerating the arrhythmia: symptoms, hypotension, and evidence of heart failure or ischemia.
- Echocardiogram to assess Left Ventricular EF and for valvular heart disease.
- Rate control (for atrial fibrillation with rapid ventricular response): Use caution when considering beta-blockers and calcium channel blockers in patients with heart failure or hypotension (Table 9.4).

TABLE 9.3 POSTOPERATIVE MANAGEMENT OF PATIENTS WITH PREEXISTING ATRIAL FIBRILLATION

Rate control	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 post-op blood pressure. In most cases, a heart rate of 80–100 is reasonable Metoprolol IV. Can start 5 mg IV q 6 h and individualize dosing OR Diltiazem IV infusion Continue digoxin if receiving preop Transition to PO meds when tolerating a diet For patients taking a diet: In most cases, resume patient's usual outpatient rate control regimen. Watch for hypotension as in some cases patients are relatively volume depleted and the blood pressure-lowering effect of some rate control medications may be less well tolerated initially post-op
Anticoagulation	Resume anticoagulation when surgically acceptable. Bridge with heparin if indicated If anticoagulation is not started immediately due to bleeding risk, venous thromboembolism prophylaxis should still be given unless there is a contraindication

- Anticoagulation: Post-op atrial fibrillation often resolves spontaneously. There is practice variation regarding the initiation of anticoagulation during the first 48 h of new-onset post-op atrial fibrillation. The decision to anticoagulate must include discussion with the surgery team regarding bleeding risk. If the bleeding risk is acceptable, antithrombotic therapy for post-op atrial fibrillation should be started after 48 h of atrial fibrillation if not already initiated prior to that time. Patients who receive cardioversion should receive anticoagulation with IV heparin, the timing of which is affected by the indication for cardioversion and the duration of atrial fibrillation prior to cardioversion [4].

  The type of antithrombotic therapy recommended may be based on the ACC/AHA guidelines or using the CHADS2 score (see "Discussion").

TABLE 9.4 RATE CONTROL STRATEGIES FOR NEW-ONSET POST-OP 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 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 h, then 0.5 mg/min × 18 h Indicated for refractory atrial fibrillation, or atrial fibrillation with heart failure Check baseline TSH, PFTs
Esmolol	50–300 mcg/kg/min IV. Can bolus 150–300 mcg/kg IV initially Watch for hypotension
PO medications	Multiple options: Metoprolol, atenolol, diltiazem Digoxin and amiodarone if indicated. Generally start with IV agents if tachycardic and rate control needed urgently
Cardioversion	Immediate cardioversion is indicated if hemodynamically unstable. Must address anticoagulation

DISCUSSION

DECISION TO ANTICOAGULATE

The decision to start antithrombotic therapy for new-onset post-op atrial fibrillation should be determined by the patient's risk factors. As noted above, antithrombotic therapy should be considered if post-op atrial fibrillation lasts over 48 h, and before 48 h on an individual basis. The bleeding risk must always be discussed with the surgeon. There are two main risk stratification tools used in practice, the ACC/AHA guidelines (Table 9.5) and the CHADS2 score (Table 9.6) [4, 5].

POSTOPERATIVE ATRIAL FIBRILLATION THAT RESOLVES

In the nonoperative setting, because the risk for thromboembolic events is similar for paroxysmal and persistent or permanent atrial fibrillation, the recommendations for anticoagulation are similar. Post-op, patients may have brief, self-limited episodes of atrial

TABLE 9.5 ANTITHROMBOTIC THERAPY FOR ATRIAL FIBRILLATION: ACC/AHA GUIDELINES (2006)

No risk factors	Aspirin 81–325 mg daily
1 moderate-risk factor	Aspirin 81–325 mg daily or warfarin (INR 2–3)
Any high-risk factor or >1 moderate-risk factor	Warfarin (INR 2–3)

Moderate-risk factors: Age ≥75, HTN, Heart Failure, LVEF ≤35 %, DM
High-risk factors: Previous stroke, TIA, or embolism; mitral stenosis, prosthetic heart valve (higher INR target if indicated)

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TABLE 9.6 CHADS2 RISK STRATIFICATION FOR ATRIAL FIBRILLATION

Score	Annual stroke risk	Anticoagulation
0	1.9	ASA
1	2.8	ASA or warfarin
2	4.0	Warfarin
3	5.9	Warfarin
4+	>7 %	Warfarin

Risk factors: 1 point for CHF, HTN, Age >75, DM; 2 points for a history of TIA/CVA
However, if the CHADS2 score is 2 because of a history of TIA/CVA, the annual stroke risk is likely *greater* than 4 %

Reprinted with permission from [5]

V

fibrillation that resolve once the postoperative stress resolves; anticoagulation is generally not necessary for these patients. This decision should be made on an individual basis taking into consideration the patient's risk factors and personal values.

ANTICOAGULATION AND BRIDGING THERAPY

- The decision to use bridge heparin therapy (although there is no universally accepted definition of "bridge heparin", it is usually with low-molecular-weight heparin preop and either low-molecular-weight heparin or IV unfractionated heparin post-op) is a balance of the risk of thromboembolism associated with an interruption in warfarin versus the bleeding risk associated with bridge heparin therapy. Presently, in the absence of robust data, treatment decisions should be individualized.

- For a brief interruption in anticoagulation, mathematical modeling suggests that the risk of stroke for most patients with atrial fibrillation is low [6]. However, this modeling does not account for stroke risk associated with surgery itself or for the potential for "rebound" hypercoagulability when warfarin is stopped. Recent data suggests that the actual perioperative stroke risk for patients with atrial fibrillation may be substantially higher than previously appreciated [7].
- The 2012 ACCP practice guidelines offer evidence-based recommendations for perioperative anticoagulation management [3]. For patients at high risk for perioperative thromboembolism (defined as CHADS2 score =5–6, stroke/TIA within the past 3 months or associated rheumatic valvular heart disease), bridge heparin is recommended. For patients at low risk (CHADS2 score = 0–2 and no prior stroke/TIA), bridge heparin is not recommended. For patients at moderate risk (CHADS2 score =3–4), the limited data do not allow a specific approach to be recommended – patient and surgery-specific factors should be assessed on a case-by-case basis.
- Low-molecular-weight heparin therapy can be expensive—check with patient's insurance for coverage. Additionally, it is not fully reversible—a significant post-op consideration.
- Warfarin need not be stopped for certain procedures, e.g., dental extractions and cataract surgery. Ensure that the preop INR is <3.0 and communicate with the surgeon to confirm.

TYPE OF SURGERY OR PROCEDURE

- Individualize anticoagulation recommendations for the *type* of surgery (e.g., neurosurgery, spine surgery, and highly vascular tumors may require a longer period off of anticoagulation), the surgeon's preference, and the baseline dose of warfarin (patients requiring lower doses tend to have INRs that fall less quickly).
- Do not assume that outpatient procedures are low risk for post-procedure surgical bleeding (e.g., angioembolization). Discuss with the surgeon or interventionalist.

DABIGATRAN

Dabigatran is a newer anticoagulant with less "real-world" experience compared with warfarin. Its clearance is affected by renal function. Based on limited studies, the recommendations for surgeries in which there is a "high" risk of bleeding or in which complete hemostasis is required (including abdominal, cardiac, neurosurgery, any major organ surgery, and the use of spinal anesthesia) are to hold dabigatran

for 2–4 days in patients with a GFR > 50 ml/min, and 4 days for a GFR of 30–50. For "standard" risk of bleeding, the recommendations are to hold 24 h for GFR > 50, and at least 2 days for GFR 30–50 [2]. Note that while there exist recommendations for GFR <30, dabigatran is contraindicated for patients with a GFR <15 mL/min, and most patients with GFR 15–30 mL/min also should not receive dabigatran. When reinitiating dabigatran post-op, it is important to recognize that its anticoagulant effect begins on the first day, unlike warfarin, and decisions regarding bleeding risk must take these pharmacokinetics into account (see Chap. 23).

RHYTHM CONTROL

When rhythm control is considered, it is advisable to obtain cardiology consultation. Amiodarone is often used but has a very long half-life and may cause significant long-term side effects. Dronedarone is a newer agent with potentially less pulmonary and thyroid side effects compared with amiodarone. However, it is only available PO, and has cautions in patients with heart failure and may increase cardiovascular events in high-risk patients with permanent atrial fibrillation; it is not advised in new-onset post-op atrial fibrillation pending resolution of these safety concerns. Other antiarrhythmic agents and cardioversion may be considered in consultation with a cardiologist.

PREVENTION OF POSTOPERATIVE ATRIAL FIBRILLATION

- In cardiac surgery, beta-blockers are routinely used. Both beta-blockers and amiodarone have indications for the prevention of atrial fibrillation in cardiac surgery, and this aspect of management is usually deferred to the cardiac surgeon.
- In noncardiac surgery, however, there is little evidence to support interventions to reduce the risk of postoperative atrial fibrillation. One retrospective study found an association between statin use and a reduced risk of postoperative atrial fibrillation in patients undergoing noncardiac surgery [8]; prospective data is needed before using statins routinely to prevent post-op atrial fibrillation.

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Chapter 10
Hypertension

Nason P. Hamlin and Gail A. Van Norman

PREOPERATIVE EVALUATION

- Assess level of blood pressure control.
- Avoid elective surgery in patients with hypertensive urgency or emergency.
- Assess for complications of long-standing hypertension (stroke, hypertensive cardiomyopathy, nephropathy).
- Consider delaying elective surgery in patients with poorly controlled HTN, e.g., BP > 180/110. See "Discussion" below.
- Advise preoperative medication management—see Table 10.1.

POSTOPERATIVE MANAGEMENT

- Assess underlying cause of post-op hypertension: Pain, alcohol withdrawal, beta-blocker or clonidine withdrawal, essential hypertension, measurement error[1], etc.
- Mild to moderate BP elevations, especially in patients not previously hypertensive, usually do not require treatment. Treat the underlying cause.
- Low blood pressures are common post-op due to blood loss, sedation, pain medications, and bed rest. Resume blood pressure medications with caution (see Table 10.2 for recommendations regarding resumption of blood pressure medications post-op).
- Postoperative patients are often NPO for prolonged periods of time. Table 10.3 shows IV/transdermal options for treating hypertension.

[1] Tremor and post op shivering can cause falsely high blood pressure readings with electronic BP cuffs. It is best to confirm very high readings with a "manual" cuff and stethoscope.

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TABLE 10.1 PREOPERATIVE MANAGEMENT OF ANTIHYPERTENSIVE MEDICATIONS

Beta-blockers	Continue, and take on the morning of surgery
ACE-inhibitors	Hold on the morning of surgery unless patient has poorly controlled HTN at baseline, e.g., SBP > 180 or DBP > 110
ARBs	Hold on the morning of surgery
Diuretics	Hold on the morning of surgery
Calcium channel blockers	Consider holding on the morning of surgery
Clonidine	Continue, and take on the morning of surgery. Transition to clonidine transdermal preoperatively if expected to be NPO post-op

TABLE 10.2 MANAGEMENT OF ANTIHYPERTENSIVE MEDICATIONS POST-OP

Beta-blockers	Continue. Hold or reduce if symptomatic hypotension or bradycardia. Common hold parameters are for SBP < 100 or HR < 60, but need to individualize these for each patient
ACE-inhibitors and ARBs	If given only for HTN, often do not restart if SBP remains below 120 post-op
Diuretics	Consider holding for the first few days post-op after major surgery—patients are at risk of hypovolemia and hyponatremia
Clonidine	Continue either PO or transdermal to avoid rebound HTN
Calcium channel blockers	Continue. Hold or reduce if symptomatic hypotension or bradycardia

TABLE 10.3 IV AND TRANSDERMAL OPTIONS FOR TREATING HYPERTENSION

Metoprolol	5 mg IV q 4–6 h. Titrate to desired BP and HR
Labetalol	20–80 mg IV q 5–10 min (up to 300 mg)
Nitroglycerin	IV drip 5 mcg/min, titrate to desired BP 1–2″ ointment q 6 h (works more slowly than drip)
Hydralazine	20 mg IV. Repeat after 20 min if needed. If still no effect, try another agent. Caution in patients with CAD
Esmolol	500 mcg/kg for the first minute, then 50–300 mcg/kg/min. Use only if minute-to-minute titration is needed. Longer acting drugs are usually preferred
Nicardipine	More commonly used in neurosurgical patients

DISCUSSION

- Hypertension is not a significant risk factor for major adverse cardiac events, but it is a significant risk factor for intraoperative blood pressure lability and the incidence of perioperative myocardial ischemia [1, 2]. These are major reasons for perioperative medical consultation concerning uncontrolled hypertension.
- The traditional cutoff of deferring surgery if blood pressure is greater than 180/110 is not well supported by contemporary data [1, 2], but many anesthesiologists would be unwilling to take a patient into the OR for elective surgery with a systolic BP > 180 or a diastolic BP > 110. Some studies show that this may be associated with modest increases in the risk of perioperative stroke. There is no good data that says, however, that deferring surgery for definitive blood pressure control is superior to acute blood pressure control in the preoperative holding area. Blood pressure risk is a continuum and must be balanced by many factors, including the urgency of surgery. Medications can be given in the preop holding area to ameliorate the high pressure without having to cancel surgery. It is best to work with the anesthesiologist.
- There are some surgical procedures that should not be done without better control of hypertension because of the risks of increased intraoperative bleeding. Facial plastic surgery and intraocular surgery are examples. On the other hand, acutely lowering blood pressure in patients with certain types of problems, such as patients with high intracranial pressure, is more dangerous than leaving things alone, even if significant hypertension is present. Again, work with your anesthesiology colleagues.
- It is also important to have an understanding of what happens in the intra-op phase controlled by the anesthesia team. Intra-op SBP can average 50 mm Hg below ambulatory levels. Tight control preop may lead to profound hypotension intra-op requiring pressors and extra fluids. A reasonable approach is to hold ACE inhibitors and Angiotensin Receptor Blockers unless the systolic BP is >180 or the diastolic BP is >110 on the morning of surgery. This practice remains controversial—the evidence is conflicting and based on small studies or retrospective cohorts.

- Our practice is to hold diuretics on the morning of surgery. While the risk of taking the diuretic is theoretical, there is also no clear advantage in patients who are taking a diuretic for hypertension to take it on the morning of surgery. One small study shows no difference [3].
- When choosing blood pressure agents, consider the patient's preoperative home medications, and whether the patient can take PO medications or must remain strictly NPO. Often a patient's bowel function has returned enough to absorb critical medications, even if the patient is not yet on a full diet—discussion with the surgery team is essential. Nitroglycerin is favored over hydralazine in patients with CAD. IV metoprolol or labetalol are useful for blood pressure control in patients who are NPO—however they must be given with caution in patients with severe asthma and generally avoided in decompensated heart failure.

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Chapter 11
Valvular Heart Disease

Ashok Reddy

The ACC/AHA guidelines identified severe valvular disease as an "Active Cardiac Condition" (i.e., high risk) for noncardiac surgery [1]. The type and degree of valvular dysfunction, as well as the nature of the planned surgery, all influence perioperative risk and determine the need for intervention. Identifying pathologic murmurs and distinguishing them from functional murmurs by careful history and exam is the first essential step. Abnormalities of the aortic and mitral valves are the most common, and generally pose the most clinically significant risk.

AORTIC STENOSIS

- History: Aortic stenosis (AS) is the most common valvular heart disease in the elderly. Preoperative evaluation should include assessment and risk stratification of previously diagnosed aortic stenosis, and identification of previously undiagnosed disease. Coronary artery disease is a common comorbidity.
- Physical exam findings: Systolic ejection murmur (right 2nd intercostal space, mid to late peak intensity), a softer than normal S2, and carotid pulse with delayed upstroke.
- Studies:
  - AS is a progressive disease. The mean annual decrease in valve area is about 0.1 cm^2, but rapid progression can occur and is not predictable [1]. A reasonable approach would be to obtain an echo within 3 months of surgery for asymptomatic patients with known severe disease, 6–12 months for moderate disease, 2 years for mild disease, and 2–3 years for aortic sclerosis.
  - If there is any uncertainty about a suspicious murmur, it is best to order a preoperative echocardiogram. Echocardiographic severity is shown in Table 11.1.

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TABLE 11.1 ECHOCARDIOGRAPHIC SEVERITY FOR AORTIC STENOSIS

Stage	Aortic jet velocity (m/s)	Mean gradient (mmHg)	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

- Perioperative risk:
  - Severe aortic stenosis poses the "greatest risk for noncardiac surgery" [1]. Precise risk is difficult to estimate, as the literature varies with regard to study design, severity of AS, and outcomes measured. A prospective study from 1977 showed a 17 % risk of cardiac complications and 13 % cardiac mortality in 23 patients with AS [2]. The ACC/AHA perioperative guidelines quote an approximate mortality of 10 % for patients with severe AS, but reference a retrospective study of only 19 patients [1]. Other more recent studies have generally been retrospective, with results ranging from increased rates of the combined outcome of MI and mortality, to increased rates of MI but not mortality, to no differences in lower risk populations.
  - Aortic sclerosis without stenosis is not in itself considered an independent perioperative risk factor. However, there is an increased incidence of cardiovascular disease in patients with this condition, and it may be a marker for coronary atherosclerosis [1].
  - Patients with severe aortic stenosis may have impaired platelet function and decreased levels of von Willebrand factor, which can be associated with clinical bleeding [1].
- Management:
  - Valve replacement is recommended in symptomatic patients prior to noncardiac surgery. Balloon valvotomy is no longer recommended as a temporizing measure for patients with severe AS requiring urgent noncardiac surgery—rather, patients with severe asymptomatic AS may be managed medically and symptomatic patients should be considered for valve replacement [3]. Newer approaches to valve replacement include transcatheter aortic valve implantation (TAVI), but its use is limited to selected subsets of patients.
  - Suggested perioperative management in asymptomatic patients with moderate to severe disease, after echocardiographic evaluation, includes close hemodynamic monitoring

(up to 48 h postop), consideration of consultation with a cardiac anesthesiologist, judicious maintenance of intravascular volume, and consideration of beta-blockers. Maintaining sinus rhythm and preventing tachycardia, if possible, are also critically important.

- If there is further uncertainty regarding the patient's clinical picture or echocardiographic result, do not hesitate to consult a cardiologist.
- It should be noted that patients with subaortic stenosis (i.e., idiopathic hypertrophic subaortic stenosis (IHSS)) should be managed similarly to patients with aortic stenosis (avoid tachycardia, volume depletion).
- It is helpful to maintain excellent IV access. In the event that there is unanticipated bleeding or volume loss, rapid IV resuscitation is essential.
- Avoid the use of nitrates in patients with critical aortic stenosis or IHSS as they reduce filling pressures and may precipitate sudden death.

- See Fig. 11.1 for a suggested diagnostic algorithm for the preoperative evaluation of patients with known or suspected aortic stenosis.

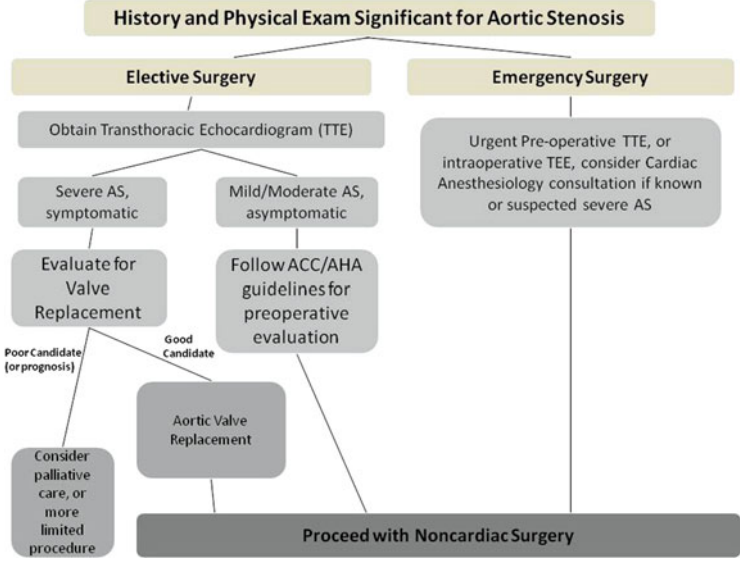

Fig. 11.1 Suggested preoperative algorithm for patients with a history and physical exam significant for aortic stenosis

MITRAL STENOSIS

- History: Increasingly rare condition but important to recognize. Symptoms are nonspecific and typically consist of dyspnea, fatigue, and decreased exercise tolerance.
- Physical exam findings: Low-pitched blowing diastolic murmur, which is best heard with the bell of the stethoscope at the apex. The first heart sound (S1) is usually loud (if the leaflets remain pliable) and a narrowly split S2 with an opening snap can sometimes be heard. There may be prominent "a" waves of the jugular venous pulse, a palpable right ventricle heave, and sometimes a flushed facial appearance.
- Management:
  - Preoperative surgical correction of mitral valve disease is generally not indicated, unless there is a need to do so irrespective of the proposed surgery.
  - Balloon valvotomy or open surgical repair prior to high-risk surgery may be beneficial if stenosis is severe.
  - Tachycardic states cause a reduction in the diastolic filling period and can result in severe pulmonary congestion. Rate control is beneficial, and the use of medications such as beta-blockers should be considered.
  - Over 50 % of individuals with mitral stenosis will develop chronic atrial fibrillation and over 80 % will develop paroxysmal atrial fibrillation, and thus patients are at risk for perioperative atrial fibrillation (see Chap. 9).

AORTIC REGURGITATION

- History: Patients are often asymptomatic initially. With severe aortic regurgitation, patients may have palpitations and symptoms of left-sided heart failure.
- Physical exam findings: Wide pulse pressure with high-pitched, decrescendo, early diastolic murmur along the left sternal border is the classic finding. A mid-diastolic murmur at the apex (Austin Flint murmur) is probably caused by the regurgitant stream striking the mitral valve leaflet. An S3 may be present, which warrants concern for LV dysfunction.

- Management:
  - Asymptomatic patients with AR generally tolerate anesthesia and surgery well.
  - Symptomatic patients (or asymptomatic patients with significantly reduced LV function) with AR should be considered for valve replacement.
  - Perioperative management should include attention to volume control and afterload reduction.
  - Unlike mitral stenosis, bradycardia can worsen AR by increasing diastolic time and thus very low heart rates should be avoided.

MITRAL REGURGITATION

- History: Most common causes are papillary muscle dysfunction and mitral valve prolapse. With symptomatic disease, patients may present with symptoms of left-sided heart failure. Atrial fibrillation is a common comorbidity.
- Physical exam findings: Apical holosystolic murmur, a third heart sound, and a diastolic flow rumble. Auscultation in the sitting, standing, squatting, and standing-after-squatting positions may identify a tendency to volume- or stress-related regurgitation.
- Management:
  - Antibiotic prophylaxis is no longer recommended for patients with mitral valve prolapse.
  - In patients with severe MR undergoing high-risk procedures, preoperative optimization with diuretics, and afterload reduction prior to surgery should be considered.

PROSTHETIC HEART VALVES

There are three main considerations:

1. Function of the prosthetic valve: Assess for signs of decreased valve function and if indicated obtain preoperative echocardiogram.
2. Management of anticoagulation: Anticoagulation in patients with mechanical or bioprosthetic valves requires careful perioperative planning—see Chap. 23.

TABLE 11.2 HIGH-RISK CONDITIONS FOR INFECTIVE ENDOCARDITIS

Prosthetic heart valves or prosthetic material used for cardiac valve repair
History of previous infective endocarditis
Congenital heart disease (CHD) in the following categories: ■ Unrepaired cyanotic CHD, including palliative shunts and conduits ■ Completely repaired congenital heart defect repaired with prosthetic material or device, whether placed by surgery or by catheter intervention, during the first 6 months after the procedure ■ Repaired CHD with residual defects at or near the site of a prosthetic patch or device (thus preventing endothelialization)
Cardiac transplantation recipients with valve regurgitation due to structurally abnormal valve

Reprinted with permission from [6]

3. Endocarditis Prophylaxis.
   - Guidelines from ACC/AHA recognize that there is insufficient evidence that prophylactic antibiotics prevent invasive procedure-related infective endocarditis (IE) [4, 5]. However recommendations focus on providing prophylaxis to patients with underlying cardiac conditions who have the highest risk of adverse outcome from infective endocarditis [4, 6].
   - The ACC/AHA guidelines find it reasonable to provide endocarditis prophylaxis for patients with the high risk underlying cardiac conditions, as shown in Table 11.2 [6].
   - In high-risk patients, endocarditis prophylaxis is recommended for the procedures shown in Table 11.3 [6].
   - While IE prophylaxis is no longer recommended for general GI/GU procedures, patients at high risk for endocarditis with ongoing infections of the GI or GU tract should be considered for antibiotics, and patients with known enterococcus urinary tract colonization may be treated with antibiotics to eradicate the organism. Penicillin, ampicillin, piperacillin, or vancomycin are reasonable choices. No published studies demonstrate that such therapy would prevent enterococcal IE.
   - The antibiotic regimens of high-risk patients who are undergoing the procedure specified above are listed in Table 11.4 [6]. Note that cephalosporins should be avoided in patients who have a history of anaphylaxis, angioedema, or urticaria with penicillins.

TABLE 11.3 PROCEDURAL INDICATIONS FOR ENDOCARDITIS PROPHYLAXIS

In high-risk patients, endocarditis prophylaxis is recommended for patients undergoing

- All dental procedures involving manipulation of gingival tissue or the periapical region of the teeth, or perforation of the oral mucosa
- Respiratory tract procedures involving incision or biopsy of the respiratory mucosa
- Respiratory tract procedures to treat an established infection (e.g., abscess or empyema)
- Procedures involving infected skin, skin structures, or musculoskeletal tissue

Prophylaxis is no longer recommended for

- Routine anesthetic injection through noninfected tissue
- Placement or adjustment of removable prosthodontic or orthodontic appliances or brackets
- Dental radiographs
- Shedding of deciduous teeth
- Bleeding from trauma to the lips or oral mucosa
- Bronchoscopy without mucosal incision
- GI or GU procedures (e.g., EGD/Colonoscopy/Cystoscopy) (See text)

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TABLE 11.4 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
Reprinted with permission from [6]

OTHER STRUCTURAL HEART DISEASE

Perioperative considerations in patients with other structural heart conditions, such as congenital cyanotic heart disease, are beyond the scope of this book. However, strong consideration should be made to coordinating care with the assistance of a cardiology consultant.

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Chapter 12
Implantable Cardiac Devices

G. Alec Rooke

It is not uncommon to see patients for preoperative evaluation who have a permanent pacemaker or an implantable cardioverter-defibrillator. Perioperative management of these devices requires both knowledge of how these devices function as well as an understanding of the particular risks posed by electrocautery or other electromagnetic interference to the function of the device.

PACEMAKER AND ICD FUNCTION

Basic 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, as shown in Table 12.1 [1–3].

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 [4]:

- 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/ICU monitors has similar technology and can fool the pacer/implantable cardioverter-defibrillator (ICD) into thinking the patient is active and so leads to an inappropriate paced tachycardia.

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TABLE 12.1 PACEMAKER TERMINOLOGY

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

- Bioimpedance measurement within the myocardium (an index of sympathetic nervous system activity): This measurement is made at the tip of the lead. No known interactions in the OR.

MOST COMMON PACING MODES

VVI: Senses and paces the ventricle.
VVIR: Same as VVI, but with rate-adaptive mechanism.
DDD: Both atrium and ventricle are sensed and paced individually.
DDDR: Same as DDD, but with rate-adaptive mechanism to alter atrial pacing.

IMPLANTABLE DEFIBRILLATORS [1, 2]

- Respond to tachyarrhythmias (typically ventricular tachycardia and fibrillation) based on detection of defined, high ventricular rates.
- Therapies include anti-tachycardia pacing, 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. How the pacemaker component of the ICD is programmed depends on the patient's day-to-day requirement for pacemaker support.

CARDIAC RESYNCHRONIZATION THERAPY

These devices pace both the right and left ventricles in order to produce a more coordinated left ventricular contraction [1, 2]. If defibrillation capability is present, it is referred to as 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.

ELECTROMAGNETIC INTERFERENCE

Electromagnetic sources, such as electrocautery or high-frequency radio-ablation used during surgery, can interfere with implanted cardiac devices and lead to a variety of undesired events [1, 5]. Monopolar diathermy radiates far more electromagnetic interference (EMI) than bipolar, but it is impractical to substitute bipolar for monopolar cautery in almost all circumstances. Monopolar cautery can lead to the following:

- Suppression of demand pacing in the atrium, ventricle, or both.
- Inappropriate "tracking" of falsely sensed "atrial" events. Normal dual-chamber pacing mode will use a sensed atrial depolarization to initiate (trigger) a ventricular paced beat (unless inhibited by a sensed ventricular depolarization). If EMI is sensed on the atrial channel, the device can misinterpret this signal and then pace the ventricle at a high rate (up to a programmed limit).
- Activate asynchronous pacing that could result in a competing rhythm if it occurs in a patient who is not pacer dependent.
- Activation of shock therapy for falsely detecting EMI artifact as VT or VF in an ICD.
- Transient lowering of the battery voltage and device malfunction: When the device recovers, the programming returns to generic default values that may be very different from those set for the patient. This phenomenon is often referred to as "power on reset."
- Arbitrary reprogramming of the device from high-density EMI (very rare with current technology).
- Device destruction with complete loss of any pacing or shock function from very high EMI (e.g., can occur with cautery applied directly to the device).
- Myocardial burns from lead insulation failure when cautery current travels down the wire and burns the tissue at the lead tip (very rare).

PERIOPERATIVE MANAGEMENT

PREOPERATIVE CHECKLIST

Device interrogation by a programming box, if available, is the easiest and most complete method to obtain the desired preoperative information [5]. However, if this option is unavailable, the following checklist will allow any clinician to obtain considerable useful information [6].

1. *Device identification*.
   (a) 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 managing or implanting cardiologist. The managing physician should be able to provide information regarding the patient's device type, indication for the device, special concerns, and recommendations for management of the device during the operative procedure.
   (b) A *chest X-ray* provides clear information as to the device and potential pacing capabilities. Thin wires going to the atrium, right ventricle, and possibly the left ventricle identify a patient with at least some degree of need for pacemaker function. Leads with fat, densely radio-opaque sections (usually in the superior vena cava and right ventricle) identify the device as an ICD. Of course, combinations of ICD and pacing leads may be present. Typically, pacing leads will be bipolar with the second electrode approximately 1 cm from the tip.
   (c) 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 below) or check the Web site and quickly obtain information about the device capability including the device's *response to a magnet*, but the company will not have any patient-specific information.
2. *Contact* the physician who normally manages the device. This should be able to provide information regarding the device type, indication for the device, special concerns, and recommendations for management of the device during the operative procedure. Ideally, an interrogation should be performed within 6 months of the planned surgery. This time period can be significantly extended if the device is no more than a few years old and the patient has been doing well. If the battery is found to be near its end of life, elective surgery should generally be postponed until the device has been replaced. In this situation, risk of device malfunction increases the closer the cautery is performed to the device and leads. If you have concerns, consult your local electrophysiologist specialist.

3. Obtain a long *rhythm strip* or observe on a monitor. This will help to determine the underlying rhythm, and if the patient is pacemaker dependent. Make sure that the monitor is set to display pacing spikes. Most modern monitors found in ORs, ERs, and ICUs have electrical filters that prevent visualization of the spikes unless special circuitry is turned on.
4. If the device is a pacemaker, *place a ring magnet* over the device while observing the rhythm strip. Almost all pacemakers (but no ICDs) will then convert to asynchronous pacing. This accomplishes several goals:
   (a) Identifies the device as a pacemaker.
   (b) Provides evidence that the battery is OK because a low battery is associated with a pacing rate that is approximately 10 or more bpm below the normal magnet rate (normal is 85 bpm for Medtronic, 90 bpm for Biotronik, and 100 bpm for Guidant/Boston Scientific and St. Jude).
   (c) Documents proof (or failure) of capture when spikes stimulate the tissue in a non-refractory state.
5. Patients on diuretics or acutely ill should have their *electrolytes* checked. Pacing thresholds can be affected by electrolyte disturbances.

INTRA-OPERATIVE MANAGEMENT

For all patients, attempts should be made to *minimize EMI* [2, 5]:

- 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.

If a *programming box* and trained personnel are available to evaluate the device immediately prior to surgery, then all necessary device information is available and any necessary programming changes can be made [5]:

- For ICDs, tachycardia sensing will be disabled to prevent unwanted shocks. *Defibrillation pads* should then be placed on the patient.

- For all devices, patients dependent on the device to maintain a reasonable heart rate will typically be changed to asynchronous pacing. Even if the patient is left in demand pacing, other features may be disabled.
- A discussion with the programmer about the device is helpful as it makes the anesthesia team aware of how the device might perform during surgery.

If *interrogation is not available*, then proceeding with surgery must be a carefully weighed decision that includes the risk to the patient of EMI causing device dysfunction versus the risk to the patient not proceeding with the surgery. EMI risk increases with each of the following:

- Monopolar cautery that will be applied close (within 8 cm) to the device.
- Monopolar sensing (almost all devices use bipolar sensing but it is almost impossible to know without interrogation).
- Improper grounding pad placement.
- Device battery at end of life.

If surgery proceeds without interrogation and programming, the anesthesia team will likely perform the following [5–7]:

- For ICDs, *disable tachycardia sensing* by placing a ring magnet over the device. Defibrillation pads are not mandatory—in the event of V-tach or V-fib, simply remove the magnet. Care must be taken, however, to avoid dislodging the magnet. Some ICDs have idiosyncratic responses to the magnet such as the device will emit beeps or only result in disabled arrhythmia detection for a certain length of time: a call to the company (see contact information below) will provide this vital information.
- For pacemakers, the ring magnet will convert the device to *asynchronous pacing*. To avoid competing rhythms, especially in patients with an intrinsic rhythm, it is best to wait to observe significant inhibition of demand pacing before choosing to place a magnet. The desire to minimize the higher heart rate associated with the use of a magnet is particularly germane to some patients, for example, those with coronary artery disease or aortic stenosis.
- Worst-case scenario is a patient with an *ICD and pacemaker dependency*. Use of a magnet will prevent inadvertent shocks but nothing can be done to 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 will have to be of limited duration or have a temporary pacemaker placed.

- Be aware that the *rate-responsive feature* may lead to a paced tachycardia if the sensor becomes activated. Jiggling the patient can trigger the piezoelectric activity sensor, and the minute ventilation sensor can interact with the similarly designed bioimpedance method of the anesthesiologist's respiratory rate monitor. Awareness of the potential problem and knowing what the upper "sensor" rate is programmed at (the maximum heart rate that the sensor can induce) aid in the detection of the cause and institution of the correct intervention (e.g., quit wiggling the patient, turn off the anesthesia respiratory rate monitor).

POSTOPERATIVE MANAGEMENT

Device interrogation after surgery should be performed [5]:

- Prior to leaving a monitored setting, if any programming changes were made for surgery, those settings should be restored to the original values unless the clinical situation dictates different settings.
- Patients with ICDs whose tachycardia therapies were disabled for surgery must remain on a cardiac monitor with defibrillation and pacing capability until ICD shock therapy is restored.
- Other situations which should prompt 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, 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 above the umbilicus, had lithotripsy or electroconvulsive therapy and were not interrogated after the procedure should see their cardiologist for an interrogation within 1 month.

COMPANY CONTACT INFORMATION

- Biotronik: (800) 547-0394
- Ela Sorin: (303) 467-6101
- Guidant/Boston Scientific: (800) 227-3422
- Medtronic: (800) 723-4636
- St. Jude: (800) 933-9956

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PART VI
Pulmonary

Chapter 13
Pulmonary Risk Assessment and Management

Christopher J. Wong and John H. Choe

PREOPERATIVE EVALUATION

- Preoperative evaluation of all patients should include an assessment of risk factors for pulmonary complications (see Table 13.1).
- A thorough cardiovascular and respiratory exam should be performed.
- Asthma, COPD, Obstructive Sleep Apnea, and Pulmonary Hypertension are discussed in separate chapters (Chap 14, 15, 16).
- Note that obesity and mild–moderate asthma have *not* been found to be risk factors for postoperative pulmonary complications [1].
- In patients with pulmonary HTN, having New York Heart Association (NYHA) functional class >2, history of PE or OSA increases the risk of postoperative pulmonary complications [5].
- Albumin <3.6 g/dl predicts postoperative pulmonary complications. Surgeons are usually highly attentive to nutritional status for other reasons (overall morbidity, mortality, wound healing, etc.) and may delay surgery for those reasons. It is unclear if correction of hypoalbuminemia changes outcomes; generally, studies of perioperative nutritional supplementation (both enteral and parenteral) have been disappointing.
- Advise smoking cessation. Smoking cessation was previously thought to have benefit if done 6–8 weeks or greater prior to surgery, with concern for harm if cessation occurred too close to surgery. However, a meta-analysis concluded that the existing evidence does not support an increased risk of complications due to stopping smoking prior to surgery; benefits were greater the longer the period of smoking cessation [2].

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TABLE 13.1 RISK FACTORS FOR PULMONARY COMPLICATIONS [1,5]

COPD
Age >60
ASA class II or higher
Functionally dependent
CHF
Pulmonary hypertension
Delirium
Alcohol use
Obstructive sleep apnea
Albumin <3.6 g/dL
Surgery factors: Prolonged surgery more than 3 h; site of surgery—abdominal, thoracic, neurosurgery, head and neck, and vascular surgery; emergent surgery; general anesthesia

ASA American Society of Anesthesiologists

TABLE 13.2 PREOPERATIVE PULMONARY DIAGNOSTIC TESTS

Chest X-ray	■ Routine pre-op chest X-rays are *NOT* indicated ■ No consensus—guidelines differ. ACP guidelines: "may be helpful" in patients >50 years of age who are undergoing upper abdominal, thoracic, AAA surgery, or in patients with cardiac or pulmonary disease [1] ■ Rarely changes management dramatically, but may be useful in these select populations
Pulmonary function tests (PFTs)	■ Routine PFTs *NOT* indicated except for certain surgeries (e.g., thoracic surgery—usually defer this testing to the surgeon) ■ Known COPD: Assess by symptoms and exam ■ Consider for patient with suspected but previously undiagnosed obstructive lung disease
Arterial blood gas (ABG)	■ Consider for patients with elevated serum HCO_3, O_2 dependence, moderate to severe COPD, or suspected obesity-hypoventilation syndrome

- Diagnostic tests such as a chest X-ray, pulmonary function tests, and an arterial blood gas should be considered on an individual basis. Often these tests do not change perioperative management (see Table 13.2).

POSTOPERATIVE MANAGEMENT

Asthma, COPD, Obstructive Sleep Apnea, and Pulmonary Hypertension are discussed in separate chapters (see Chap. 14, 15, 16). General respiratory care in the postoperative patient includes attention to pulmonary symptoms, lung exam, and oxygen saturation. Venous thromboembolism prophylaxis should be considered in all inpatients (see Chap. 17). Patients may have hypoxia from a number of causes, including pulmonary edema, atelectasis, hypoventilation, pleural effusions, pneumonia, and pulmonary embolism. Lung expansion maneuvers are generally recommended but controversies exist with regard to which surgeries and patients will most benefit, and which type of treatment is most efficacious. Patients receiving mechanical ventilation should receive preventive measures against ventilator-associated pneumonia, which vary by protocol but typically include semi-upright bed positioning, daily sedation vacations, and a weaning plan. Table 13.3 shows general pulmonary recommendations in the postoperative setting.

TABLE 13.3 POSTOPERATIVE RESPIRATORY CARE

Lung expansion maneuvers (e.g., incentive spirometry)	■ Recommended in ACP guidelines [1] ■ Cochrane review found no evidence of incentive spirometry reducing pulmonary complications in upper abdominal surgery, but was limited by few quality studies [3] ■ For patients unable to participate in incentive spirometry, continuous positive airway pressure (CPAP) therapy has shown benefit in reducing pulmonary complications in some RCTs [5]
Nasogastric (NG) tube	■ ACP guidelines recommend selective use of an NG tube for decompression for "postoperative nausea or vomiting, inability to tolerate oral intake, or abdominal distension." There is no clear benefit from routine use of NG tubes in all surgical patients [1,5] ■ In practice, we defer this to the surgery team. For many patients, a new anastomosis (e.g., esophageal surgery) makes NG tube placement potentially dangerous—always discuss with the surgical team
Pulse oximetry	■ Recovery room pulse oximetry is routine and managed by the anesthesia team ■ Consider for patients with sleep apnea or high risk of hypoxemia (see Chap. 15)

DISCUSSION

Risk stratification. Despite attention paid to cardiovascular risk stratification and complications, pulmonary complications likely exceed those of cardiovascular complications, affecting 2–19% of nonthoracic surgeries and 8–39 % of cardiothoracic surgeries [5]. Cardiovascular risk stratification, however, has benefited from easy-to-use, well-validated risk tools such as the Revised Cardiac Risk Index (see Chap. 6). Risk models for postoperative pulmonary complications have identified age, preoperative O_2 saturation recent respiratory infection, preoperative anemia, upper abdominal or thoracic surgical site, duration of surgery, and emergent procedures as risk factors—however the scoring system requires adding up weighted scores for each risk factor [4].

Other pulmonary conditions. Other conditions have had increasing evidence for risks of postoperative complications, including obstructive sleep apnea and pulmonary hypertension. These are discussed separately: Chaps. 14, 15, 16, and 17.

Interventions not yet currently supported by evidence. Pulmonary artery catheterization and perioperative nutritional supplementation have not been shown in prospective studies to reduce pulmonary complications from surgery, although the primary surgical team or anesthesiology a team may have reasons to use these strategies [1,5].

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Chapter 14
Asthma and COPD

Christopher J. Wong and John H. Choe

PREOPERATIVE EVALUATION

- Assess for COPD: Increases risk of pulmonary complications (pneumonia, atelectasis, respiratory failure, and COPD exacerbation—relative risk 2.7–4.7) [1].
- Mild to moderate asthma has not been shown to pose a significant perioperative pulmonary risk [2].
- Delay purely elective surgery for patients with acute exacerbations of asthma or COPD.
- For patients with known asthma or COPD, routine preoperative pulmonary function tests (PFTs) are not necessary—history and exam can assess severity.
- PFTs with spirometry should be reserved for patients who are suspected of—but have not yet been diagnosed with—chronic obstructive pulmonary disease or asthma [2].
- Recommend smoking cessation.
- Consider ABG if the patient is suspected to have baseline CO_2 retention.
- Our practice is generally not to order routine chest radiographs in patients with stable COPD or asthma unless guided by symptoms or physical examination findings suggestive of new or worsening disease. Reviews of the utility of chest radiographs have generally found that while abnormal CXR findings are not unusual, only rarely do such findings influence preoperative management [2].

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POSTOPERATIVE MANAGEMENT

- Consider scheduled nebulizers with albuterol and ipratropium in patients with COPD.
- Watch for and treat respiratory complications in patients with COPD.
- Postoperative use of epidural catheters for pain management may reduce the risk of pulmonary complications in patients with COPD [1, 3], and in general populations [4].
- Nicotine replacement therapy if indicated.
- Lung expansion maneuvers such as incentive spirometry (not specific to patients with obstructive lung disease, see Chap. 13). Lung expansion strategies can also include CPAP for patients unable to participate in incentive spirometry.

MEDICATION MANAGEMENT

It is uncertain whether optimization using ipratropium, albuterol, cortico steroids, smoking cessation, or antibiotics improves surgical outcomes. For COPD, studies widely cited showing benefit from these measures are from the early 1970s and have not been repeated [1]. It is reasonable, however, to treat using these agents if they would be used based on the patient's condition regardless of surgery.

- Inhaled beta agonists and anticholinergics: Normally administered as usual, including on the morning of surgery. Although correct administration via metered dose inhaler can be equally effective, delivery via nebulizer or through the ventilator circuit may be necessary during the postoperative period.
- Corticosteroids: For active exacerbations requiring corticosteroids, *discuss with surgical team*—may impair wound healing. Assess for and treat hyperglycemia. For patients who are maintained on systemic corticosteroids frequently or chronically, they may be at risk for adrenal insufficiency in the setting of acute systemic stress of surgery. See Chap. 22 for discussion. Inhaled corticosteroids should be continued in the perioperative period, including on the morning of surgery.
- Theophylline: Although infrequently used in most current practice, the relatively narrow therapeutic window and potential for arrhythmias may complicate postoperative management. Discuss with Pulmonology, but consider discontinuation of this medication prior to surgery in favor of other agents, as current practice generally supports the use of theophylline in only a small number of patients refractory to other agents [5, 6].

DISCUSSION

PFTs: Lower baseline FEV1s may in fact confer a higher surgical risk, but it is unclear whether preoperative testing will change outcomes, risk stratification, or decision-making in patients undergoing noncardiothoracic surgery.

Perioperative beta-blockers: *COPD*. A systematic review demonstrated that patients with COPD who receive beta-blockers had no difference in symptoms or FEV1, even in patients with severe obstruction (FEV1 <50%) and in patients with a positive bronchodilator response [7]. However, in patients with even more severe COPD, or those with a history of previous adverse reactions even to cardioselective beta-blockers, the risk of COPD exacerbation must be weighed against the potential benefit of perioperative beta-blockade. *Asthma*. Another systematic review found no significant difference between cardioselective beta-blockers and placebo in patients with mild to moderate reactive airways disease—this included both COPD and asthma [8]. The above data pertain to patients taking beta-blockers in general. There are insufficient data for beta-blockers strictly given for *perioperative* reasons, since most perioperative beta-blocker trials excluded patients with asthma. Note, however, that there are relatively few indications currently for perioperative beta-blockers (see Chap. 8).

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Chapter 15
Obstructive Sleep Apnea

Molly Blackley Jackson

Obstructive sleep apnea (OSA) is a major risk factor for intra- and postoperative complications, including post-extubation hypoxemia, hypercarbia, unplanned reintubation, pneumonia, all-cause respiratory failure, cardiac complications (including arrhythmia and myocardial injury), unplanned ICU transfer, longer length-of-stay, and even sudden death [1–3]. The use of sedatives/analgesics and postoperative sleep deprivation likely play a major role in these adverse events [4].

Sleep-disordered breathing is common, affecting 20% of adults, with up to 7% with moderate or severe OSA, and studies have suggested that up to 80% of patients with OSA in the general population are undiagnosed [5]. These numbers are likely higher among surgical patients, especially candidates for bariatric surgery [6]. In patients with OSA, pre-op CPAP compliance has been shown to reduce postoperative complications [7].

PREOPERATIVE EVALUATION

HISTORY/EXAM

- Risk factors: Advanced age, male, hypertension, obesity, alcohol intake, menopause.
- Symptoms: Daytime somnolence or napping, non-restorative sleep, witnessed snoring /apnea, awakening from sleep (restlessness, choking), morning headaches.
- Use a systematic screening tool, such as STOP-Bang. See Table 15.1 [8].

Workup: Consider if risk is high and surgery is not urgent.

- Gold standard: Overnight polysomnogram (PSG).

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TABLE 15.1 STOP-BANG SCREENING TOOL FOR OBSTRUCTIVE SLEEP APNEA [8]

S = Snoring. *Do you snore loudly* (*louder than talking or loud enough to be heard through closed doors*)?
T = Tiredness. *Do you often feel tired, fatigued, or sleepy during daytime?*
O = Observed apnea. *Has anyone observed you stop breathing during your sleep?*
P = Pressure. *Do you have or are you being treated for high BP?*
B = BMI > 35 kg/m^2
A = Age > 50 years
N = Neck circumference >40 cm
G = Male gender

High risk of OSA: ≥3 of the above
Low risk of OSA: <3 of the above

Using 3 as a cutoff, this tool has a 93% sensitivity and 47% specificity for OSA

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- Apnea–hypopnea index (AHI) = number of apneas + hypopneas/number of hours of sleep: 5–15 (mild), 15–30 (moderate), >30 (severe).
- CPAP machine covered by Medicare and Medicaid if AHI >15, *or* AHI >5 with severe symptoms or comorbidities (HTN, CAD, CVA, etc.) [4].

PATIENTS WITH KNOWN OSA

- Document CPAP or BIPAP settings, type of mask (nasal vs. full face), amount of bleed-in oxygen (if any), and actual patient compliance.
- If patients have an ill-fitting mask, refer back to their sleep clinic for mask refitting.
- Remind patients to bring mask and machine (labeled with name) to the hospital.
- Assess for signs and symptoms of pulmonary hypertension (see Chap. 16) and right heart failure; consider echocardiogram in selected cases (see "Discussion").
- Consider obtaining a preoperative room air ABG, if mild hypoxia or evidence for daytime hypercarbia (e.g., elevated serum bicarbonate).
- Alert anesthesia and operative team to the presence of known or suspected obstructive sleep apnea (OSA) before surgery.

POSTOPERATIVE MANAGEMENT

- Extubate directly to CPAP/BiPAP at home settings, and continue when sleeping (including naps).
- Close respiratory monitoring, especially with sedating medications (e.g., opiates).
- Consider ICU care, or continuous pulse oximetry monitoring if on floor care, depending on the extent of surgery, severity of OSA, and compliance with CPAP.
- Semi-upright (30–45°) or lateral (side-lying) positioning, if possible.
- If cannot tolerate CPAP or cannot use CPAP due to the surgical site, initiate supplemental O_2 while sleeping (exercise caution in patients with COPD).
- Minimize opiate medications when possible (considering scheduled acetaminophen or NSAIDS to augment pain control in appropriate candidates).
- If surgery is urgent and the risk for OSA is high but there is no time for testing, consider intensive respiratory observation (ICU or similar) for the first 24 h; if any evidence of hypercarbia or hypoxemia, consider ABG and/or a trial of noninvasive positive pressure ventilation (CPAP or BiPAP).

AMBULATORY SURGERY

Monitoring in patients with OSA after ambulatory surgery is controversial. ASA practice guidelines (based on expert opinion) recommend observing patients for an additional 3 h before discharging home, and if there is any episode of airway obstruction or apnea, monitoring should continue for an additional 7 h [9]. These recommendations hold even for patients who undergo only regional anesthetic block.

DISCUSSION

We recommend very close attention perioperatively to patients with OSA. The appropriate setting for adequate respiratory monitoring is institution and surgery dependent. It deserves mention that most screening tools for OSA are quite sensitive, but not terribly specific, and are not designed specifically for “preoperative” screening. Thus, these tools recommend formal testing for OSA in a higher percentage of patients than may be necessary prior to surgery. Using sound

clinical judgment in combination with these tools is a reasonable approach.

At least mild pulmonary hypertension (PAH) may be present in up to half of the patients with OSA, although OSA is an unusual cause of moderate or severe PAH. Many patients with OSA have dyspnea on exertion due to obesity and deconditioning, and/or edema due to venous stasis, without having right heart failure or PAH. Neck veins in these patients are difficult to assess. It is unknown to what degree screening for PAH by transthoracic echocardiogram (TTE) changes management or affects outcomes. The American College of Chest Physicians does not recommend routine evaluation for PAH in all-comers with OSA, but consideration of TTE is reasonable in newly diagnosed patients who are set to undergo high-risk surgical procedures and/or are likely to receive high doses of post-op opioids [10]. TTE may also be considered in patients with OSA who have poor exercise tolerance and/or who are anticipated to undergo laparoscopic surgery.

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Chapter 16
Pulmonary Hypertension

Brian S. Porter

BACKGROUND

- Overview: Pulmonary hypertension confers increased risk for perioperative morbidity and mortality in noncardiac surgery [1]. In the absence of evidence-based guidelines, perioperative management of patients with this condition demands thoughtful clinical reasoning.
- Definition: Pulmonary arterial hypertension (PAH) is defined as mean Pulmonary Artery Pressure (mPAP) of >25 mmHg at rest, with wedge pressure <15 mmHg, and pulmonary vascular resistance >3 Wood units, with other causes of pulmonary hypertension (PH) excluded [2].
- Types/Risk factors: See Table 16.1 [3].

PREOPERATIVE EVALUATION

TESTING FOR PULMONARY HYPERTENSION

- Routine screening for pulmonary hypertension is not recommended.
- Consider testing based on clinical suspicion. Symptoms and findings suggestive of pulmonary hypertension include dyspnea on exertion, unexplained hypoxia, decreased DLCO on PFTs, and signs consistent with right-sided heart failure such as pedal edema or elevated neck veins.
- ECG patterns of right axis deviation or right bundle branch block are suggestive of right ventricular hypertrophy and pulmonary hypertension, but are not specific [4].
- Echocardiogram is the preferred test in the initial workup of suspected pulmonary hypertension [5]. However, it relies on

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TABLE 16.1 CLASSIFICATION AND TYPES OF PULMONARY HYPERTENSION [3]

Pulmonary arterial hypertension (PAH)	**Pulmonary hypertension (PH)**
Idiopathic (formerly "Primary Pulmonary Hypertension")	Left-sided heart disease, including valvular heart disease
Familial	Lung disease
Associated with other conditions	COPD
Connective tissue disorders	Interstitial lung disease
Congenital shunts	Sleep disordered breathing
Portal hypertension	Hypoventilation disorders
HIV	High altitude
Drugs (fen-phen)	Chronic thromboembolic disease
Others (e.g., Gaucher's, sickle cell)	Miscellaneous: e.g., Sarcoidosis, histiocytosis X
Pulmonary veno-occlusive disease	

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the presence of a tricuspid regurgitant jet to estimate the pulmonary artery systolic pressure (PASP), and this finding is not always present.

- Pulmonary artery catheterization is the gold standard and can measure the hemodynamic variables required for a formal diagnosis (mPAP, wedge pressure, pulmonary vascular resistance), but is invasive.
- Obstructive sleep apnea (OSA) alone is thought to cause at most mild pulmonary hypertension. A patient with OSA who is found to have moderate or severe pulmonary hypertension should receive workup for other etiologies.

PATIENTS WITH KNOWN PULMONARY HYPERTENSION

- Echo: Routine testing is indicated every 12 months for functional class I–II, and every 6 months for functional class IV, with discretion allowed for center-specific protocols and for class III (functional class is similar to NYHA class) [2]. We recommend an echocardiogram within 12 months of surgery for moderate to severe pulmonary hypertension, with consideration to repeat depending on a patient's interval history.
- Assessment of severity: Do not rely strictly on "mild," "mild–moderate," "moderate," and "severe" classifications by

echocardiogram calculation of PASP alone—there are no strict definitions. Useful markers of severity are:

- Functional capacity (NYHA or WHO functional class, 6-min walk distance)
- RV function
- Mean and/or systolic PA pressures (mPAP and PASP)
- Hypoxia

Example: A patient with "moderate" pulmonary hypertension by echo, good functional capacity (>4 METS), and normal RV function is less worrisome than a patient with poor functional capacity and/or baseline RV dysfunction.

- Suggested preoperative strategy for patients with pulmonary hypertension: See Table 16.2.

Examples

- Patient has severe idiopathic PAH, PASP of 90 on right heart cath, and NYHA Class IV symptoms despite therapy with treprostinil and sildenafil, now with severe back pain and spinal stenosis. Patient discusses the overall prognosis and risks of spine surgery and decides against it. She elects epidural steroid injections instead, with temporary cessation of warfarin for the procedure.
- Patient without identified risk factors is identified in preop evaluation as having poor functional capacity. Workup reveals PASP of 55 mmHg by echocardiogram. Elective hysterectomy is deferred and patient is referred to pulmonology for further workup.
- Patient with idiopathic Pulmonary Arterial Hypertension, moderate in severity, being initiated on bosentan, desires hip replacement. It is decided to wait until the patient is optimized on therapy and in consultation with cardiology and anesthesiology, surgery proceeds 6 months later with improved PA pressures and functional status.
- Patient has PASP of 50 mmHg by echo, attributed to long-standing COPD. Patient is undergoing cholecystectomy and has very good exercise tolerance. Surgery proceeds without further workup.
- Patient is discovered to have a 9 cm abdominal artery aneurysm. Preoperative medical evaluation reveals symptoms consistent with pulmonary hypertension, and this is confirmed by echocardiography with an estimate PASP of 74 mmHg. Urgent consultation with a cardiac anesthesiologist is obtained, and

TABLE 16.2 SUGGESTED PERIOPERATIVE MANAGEMENT STRATEGIES FOR PATIENTS WITH PULMONARY HYPERTENSION

Category	Characteristics[a]	Management strategy
Severe	NYHA III/IV mPAP > 55 PASP > 60, 6-min walk distance <150 m	*Elective surgery*: Defer. Strongly consider pulmonology or cardiology consultation *Urgent or emergency surgery*: Obtain urgent cardiac anesthesiologist and pulmonology or cardiology consultation. If risk is excessive or not within the patient's goals of care, consider palliative care or more limited procedure
Moderate	NYHA II mPAP 41–55 PASP 45–59	*Elective surgery*: *If etiology is unknown*, consider workup prior to surgery. Goal is to identify etiology and determine whether treatment of pulmonary hypertension and/or underlying disease state is indicated *If etiology is known*, consider whether pulmonary hypertension is expected to improve or whether other management will be undertaken prior to surgery *Urgent or emergency surgery*: Consider cardiac anesthesiologist consultation depending on the assessment of the patient's severity and type of surgery
Mild	NYHA I mPAP 26–40 PASP <45	Proceed with surgery in most cases If etiology is unknown, it would still be reasonable to complete workup prior to purely elective surgery

[a]There are no strict definitions of mild, moderate, or severe pulmonary hypertension—these characteristics are guidelines only

the patient is admitted to the ICU where she receives pulmonary artery catheterization and trials of vasodilatory agents, including oxygen, nitroglycerin, and inhaled nitric oxide. Pulmonary hypertension improves to an mPAP of 35 on nitroglycerin drip and she is taken to the operating room with a plan to continue this through the perioperative period [6].

- Anticoagulation: Many patients with PAH or PH due to chronic thromboembolic disease are managed with anticoagulation. In most cases, bridging therapy with heparin is not indicated, but it is best to consult with the patient's pulmonologist or cardiologist (See Chap 23).
- Medication management: If a patient is being treated with prostacyclins or vasodilators, it is crucial to work with the anesthesiologist and the patient's pulmonologist or cardiologist. In many cases the patient's baseline therapy is continued and vasodilators are used in addition as needed.
- Infections: Preoperative immunization against influenza and pneumococcus is recommended for patients with pulmonary hypertension.
- Intraoperative planning: This is generally left to the surgeon and anesthesiologist.
- Considerations:
  - Open rather than laparoscopic surgery may be preferred as carbon dioxide insufflation causes acidemia and increased pulmonary/systemic hypertension.
  - Consider reducing the length of the procedure to keep anesthesia time <3 h and/or splitting a high-risk procedure into multiple lower risk procedures if possible.

POSTOPERATIVE MANAGEMENT

- Patients with severe pulmonary hypertension are likely to require postoperative management in an ICU setting. Consider specialized consultation.
- Discuss the intraoperative course with anesthesia. In one study, intraoperative vasopressor use was associated with increased morbidity and mortality [6].
- Pay close attention to volume status and symptoms and signs of RV failure and respiratory failure [6, 7]. Patients coming from the operating room may have received significant volumes of intravenous fluid and may require diuresis to optimize hemodynamics.
- If indicated, reinitiate anticoagulation when bleeding risk is acceptable. In most cases patients do not require bridging therapy with heparin, but should have standard VTE prophylaxis until INR is therapeutic or the patient is ambulatory.

- If the patient is on prostacyclins or vasodilators, in most cases these are continued postoperatively at their baseline doses. Specific questions with regard to these medications should be directed to the consulting cardiologist or pulmonologist.

DISCUSSION

- Pulmonary hypertension and severe mitral stenosis (which can lead to pulmonary hypertension) are two of the most challenging conditions for cardiac anesthesiologists to manage. The primary complication is acute right ventricular failure, which results in a downward spiral of intrapulmonary shunting, decreased oxygenation, acidosis, and increased pulmonary pressures. Other complications include persistent postoperative hypoxia, coronary ischemia, and higher mortality rate.
- Right heart failure following cardiac surgery is a well-known risk and such patients undergoing cardiac surgery are screened for pulmonary hypertension. The management of patients undergoing cardiac surgery is beyond the scope of this chapter.
- Select subsets of patients with pulmonary hypertension seem to have greatly elevated surgical risk. Pregnant patients with pulmonary hypertension and Eisenmenger's syndrome undergoing C-section have perioperative mortality of up to 50% [8]. Cirrhotic patients with portopulmonary hypertension undergoing liver transplantation have a 35% mortality rate, and mortality increases to 100% for patients with PAP >50 mmHg [9, 10].
- In a variety of other studies examining outcomes following noncardiac surgery, pulmonary hypertension clearly seems to increase the risk for perioperative mortality and morbidity, especially heart failure:
  - One study ($N = 62$) found that patients with severe pulmonary hypertension (RVSP >70 mmHg by echo) experienced increased mortality (9.7% vs. 0%) and major adverse events (24% vs. 3%) compared to controls. Major adverse events included heart failure, prolonged intubation, stroke, myocardial ischemia/infarction, or major arrhythmia. Predictors of mortality included emergent surgery, CAD, and higher PASP [11].

- A retrospective study ($N = 145$) of patients with PH (mean RVSP 68 mmHg) who underwent noncardiac surgery, excluding PH secondary to left-sided heart disease, showed a 30-day mortality of 7%, primarily due to respiratory failure and/or right ventricular failure. Preoperative RVSP/SBP ratio >0.66, right axis deviation on ECG, and RVH on echo were associated with increased risk of early mortality. Morbidity was 42%; predictors of morbidity included NYHA class II or higher, history of PE, intermediate/high-risk surgery, and anesthesia time >3 h. Finally, intermediate/high-risk surgery increased the risk of morbidity by 2.5× compared to low-risk surgery (62% for thoracic surgery, 48% for orthopedic surgery, 17% for gynecologic/urologic/plastic/dermatologic/breast surgery) [6].
- In a single-institution retrospective case–control study of patients with pulmonary hypertension (defined by mPAP >25 by right heart cath) undergoing noncardiac surgery ($n = 173$), 26% of patients with pulmonary hypertension experienced perioperative morbidity or mortality, compared to 3% of controls. Patients with pulmonary hypertension were more likely to develop heart failure, hemodynamic instability, sepsis, or respiratory failure, and had longer ICU and hospital stays. In multivariate analysis, the existence of pulmonary hypertension was an independent predictor of postoperative morbidity [12].
- A large database cohort (~3,300 patients with pulmonary hypertension matched with ~9,900 controls) showed that patients with primary pulmonary hypertension undergoing total hip replacement had a 5% mortality rate, and 2% for total knee replacement. The presence of pulmonary hypertension of either type (PAH or PH under current classification) conferred increased mortality and length of stay compared to matched controls. This study used ICD-9 codes to identify pulmonary hypertension and did not assess the severity of pulmonary hypertension [13].

- Guidelines:
  - There are no published guidelines endorsing a pulmonary artery pressure above which surgery is contraindicated.
  - There are no recommendations concerning pulmonary hypertension in the ACC/AHA guidelines for perioperative risk assessment for noncardiac surgery [14].
  - A recent consensus statement on pulmonary hypertension discusses only cardiac surgery [2].

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Chapter 17
Venous Thromboembolic Disease

Reena Julka and Christopher J. Wong

The risk of new or recurrent Venous Thromboembolism (VTE) versus the risk of perioperative bleeding while on anticoagulation should *always* be discussed with the surgeon.

PREOPERATIVE EVALUATION

ASSESSMENT: PATIENTS NOT CURRENTLY RECEIVING ANTICOAGULATION FOR VTE

- Risk factors: Previous VTE, malignancy, hereditary thrombophilias, and pregnancy.
- Meds: Hormone replacement therapy or oral contraceptives should be stopped if possible (see Chap. 4, Perioperative Medication Management).
- Exam: Assess for signs or symptoms of VTE.
- Imaging: There are no data to support screening imaging studies prior to surgery.
- Surgery type: Certain procedures confer greater VTE risk.

ASSESSMENT: PATIENTS RECEIVING ANTICOAGULATION FOR VTE

- There are different recommendations available regarding the perioperative management of patients with a prior VTE who are receiving anticoagulation. 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 not be performed within the first month following a VTE, and should be discouraged within the first 3 months. Patients may also have increased risk if they additionally have a hypercoagulable state. There is practice variation regarding the use of IV heparin or therapeutic-dose

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low-molecular-weight heparin (LMWH) for bridging. IV heparin has the advantage of reversibility, and remains a useful postoperative option. Its disadvantage, especially preop, is that it requires administration in the hospital. All decisions must be individualized for a patient's particular risk of both VTE and surgical bleeding (Table 17.1) [1–4].

- Bridging protocols: There are various bridging protocols in use.
  - IV heparin: For preoperative use, stop warfarin 5 days prior to the procedure (holding five doses). Start IV heparin when the INR falls below the patient's target dose range (usually 3 days prior to the procedure, but varies depending on the patient and the baseline warfarin dose). Stop heparin infusion 4–6 h prior to surgery. After surgery, check with surgeon for when bleeding risk is acceptable and consider giving without an initial bolus.
  - LMWH: For preoperative use, stop warfarin 5 days prior to the procedure (holding five doses). Start LMWH when the INR falls below the patient's target dose range (usually 3 days prior to the procedure, but varies depending on the patient and the baseline warfarin dose). Last dose is usually given in AM the day prior to surgery (i.e., >24 h prior). For patients who receive once-daily bridging, e.g., enoxaparin 1.5 mg/kg once daily or dalteparin 200 U/kg once daily, it is recommended to give ½ the dose in the morning on the day prior to surgery. For patients who receive twice-daily dosing, e.g., enoxaparin 1 mg/kg twice daily or dalteparin 100 U/kg twice daily, it is recommended to give the last dose in the morning on the day prior to surgery. After surgery, LMWH may be restarted when surgical bleeding risk is acceptable, usually at least 48–72 h post-op. (A 24-h interval may be acceptable for low-bleeding-risk surgery per ACCP guideline.) IV heparin may be used post-op when rapid reversibility of anticoagulation may be needed. As always, discussion with the surgical team is essential. Until therapeutic-dose anticoagulation has been resumed, prophylactic-dose pharmacologic VTE prophylaxis should be given if the bleeding risk is acceptable.
  - LMWH should be avoided in patients with a CrCl <30. Work with the patient's pharmacist or use IV heparin if bridging therapy is indicated.
  - The timing of warfarin re-initiation depends on the assessment of bleeding risk. ACCP guidelines recommend resuming warfarin approximately 12–24 h after surgery if there is adequate hemostasis [4].

TABLE 17.1 MANAGEMENT OF PATIENTS WITH PRIOR VTE IN THE PERIOPERATIVE PERIOD [1–4]

Time of VTE prior to surgery	Risk of recurrent VTE after stopping anticoagulation	Management	
		Preop	Post-op
Within 1 month	Approaches 50 % if stopped prior to 1 month	**Avoid surgery if possible** Bridge with IV heparin or LMWH Consider IVC filter	Bridge with IV heparin or LMWH
1–3 months prior	Risk decreases sharply after 1 month At 1 month about 8 % At 3 months about 4 %	Avoid surgery if possible Consider bridge therapy with IV heparin or LMWH	Bridge with IV heparin or LMWH
>3 months prior	3 months of anticoagulation is a reasonable amount of time prior to surgery	No bridging unless severe hypercoagulable state is present Most patients will have completed VTE therapy after 3 months—if they are still receiving anticoagulation there is usually an additional risk factor or indication	Prophylaxis-dose LDUH or LMWH until on therapeutic anticoagulation Consider bridging with IV heparin or therapeutic-dose LMWH if severe hypercoagulable state

LDUH low-dose unfractionated heparin, *LMWH* low-molecular-weight heparin
Notes: If a patient is hospitalized and not receiving bridge therapy, then prophylaxis-dose LDUH or LMWH should be given
Patients with a creatinine clearance <30 mL/min should not receive LMWH for bridge therapy but instead should receive IV unfractionated heparin

VI

- IVC filters: Exist only to prevent PE. Anticoagulation is still indicated once surgical bleeding risk is low enough. Possible indications for IVC filters are the following:
  - Acute proximal DVT with an absolute contraindication to therapeutic anticoagulation due to bleeding [5].

- Acute VTE within 2 weeks of surgery AND high risk of bleeding while on IV heparin [1, 6].
- Large PE and poor baseline cardiopulmonary reserve such that another embolic event would be poorly tolerated (even if able to be anticoagulated) [7].

- *Potentially retrievable* IVC filters: May be considered when the contraindication to anticoagulation is likely to be temporary, e.g., <2 weeks. Ability to remove a filter decreases with time—retrieval should generally occur by 3 months [8, 9]. A time course for possible retrieval should always be discussed with the proceduralist.

POSTOPERATIVE MANAGEMENT

The main concerns for postoperative 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 recommendations are shown in Table 17.2.

NOTES ON PROPHYLAXIS

- The suggested types of prophylaxis in Table 17.2 for each type of surgery are based on the 2012 American College of Chest Physicians (ACCP) guidelines [10, 11]. Note that the ACCP guidelines do not make specific dose recommendations for all methods of pharmacologic prophylaxis. Specific dosing recommendations (e.g., for LMWH) are further derived from the University of Washington Department of Pharmacy Anticoagulation Services web site [3]. Be aware that decisions regarding timing and method of prophylaxis are usually at the discretion of the surgeon with consideration to the risk of surgical bleeding. For further dose-related questions, one should discuss with a clinical pharmacist.
- The current ACCP guidelines stratify the risk of VTE in patients undergoing abdominal/pelvic surgery using the Rogers score or the Caprini score. In general, the new guidelines favor individualized assessment taking into account both patient risks and surgical risks of VTE [11]. There are many patient-specific risks for VTE; in addition to known hypercoagulable states, important patient risks for VTE include postoperative complications resulting in a longer hospital course, advanced age, and malignancy.

TABLE 17.2 RECOMMENDED VTE PROPHYLAXIS [3, 10, 11]

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 q 12 h or dalteparin 5,000 U SC once daily) Start ≥12 h preop, and give the first post-op dose after ≥12 h post surgery Treatment duration: Minimum 10–14 days	LDUH, fondaparinux, warfarin, aspirin, IPC Treatment duration: minimum 10–14 days	Treated duration recommended to extend for up to 35 days ACCP guidelines "suggest" LMWH in preference to the other options. With the exception of fondaparinux, the 2nd-line options listed may not be as effective Use of aspirin alone remains controversial Consider IPC in addition to pharmacologic while hospitalized If increased bleeding risk: IPC or no prophylaxis Newer anticoagulants (THA, TKA only): See text
Knee arthroscopy	No prophylaxis		

LDUH Low-dose unfractionated heparin, dosing usually 5,000 U SC Q8H or Q12H
LMWH Low-molecular-weight heparin, suggested dosing listed in the above Table
IPC Intermittent pneumatic compression
Warfarin is dose adjusted to an INR 2–3

(continued)

TABLE 17.2 (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)	LMWH, LDUH +/– ES/IPC Extend duration if abd/pelvic cancer surgery	IPC	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 If cannot use LMWH or LDUH, and not at high risk of bleeding, can use low-dose aspirin (160 mg), fondaparinux, or IPC

Bariatric	LMWH high-dose prophylaxis (e.g., enoxaparin 40 mg SC q 12 h for BMI > 40) +/– IPC	LDUH +/– IPC	Consult with clinical pharmacist for weight-based dosing. Consider higher doses of LDUH if this option is chosen
Cardiac surgery	IPC		If prolonged hospital course due to non-hemorrhagic complications: Add LDUH or LMWH
Thoracic surgery	Moderate risk of VTE: LDUH, LMWH Can add ES/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

LMWH Low-molecular-weight heparin, e.g., enoxaparin 40 mg SC once daily unless otherwise noted, dalteparin 5,000 U SC once daily
LDUH Low-dose unfractionated heparin, typically 5,000 U Q8H or Q12H
IPC Intermittent pneumatic compression
ES Elastic stockings, recommended 18–23 mmHg at the ankle [11]

- *Aspirin*: The American Academy of Orthopedic Surgeons guidelines allow for the use of aspirin 325 mg BID as prophylaxis [12]. The ACCP guidelines now accept this as an option for orthopedic surgery, although there is still controversy regarding its use [10].
- For orthopedic surgery, the fondaparinux, rivaroxaban, and warfarin options may have increased bleeding risk compared to the other methods [10].
- *Neuraxial anesthesia*: The use of neuraxial anesthesia may complicate the use of LMWH and warfarin [3]. Generally use LDUH instead.
- *Body weight*: Dose adjustment of LMWH is often needed in the very obese (e.g., the bariatric surgery patient) and those with very low body weight.
- *Chronic kidney disease*: For VTE prophylaxis, dalteparin does not typically need dose adjustment. However, other LMWH such as enoxaparin may need dose adjustment or additional monitoring with factor Xa levels.
- *Vascular surgery*: Unless other risk factors are present, no pharmacologic prophylaxis is recommended. Most patients receive either heparin or antiplatelet agents.
- *Burns*: If there are additional risk factors (advanced age, morbid obesity, extensive or lower extremity burns, lower extremity trauma, femoral venous catheter, prolonged immobility) then use LMWH or LDUH when surgically acceptable.
- *New oral anticoagulants*: Dabigatran, a direct IIa (thrombin) inhibitor, has been approved in the USA for stroke prevention in atrial fibrillation. It has also been studied for VTE prophylaxis in patients undergoing hip and knee arthroplasty and for treatment of acute VTE, demonstrating efficacy comparable to enoxaparin and warfarin, respectively; however it has not been yet approved in the USA for these indications. Rivaroxaban, a direct Xa inhibitor, has been approved in the USA for VTE prophylaxis in those undergoing knee or hip arthroplasty. Both dabigatran and rivaroxaban are renally metabolized and may need dose reduction in those with at least moderate renal impairment. Apixaban, another direct Xa inhibitor, has been approved in Europe for VTE prophylaxis following knee and hip arthroplasty but is still undergoing further study in the USA [13]. According to the ACCP guidelines, newer anticoagulants may be considered for patients who decline injections. However, the long-term safety is unknown, and only rivaroxaban currently has FDA approval for VTE prophylaxis.

TABLE 17.3 DIAGNOSTIC TESTING FOR SUSPECTED POSTOPERATIVE VTE

Test	Notes
Chest CT, PE protocol	Requires 18 gauge antecubital IV, Power PICC™, or Power Port™ to deliver an adequately timed contrast bolus for the study to be properly interpreted Uses IV contrast—caution in patients with kidney disease
V/Q scan	Consider if contraindication to CT 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 single negative lower extremity duplex does not rule out PE
D-dimer	Not used—generally not useful in post-op patients, who may have elevated values due to other reasons, and in whom low values would not preclude further evaluation for VTE

PATIENTS WITH PRIOR VTE RECEIVING ANTICOAGULATION

Resume anticoagulation as described in Table 17.1, with close consultation with the patient's surgeon with regard to timing and bleeding risk.

POSTOPERATIVE VTE

Despite best efforts, postoperative VTE still occurs. Patients may present with acute hypoxia, dyspnea, tachycardia, and limb edema. Keep in mind that patients in the postoperative state may have other explanations for symptoms of VTE, so 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 17.3.

Immediate Management

- Immediate management consists of stabilization of the patient. Severity of the VTE and risk of bleeding must be assessed. Treat with therapeutic-dose anticoagulation as soon as possible. *Must* discuss bleeding risk with surgery team. If anticoagulation is not an option due to bleeding risk, then an IVC filter may be considered. In some cases, anticoagulation may be started but there is still considerable risk of bleeding—IV heparin may be favored due to its shorter half-life and reversibility. For low risk of bleeding, LMWH is often acceptable (Table 17.4).

TABLE 17.4 STRATEGIES FOR MANAGEMENT OF POSTOPERATIVE VTE

Bleeding risk	Management of DVT/PE
Anticoagulation unacceptable	IVC filter until able to anticoagulate Consider potentially retrievable IVC filter Give prophylactic-dose LDUH or LMWH if possible
Anticoagulation acceptable, but high risk	IV heparin. Consider using "no-bolus" protocol
Anticoagulation acceptable, low risk	IV heparin or LMWH (therapeutic dose) Begin warfarin

- IV heparin and LMWH have been found to be equal in efficacy for VTE. A systematic review found that LMWH had a significant reduction in thrombotic complications, hemorrhage, and mortality compared to UFH in patients with DVT [14]. However, IV heparin is advantageous postoperatively because of its short half-life and is reversible.
- Thrombolytics are indicated for massive PE (SBP <90) [15]. Contraindications include intracranial neoplasm, history of intracranial hemorrhage/hemorrhagic stroke, and internal bleeding within 6 months. Due to bleeding risk, this option must *always* be discussed with the surgeon.
- Catheter embolectomy is an option in centers with appropriate expertise for patients with massive PE [5, 15].
- Upper extremity and catheter-associated DVT: Current recommendations favor treating with LMWH, IV heparin, or fondaparinux [16]. In the postoperative setting, choice of anticoagulant must consider bleeding risk and reversibility.

Subacute and Long-Term Management

- For acute VTE, administer IV heparin/LMWH for at least 5 days total and until the INR is ≥2.0 for at least 24 h (i.e., usually need to give additional heparin after the first INR is in target range).
- If using dalteparin as a LMWH agent, dosing is typically 200 U/kg SC daily. Discuss with a clinical pharmacist for dose adjustments that may need to be made for CrCl < 30, weight >98 kg, and pregnancy. Enoxaparin dosing is typically 1 mg/kg SC BID and similar dose adjustments may be necessary, particularly for CrCl <30.

- Consider LWMH alone if VTE is in association with malignancy [17]. However, cost is a concern.
- Duration of therapy for VTE is 3 months if there was a reversible, transient risk factor (e.g., recent surgery, immobilization) [16].
- Duration of therapy is at least 3 months for unprovoked VTE. After 3 months, risk–benefit of further anticoagulation should be assessed. For a proximal DVT with low bleeding risk and close monitoring while on anticoagulation, long-term therapy is recommended. For a second unprovoked VTE, long-term therapy is also recommended [4, 16].
- Use compression stockings for DVT to reduce the risk of post-thrombotic syndrome.

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PART VII
Renal

Chapter 18
Chronic Kidney Disease

Reena Julka and Ashok Reddy

Chronic kidney disease (CKD) affects 5% of the general population [1]. In the United States, hemodialysis-dependent end-stage renal disease has increased by 20% since 2000 [2]. In a systematic review and meta-analysis, CKD was an independent risk factor for postoperative mortality and cardiac events—with a similar strength of association as diabetes, stroke, and coronary disease [1]. However, patients with CKD can safely undergo surgery with appropriate medical management.

PREOPERATIVE EVALUATION

In the preoperative setting, it is important to document the history of existing renal disease, severity (e.g., chronic kidney disease stage), history of transplant, and etiology of disease. Information including baseline creatinine and any major problems in the past (e.g., renal failure during an admission for sepsis) is vital. Preoperative measurement of the serum creatinine and electrolytes is appropriate for all these patients.

CKD affects renal drug elimination, drug absorption, drug distribution, and non-renal clearance [3]. The normal creatinine clearance (CrCl) is generally >100 mL/min. Patients need adjustments to most commonly used medications when the CrCl falls below 50 mL/min. Glomerular filtration rate and/or CrCl is estimated using the Modification of Diet in Renal Disease (MDRD) study or using Cockcroft–Gault equation. These estimates are less accurate in certain circumstances including when patients have more or less muscle mass [4]. Also these estimates assume that the patient is at a steady state—thus in patients with rapidly rising creatinine the calculations overestimate the patient's renal function [4].

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The major morbidity and mortality in patients with end-stage renal disease (ESRD) is cardiovascular disease- the largest single cause being fatal arrhythmias [2]. It is estimated that left ventricular hypertrophy is as high as 30% in patients with CKD not yet on dialysis. Additionally the incidence of pulmonary hypertension in patients with ESRD may be as high as 40% [2]. These comorbid conditions lead to the importance of a thorough preoperative cardiovascular and pulmonary risk assessment. Care for patients with hemodialysis-dependent ESRD or history of renal transplant should be coordinated with a nephrologist.

COMMON MANAGEMENT ISSUES

Hemodialysis

It is preferred that hemodialysis (HD) is carried out on the day before surgery to minimize any risks from anticoagulation and from unresolved fluid or electrolyte shifts [2]. Informing inpatient nephrology teams about HD patients on the day of surgery can be useful if there are major issues with fluid or potassium control in the postoperative setting.

In the preoperative setting, history of vascular access (right or left arm, history of clotting, or history of stenosis) can provide useful information to staff and clinicians involved in the patient's care. In general, HD catheters should not be used for purposes other than dialysis. Documenting a patient's usual dialysis days and length of time is helpful information in coordinating hemodialysis care.

Fluid and Electrolyte

Recording the "dry weight" prior to surgery is helpful in managing the patient's volume status. Patients who are above their dry weight are at risk of pulmonary edema and poorly controlled HTN while those who are under their dry weight are at risk of hypotension in the postoperative setting. Common electrolyte disturbances include hyperkalemia and metabolic acidosis. In general, these should be monitored and treated in the pre- and postoperative setting to reduce the risk of ventricular arrhythmia.

Medications

Reviewing the medication list looking for drugs that may impair renal function or which require dose adjustment according to the patient's estimated CrCl is important.

- Useful resources include Micromedex®, e-books, and textbooks such as the ACP guide for renal dosing [5], and pharmacists are essential resources for dose adjustment recommendations depending on the medication and the patient's estimated CrCl.

- Certain antibiotics (vancomycin, aminoglycosides, etc.) not only need dose adjustment but also close monitoring in the inpatient setting.
- Avoid nonsteroidal anti-inflammatory agents (NSAIDs) if possible.
- 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 is impaired by renal insufficiency—use with caution in patients with CKD (dose adjustments are available but close monitoring of anti-factor Xa is recommended).
- Use caution reinstituting ACE inhibitors and ARBs—monitoring renal function and electrolytes closely in the postoperative period.

Anemia

Loss of erythropoietin production as renal function declines often leads to significant anemia. Typically, nephrologists use erythropoietin-stimulating agents (ESAs) and supplemental iron (PO/IV) to target a hematocrit of ~33% [6]. In the preoperative period discussion with nephrology can be helpful in optimizing anemia prior to surgery with the knowledge that benefit of ESAs and supplemental iron takes a number of weeks to achieve.

POSTOPERATIVE MANAGEMENT

Postoperative management includes diligent medication monitoring as described above. Dose adjustments in antibiotics are often required, as is avoidance of NSAIDs. Adequate volume resuscitation after major surgeries is essential. Resumption of chronic ACE-I or ARB medications should be started with care once renal function is established to be stable post-op. Many patients require diuretics chronically to maintain their volume status, and typically need diuretics resumed post-op provided they are not volume depleted.

For patients who receive hemodialysis, care is best managed in consultation with a nephrologist. Patients may require additional dialysis or ultrafiltration depending on the volume load received intraoperatively and the patient's clinical stability.

BLEEDING

Patients with CKD and ESRD are at risk of uremia which can cause platelet dysfunction resulting in increased perioperative bleeding [3]. This can be reduced by adequate hemodialysis. If excessive bleeding continues there are additional strategies that may be helpful, including stopping all medications that may inhibit platelet function including aspirin. Discussion with a nephrologist or a hematologist is often helpful with regard to the use of desmopressin, cryoprecipitate, or transfusion.

CONTRAST PROCEDURES

Patient with CKD may need evaluation requiring contrast media. First, consider the necessity of the procedure and any alternatives (ultrasound, non-contrast CT scan, or MRI without gadolinium). If the test is required, consider pre-hydration and the use of *N*-acetylcysteine prior to contrast procedure [7]. Note however that there is practice variation with regard to radiology protocols, and more recent studies have not found benefit with the use of *N*-acetylcysteine [8].

- If the patient can tolerate volume expansion with sodium bicarbonate, consider treatment before and after contrast studies. The patient should receive a bolus of 3 mg/kg of isotonic bicarbonate for 1 h prior to the procedure and continued at a rate of 1 mL/kg/h for 6 h after the procedure.
- *N*-Acetylcysteine, at a dose of 1,200 mg orally twice daily, can be administered the day before and on the day of the procedure. (Note: Protocols vary between 600 and 1,200 mg twice daily.)

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Chapter 19
Acute Kidney Injury

Reena Julka and Ashok Reddy

Acute kidney injury (AKI) remains a significant concern in the perioperative period. The incidence of postoperative AKI has been found to be approximately 1 % in noncardiac surgical patients [1, 2]. In those admitted to the ICU after noncardiac surgery, the AKI rate has been shown to be 7.5 % [3]. Some studies indicate higher rates [3, 4], and reports may vary according to the definition of AKI which has evolved over recent years. AKI is associated with significant morbidity and mortality in hospitalized patients. It has further been associated with increased 30-day, 60-day, and 1-year all-cause mortality [1].

PREOPERATIVE EVALUATION

Patients should undergo risk assessment to include assessment of baseline renal function, and identification of those patients with chronic kidney disease (see Chap. 18).

RISK PREDICTORS

- A large retrospective study identified seven independent preoperative predictors of postoperative renal dysfunction (defined as a Cr Cl <50 ml/min) [1]. They were age, emergent surgery, liver disease, body mass index, high-risk surgery, peripheral vascular occlusive disease, and chronic obstructive pulmonary disease necessitating chronic bronchodilator therapy. Several intraoperative management variables were independent predictors of acute renal failure: total vasopressor dose administered, use of a vasopressor infusion, and diuretic administration.
- In evaluating patients with postoperative acute kidney injury (AKI) admitted to the ICU, similar risk factors were found, but ischemic and congestive heart disease, an elevated Revised

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Cardiac Risk Index score, and American Society for Anesthesiologists (ASA) physical status were identified as additional predictors [3].

- A specific risk index for AKI after general surgery has subsequently been developed. The significant independent risk factors that were identified were age 56 or older, male gender, active congestive heart failure, ascites, hypertension, emergency surgery, intraperitoneal surgery, mild or moderate renal insufficiency (defined as preoperative creatinine between 1.2 and 1.9 or >2), and diabetes on oral or insulin therapy. Compared with 0–2 risk factors, having 3, 4, 5, 6, or more risk factors conferred a hazard ratio of AKI by 3.1, 8.5, 15.4, and 46.2, respectively [2].

POSTOPERATIVE MANAGEMENT

As with all patients, efforts should be made to minimize the risk of developing AKI.

DEFINITION

- The Risk-Injury-Failure-Loss-End (RIFLE)-stage kidney disease and Acute Kidney Injury Network (AKIN) classifications were developed to provide a consensus definition and to aid in early detection and grading of severity of AKI.
- Early severity kidney injury is defined as urine output <0.5 ml/kg/h for >6 h. Further, the RIFLE criteria include a GFR decrease >25 % or a 50 % increase in serum creatinine above baseline within a 7-day window. Meanwhile, the AKIN criteria additionally specify an increase in creatinine of 0.3 mg/dl within 48 h to reflect that small changes within the "normal range" can actually be significant [4, 5].

APPROACH TO POST-OP AKI

Consider the following differential diagnoses:

Prerenal Causes

- Most patients having procedures third space considerable quantities of fluid at their surgical site. As a result they are typically intravascularly volume depleted. Significant output from NG tubes or diarrhea may also exacerbate the situation. When a patient appears to be acutely volume deficient a check of the

hematocrit is reasonable as bleeding is also a common cause of acute hypovolemia and one that deserves acute attention.

- Acute renovascular compromise or atherosclerotic emboli can occur, particularly with aortic surgery and some nephrectomies, but this should be obvious by the history, discussion with the team, and/or operative note. Pre-renal azotemia can occur with severe congestive heart failure (due to poor forward flow from the heart to the kidneys), but these patients are usually obvious by history, exam, or laboratory findings. In the appropriate patient population one should also consider pancreatitis, sepsis, abdominal compartment syndrome, and cirrhosis as pre-renal causes of AKI.

Renal Causes

- The most common renal cause for postoperative AKI is acute tubular necrosis (ATN). Patients with intra- or postoperative hypotension are at the highest risk and a review of the anesthesia record and postoperative vital signs can be very helpful in these circumstances.
- As with other forms of trauma, creatinine kinase levels will rise after surgery; specifically, obese patients and those with long procedures are at risk for rhabdomyolysis. A check of serum CK or urine myoglobin is reasonable. Acute interstitial nephritis (AIN) can occur, with one potential cause being perioperative medications such as antibiotics. Urine sediment may show white blood cells, red blood cells, white cell casts, and eosinophiluria. Intravenous contrast administered during radiology procedures may exacerbate renal insufficiency.

Postrenal Causes

- When patients with acute renal insufficiency are post-op from abdominal procedures it is reasonable to check an ultrasound to assess that they do not have unilateral or bilateral hydronephrosis due to some unexpected consequence of their surgery.
- Kidney stones may also form acutely, and these can also be identified (or at least the obstruction noted) by ultrasound.
- If bladder outlet obstruction is suspected, a bladder scan (or single I/O cath) can help eliminate this concern immediately (although it should be noted that bladder scans are difficult to interpret in patients with ascites). For patients with an indwelling catheter and an indeterminate bladder scan, consider flushing the catheter once to assure that it is not obstructed.

EVALUATION

- Patients need a thorough review of their records with attention to vital signs, input/output, weights, medications, and recent studies. Findings on physical exam of tachycardia, a low JVP, poor skin turgor, dry mucous membranes, and minimal amounts of concentrated urine suggest volume depletion. In difficult cases when patients are not responding as expected to fluid challenges, measurement of central venous pressure with a central venous catheter can be helpful.
- A marked increase in clear output from pelvic or abdominal drains should raise concerns for urinary leaks or fistula formations. A spot fluid creatinine performed on the drain output will settle the question quickly. Drain output usually has a creatinine value that is near serum levels. When a drain is contaminated by urine the creatinine in the fluid is usually markedly elevated (10- to 100-fold).
- Placement of a Foley catheter may be appropriate in some circumstances to monitor urine output closely and to assess for distal obstruction. Renal ultrasound may be used when indicated to assess for proximal urinary tract obstruction and extra-vesicular fluid collections.
- Laboratory studies should include a basic metabolic panel, complete blood count, and full urinalysis with examination of sediment, along with a urinary Na, creatinine, and osmolality. High urinary specific gravity/osmolarity, a low urinary sodium, and <1 % fractional excretion of sodium (FENa) support the diagnosis of prerenal azotemia (see below). The changes of ATN are typified by muddy brown granular and epithelial cell casts. The presence of significant number of red cells may indicate a stone or a ureteral trauma. Excessive number of eosinophils can indicate interstitial nephritis. Urine myoglobin and/or blood without RBCs in urinalysis can suggest rhabdomyolysis (Table 19.1).

MANAGEMENT

- Because hypovolemia is the most common cause of postoperative renal insufficiency, treatment should generally start with a vigorous fluid resuscitation. Classically lactated ringers or normal saline are used for resuscitation. However, caution should be used with massive infusions of normal saline as it can precipitate hyperchloremic metabolic acidosis. Routine use of diuretics in the immediate postoperative period is generally contraindicated. If there is any doubt about the patient's

TABLE 19.1 URINE CHARACTERISTICS IN THE WORKUP OF ACUTE KIDNEY INJURY

Urine findings	Pre-renal	Renal
Urinary sediment	None or hyaline casts	Muddy brown casts, eosinophils
Specific gravity	>1.020	<1.010
Osmolality	>500	<350
Sodium	<20	>40
Fractional excretion of sodium	<1	>1

Fractional excretion of sodium: $$\text{FENa, percent} = \frac{\text{UNa} \times \text{PCr}}{\text{PNa} \times \text{UCr}} \times 100,$$

where U = urine, P = plasma, Na = sodium, Cr = creatinine

intravascular volume status, measurement of the central venous pressure may be helpful.

- If the patient's renal function does not improve once it is determined that the patient is volume replete, then a search for an alternate diagnosis should be started. If the patient maintains reasonable urine output, then fluids can be continued at a maintenance rate. If urine output falls off, some attempt at maintaining urine output with IV furosemide may be worth considering. If there is any concern for an obstructive process (e.g., recent abdominal or pelvic surgery) an ultrasound should be performed immediately. Any medications that could be adversely affecting renal function should be discontinued if possible and all other medications should be adjusted for the patient's current level of renal function (See Chap. 18 for management details). Nephrology consultation is usually advisable.

DISCUSSION

- Although risk factors have been identified for development of post-op AKI, there has been a lack of reliable evidence behind pharmacologic strategies during surgery to prevent AKI [6]. A meta-analysis has not shown *n*-acetylcysteine to prevent AKI after major surgery [7]. However, recent literature suggests that

statin use preoperatively is associated with lower odds of AKI, acute dialysis, and mortality [8].

- While some of the causes of AKI are similar to those of medical patients, it is important to remember the causes of AKI that are specific to surgery. Patients undergoing cardiac surgery with the use of cardiopulmonary bypass have a high occurrence of AKI, ranging around 20–30 %. The etiology is felt to be multifactorial, including reduced renal perfusion pressure, activation of proinflammatory agents, and possibly direct nephrotoxicity [5]. Similar etiologies have been identified for postoperative AKI in noncardiac surgery including prerenal/hemodynamic factors and a surgery-related inflammatory response with activation of cytokines and leukocyte infiltration [4]. Other possible contributors are exposure to renally toxic agents (contrast, myoglobin, anti-inflammatories, aminoglycosides), surgical trauma (e.g., cross clamping of the aorta), and surgical complications (ligation of a ureter).

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PART VIII
Gastroenterology

Chapter 20
Liver Disease and Perioperative Risk

Kara J. Mitchell

Cirrhosis is a major risk factor for perioperative complications due to a number of physiologic changes:

- Baseline increased cardiac index and decreased systemic vascular resistance, augmented by anesthetics and blood loss.
- Poor hepatic metabolism of anesthetic agents and other medications administered perioperatively.
- Bleeding risk from impaired synthesis of thrombopoietin and clotting factors, and splenic platelet sequestration.
- Pulmonary risk from ascites or pleural effusions (restriction); pulmonary 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 steatohepatitis, etc.) generally tolerate surgery well. The role of the medical consultant includes preoperative risk assessment, optimization of liver disease, and prevention and management of postoperative complications.

PREOPERATIVE EVALUATION

Asymptomatic patients: Preoperative assessment should include a careful history and physical exploring for risk factors for or signs of liver disease: Alcohol use, blood transfusions, IV drug use, sexual history, jaundice, spider telangiectasias, palmar erythema, gynecomastia, testicular atrophy, splenomegaly, encephalopathy, ascites, and peripheral edema. Further workup should be performed based on history and exam findings. Checking serum AST, ALT, alkaline

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phosphatase, and bilirubin in asymptomatic patients without risk factors for liver disease leads to many positive tests in patients who are probably not at increased risk for surgery; this is controversial, but generally not recommended.

Patients with known 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.

RISK STRATIFICATION

Hepatitis: Acute viral hepatitis carried 10 % mortality and 11 % morbidity in one study of open liver biopsy [1,2]. Older studies of alcoholic hepatitis demonstrated 55–100 % mortality in patients undergoing 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 [3].

Cirrhosis: There are more data regarding patients with cirrhosis and perioperative risk. Scoring systems include the Child–Pugh classification and the Model for End-Stage Liver Disease (MELD) score.

The *Child–Pugh* classification of cirrhosis correlates well with operative morbidity and mortality in retrospective studies [4–6]. The score is calculated using INR, albumin, bilirubin, and the presence or absence of encephalopathy and/or ascites; calculators are widely available in textbooks and online. Table 20.1 shows approximate postoperative risk for Child–Pugh class A, B, and C.

Modified MELD score: Higher scores generally correlate with worse outcomes [5,6,8,9]. For patients with MELD >15, the finding of serum albumin <2.5 has been shown to correlate with worse outcomes [10].

TABLE 20.1 MORTALITY IN PATIENTS WITH CIRRHOSIS UNDERGOING ABDOMINAL SURGERY [2,7]

Class A	5–6 points	~10 % mortality
Class B	7–9 points	~30 % mortality
Class C	10–15 points	~75–80 % mortality

Calculators are widely available online to determine the MELD score. MELD = $3.78 \times \log_e$ (bilirubin in mg/dl) + $11.2 \times \log_e$ (INR) + $9.57 \times \log_e$ (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 20.2 [9].

Other risk factors for morbidity include ascites, encephalopathy, infection, anemia, malnutrition, jaundice, hypoalbuminemia, portal hypertension, prolonged PT (that does not correct with vitamin K), hypoxemia, and renal insufficiency [1].

SURGICAL RISK

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 vascular adhesions is required.
- Cardiac surgery: 100 % morbidity, 80 % mortality with Child B; 25 % morbidity, 0 % mortality with Child A, in one study [11].
- Hepatic resection.

PREOPERATIVE MANAGEMENT

Surgery is generally contraindicated with acute or fulminant hepatitis, alcoholic hepatitis, severe chronic hepatitis, Child class C cirrhosis, and/or severe complications of liver disease, such as coagulopathy, acute renal failure, hypoxic pulmonary disease, infection, etc. [1]. Surgery may be considered for patients with Child class A and B cirrhosis (and possibly a subset of patients with Child class C cirrhosis and MELD score <14) only after thorough evaluation by a Hepatologist and optimization of medical management. If applicable, consideration should be given to delaying elective surgery until after liver transplantation.

Consider making the following recommendations for all patients proceeding to surgery with compensated Child's class B disease:

- Delay surgery until after transplantation and/or suggest a less-invasive option: angioplasty in place of cardiac surgery, cholecystostomy in place of cholecystectomy, etc.
- Preoperative TIPS may reduce perioperative morbidity (decreased GI bleeding) for patients with severe portal hypertension [12].

TABLE 20.2 POSTOPERATIVE MORTALITY OF PATIENTS WITH CIRRHOSIS AS PREDICTED BY THE 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)	

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- Treat ascites with diuretics (if peripheral edema present), salt restriction, and/or paracentesis.
- Evaluate renal function preoperatively, recalling that calculated creatinine clearance may underestimate the degree of impairment.
- Correct coagulopathy with vitamin K and FFP and/or factor VIIA to normalize PT, ± cryoprecipitate, or DDAVP. FFP or factor VIIA, if given, should be given immediately before or during surgery due to short factor half-life and risk for volume overload.
- Keep extra cross-matched blood on hand, but note that transfusion may be associated with worsened outcomes [10].
- Consider transfusing platelets if severe thrombocytopenia is present; optimal goal platelet count is unknown.

POSTOPERATIVE MANAGEMENT

- Watch clinically (consider ICU) for exacerbation of liver disease postoperatively: ascites, jaundice, encephalopathy, etc.
- Monitor renal function (BUN, Cr, electrolytes) and hepatic synthetic function (albumin, PT/INR, 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.
- Manage encephalopathy in the usual fashion (lactulose, rifaximin, etc.), and consider potential causes such as GI bleeding, infection, medications, and the surgery itself.
- Use short-acting analgesics, such as fentanyl. Avoid benzodiazepines; if one must be used (i.e., to treat alcohol withdrawal), lorazepam is a preferred choice.
- Avoid hypercarbia, which may cause splanchnic vasodilation and decrease portal blood flow.
- Use beta-blockade (unless contraindicated) and avoid fluid overload in patients with gastroesophageal varices.
- Optimize perioperative nutritional support.
- Limit acetaminophen use to not more than 2 g/day.

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PART IX
Endocrine

Chapter 21
Perioperative Diabetes Management

Nason P. Hamlin

Optimal glycemic control in the perioperative period decreases the infection rate and other complications [1–6]. The goal is to prevent hyperglycemia, not just to react to it. The traditional practice of writing only for a "sliding scale" as well as the term "sliding scale" should be abandoned [7]. Good glycemic control requires you to be proactive, not just reactive. Think in terms of *basal*, *prandial* (mealtime), and *correction insulin* therapy. Although some concerns have been raised about "intensive" insulin therapy because of the risk of hypoglycemia, this does not negate the benefit of optimal glucose control, the definition of which includes minimizing hypoglycemia [8–12].

Note that the HbA1c level does not correlate well with operative outcomes and an elevated level should not be a reason to cancel surgery. (Note: The HbA1c may be inaccurate in hospitalized patients due to end-stage renal disease, erythropoietin, acute anemia, RBC transfusions, hemoglobinopathies, microhemolysis from heart valve replacement, increased RBC mass from testosterone therapy, etc.).

RECOMMENDATIONS FOR PERIOPERATIVE USE OF ANTIDIABETIC MEDICATION (FOR PROCEDURES THAT REQUIRE A RESTRICTED ORAL INTAKE)

PERIOPERATIVE MANAGEMENT OF NON-INSULIN THERAPIES IS SHOWN IN TABLE 21.1.

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TABLE 21.1 PERIOPERATIVE MANAGEMENT OF NON-INSULIN ANTIDIABETIC THERAPIES

Insulin secretagogues: Glyburide, glipizide, glimepiride (Amaryl®), repaglinide (Prandin®), nateglinide (Starlix®)	Do not take on the morning of surgery Restart post-op when patient resumes eating
Metformin (and combination drugs containing metformin)	Do not take on the morning of surgery Restart when patient is eating and renal function has been confirmed to be acceptable[a]
TZDs ("glitazones"): Rosiglitazone (Avandia®)[b], pioglitazone (Actos®)	Do not take on the morning of surgery Restart post-op once patient resumes eating
Other therapies: Incretins: Exenatide (Byetta®)[c], liraglutide (Victoza®) Dipeptidyl peptidase-4 inhibitors: Sitagliptin (Januvia®), saxagliptin (Onglyza®), linagliptin (Tradjenta®) Amylin analogs: Pramlintide (Symlin®)	Do not take on the morning of surgery Restart post-op once patient is eating and has no nausea

[a]Generally considered a serum creatinine of 1.5 for men and 1.4 for women, although creatinine clearance is a better measure of renal function. This is only necessary if the procedure is likely to cause renal dysfunction, in which case verify acceptable renal function 48 h after surgery, or IV contrast, before resuming metformin [13]
[b]Note Black Box warnings
[c]Note: There is not enough experience yet to give post-op recommendations for restarting the weekly form of exenatide (Bydureon®)

INSULIN

Understanding the terminology (see Table 21.2).

Preop

Patients need to continue BASAL insulin but withhold PRANDIAL insulin. Because basal insulin is frequently providing some prandial coverage (especially with NPH insulin), it is often necessary to reduce basal insulin by a percentage for NPO patients. Recommended preoperative adjustments are shown in Table 21.3.

TABLE 21.2 INSULIN TERMINOLOGY

BASAL insulin	Longer acting insulins, e.g., glargine (Lantus®), detemir (Levemir®), and NPH, which provide a constant supply of "background" insulin, regardless of meals. All patients with Type 1 diabetes *require* this and many with Type 2 diabetes *need* this, especially in the perioperative period
PRANDIAL (mealtime) insulin	The fixed dose (or altered dose for larger or smaller meals) of rapid-acting insulin, e.g., lispro, aspart, glulisine, or regular, which is given before a meal to mimic the body's normal response to a caloric load
CORRECTION insulin (replaces the older term "sliding scale")	The variable amount of rapid-acting insulin given *in addition to* the prandial and/or basal insulin to correct hyperglycemia. Correction insulin can also be given at bedtime although it is reasonable to be more conservative at this time due to the greater risk of nocturnal hypoglycemia

Post-op: Transitioning from Insulin Infusion to Subcutaneous Insulin Once Patient is Eating

When to transition:

- The patient should be eating a reasonable amount of calories and have a reasonably stable blood sugar on the insulin infusion.
- Discontinue the infusion at mealtime and give the basal and short-acting prandial insulin per schedule. If the infusion is stopped at breakfast or lunch and basal insulin (e.g., glargine) is not scheduled until evening, you can give a one-time dose of NPH (roughly half the dose of the planned evening glargine) to serve as a bridge to the first glargine dose that evening. For patients transitioning at bedtime, continue the infusion for 2 h after the glargine, detemir, or NPH dose to compensate for the slower onset of the basal insulin.

Calculating the dose:

- The subcutaneous (SC) dose is only 60–80 % of the IV dose. Post-op the requirements also tend to go down with time, so a reasonable plan is to calculate the amount of insulin given via infusion over the last *16 h* to give you the estimated *24-h* subcutaneous insulin requirement.
  Last 16-h total IV dose = Next 24-h total SC dose

TABLE 21.3 PREOPERATIVE INSULIN RECOMMENDATIONS

Basal insulin	*NPH*[a]	75 % of the usual evening dose the night before surgery 50 % of the usual AM dose (if applicable) on the morning of surgery
	Glargine (Lantus®)	Take 50–75 % of the usual evening dose (50 % if the patient takes more than 50 units normally)
	Detemir (Levemir®)	Take 50–75 % of the usual morning dose (50 % if the patient takes more than 50 units normally)[b]
	Premixed insulin (NPH/Reg 70/30, Humalog® 75/25 or 50/50 mix, Novolog® 70/30 mix)	Take 75 % of the usual evening dose Take 50 % of the usual morning dose
	Insulin pump	Discuss with diabetes provider. 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 tolerating an adequate diet, then resume the pump if the patient is stable, alert, and able to manage the pump. Endocrinology consultation should be considered
Prandial (mealtime) insulin	*Short-acting insulin*	Do not take on the morning of surgery with the exception of correction algorithms for hyperglycemia using rapid-acting analogs—lispro (Humalog®), aspart (Novolog®), glulisine (Apidra®) Note: Do not use regular insulin (U-100 and U-500) for correction due to prolonged duration of effect

[a]Has a peak and thus provides some prandial coverage
[b]For patients who have classic type 1 diabetes mellitus, take no less than 75 % (usually 80 %) of the usual evening or AM dose—as always, discuss with the patient's diabetes provider if necessary

TABLE 21.4 EXAMPLE OF IV INSULIN INFUSION TO SUBCUTANEOUS INSULIN TRANSITION

Example

1. Assess IV requirement: Your patient has required *3* units of insulin IV per hour *for the last 16 h*
2. Calculate SC dose: $3 \times 16 = 48$ *units total SC dose*
3. Divide into *basal* and *prandial (premeal)*:

Basal:	Prandial:
$\frac{1}{2} \times 48 = 24$ *units of basal insulin* (e.g., glargine qhs)	$\frac{1}{2} \times 48 = 24$ *units of prandial insulin* (e.g., lispro, aspart, glulisine divided before each meal)
	24 units/3 = *8 units before each meal* (if isocaloric)

Next, divide the 24-h SC dose as follows:

~50 % of the estimated requirement is given as basal glargine, usually at bedtime, or NPH or detemir BID.

~50 % of the estimated requirement is given as lispro, aspart, or glulisine as three equally divided mealtime (prandial) doses. (*Note*: If the patient is not eating three full meals a day, you may want to give more than 50 % basal and less prandial insulin.) An example is shown in Table 21.4.

Modify the insulin dose by 20–30 % every day until the patient has optimal glycemic control. Current guidelines target a premeal glucose <140 and a random glucose <180 (while avoiding hypoglycemia) for a majority of hospitalized patients who are not critically ill [14].

Evaluate the blood glucose pattern to determine which insulin should be adjusted.

IX

Special Considerations

- If the patient is on steroids, give no more than 40 % basal and at least 60 % prandial.
- Prandial insulin works best if given at least 10–15 min before the meal as this prevents large postprandial spikes. In the hospital this is not always possible but should be considered when titrating insulin doses, especially if the timing of the insulin changes frequently.

- Consider using Regular insulin for prandial coverage (but not correction dose) for patients with gastroparesis or patients with chronic nausea, such as those receiving chemotherapy.
- Glargine starts to work in about an hour and lasts 20–24 h in most patients with no pronounced peak. Sometimes it is dosed twice daily, especially in those with type 1 DM.
- Detemir is similar to glargine. It starts to act in about an hour and is "relatively flat" as far as any peak is concerned. Duration is variable but is up to 23 h at usual doses. It is often given twice daily, especially in type 1 diabetes.
- NPH starts to work in 1–1.5 h, peaks in 4–12 h, and lasts up to 24 h (usually no more than 18–20 h) but rarely provides sufficient effect to allow for once-daily dosing (typically dosed 2–3 times per day).
- Lispro/aspart/glulisine start to work in 5–10 min, peak in 0.5–1.5 h, and have a functional duration of 3–5 h; however, a residual effect can be seen out to 6–8 h. That is why there can be a problem with "stacking" with frequent correction doses.
- Regular insulin (subcutaneous) has a 30–60-min onset, peaks in 2–4 h, and lasts 8–12 h. (It should not be used as a correction dose. Use a rapid-acting analogue instead).
- U-500 insulin use entails some special concerns. It is used in OB patients, patients with lipodystrophy, very-insulin-resistant obese patients, and some others. If a patient was on U-500 at home, it is suggested that an endocrinologist be involved. The diabetes teaching team should also work with the patient's nurse.

SPECIAL SITUATIONS: TPN AND TUBE FEEDS

The key point is to use the insulin infusion rate to take a lot of the guesswork out of calculating the correct dose.

TPN

- Do not add insulin to the TPN bag until the patient is stable and the 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 the IV protocol for the previous 12 h *and multiply by 2* for the 24-h requirement.

- Add 80–100 % of the calculated 24-h dose of insulin to the next night's TPN bag. *Stop the insulin infusion when the insulin containing TPN bag is started* (this is critical). *Exception: See below for cyclic TPN*. Correct with the subcutaneous insulin correction algorithm for hyperglycemia q 6 h. Choose the algorithm based on the total amount of insulin required (<40 units = low dose, 40–80 units = medium dose, >80 units = high dose). Adjust the amount of insulin in the TPN daily until the patient has adequate glycemic control (BG 140–180).
- If the patient is on *cyclic TPN*, make sure to use the insulin infusion rate during the time the TPN is running to calculate the amount of insulin to be added to the TPN bag. The patient may still need the insulin infusion restarted if the patient is NPO or SC insulin (NPH for basal needs) if eating when the TPN is not running.

TUBE FEEDING

Recommendations for patients receiving tube feeds are shown in Table 21.5.

TABLE 21.5 RECOMMENDED INSULIN MANAGEMENT FOR PATIENTS RECEIVING TUBE FEEDS

Continuous tube feeds	■ Continue the insulin infusion protocol ■ If changing to subcutaneous insulin, use the insulin infusion requirement to calculate the dose, as described above, then divide the short-acting (prandial) component into q6h doses of *Regular* insulin ■ If the patient has not been on an insulin infusion, calculate the SC daily basal/prandial insulin requirement using body weight, 0.2–0.5 units/kg. Age, renal function, and baseline glucose control need to be considered in dosing [14]
Bolus tube feeds	■ Give Regular insulin 30–45 min before the bolus feed and check finger stick glucose 2 h later ■ Adjust the dose of insulin to achieve post-bolus target glucose of 140–180

(continued)

TABLE 21.5 (CONTINUED)

Cyclic tube feeds[a]	■ 8-h cycle: Give 1/3rd to 1/2 of the basal requirement as NPH and half as many units of the bolus dose as Regular at the start of the cycle. Re-dose basal as needed 12 h after the initial dose ■ 12-h cycle: Give ½ the basal requirement as NPH and ¼ of the bolus requirement as Regular at the start of the cycle and re-dose the Regular insulin 6 h into the feed. Re-dose the basal as needed 12 h after the initial dose ■ Titrate the insulin dose daily until you achieve adequate glycemic control (BG 140–180) ■ The patient should also be corrected with a rapid acting insulin algorithm for hyperglycemia q4h rather than premeal. Choose an algorithm based on the total amount of insulin required (i.e., <40 units = low dose, 40–80 units = medium dose, >80 units = high dose)

[a]Note: Cyclic tube feeds are challenging. Covering an 8–12-h "meal" followed by 16–12 h of "fasting" requires constant titration of insulin doses based on glucose monitoring. Tube feeds may also be interrupted by procedures or clogging of the tube, thus increasing the risk for hypoglycemia

Remember—"The lab is the gold standard, not the glucose meter."

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Chapter 22
Stress-Dose Steroids

Kara J. Mitchell

Patients are treated with glucocorticoids for a multitude of conditions, including chronic obstructive pulmonary disease (COPD), organ transplantation, autoimmune diseases, and other inflammatory conditions. This chapter addresses supplemental steroid dosing (commonly called "stress-dose steroids") for patients with tertiary (iatrogenic) adrenal insufficiency as a result of glucocorticoid use. Note that *all* patients with primary adrenal insufficiency (Addison's disease) or ACTH deficiency (hypothalamic or pituitary dysfunction) require stress-dose steroids [1].

ASSESSMENT OF HYPOTHALAMIC–PITUITARY–ADRENAL AXIS

In general, higher doses of glucocorticoid and longer duration of therapy may render the hypothalamic-pituitary-adrenal (HPA) axis more suppressed, but considerable variability is seen between patients [1,2,4]; see Table 22.1. Recovery from tertiary (iatrogenic) adrenal insufficiency may take months [1,4], so the clinical history for determination of supplemental steroid dosing should include all glucocorticoid use within the past year.

PERIOPERATIVE MANAGEMENT

Supplemental dose steroids are recommended for patients in whom the HPA axis is suppressed, and may be considered on an individual basis for patients in whom the HPA axis may be suppressed. Dosing recommendations, based on expert opinion as large randomized

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TABLE 22.1 ASSESSMENT OF HPA AXIS SUPPRESSION BASED ON GLUCOCORTICOID EXPOSURE HISTORY [2]

HPA axis status	Glucocorticoid exposure	Management
NOT suppressed	■ <3 weeks ■ Every-other-day therapy ■ AM dose of <5 mg prednisone or equivalent[a]	Take usual AM dose of glucocorticoid
MAY be suppressed	■ Intermediate-dose glucocorticoid use (5–20 mg prednisone or equivalent/day) ■ Inhaled steroid use ■ Class I topical glucocorticoid use ■ Significant glucocorticoid use in the past year	ACTH stimulation test [3] vs. empiric supplemental steroids without testing
IS suppressed	■ >20 mg/day of prednisone or equivalent for >3 weeks ■ Clinically Cushingoid appearance	Supplemental steroids

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

trials are lacking, are shown in Table 22.2 [5]. Dosing should be individualized based on the patient's preoperative steroid dose, anticipated duration and stress of surgery, concomitant use of medications (i.e., rifampin) that alter glucocorticoid metabolism, and possible complications of steroid administration. If postoperative complications arise, causing ongoing stress, then supplemental dosing may need to be continued.

COMPLICATIONS

Patients receiving glucocorticoid therapy should be followed clinically for complications, such as those noted in Table 22.3 [1,2,4,5].

TABLE 22.2 DOSING RECOMMENDATIONS FOR SUPPLEMENTAL GLUCOCORTICOID ADMINISTRATION [5]

Surgical risk	Examples	Recommendation
Minor surgery	Inguinal hernia repair Colonoscopy	Take usual AM steroid dose (target at least 25 mg of hydrocortisone or equivalent)
Moderate surgery	Open cholecystectomy Extremity revascularization Total knee replacement Abdominal hysterectomy	Take usual AM steroid dose plus: 25–50 mg hydrocortisone IV prior to surgery followed by 50–75 mg hydrocortisone equivalent × 1–2 days (e.g., 25 mg q 8 h ×24 h); then resume baseline dose
Major surgery	Whipple Esophagectomy Total proctocolectomy Cardiac surgery	Take usual AM steroid dose plus: 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 h ×48 h); then taper dose by 1/2 per day until maintenance dose reached[a]

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

TABLE 22.3 COMPLICATIONS OF GLUCOCORTICOID THERAPY

- 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/GI hemorrhage
- Insulin resistance
- Fluid retention/worsened BP control
- Subcapsular cataract formation
- Myopathy/proximal muscle weakness

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PART X
Hematology

Chapter 23
Anticoagulation

Kelly Wentworth

In patients who receive chronic anticoagulation, we must weigh the risks of cessation of anticoagulation against the surgical bleeding risk of maintaining anticoagulation. We must also assess the risk of delaying surgery versus the benefit of extending preoperative anticoagulation. All cases need to be individualized based on the patient's own risks and benefits.

Recommendations for preoperative and postoperative management of anticoagulation are shown in Tables 23.1 and 23.2.

ATRIAL FIBRILLATION

For nonvalvular atrial fibrillation, note that there are slight differences in bridging recommendations between the ACC/AHA guidelines and the ACCP guidelines. The ACC/AHA guidelines are shown in Table 23.2—they recommend bridging with low-molecular-weight heparin if a history of TIA, CVA, or prior embolic events [1, 3]. The ACCP guidelines recommend bridge therapy for a CHADS2 score of 5–6, individualizing bridge therapy decision based on patient and surgery risk factors for a score of 3-4, and no bridge therapy for a score of 0-2 provided no history of TIA/CVA [2]. We recommend discussing the management strategy with the surgical team.

CESSATION OF WARFARIN

Protocols vary as to when to stop warfarin prior to surgery. As noted above, for mechanical valves, ACC/AHA guidelines recommend cessation 48–72 h prior to surgery, although in our practice we follow the

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TABLE 23.1 RECOMMENDATIONS FOR ANTICOAGULATION MANAGEMENT IN PATIENTS WITH PROSTHETIC HEART VALVES UNDERGOING MAJOR NONCARDIAC SURGERY [1, 2]

Indication	Usual anti-thrombotic therapy	Preoperative management[a]	Postoperative management
Mechanical prosthetic heart valves			
Mechanical bileaflet aortic valve without other risk factors	Warfarin adjusted to INR 2.0–3.0	Withhold warfarin 48–72 h or 5 days prior to procedure to allow INR to fall to <1.5[a] No bridging required	Prophylactic-dose heparin Restart warfarin when surgically acceptable, typically 12–24 h post-op
Mechanical mitral valve	Warfarin adjusted to INR 2.5–3.5	Withhold warfarin 5 days prior to procedure to allow INR to fall to <2.0 Start IV UFH or therapeutic LMWH when INR falls below 2.0. Stop UFH 4–6 h prior to procedure. If using LMWH, give ½ dose 24 h prior to procedure[b]	Start IV UFH as soon as surgically acceptable. If using LMWH, resume when hemostasis is achieved, usually around 48–72 h. Continue until INR is therapeutic Restart warfarin when surgically acceptable
Mechanical aortic valve with additional risk factor(s)[c]	Warfarin adjusted to INR 2.5–3.5	Withhold warfarin 5 days prior to procedure to allow INR to fall to <2.0 Please see text for details. Start IV UFH or therapeutic LMWH when INR falls below 2.0. Stop UFH 4–6 h prior to procedure. If using LMWH, give ½ dose 24 h prior to procedure[b]	Start IV UFH as soon as surgically acceptable. If using LMWH, resume when hemostasis is achieved, usually around 48–72 h. Continue until INR is therapeutic. Please see text for details Restart warfarin when surgically acceptable

Bioprosthetic heart valves[c]			
Bioprosthetic aortic valve with risk factors[d]	Warfarin adjusted to INR 2.0–3.0	Withhold warfarin 5 days prior to procedure to allow INR to fall to <2.0 Start IV UFH or therapeutic LMWH when INR falls below 2.0. Stop UFH 4–6 h prior to procedure. If using LMWH, give ½ dose 24 h prior to procedure[b]	Start IV UFH as soon as surgically acceptable. If using LMWH, resume when hemostasis is achieved, usually around 48–72 h. Continue until INR is therapeutic Start warfarin when surgically acceptable
Bioprosthetic mitral valve with risk factors[d]	Warfarin adjusted to INR 2.0–3.0	Withhold warfarin 5 days prior to procedure to allow INR to fall to <2.0 Start IV UFH or therapeutic SQ LMWH when INR falls below 2.0. Stop UFH 4–6 h prior to procedure. If using LMWH, give ½ dose 24 h prior to procedure[b]	Start IV UFH as soon as surgically acceptable. If using LMWH, resume when hemostasis is achieved, usually around 48–72 h. Continue until INR is therapeutic Start warfarin when surgically acceptable

UFH unfractionated heparin, *LMWH* low-molecular-weight heparin

[a]ACC/AHA guidelines recommend holding warfarin 48–72 h prior to procedure [1]. ACCP guidelines recommend holding warfarin 5 days prior to procedure [2]

[b]Typically, patients will need IV heparin 2 days prior to procedure if INR falls as expected. There is practice variation with the use of LMWH instead of IV heparin. Use of LMWH is a class IIB recommendation as per the ACC/AHA guidelines. Avoid LMWH if CL_{CR} <30 [1, 2]

[c]Note that for bioprosthetic valves without risk factors some centers treat with warfarin adjusted to an INR of 2.0–3.0 for the first 3 months post valve surgery. If procedures requiring reversal of warfarin are required within this time period, it is best to discuss with the cardiac surgeon

[d]Risk factors: Atrial fibrillation, previous thromboembolism, LV dysfunction, hypercoagulable state

TABLE 23.2 RECOMMENDATIONS FOR ANTICOAGULATION MANAGEMENT IN PATIENTS RECEIVING ANTICOAGULATION FOR OTHER INDICATIONS UNDERGOING MAJOR NONCARDIAC SURGERY [1, 4, 6, 8]

Indication	Preoperative management	Postoperative management	Comment
Non-valvular atrial fibrillation without prior TIA, stroke, or embolic disease	Withhold warfarin 5 days prior to procedure to allow INR to fall to <1.5	Prophylactic-dose heparin Restart warfarin when surgically acceptable	Bridging is not required. Please see text for details
	Dabigatran: Standard bleeding risk: CL_{CR} >50: Hold for 24 h prior CL_{CR} 30–50: Hold for 48 h prior High bleeding risk[a]: CL_{CR} >50: Hold for 2–4 days prior CL_{CR} 30–50: Hold for 4 days prior	Dabigatran: Restart dabigatran when surgically acceptable. Note that anticoagulant effect starts quickly compared with re-initiation of warfarin	Typically the short-term risk of embolic disease with atrial fibrillation is low See Chap. 9 and discussion in the text
Non-valvular atrial fibrillation *with* prior TIA, stroke, or embolic disease	Withhold warfarin 5 days prior to procedure to allow INR to fall to <2.0	Consider therapeutic-dose IV UFH or SC LMWH if surgically acceptable until warfarin can be restarted	Bridging therapy with IV UFH or LMWH is recommended
	Dabigatran: Standard bleeding risk: CL_{CR} >50: Hold for 24 h prior CL_{CR} 30–50: Hold for 48 h prior High bleeding risk[a]: CL_{CR} >50: Hold for 2–4 days prior CL_{CR} 30–50: Hold for 4 days prior	Dabigatran: Restart dabigatran when surgically acceptable. If unable to take PO, consider IV heparin or SC LMWH. Note that anticoagulant effect starts quickly compared with re-initiation of warfarin	See Chap. 9 and discussion in the text

Heart failure	Discuss with the patient's cardiologist	Discuss with the patient's cardiologist	In general, warfarin is withheld without bridge therapy if there is no history of prior thromboembolic events
Pulmonary hypertension	Discuss with the patient's pulmonologist	Discuss with the patient's pulmonologist	Patients requiring warfarin for pulmonary hypertension are likely high-risk surgical candidates apart from the risk of thromboembolism. See Chap. 16
Hypercoagulable state	Consider bridge therapy on an individual basis	Consider bridge therapy on an individual basis	Generally the more severe hypercoagulable states (e.g., antiphospholipid antibody syndrome with prior arterial event) merit bridge therapy
Venous thromboembolism—please see Chap. 17			

[a]"High" surgical bleeding risk includes cardiac surgery, neurosurgery, abdominal surgery, surgery involving major organs, and any procedure in which complete hemostasis is required, including neuraxial procedures. Guidelines also recommend checking TT (thrombin clotting time) 6–12 h prior to surgery for high surgical bleeding risk, and if elevated, consider delaying surgery. Note that there are recommendations for patients with CL_{CR} <30 (hold 2–5 days for standard bleeding risk, >5 days for high bleeding risk), but dabigatran is typically not used in patients with this degree of renal dysfunction [6, 8]

ACCP guidelines of stopping 5 days (= hold 5 doses) prior to surgery. Patients with lower doses of warfarin may require a longer time to allow their INR to fall sufficiently. The exact timing of when to stop warfarin prior to surgery should be individualized.

BRIDGING THERAPY

There are various bridging protocols in use.

- IV heparin: For preoperative use, stop warfarin 5 days prior to the procedure (holding 5 doses). Start IV heparin when the INR falls below the patient's target dose range (usually 3 days prior to the procedure, but varies depending on the patient and the baseline warfarin dose). Stop heparin infusion 4–6 h prior to surgery. After surgery, check with the surgeon for when bleeding risk is acceptable and consider giving without an initial bolus.
- LMWH: For preoperative use, stop warfarin 5 days prior to the procedure (holding 5 doses). Start LMWH when the INR falls below the patient's target dose range (usually 3 days prior to the procedure, but varies depending on the patient and the baseline warfarin dose). Last dose is usually given in the AM on the day prior to surgery (i.e., >24 h prior). For patients who receive once-daily bridging, e.g., enoxaparin 1.5 mg/kg once daily or dalteparin 200 units/kg once daily, it is recommended to give ½ the dose in the morning on the day prior to surgery. For patients who receive twice-daily dosing, e.g., enoxaparin 1 mg/kg twice daily or dalteparin 100 units/kg twice daily, it is recommended to give the last dose in the morning on the day prior to surgery. After surgery, LMWH may be restarted when surgical bleeding risk is acceptable. This is usually 48–72 h after surgery for high-bleeding-risk surgery, and 24 h after surgery for low-bleeding-risk surgery. As always, we recommend discussing with the surgical team. IV heparin may also be used post-op. Patients should receive VTE prophylaxis doses when not yet resuming therapeutic-dose anticoagulation.
- LMWH should be avoided in patients with a CrCl <30. Work with the patient's pharmacist or use IV heparin if bridging therapy is indicated.
- For either IV heparin or LMWH, warfarin typically should be reinitiated 12–24 h postoperatively and when adequate hemostasis is achieved [2].

MINOR PROCEDURES

Many minor procedures may be performed while on therapeutic anticoagulation due to lower bleeding risk and the ability for local control measures to obtain hemostasis (see Table 23.3). One should always discuss this with the surgeon. An INR should be checked to ensure that the patient's anticoagulation is not supratherapeutic.

STRATEGIES TO REVERSE WARFARIN EFFECT

Consider whether the indication is for active bleeding or reversal for surgery, and the time period over which you wish to reverse anticoagulation. See Table 23.4 for recommendations [8].

IV Vitamin K: Acts quickly and reverses quickly. Useful if you seek to reverse warfarin effect within 24 h. There is a risk of anaphylaxis to the IV form.

PO or SC Vitamin K: There is reasonable data showing that low-dose PO vitamin K may be used to reverse warfarin effect with similar efficacy as IV vitamin K (note different dosing) at 24 h, although IV administration acts more quickly in the first few hours [5]. Be careful not to overdose PO vitamin K if reversing with the intention of reestablishing therapeutic anticoagulation with warfarin in the near future. The data for SC vitamin K is sufficiently mixed such that PO or IV is preferred. Avoid vitamin K administration in patients with a

TABLE 23.3 ANTICOAGULATION MANAGEMENT FOR MINOR PROCEDURES

Cataract surgery	Stopping warfarin is usually not indicated
Other ophthalmologic procedures	Should be decided on a case-by-case basis
Dermatology	Stopping warfarin is usually not indicated unless the surgery is extensive
Dental surgery	Stopping warfarin is usually not indicated except in very large cases or bone excision. Consider adding an oral pro-hemostatic agent such as aminocaproic acid mouthwash postoperatively

Confirmation with the surgeon is always advised

X

TABLE 23.4 MANAGEMENT OPTIONS FOR REVERSAL OF WARFARIN ANTICOAGULATION

INR	Clinical setting	Therapeutic options
<4.5	No bleeding	Hold warfarin until INR in therapeutic range
	Rapid reversal required	Hold warfarin and consider vitamin K 2.5 mg PO
4.5–10	No bleeding	Hold warfarin until INR in therapeutic range. Consider vitamin K 2.5 mg PO
	Rapid reversal required	Hold warfarin and give vitamin K 2.5 mg PO or 1 mg IV infusion
>10	No bleeding	Hold warfarin until INR in therapeutic range and give vitamin K 2.5 mg PO or 1–2 mg IV infusion Repeat Q24h as necessary
	Rapid reversal required	Hold warfarin and give vitamin K 1–2 mg IV infusion Repeat Q6–24 h as necessary
Any INR	Serious or life-threatening bleeding	Hold warfarin and give vitamin K 10 mg IV infusion over 30 minutes and supplement with 2 units FFP. Consider PCC (prothrombin complex concentrates) Repeat as necessary guided by INR

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mechanical valve who will be undergoing surgery as this may induce a hypercoagulable state.

FFP: Acts quickly, but also has a relatively short duration. Useful immediately prior to procedure, e.g., less than 12 h, or for any indication where rapid reversal is required. Note that it may have to be re-dosed or vitamin K concurrently administered if prolonged reversal of anticoagulation is required.

STRATEGIES TO REVERSE DABIGATRAN EFFECT

There is no antidote to reverse dabigatran. If mild bleeding occurs, stopping dabigatran should be sufficient. In more serious bleeding, consider transfusing packed red blood cells, FFP, or PCC. Dabigatran can also be removed by hemodialysis [4, 6, 7].

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Chapter 24

Preoperative Evaluation of Disorders of Hemostasis

Ronald Huang

PREOPERATIVE EVALUATION OF HEMOSTASIS

Assessing the risk of perioperative bleeding is a fundamental component of the preoperative evaluation.

PROCEDURAL BLEEDING RISK

The risk of perioperative bleeding depends on both normal hemostasis and the type of surgery or procedure being performed. Procedures can be classified as having a low, moderate, or high risk of bleeding based on whether vital organs are involved, the amount of surgical dissection, exposure of the surgical site, likelihood of a complication adversely affecting the outcome of surgery, and frequency of bleeding complications (see Table 24.1).

HISTORY

A hemostatic history should be obtained on all patients regardless of the procedure being performed [1–4]. Patients with hemostatic disorders are typically aware of their disorder, have personally had or have family members who have had problems with bleeding, or have easily identifiable risk factors.

Patients should be asked about any bleeding symptoms, a history of excessive bleeding associated with trauma or surgery, including dental procedures or tonsillectomy, and a family history of bleeding disorders. In addition, patients should be asked about a past medical history of hepatic, renal, or hematologic disease and about their current medication use, including aspirin, pain medications, antiplatelet medications, or anticoagulants.

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TABLE 24.1 RISK OF BLEEDING WITH SURGICAL OR INVASIVE PROCEDURES

Risk	Type of Procedure	Examples
Low	Nonvital organs involved, exposed surgical site, limited dissection	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 (non cataract) surgery, cardiopulmonary bypass, prostatectomy, bladder surgery, major vascular surgery, renal biopsy, bowel polypectomy

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LABORATORY STUDIES

Routine preoperative laboratory testing is generally not indicated for patients without identifiable risk factors or symptoms [5–11]. For low-risk procedures, if the history is reassuring for normal hemostasis, no further testing is required. For moderate- to high-risk procedures, it is reasonable to supplement the history with a platelet count, prothrombin time (PT), and an activated partial thromboplastin time (aPTT). For any procedure, additional testing should be performed as indicated by the history. If the history or initial laboratory testing suggests that a bleeding disorder is present, then consultation with a hematologist should be considered.

PERIOPERATIVE MANAGEMENT OF SPECIFIC BLEEDING DISORDERS

THROMBOCYTOPENIA AND PLATELET DYSFUNCTION

Both elective and emergent surgical procedures can be safely performed for most patients with thrombocytopenia or platelet dysfunction with the use of platelet transfusions. Recommendations

TABLE 24.2 RECOMMENDATIONS FOR PLATELET TRANSFUSION FOR THE SURGICAL PATIENT [12, 13]

Plts <50,000/μL—Platelet transfusion is indicated for the surgical patient
Plts 50,000–100,000/μL—Platelet count >50,000/μL is considered adequate for most procedures, except for CNS procedures for which platelet transfusion is indicated for platelet count <100,000/μL
Plts >100,000/μL—Platelet transfusion is usually not necessary
Platelet transfusion may be indicated despite an apparently adequate platelet count if there is known or suspected platelet dysfunction, or there is ongoing or anticipated bleeding

for platelet transfusion for the surgical patient are listed in Table 24.2.

When thrombocytopenia is due to increased platelet destruction from immune thrombocytopenic purpura (ITP), platelet transfusions are less effective and are reserved for emergent procedures or life-threatening bleeding. For elective procedures, patients with ITP are often treated preoperatively with steroids and intravenous immunoglobin to increase the platelet count to adequate levels such that transfusion is not needed. Newer modalities to increase the perioperative platelet count include the use of thrombopoitein mimetics. Consultation with the patient's hematologist is advised.

EFFECT OF PLATELET TRANSFUSIONS

Platelet transfusions are either pooled (random donor) platelets or apheresis (single donor) platelets. Pooled platelets are prepared from platelets that have been separated from a unit of whole blood. Six units of pooled platelets from separate donors are usually combined into a single bag for transfusion, called a "six-pack." Apheresis platelets are collected from a single donor. The effect of platelet transfusions is variable, but 4–6 pooled platelets or a single unit of apheresis platelets is expected to increase the platelet count by 30–60,000/μL in an average sized patient. A posttransfusion platelet count can be sent 10–60 min after transfusion to assess for response. The platelet count will gradually fall to pre-transfusion levels after 2–3 days.

If a patient does not respond to platelet transfusions, a pre- and posttransfusion platelet count should be obtained. A patient is refractory to platelet transfusions if the platelet count fails to increase by 10,000/μL. The next step is to send panel reactive antibody (PRA) to test for the presence of HLA antibodies. If the patient has a high or a positive PRA, apheresis platelets will be collected from an HLA-matched donor for transfusion. This process may take days, and other

options are available while waiting for HLA-matched platelets if platelet transfusions are required. The local blood center should be contacted.

VON WILLEBRAND DISEASE

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 a deficiency or dysfunction of vWF. Type 1 vWD represents a mild deficiency of vWF; type 2 vWD represents a group of subtypes that are characterized by dysfunctional vWF; type 3 vWD represents a severe or complete deficiency of vWF. The prevalence of vWD has been estimated to be as high as 1 % of the general population, but clinically significant vWD is far less common [14]. Patients with any type of vWD may have excessive bleeding with trauma or surgery. If a diagnosis of vWD is suspected, initial laboratory testing should include vWF antigen, ristocetin cofactor activity (which tests the ability of a patient's vWF to agglutinate platelets in the presence of ristocetin), and factor VIII activity.

Although routine prophylaxis is generally not required for patients with vWD, surgical prophylaxis with either desmopressin or plasma concentrates is recommended. Desmopressin is most effective for type 1 vWD as its effect is to transiently increase the patient's own factor VIII and vWF by three to five times. Desmopressin is typically given at a dose of 0.3 μg/kg IV infused over 30 min, but it can also be self-administered subcutaneously or intranasally. Factor VIII and vWF levels increase 30–60 min after administration of desmopressin, and the increased levels remain for 8–10 h. If necessary, desmopressin can be given every 12–24 h for up to 36 h (tachyphylaxis to desmopressin is common). Prior to using desmopressin for surgical prophylaxis, patients with vWD should receive a test dose of desmopressin to establish responsiveness. Factor VIII activity and ristocetin cofactor activity are measured at 1 and 4 h after desmopressin administration to assess response.

For those patients with vWD who are not candidates for desmopressin, virus-inactivated plasma concentrates of factor VIII and vWF are recommended for surgical prophylaxis. Concentrate dosing generally ranges from 25 to 50 IU/kg, but the dose should be based on preoperative factor VIII activity or ristocetin cofactor activity. Factor VIII activity should be monitored every 12 h on the day of the initial dose and every 24 h after to ensure that supratherapeutic levels of factor VIII are avoided. Monitoring ristocetin cofactor activity is also reasonable. Treatment is generally continued postoperatively until hemostasis has been achieved. Consultation with a hematologist is recommended.

ACQUIRED DISORDERS OF COAGULATION

Acquired disorders of coagulation from liver disease, vitamin K deficiency (from inadequate dietary intake, antibiotics, or disease of malabsorption), and anticoagulants are common. Perioperative management of patients with liver disease and anticoagulants are discussed in Chap. 20 and 23. Vitamin K deficiency will be discussed here.

Vitamin K deficiency is suspected in the appropriate clinical context and results in a prolonged PT that corrects with mixing studies. Vitamin K can be administered orally or intravenously. For elective surgeries, oral vitamin K is usually sufficient though the prothrombin time should be monitored and in most cases repeated the morning of surgery. For more urgent or emergent surgeries, intravenous vitamin K or supplementation with fresh frozen plasma (FFP) may be necessary.

CONGENITAL COAGULATION FACTOR DEFICIENCIES

Congenital factor deficiencies are rare, especially when compared with acquired coagulation factor deficiencies from liver disease, anticoagulants, or vitamin K deficiency. The most common of the congenital factor deficiencies are hemophilia A (factor VIII deficiency) and hemophilia B (factor IX deficiency). The incidence of hemophilia A is 1:5,000 male births, and the incidence of hemophilia B is 1:30,000 male births [15]. There is some variability depending on the severity of the factor deficiency, but patients with hemophilia are usually diagnosed as children and are followed by a hematologist. Patients with hemophilia should receive either plasma-derived factor or recombinant factor for surgical prophylaxis. Dosing will vary based on the patient and the product, but enough factor should be given to reach 80–100 % of normal factor VIII or factor IX activity. Factor activity levels should be monitored. Patients should receive factor replacement for 10–14 days following surgery. Consultation with a hematologist is recommended.

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Chapter 25
Postoperative Thrombocytopenia

Elizabeth Kaplan

BACKGROUND

- Common hematologic abnormality after major surgery, although actual incidence not reported in literature [1].
- Defined as platelet count <150,000. Generally, platelets >50,000 are not associated with significant bleeding. Spontaneous bleeding usually does not occur with platelets >20,000.

EVALUATION

- *History*: Review medications (e.g., heparin), transfusion history, symptoms of infection, symptoms/history of liver disease.
- *Exam*: Assess for infection, splenomegaly, signs of liver disease, evidence of thrombosis.
- *Differential diagnosis*: Degree of thrombocytopenia is useful in helping to determine etiology, as shown in Table 25.1. Other etiologies not specific to the postoperative setting should also always be considered including ITP, sequestration, and malignancy-associated.
- *Labs*: Consider the following studies; however send only those that are appropriate to the clinical situation: CBC, reticulocyte, haptoglobin, PT/PTT/INR, fibrinogen and peripheral smear, and heparin-induced thrombocytopenia (HIT) panel.
- *Consultation*: Consider hematology consult if no obvious etiology is found or if levels are low enough that platelet transfusion is considered.
- *Treatment*: Platelet transfusions are usually indicated only for platelets <10,000 or <50,000 with active bleeding—important to discuss with the surgical team. Intramuscular injections

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TABLE 25.1 POTENTIAL ETIOLOGIES OF POSTOPERATIVE THROMBOCYTOPENIA

Platelet decrease	Etiology	Description
Mild–moderate	Consumption	Seen in larger blood loss surgeries
		Occurs immediately after surgery
		Returns toward normal within 2–3 days
	Thrombocytopenia due to infection	Associated with both viral and bacterial infections
		In severe cases, part of disseminated intravascular coagulation (DIC)
		Other mechanisms less well understood [1]
	Pseudo-thrombocytopenia	Artifact due to EDTA in CBC tube. Clumping present on smear. Redraw platelet count in tube containing citrate instead of EDTA
	Heparin-induced thrombocytopenia	HIT—See text
	Posttransfusion thrombocytopenia	Occurs soon after transfusion (may be soon after surgery if transfusions given during case)
		Severity tends to be proportional to the volume of blood administered
		Clinical course usually benign
		Platelet count usually returns to normal within 3–5 days after blood transfusion [1]

Severe	Drug-induced immune thrombocytopenia	Quinidine, digoxin, valproic acid, alpha methyl dopa, penicillin class drugs, thiazides, trimethoprim/sulfamethoxazole, cimetidine, famotidine Platelet count is often extremely low (can be less than 20,000) Can cause postoperative bleeding Platelet transfusions useful Steroids not shown to be useful [1]
	Posttransfusion purpura	Acute thrombocytopenia caused by alloimmunization against transfused platelets occurs ~5–8 days after the transfusion Clinical presentation is similar in its severity to drug-induced immune thrombocytopenia with levels dropping below 20,000 and sudden onset of bleeding [1]
	DIC	Can occur in the setting of severe infection as mentioned above Can also occur (separate from infection) after significant surgeries presenting with an acute thrombocytopenia immediately after surgery with a bleeding diathesis that is more severe and more extensive than that which is expected from the degree of thrombocytopenia (because it is also associated with a coagulopathy) DIC, not in the setting of infection, is hypothesized to be initiated by extensive surgical injury to the endothelium of the blood vessels and alteration of function of the endothelial cell [1]
	TTP	Rare. Decreased platelets, increased LDH, normal PT/PTT [1] Classic pentad is fever, neurologic symptoms/altered mental status, renal failure, microangiopathic hemolytic anemia, and thrombocytopenia

should be avoided in patients who are thrombocytopenic. Other drugs that interfere with platelet function (NSAIDs, aspirin, beta-lactam antibiotics) should generally be avoided depending on the indication.

HEPARIN-INDUCED THROMBOCYTOPENIA

HIT is an increasingly recognized cause of perioperative complications, including skin necrosis, DVT, pulmonary embolism, venous sinus thrombosis, and stroke [2, 3]. HIT must be recognized in order to treat and prevent potentially catastrophic complications.

WHEN TO SUSPECT [2, 3]

1. Unexplained thrombocytopenia
2. Thrombosis associated with thrombocytopenia
3. Platelet count that has fallen 50% or more from a baseline value (note that it may still be in the normal range)
4. Necrotic skin lesions at heparin injection sites

AND

Prior exposure to heparin

- Platelet counts do not usually fall below 20,000 as a consequence of HIT, and other causes (drug-induced thrombocytopenia, DIC, ITP, etc.) should be suspected if the platelet count is in this range.
- Postoperative patients (particularly those with long spine surgeries) often have depressed platelet counts for days postoperatively, but if the platelet count fails to rebound or falls 50% or more from a baseline value, a diagnosis of HIT should be entertained.
- Nonimmune-mediated decrease in platelet count is seen in many patients within 2 days of starting heparin, but causes a lesser drop and will usually rebound despite continued heparin treatment.

TIME COURSE

Development of HIT varies depending on patients' prior exposure to heparin (and whether they already have antibodies). It is important to realize that a patient may present with HIT *after* stopping heparin (Table 25.2).

TABLE 25.2 TIMING OF PRESENTATIONS OF HIT

Early	Within the first 1–2 days of starting heparin	Seen in patients with prior exposure to heparin (usually in the preceding 3 months), and hence prior antibodies
Usual	Within 5–10 days of starting heparin therapy	Presumed to be due to the formation of new antibodies
Late	After discontinuation of heparin therapy. May be >2 weeks or more from last exposure to heparin	Can occur after the patient's discharge from the hospital. Suspect in a patient returning to the hospital with a new thrombotic complication, particularly after an orthopedic or other surgery where heparin prophylaxis was used

DIAGNOSIS

HIT is a clinical diagnosis, but certain lab tests are useful in supporting the diagnosis. HIT is caused by antibodies against the heparin/platelet factor 4 complex, and multiple tests are available to assess for the presence of these antibodies. The ELISA immunoassay that is the most common test used is extremely sensitive but not specific. A negative test can be useful in ruling out the diagnosis, but a positive test does not confirm it without further supporting features. We recommend first checking heparin antibody ELISA assay [4]. If the ELISA test is positive and there is a high clinical suspicion, then treat as HIT positive. If there is high clinical suspicion of false positive, a serotonin release assay (SRA) can be checked [4].

TREATMENT

- Stop all heparin products (this includes heparin flushes).
- Start a non-heparinoid anticoagulant (direct thrombin inhibitors argatroban and lepirudin are approved for use in the USA). Pharmacy protocols exist for this treatment and will vary from hospital to hospital.
- Start warfarin (only AFTER non-heparinoid anticoagulant has been started) with a plan to anticoagulate for at least 6 weeks, but NOT until the patient's platelet count is greater than 100–150 K due to the risk of transient hypercoagulability.
- Therapy should be overlapped for at least 5 days prior to discontinuation of the direct thrombin inhibitor.
- Hematology consultation is indicated when treating hospitalized patients with HIT.

PREVENTION

- Low-molecular-weight heparins (enoxaparin, dalteparin, etc.) appear to have a lower risk of HIT, and should be used when appropriate.
- Avoid unnecessary use of heparin.

CAN PATIENTS WITH A HISTORY OF HIT EVER BE RECHALLENGED WITH HEPARIN?

While not recommended if other forms of anticoagulation are available, most patients with immune-mediated HIT lose their HIT antibodies within 3 months of ceasing therapy, and short-term heparin use (such as for cardiac bypass surgery) has been shown to be safe [5].

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Chapter 26
Perioperative Management of Anemia

Ronald Huang

Both preoperative [1,2] and postoperative [3] anemia are associated with increased mortality after surgery. However, red blood cell transfusions are associated with their own risks and costs [4–7]. Therefore, the goals of managing anemia in the perioperative setting are preventing significant anemia and blood loss and the judicious use of red blood cell transfusions.

PREOPERATIVE EVALUATION

History: Patients should be asked about symptoms of anemia such as fatigue, exertional dyspnea, palpitations, lightheadedness, or angina. Patients should also be asked about a history of anemia or blood transfusions, and about risk factors for anemia such as bleeding symptoms, chronic medical conditions including chronic kidney disease, or nutritional deficiencies especially in the elderly and alcoholics. A hemostatic history should also be obtained.

Laboratory studies: If there is any concern for anemia based on the history or a significant amount of blood loss is expected with surgery, then a hemoglobin or hematocrit should be reviewed preoperatively. Additional laboratory studies will depend on the history and type of anemia. If there is a likelihood of transfusion, a type and screen should be performed as early as possible.

Management: If surgery is elective, previously undiagnosed anemia should be evaluated prior to surgery. Management of preoperative anemia is directed toward causes of anemia that are reversible or that require attention prior to elective surgery. In some cases, epoetin alfa is used preoperatively to reduce the need for blood transfusions, typically in patients with religious beliefs not allowing transfusion of

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blood products. This approach, however, must weigh the potential risks of this therapy closely. 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 or it can be given as 600 U/kg once weekly 21, 14, and 7 days prior to surgery, and on the day of surgery. Iron and ascorbic acid are given with epoetin alfa. Hemoglobin should be monitored for an appropriate response. The increased risk of thrombosis and cancer progression should be discussed with patients. Correction of anemia by transfusion prior to surgery is generally reserved for urgent procedures and should be decided on a case-by-case basis. The preoperative management of anemia also includes the careful discontinuation or substitution of medications that predispose the patient to bleeding, and addressing any bleeding disorders.

INTRAOPERATIVE MANAGEMENT

The intraoperative management of anemia is performed by the anesthesia and surgical teams. Surgical technique and hemostasis are central to minimizing blood loss. The amount of blood loss can be estimated by direct visualization, using standard methods to quantify blood loss (e.g., suction devices), monitoring for physiologic changes of anemia, and laboratory studies. In addition to allogeneic red blood cell transfusion, the intraoperative management of anemia may include transfusion of autologous red blood cells collected preoperatively (preoperative autologous blood donation), immediately preoperatively (acute normovolemic hemodilution), or intraoperatively (red blood cell salvage).

POSTOPERATIVE MANAGEMENT

The postoperative evaluation of anemia begins with reviewing the operative report for estimated blood loss and blood products administered during surgery. The medical consultant should assess the patient for ongoing blood loss, including surgical drains, and monitor for signs and symptoms of anemia. Not all patients require laboratory studies postoperatively. If there is significant intraoperative or ongoing postoperative blood loss, the patient is symptomatic or is at increased risk for bleeding, then a postoperative hemoglobin and hematocrit should be monitored.

TABLE 26.1 RECOMMENDATIONS FOR RED BLOOD CELL TRANSFUSION BASED ON HEMOGLOBIN [8–10]

Hgb < 6–7 g/dL—Red blood cell transfusion is indicated
Hgb 7–10 g/dL—Optimal transfusion threshold is unclear
Hgb > 10 g/dL—Red blood cell transfusion is usually not necessary
Transfusion may be considered when the hemoglobin is between 7 and 10 g/dL, and there is ongoing or anticipated blood loss, there is clinical evidence of decreased tissue perfusion and oxygenation, the patient is older than 65, or there is a history of cardiopulmonary disease

Postoperative anemia is primarily managed with red blood cell transfusion. In addition to allogeneic red blood cell transfusions, autologous blood collected preoperatively can be used in the postoperative setting. Red blood cell salvage is also performed postoperatively. Blood is collected from surgical drains and transfused after processing. The decision to use postoperative red blood cell salvage is appropriately left to the surgical team. The postoperative management of anemia also involves preventing additional blood loss by limiting the number and frequency of blood draws, taking careful consideration prior to starting or resuming medications that predispose patients to bleeding, and monitoring for and treating hemostatic abnormalities.

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 [8–10]. Instead, the decision to transfuse depends on a combination of factors, of which the most commonly used is the hemoglobin. The decision to transfuse should also take into account whether there are ongoing or anticipated blood losses, as well as how the patient is tolerating the degree of anemia. Recommendations for red blood cell transfusion based on hemoglobin are listed in Table 26.1. In surgical patients, studies in patients receiving CABG and hip fracture repair did not show any difference between those receiving restrictive and liberal transfusion strategies [11,12].

EFFECT OF RED BLOOD CELL TRANSFUSIONS

One unit of packed red blood cells is expected to increase the hemoglobin by 1 g/dL or the hematocrit by ~3 % in an average sized patient if there is no active bleeding. A posttransfusion hemoglobin or hematocrit can be sent as soon as 15 min following transfusion to assess for response.

RISKS OF TRANSFUSION

Risks of transfusion to be considered 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, and hyperkalemia. There remain concerns for other possible adverse effects, including potential exposure to emerging infectious agents, and immunomodulation from transfused blood that may predispose to bacterial infection.

PATIENTS WHO DECLINE BLOOD TRANSFUSION

Informed consent must be obtained prior to blood transfusion. Patients may decline transfusions for many reasons, most commonly for religious reasons (Jehovah's Witnesses). Witnesses do not accept whole blood or any of the "four major components" (i.e., red blood cells, platelets, plasma, and white blood cells). Devout Witnesses also believe that blood should not be taken out of the body and stored for any length of time, and do not accept preoperative autologous blood donation. Witnesses are able to make a personal decision whether to accept certain medical therapy such as blood subfractions, recombinant coagulation factors, and autologous blood so long as it maintains a continuous circuit with their body. When caring for a Witness, it is important to respect the patient's decision, establish a working relationship, maintain confidentiality, review the patient's personal position on medical therapy, and develop an appropriate blood management plan including a clear course of action if the worst-case scenario were to occur [13].

Many of the strategies used for patients who decline blood transfusions are the same that are used for other patients to reduce the use of blood transfusion [14]. The perioperative strategies for patients who decline transfusions, are most effective when combined in a blood management plan. If there is a question whether care can be provided for such a patient, resources are available [13, 14]. The Society for the Advancement of Blood Management, which is not affiliated with Jehovah's Witnesses, also maintains a list of hospitals in the United States with bloodless medicine and surgery programs (http://www.sabm.org).

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PART XI
Neurology

Chapter 27
Parkinson's Disease

Elizabeth Kaplan

Patients with Parkinson's disease are at increased risk for perioperative complications. In a prospective study of perioperative complications, patients with Parkinson's disease were at significantly higher risk for all serious complications after correcting for all other risk factors in a multivariate analysis (Odds ratio, 8.14, CI 1.76–37.67) [1].

Patients are generally thought to be at increased risk because of difficulty with mobility, swallowing, and decreased pulmonary reserve. These patients are also at increased risk for gastric dysmotility, orthostatic hypotension, delirium, and falls. There is no broad consensus statement or treatment guideline for the perioperative approach to this disease [2].

Many perioperative complications of Parkinson's disease can potentially be reduced by minimizing interruptions in Parkinson's disease medications [2].

PREOPERATIVE EVALUATION

- Take a detailed history and perform an exam with particular focus on typical symptoms and signs related to the patient's Parkinson's disease, exact medication use including dosing and time of administration, and typical reaction if the patient misses a dose [2].
- Patients with Parkinson's tend to show a restrictive type picture on pulmonary function testing and this is improved by treatment with levodopa [3]. However, it is not necessary to routinely obtain PFTs before surgery.
- If a patient has a deep brain stimulator, anesthesia must be alerted as the anesthesiologist may need to plan for coordinating with the device's programmer to temporarily turn it off during surgery.

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PERIOPERATIVE MEDICATION MANAGEMENT

- In general, one should attempt to keep the patient's Parkinson's medication regimen the same as the outpatient regimen [2]. In the case of some medications, including carbidopa/levodopa, patients may be very sensitive to the exact timing of their doses.
- If the patient is expected to be NPO postoperatively, discuss with the patient's neurologist about the possibility of having the patient titrate medications down to the lowest possible dose prior to surgery [2].
- Be mindful of potential interactions of Parkinson's medications with typical perioperative medications (anesthetics, antinausea medications, pain medications) [2].
- Consultation with the patient's outpatient neurologist about perioperative medication management prior to surgery is recommended.
- Side effects and interactions of each drug in a patient's regimen should be considered and are discussed in brief below [2].

CARBIDOPA/LEVODOPA (SINEMET®)

- May precipitate confusion or hallucinations at higher doses and may increase the risk of urinary retention.
- Acute discontinuation of levodopa may rarely precipitate a neuroleptic malignant-like syndrome. It is best to taper the dose slowly. Some authors recommend reducing the dose of carbidopa/levodopa to the lowest possible preoperatively, and then resuming the drug postoperatively as soon as possible.

MAO B INHIBITORS: SELEGILINE (ELDEPRYL®), RASAGILINE (AZILECT®)

- Although designed to be a selective inhibitor of monoamine oxidase (MAO) type B, at higher doses (>10 mg) this drug does not act selectively. There are numerous drug interactions (at any dose), especially with meperidine and antidepressants (such as fluoxetine). At higher doses, interactions with sympathomimetic drugs and all narcotic analgesics are possible.
- The traditional practice of discontinuing these medications 2 weeks prior to surgery may not be advisable in all patients with Parkinson's disease because of the risk of a flare of

Parkinson's disease symptoms, and because in some cases the anesthesiologist is able to take the medication into account without stopping it. If you are not able to stop these drugs preoperatively (e.g., emergent surgery), it is imperative to alert the anesthesiologist so that medications with higher risk (e.g., certain pressors) can be avoided. It is good practice to consult with a pharmacist about other potential drug interactions.

DOPAMINE AGONISTS: BROMOCRIPTINE (PARLODEL®), PERGOLIDE (PERMAX®), PRAMIPEXOLE (MIRAPEX®), ROPINIROLE (REQUIP®)

- These drugs can usually be given perioperatively, but use caution as they can cause postural hypotension and confusion. In general, they are held the evening before and the morning of surgery, and restarted postoperatively.

COMT (CATECHOL-*O*-METHYL TRANSFERASE INHIBITORS): ENTACAPONE (COMTAN®) AND TOLCAPONE (TASMAR®)

- These drugs increase the plasma half-life of L-dopa and prolong the therapeutic effect of those medications. They may usually be continued perioperatively. But, they may precipitate dyskinesias, hallucinations, confusion, and orthostatic hypotension.

POSTOPERATIVE MANAGEMENT

- The postoperative management of patients with Parkinson's should include general measures to improve pulmonary hygiene: incentive spirometry, elevating the head of the bed, and early mobilization. It is also important to institute measures designed to minimize the risk of delirium (see Chap. 38).
- Patients who are unable to swallow their medications may be managed with a feeding tube or an NG tube, depending on their symptoms and how long they are expected to not be able to take pills.
- If the patient is unable to take his or her usual medication by mouth for a prolonged period of time, consider Neurology consultation.
- Physical and Occupational therapy may also prove beneficial perioperatively for transfers and routine ADLs.
- Fall precautions should be considered.

- Avoid dopamine antagonists, including haloperidol, risperidone, metoclopramide, promethazine, and prochlorperazine, that are sometimes used in the postoperative period [2].

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Chapter 28
Epilepsy and Seizure Disorders

Christopher J. Wong

PREOPERATIVE EVALUATION

PATIENTS WITH PREEXISTING SEIZURE DISORDERS

History:

- Antiepileptic drugs (AEDs), including dosages and adherence.
- Seizure type, frequency, and date of most recent seizure.

Exam:

- General neurologic examination.

Laboratory or other studies:

- Most recent drug levels if indicated.
- Routine imaging or preop EEG not indicated

Perioperative planning:

- Patients may be at increased risk for seizures in the perioperative period due to infection, electrolyte, and other metabolic disturbances.
- In a retrospective study, risk of seizures in the perioperative period is estimated between 2 and 5 % for patients with preexisting seizure disorders. Factors associated with increased risk of perioperative seizures include more frequent preoperative seizures, shorter time between the last seizure and surgery, and higher number of antiepileptic medications. Type of surgery or anesthesia was not associated with increased seizure risk [1].
- Patients may also be at risk perioperatively because many antiseizure medications can only be given PO (carbamazepine, gabapentin, lamotrigine, topiramate, among others).
- Plan ahead if NPO status is anticipated post-op (Table 28.1). Recommend discussion with both Pharmacy and Neurology if a patient's baseline medication needs to be switched to an alternative agent in IV form.
- In most cases if the patient normally takes a morning dose of AED, that dose may be taken on the morning of surgery.

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TABLE 28.1 COMMONLY USED ANTIEPILEPTIC MEDICATIONS AND ROUTES OF ADMINISTRATION

Medication	PO or IV	Notes
Phenytoin (Dilantin®)	PO, IV PO dose = IV dose	Commonly used antiepileptic medication for IV administration. Side effects include hypotension and arrhythmia when given IV (must be given slowly IV). Multiple drug interactions
Lamotrigine (Lamictal®)	PO	Few significant drug interactions. May lower oral contraceptive efficacy
Levetiracetam (Keppra®)	PO, IV	Few significant drug interactions
Valproic acid (Depakote®)	PO, IV	Recommend discussion with pharmacist or neurologist to convert from PO to IV. IV dosing uses valproate sodium. Drug interactions with azoles, warfarin
Phenobarbital	PO, IV	Recommend discussion with pharmacy to convert from PO to IV. Multiple drug interactions
Carbamazepine (Tegretol®)	PO	Multiple drug interactions
Zonisamide (Zonegran®)	PO	Few significant drug interactions
Topiramate (Topamax®)	PO	Some drug interactions at higher doses

POSTOPERATIVE MANAGEMENT

PATIENTS WITH PREEXISTING SEIZURE DISORDERS

- If unable to take enteral antiepileptic medications, use IV forms (see above). Work with pharmacy and neurology consultants as needed. Transition to usual PO medications as soon as possible.
- Avoid hyponatremia. Monitor electrolytes if the surgical care is expected to produce alterations in electrolyte balance.
- When postoperative seizures do occur, they are typically the same as the preoperative seizure phenotype [1].

PATIENTS WITH NEW-ONSET SEIZURES IN THE PERIOPERATIVE PERIOD

- Exact incidence is unknown.
- Consider a broad differential diagnosis.
  - Electrolyte abnormalities, especially sodium
  - Medications, e.g., meperidine and imipenem, may lower the seizure threshold
  - Infection
  - Withdrawal syndrome such as from benzodiazepine or alcohol
  - CNS injury
  - Stroke
- Workup should include thorough history and physical, electrolytes, and evaluation for infection. Additional workup should be directed by clinical suspicion.
- Neurology consultation may be warranted depending on etiology.

DISCUSSION

Note that patients undergoing neurosurgical procedures may receive seizure prophylaxis and this aspect of management is generally deferred to the neurosurgical or neurology team. The general internist, if consulting on these patients, still needs to be aware of medication side effects and drug interactions.

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Chapter 29
Cerebrovascular Disease

Anna L. Golob and Christopher J. Wong

PREOPERATIVE EVALUATION

Cerebrovascular disease as a risk factor for postoperative cardiovascular complications. A history of cerebrovascular disease is a risk factor for cardiovascular complications in several risk stratification tools, including the Revised Cardiac Risk Index [1] and the current ACC/AHA guidelines for perioperative risk stratification [2] (see Chap. 6).

RISK OF POSTOPERATIVE STROKE

A stroke is an uncommon but often greatly feared complication of surgery.

- Observed rate is 0.3–3.5% in general surgery patients, varying by age and other comorbidities [3].
- *Prior stroke* is likely a major risk factor: 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].
- Other possible risk factors include age (not independent, but as a marker of other cardiovascular disease), female gender, hypertension, diabetes, creatinine >2, smoking, COPD, peripheral vascular disease, EF <40%, CAD, heart failure, and symptomatic carotid stenosis [6].
- Approximately one-third of postoperative strokes are embolic in nature [6, 7].
- Atrial fibrillation is discussed elsewhere (Chaps. 9 and 23).

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RECENT CEREBROVASCULAR DISEASE EVENTS

A not uncommon situation for the medical consultant is the patient who has had a recent cerebrovascular event who is then considering surgery.

- Recommendations to delay elective surgery following a stroke vary widely, from 2 weeks to 3 months.
- We recommend evaluating each case individually with regard to the type and urgency of the surgery, the patient's comorbidities as a whole, and the extent to which the TIA/CVA symptoms are stable, have been fully evaluated, and intervened upon if appropriate (e.g., carotid endarterectomy for recurrent TIA/CVA due to a carotid lesion).
- Discussion with the patient's neurologist is usually indicated.

PHYSICAL EXAM

General cardiovascular examination and neurologic examination is indicated preoperatively for patients at risk for perioperative stroke.

An asymptomatic carotid bruit is not an indication for further workup prior to surgery:

- A prospective study of 735 patients undergoing elective abdominal, cardiothoracic, breast, and extremity surgery failed to show a significant perioperative risk associated with finding an asymptomatic carotid bruit on routine preoperative physical examination. However, this study excluded patients with active symptoms [8].
- In general, further workup (e.g., a carotid duplex) in a truly asymptomatic patient with no history of TIA/CVA is not necessary because of the poor correlation between asymptomatic bruits and significant carotid disease and the overall relatively low risk of perioperative CVA in patients with known mild to moderate carotid stenosis.
- A carotid duplex should be obtained in *symptomatic* patients, those with a history of TIA/CVA, and in asymptomatic patients planned for CABG given evidence for improved outcomes with combined CABG/CEA in patients found to have severe carotid stenosis [9].

POSTOPERATIVE MANAGEMENT

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

statins, 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. 23) [10]. Vigilance in detecting new-onset atrial fibrillation may reduce embolic disease.

POSTOPERATIVE STROKE

When a postoperative stroke does occur, it may be associated with a high mortality, e.g., 26% in one series, although estimates vary [7].

Management, in general, should proceed in the same way as a stroke not associated with a procedure. However, important considerations are the following [10]:

- 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. In some cases, 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 and normal oxygenation and preventing fever remain important.
- Hyponatremia may be more difficult to avoid in the postoperative setting secondary to third spacing.

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PART XII
Rheumatology

Chapter 30

Perioperative Management of the Patient with Rheumatologic Disease

Elizabeth Kaplan

GENERAL PRINCIPLES

Patients with rheumatologic disease, e.g., rheumatoid arthritis (RA) and systemic lupus erythematosus, should receive the same preoperative cardiovascular, pulmonary, and other risk assessment as other patients.

- Evaluate the preoperative status of the patient's rheumatologic disease. In general, surgery during active flares of disease should be avoided.
- Make note of any hypercoagulable states, especially in patients with systemic lupus erythematosus (SLE).
- Assess recent history of and current steroid use, including pulse of steroids within the last year, even if the patient is no longer taking steroids (see Chap. 22).
- Determine the level of immune suppression.
- Recommend coordinated care with patient's rheumatologist.

RHEUMATOID ARTHRITIS

PREOPERATIVE EVALUATION: HISTORY TAKING FOR PATIENTS WITH RA

- Length of disease (disease duration is associated with more joint damage, particularly neck involvement)
- Current functional status
- Specific joints affected
- Current medications

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- Previous and current use of steroids
- Extra-articular manifestations of disease
- Previous complications associated with surgery

SPECIFIC PERIOPERATIVE CONCERNS FOR PATIENTS WITH RA [1]:

- Cardiovascular disease: Patients with RA are at increased risk of cardiovascular disease, particularly those with poorly controlled or long-standing disease. Cardiovascular risk stratification is not necessarily different with respect to the current ACC/AHA algorithm, but particular attention should be paid to possible cardiac symptoms in patients with RA.
- Pulmonary disease: Patients with RA may have a variety of different pulmonary complications of their disease including fibrosis, bronchiolitis, and pleuritis. Depending on their severity, these complications may impact the patient's pulmonary status in the perioperative period. Preoperative evaluation should include a thorough history of these conditions, if present, and consideration of workup if the patient has undiagnosed pulmonary symptoms at the time of the preoperative evaluation.
- Cricoarytenoid arthritis: Up to 75% of patients with RA may have arthritis of the cricoarytenoid joints. Arthritis of these joints may lead to difficulties with intubation or postoperative airway obstruction (due to irritation from ET tube). History of hoarseness, sore throat, and trouble with inspiration may be a clue to its presence although most patients are asymptomatic. This entity should be considered in a postoperative patient who is having respiratory difficulty [1].
- Cervical spine disease: Underlying C1–C2 subluxation, atlantoaxial impaction, or subaxial disease can put patients at risk for cervical spine injury when a patient's neck is manipulated during surgery (for intubation or positioning). Consider cervical spine films flexion/extension if the patient is undergoing orthopedic surgery specifically for his/her rheumatologic disease (suggests more severe overall disease), has had disease for >5 years, or has any neurologic abnormality corresponding to the cervical spine on exam. If plain films are abnormal, then it is recommended to discuss with the patient's rheumatologist and anesthesiologist prior to the surgery, and consider further evaluation with an MRI.

PREOPERATIVE EVALUATION: STUDIES TO CONSIDER IN PREOPERATIVE EVALUATION FOR PATIENTS WITH RA

- CBC to look for leukopenia related to drugs, anemia related to drug-associated duodenal irritation, and/or bone marrow suppression.
- LFTs, renal function (because of effects some RA drugs can have on these systems).
- Walking O_2 sat if history or suspicion of pulmonary complications of RA.
- Consider cervical films as discussed above.

PERIOPERATIVE MANAGEMENT OF ANTIRHEUMATIC AGENTS (TABLE 30.1)

Note that dosing of medication should be confirmed with the patient's pharmacy and/or rheumatologist.

SYSTEMIC LUPUS ERYTHEMATOSUS

- Patients with SLE have a higher risk for CAD at a relatively younger age and the presence of antiphospholipid antibodies confers a higher risk for both heart valve disease as well as thrombosis.
- There is a two- to sevenfold higher mortality rate for SLE patients undergoing both nonelective and elective hip and knee surgery compared to RA patients and controls independent of major medical co-morbidities [7].
- Important perioperative issues are medication management, thromboembolic disease, hematologic abnormalities, renal disease, immune dysfunction, and increased risk of CAD.
- Reduce risk of perioperative MI and thrombosis by addressing traditional risk factors such as smoking, use of oral contraceptive pills (OCPs), and having good blood pressure and lipid control in the preoperative setting.
- In patients with established thromboembolic disease and antiphospholipid antibody syndrome (APS), bridging therapy for anticoagulation is recommended (see Chap. 23).
- If the patient has Raynaud's phenomenon, cooling perioperatively should be limited to avoid digital ischemia.

TABLE 30.1 PERIOPERATIVE MANAGEMENT OF ANTIRHEUMATIC AGENTS

Methotrexate	■ Usually given once weekly ■ A prospective randomized trial of patients with RA undergoing elective orthopedic surgery showed fewer complications, infections, and flares in the group that continued methotrexate rather than discontinuing it [2] ■ General consensus is to continue it unless surgery is being done for a serious infection. Reasons to consider stopping medication include post-op infection, rising creatinine, prolonged NPO state, patient over age 70 ■ Recommend discussing with the patient's rheumatologist
Leflunomide (Arava®)	■ Consider stopping in patients in whom large wounds are anticipated. There is no clear data for management of leflunomide, and discussion with the patient's rheumatologist is usually warranted ■ One trial showed no difference in wound healing in orthopedic surgery patients [3]; however a second trial showed that it did affect wound healing ■ Note that long half-life (~2 weeks) may make complete discontinuation problematic
Sulfasalazine	■ Generally acceptable to continue [4]
Azathioprine	■ May be continued for minor procedures and held for a few days for major procedures, although no clear data to suggest that this is necessary [4]
Hydroxychloroquine (Plaquenil®)	■ Generally acceptable to continue ■ One retrospective study showed no difference in postoperative wound healing or infections [4]

TNF-alpha inhibitors—infliximab (Remicade®), adalimumab (Humira®), etanercept (Enbrel®)	■ Some small studies ($n = 31$ or less) have not shown a difference in orthopedic surgery, but were likely underpowered [4–6] ■ One group recommends for "sterile" site surgery to hold infliximab for 1 month, adalimumab for 3–4 weeks, and etanercept for 1–2 weeks, and for "septic" environment or risk surgery (abdominal surgery, joint replacement) to stop these agents for twice as long [4] ■ Postoperatively it is recommended to restart these agents once wound healing is complete and there is no evidence of infection usually not earlier than 10–14 days postoperatively [4] ■ We recommend discussion with the patient's rheumatologist and surgeon regarding the use of these agents in the perioperative period ■ If decision is to hold the drug (which is most likely the case for moderate to intense procedures), hold based on ½ life and hold at least two half-lives. Half-lives are listed below: ■ Etanercept (Enbrel®): 3.5–5.5 days ■ Adalimumab (Humira®): 10–20 days ■ Infliximab (Remicade®): 9.5 days ■ Certolizumab (Cimzia®): 14 days ■ Golumimab (Simponi®): 14 days
Anakinra (Kineret®), Rituximab, Abatacept (Orencia®)	Recommend discussion with the patient's rheumatologist
NSAIDs	(See Chap. 4, perioperative medication management)

OTHER RHEUMATOLOGIC DISEASES

- Consider involving the patient's rheumatologist.

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Chapter 31
Gout and Pseudogout

Elizabeth Kaplan

Surgery is a risk factor for development of crystal arthropathy, or for a flare of preexisting crystal arthropathy [1]. Gout is in the differential diagnosis of postoperative fever. 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. Gout should be considered in patients with joint pain, unexplained fever, leukocytosis, or difficulty with physical therapy. Correctly diagnosing postoperative gout may lead to earlier treatment of the patient, and may reduce the need for unnecessary infectious workup.

PREOPERATIVE ASSESSMENT

- Assess for a history of gout, including uric acid levels, medication regimen, and whether there were any previous postoperative gout attacks.
- Generally continue prophylactic medications (e.g., allopurinol) up until surgery and resume postoperatively when possible.

POSTOPERATIVE MANAGEMENT

- Attention to adequate hydration.
- New meds may induce gouty attack (e.g., diuretics, cyclosporine).
- Mobilization.

DISCUSSION

For an acute arthritis, consider the following:

- Location—Crystal arthropathies are often in large joints (e.g., knee, ankle).
- Pseudogout is common.

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- Assess clinical suspicion for septic joint—Arthrocentesis may be needed to rule out infection, as opposed to ruling in crystal disease.

GOUT

Consider gout 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; however they can be as late as almost 3 weeks postoperatively. Uric acid levels can vary in either direction (increased or decreased) at the time of an attack, and should not be used to make or exclude the diagnosis.

PSEUDOGOUT

Making a diagnosis of pseudogout is important to avoid unnecessary uric acid-lowering therapy. X-rays may show calcium pyrophosphate deposition, but this finding is neither specific nor sensitive for pseudogout. Arthrocentesis remains the gold standard. This diagnosis should strongly be considered in a postoperative patient with acute knee arthritis.

TREATMENT OF ACUTE POSTOPERATIVE GOUT OR PSEUDOGOUT (GENERALLY SAME FOR BOTH)

Typical medications used to treat acute crystal arthropathy may be relatively contraindicated in the immediate postoperative setting—always work with the surgery team to make the best treatment decision.

Consider intra-articular injection especially if flare is limited to one joint.

NSAIDs—May be contraindicated if renal failure or surgical bleeding risk.

Prednisone—May be contraindicated for concerns of wound healing, hyperglycemia, and infection risk.

Colchicine—GI side effects may limit the use in patients post abdominal surgery.

IL-1 inhibitor such as anakinra—These medications are expensive, and may be contraindicated because of concerns about effects on wound healing. Recommend involving rheumatology service if this medication is considered.

For difficult cases, consultation with a rheumatologist is indicated.

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PART XIII
Special Populations

Chapter 32

Perioperative Care of the Bariatric Patient

Ronald Huang and Ashok Reddy

Bariatric surgery is an effective long-term treatment for weight reduction [1–5]; improves obesity related comorbidities [1–5]; and decreases mortality [4]. The NIH has developed consensus guidelines on appropriate candidates for bariatric surgery: BMI >40 or BMI between 35 and 40 with a serious obesity-related health problem (e.g., Hypertension, Diabetes Mellitus (DM), Obstructive Sleep Apnea (OSA), dyslipidemia); acceptable operative risk; and ability to make necessary lifestyle changes and participate in long-term follow-up [6].

The most common bariatric surgeries performed are the Roux-en-Y gastric bypass (RYGB) (open and laparoscopic) and laparoscopic adjustable gastric band (LAGB). A laparoscopic sleeve gastrectomy (LSG) is being increasingly utilized as more data support its efficacy and safety. A description of the most common surgeries is shown in Table 32.1.

PREOPERATIVE EVALUATION

Overall success in the management of patients undergoing bariatric surgery comes from a coordinated multidisciplinary approach between social work, nutrition, pharmacy, primary care providers, endocrinology, internal medicine, and surgery.

- Obesity alone has not been demonstrated to be a risk factor for postoperative complications [7]. However, the history and physical exam may underestimate the degree of cardiac and pulmonary dysfunction experienced in these patients [7].
- Pulmonary complications related to obesity result from an increased demand for ventilation and breathing workload, respiratory muscle inefficiency, decreased functional reserve

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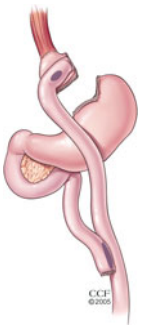
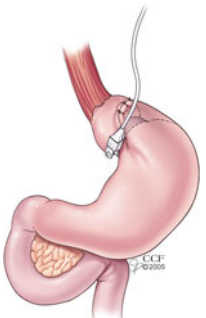
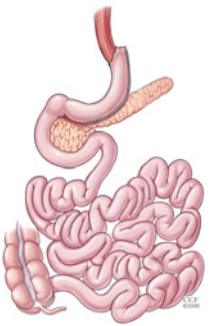
TABLE 32.1 DIFFERENCES BETWEEN ROUX-EN-Y GASTRIC BYPASS, LAPAROSCOPIC ADJUSTABLE GASTRIC BAND, AND LAPAROSCOPIC SLEEVE GASTRECTOMY [3, 6]

Surgery	Roux-en-Y gastric bypass (RYGB)	Laparoscopic adjustable gastric band (LAGB)	Laparoscopic sleeve gastrectomy (LSG)
Description	Involves making a small pouch of the stomach, just below the esophagus, that empties into a loop of jejunum. Surgery can be performed both open or laparoscopically	A device is placed around the uppermost portion of the stomach and can be adjusted to allow tailoring of the stoma outlet	The stomach is reduced in size by removal of a large portion of the stomach following the major curvature of the stomach
Images			
Reduction in BMI (kg/m^2)			
6 months	10.82	5.20	8.75
1 year	15.34	7.05	11.87
Weight loss at f/u >3 year (kg)	41.5 kg	34.8 kg	–

capacity, and closure of peripheral lung units [8]. Conditions to explore in the preoperative period include cor pulmonale, sleep apnea, pulmonary hypertension, and obesity-hypoventilation syndrome.

- Obesity-related comorbidities that influence preoperative cardiac assessment and management of obese patients include CAD, CHF, HTN, pulmonary hypertension, history of PE/DVT, and poor exercise capacity [7].
- A mortality risk assessment tool has been developed and validated to predict the risk with bariatric surgery, as shown in Table 32.2 [9]
- Current evidence does not support routine preoperative testing. Additional testing by the preoperative medical consultant should be determined by the history and physical (e.g., consideration of echocardiogram in the setting of CHF, pulmonary HTN, or poor exercise capacity suspected to be due to a cardiopulmonary cause). One should consider carefully how testing would change management.
- Bariatric surgeons often have their own protocols for preoperative testing. Depending on which type of bariatric surgery is planned the preoperative evaluation may include ultrasound of the gallbladder, endoscopy, upper GI series, fasting blood work (CBC, CMP, lipids, HA1c, TSH, Vit D 25-OH), PFTs (with ABG, full spirometry, and lung volumes), or testing for sleep apnea.
- Discontinue smoking for at least 3 months.
- Treat OSA with positive airway pressure for at least 2 weeks.
- There is evidence that very-low-calorie diets (1,000 cal per day × 3 weeks before surgery) may significantly reduce liver volume and improve operative exposure [8].

POSTOPERATIVE MANAGEMENT

NUTRITION

- Proper hydration and adequate nutrition are the focus of the postoperative bariatric diet.
- Postoperative bariatric diets vary according to institution but most follow a similar progression:
  - Patients are started on a clear liquid diet within the first 24 h after surgery.
  - The diet can typically be advanced to a full liquid diet with a high protein content prior to discharge.

TABLE 32.2 OBESITY SURGERY MORTALITY RISK SCORE (OS-MRS) PRIOR TO BARIATRIC SURGERY [9]

Class based on OS-MRS (points)	Mortality (90-day) (%)
A (0–1)	0.2
B (2–3)	1.2
C (4–5)	2.4

A point is given for BMI ≥50 kg/m², male gender, HTN, known risk factors for PE (previous thromboembolism, IVC filter, hypoventilation, pulmonary HTN), age ≥45
Reprinted with permission from [9]

  - The diet may be advanced upon discharge or on the first postoperative visit to include soft or pureed food.
- In the immediate postoperative period, patients should be reminded to eat more slowly and to eat more frequent but smaller meals, to stop eating when they are full, and to separate food from fluids by at least 30 min.
- The dietary changes following bariatric surgery are typically better tolerated for patients undergoing LAGB as opposed to RYGB or LSG since the band is not tightened when it is placed initially.
- Patients are at risk for nutrient deficiencies. Following RYGB and LSG, patients are started on a multivitamin with minerals and iron per day, calcium 1,200-1,500 mg per day (calcium citrate is preferred as it does not require an acid environment for absorption), and vitamin D3 (cholecalciferol) 800–1,200 IU per day. Approximately 6 weeks after surgery, patients will start vitamin B12 supplementation. Patients who undergo LAGB are not at the same increased risk of nutrient deficiency as those who undergo RYGB or LSG, but these patients are typically given the same supplementation.

MEDICATIONS

- Following bariatric surgery, medications must be crushed or given as a liquid. Most controlled or extended-release medications cannot be crushed or changed into a liquid formulation, so they must be changed after surgery to immediate-release medications with more frequent dosing.

- Bariatric surgery changes the pharmacokinetics of many drugs. The increase in gastric pH and the decrease in intestinal surface area available for absorption can decrease the bioavailability of a medication. This is particularly important for medications with narrow therapeutic indices such as psychiatric, antiepileptic, or transplant medications. Drug levels can be checked for most of these medications and should be followed postoperatively.
- Medication changes should be anticipated in the preoperative setting. For those patients who are taking numerous medications, controlled- or extended-release medications, medications with narrow therapeutic indices, or medications that have been shown to be problematic postoperatively, we recommend an evaluation by an experienced pharmacist.
- Diabetic patients are at risk for hypoglycemia postoperatively. Patients who undergo RYGB are at the greatest risk of hypoglycemia. In addition to decreased caloric intake, and rapid weight loss after surgery, the anatomic changes following RYGB affect hormone signaling and glucose metabolism. These patients may have dramatic decreases in the amount of insulin that they require starting on the first day or two after surgery. Patients who undergo LAGB have comparatively slower improvements in glucose control. Regardless of the type of bariatric surgery, all patients with diabetes should have their blood glucose monitored frequently after surgery. Oral sulfonylureas and meglitinides should be discontinued after bariatric surgery. Metformin should be held postoperatively but can safely be resumed once acceptable renal function is confirmed. Patients taking insulin preoperatively are initially managed postoperatively with an insulin infusion protocol while NPO. When transitioning to SC insulin, their basal insulin requirement is usually significantly reduced. See Chap. 21 for additional information.
- Patients who are taking antihypertensives are at risk for hypotension and electrolyte abnormalities postoperatively. Antihypertensive medications should be resumed carefully after bariatric surgery. Although most patients will still require antihypertensive medications at discharge, they may be able to achieve adequate blood pressure control with reduced doses or fewer medications. Patients receiving preoperative beta-blockers for cardiovascular indications should have these continued postoperatively (see Chap. 8). Diuretic agents are typically discontinued after bariatric surgery to avoid both hypotension and electrolyte abnormalities.

ROUTINE POSTOPERATIVE COURSE

The routine postoperative course depends on the type of bariatric surgery and whether the procedure was open or laparoscopic. Please see Chap. 40.

EARLY POSTOPERATIVE COMPLICATIONS

This handbook focuses on the most common complications of bariatric surgery that occur in the early postoperative period. It is important to note that many of the complications of bariatric surgery have similar presentations which can make diagnosis difficult. Physicians caring for patients after bariatric surgery must be aware of all of the possible complications.

Anastomotic leaks: The rate of anastomotic leak for RYGB was previously reported to be 2.2% [3], but a more recent review reported the rate to be 0.49% [10]. Leaks are potentially fatal and are important to recognize. They may present as sustained tachycardia or respiratory distress. Patients may also have new or worsening abdominal complaints. Anastomotic leaks can be evaluated with an upper gastrointestinal (UGI) study or by CT. If there is a high suspicion for a leak, exploratory surgery is indicated despite negative studies [8].

Venous thromboembolism (VTE): The rates of pulmonary embolism (PE) for open RYGB, laparoscopic RYGB, LSG, and LAGB have recently been reported as 0.1%, 0.12%, 0.32%, and 0.02%, respectively [5]. Pulmonary Embolism (PE) is one of the most common causes of mortality following bariatric surgery [8]. The presenting symptoms of PE are similar to anastomotic leaks and both should be considered in the appropriate clinical context. Diagnosis of a PE is usually made with CT angiogram. Anticoagulation is indicated when there is a high suspicion for PE. Anticoagulation can usually be started safely within days after surgery, but this must be discussed with the surgeon [8]. If anticoagulation is contraindicated, an IVC filter can be considered. Thrombolytics should be avoided in the early postoperative period. There is no consensus about prophylactic VTE regimens but most patients should receive sequential compression devices in addition to heparin or low-molecular-weight heparin. Patients should also be

encouraged to ambulate early. Although they have not been universally accepted, preoperative IVC filters can be considered in patients at high risk for PE [8].

Respiratory failure: Respiratory failure is a significant cause of morbidity following bariatric surgery because of the higher rates of obesity-hypoventilation syndrome and OSA in this population. The overall rate of respiratory failure has recently been described to be 0.99% [10]. Prolonged ventilator dependence or reintubation is more common following RYGB than LSG or LAGB [5, 10]. The prevention and treatment of respiratory failure include aggressive pulmonary toilet, incentive spirometry, oxygen supplementation, and early use of CPAP postoperatively when indicated [8].

Cardiac complications: The overall rate of cardiac arrest and myocardial infarction is approximately 0.1% or less [5, 10]. The prevention and management of cardiac complications following bariatric surgery is the same as for other surgeries.

Bleeding: Bleeding occurs at a higher rate (2.0%) in RYGB compared with LAGB (0.3%) [3]. Similar rates have been described more recently [10]. Indications to transfuse blood products are the same as for other surgical procedures. Patients may require an operative intervention if bleeding is persistent or severe.

Wound complications: Wound complications range in severity and include superficial and deep infections and wound dehiscence. Definitions vary by study along with the rates of wound complication. Wound complications are more common in RYGB and are more common for open RYGB than laparoscopic RYGB [5, 10]. Wound complications are primarily managed by the surgical team.

DISCUSSION

The above recommendations pertain to bariatric surgery. Severely obese patients present significant challenges to perioperative assessment and management for non-bariatric surgery. Usual testing strategies may be compromised due to weight limits for diagnostic testing, poor image quality, etc. Guidelines are available for cardiac evaluation and management of the severely obese patient undergoing surgery [7].

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Chapter 33

Perioperative Care of the Patient with a Solid Organ Transplant

Reena Julka and Christopher J. Wong

Patients with solid organ transplants are living longer and frequently undergo surgery that is unrelated to their transplant [1]. Often these patients are many years out from transplantation, and are primarily being managed by primary care providers. In most cases these patients still require specialty care, but internists are expected to have a working knowledge of care of such patients.

PREOPERATIVE EVALUATION

- Time since transplant
- Status of transplanted organ:
  - Current function (e.g., for a liver transplant recipient, would include LFTs, INR, platelet count, creatinine, last liver biopsy).
  - Presence of recurrent disease in the transplanted organ (example: hepatitis C).
  - Prior episodes of rejection and increased immunosuppression.
  - Function of other organs that may be affected by immunosuppressive regimen or transplanted organ dysfunction (e.g., renal disease from calcineurin inhibitors such as tacrolimus or cyclosporine).
- Assess immunosuppressive regimen and plan for perioperative management, especially if patients are expected to be NPO.
- Assess chronic corticosteroid use—maintenance dose, previous pulses of high-dose steroids for rejection, prior episodes of adrenal insufficiency with infection or procedures (see Chap. 22).

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- Anticipate common drug interactions with immunosuppressive meds (e.g., cyclosporine and azoles/warfarin).
- Consider involvement of the appropriate transplant/specialty service to evaluate the patient for a complete preoperative assessment of the transplanted organ. Subsequently coordinate with the transplant/specialty team to make a plan for whether they will need to follow the patient postoperatively.

POSTOPERATIVE MANAGEMENT

- Watch for opportunistic infections.
  - Keep in mind that this immunosuppressed patient population may not present with typical features of infection such as fever or leukocytosis.
  - Patients who are doing well greater than 6 months post transplant 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.
  - CMV remains a risk even beyond 6 months post transplant. CMV-negative hosts with CMV-positive donors are at the highest risk. A good screening test for CMV is the serum PCR. Identification of end-organ damage is important—some patients have CMV viremia but no active CMV disease; conversely, if there is a high level of suspicion for end-organ disease, a negative serum PCR should not necessarily dissuade further workup. If postoperative CMV infection is a concern, consultation with the transplant team and an infectious disease specialist is appropriate.
  - Consultation with transplant team/infectious disease team is often appropriate when there is high suspicion of infection or an identified infection as adjustments may need to be made in the antibiotic or immunosuppressant regimen.
- Supplemental ("stress") dose steroids when indicated (see Chap. 22).
- If NPO postoperatively, convert antirejection meds to IV. Table 33.1 *shows general guidelines—please consult with a transplant pharmacist*.

TABLE 33.1 COMMON ANTIREJECTION MEDICATIONS PO TO IV CONVERSION

Cyclosporine	Give 1/3 of total daily PO dose as continuous infusion over 24 h (e.g., usual dose of 75 mg po bid, total is 150 mg, 1/3 = 50 mg, can give as 2.1 mg/h IV infusion). Monitor levels daily Note when converting back to oral cyclosporine, the common oral formulations Neoral® and Sandimmune® are *not* equivalent 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 33.2 COMMON DRUG INTERACTIONS WITH CYCLOSPORINE AND TACROLIMUS

Increase levels	Decrease levels
Erythromycin	Rifampin
Azole antifungals	Phenytoin
Diltiazem	Phenobarbital
Verapamil	Carbamazepine
Metoclopramide	
Grapefruit juice	

- Cyclosporine and tacrolimus have multiple drug interactions. A partial list is shown in Table 33.2. It is best to review any new medication for possible interactions prior to starting it.
- Consider monitoring of immunosuppression in hospitalized patients to ensure therapeutic levels. Cyclosporine and tacrolimus, in particular, can compromise renal function and one may want to avoid administration of other nephrotoxic agents such as NSAIDs.
- Sirolimus (Rapamune®) may impair wound healing.

DISCUSSION

Patients who are recipients of solid organ transplants generally require specialized care. One of our roles is to ensure good coordination of care and to assist in evaluation of complications unique to this population.

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Chapter 34
Decision-Making Capacity

Kara J. Mitchell

Surgeons obtain informed consent from patients for the procedures they perform. Occasionally, however, the Medical Consultant will be asked to assist with assessment of a particular patient's capacity (or lack thereof) to consent to evaluation and/or treatment.

Patients are presumed to possess decision-making capacity, unless a clinical evaluation suggests that it is lacking [1–3].

Studies suggest, however, that clinicians frequently fail to recognize when patients lack decision-making capacity [1,3].

Often, the decision-making capacity of patients is questioned only when:

- The decision to be made is particularly risky or complex or
- The decision that a patient has made is in conflict with what a provider has recommended [2,3].

RISK FACTORS FOR INCAPACITY

WHAT RISK FACTORS SUGGEST THE POSSIBILITY THAT A PATIENT MAY LACK MEDICAL DECISION-MAKING CAPACITY? [2,3]

- Developmental delay
- Alzheimer Disease and other forms of dementia or cognitive impairment
- Psychiatric illness
- Residence in a Skilled Nursing Facility
- Parkinson's Disease
- Hospitalization for medical illness
- Diagnosis of brain tumor

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Note that a significant percentage of patients with these risk factors, including those with psychosis, dementia, or developmental delay, will *possess* decision-making capacity.

DO PATIENTS WITH DEMENTIA ALWAYS LACK DECISION-MAKING CAPACITY?

No. Measures of cognitive function such as the Mini-Mental Status Examination (MMSE) correlate with decision-making capacity at high scores (indicating that the patient is more likely to have capacity) and low scores (indicating 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 [1,3,4].

ASSESSING CAPACITY

WHAT ABILITIES MUST PATIENTS POSSESS IN ORDER TO DEMONSTRATE DECISION-MAKING CAPACITY? [1,3]

- Ability to communicate a choice.
- Ability to understand relevant information (risks/benefits/alternatives) regarding a proposed test or a treatment.
- Ability to appreciate the current situation and its consequences.
- Ability to manipulate information rationally.

Note:

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.

Take care to exclude the possibility of "pseudo-incapacity": the situation in which patients cannot understand information presented in medical jargon, nonnative language, rushed manner, or other improper format [3,5]. Speak in plain language, use hearing aids, use proper translation, use diagrams, and other communication tools. Provide the opportunity to ask questions for clarification.

WHAT TOOLS ARE AVAILABLE TO ASSESS THE DECISION-MAKING CAPACITY OF PATIENTS?

There are many. Of these, the Aid to Capacity Evaluation can be performed within 30 min, 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.jointcentreforbioethics.ca/tools/ace.shtml [3,5]. Other advantages of this tool include its associated availability of free training materials, its focus on the actual decision to be made by your patient, and its facilitation of clinical documentation [2,3,5].

If the capacity assessment is complex, consider involving an appropriate specialty consultant or ethics committee [1–3].

CAN A PATIENT'S DECISION-MAKING CAPACITY CHANGE?

Yes. 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. 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.

If a patient is found to lack capacity, efforts should be made to 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.

MANAGEMENT OF INCAPACITY

WHAT SHOULD I DO IF MY PATIENT LACKS DECISION-MAKING CAPACITY?

This 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.

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Chapter 35
Substance Abuse and Dependence

Ashok Reddy

Substance abuse and dependence are prevalent problems in the general population and can pose risks in the perioperative setting. Excessive levels of alcohol use can increase the risk of perioperative morbidity—including cardiopulmonary, infections, wound, bleeding, and neurologic complications [1]. Surgical patients who drink over four drinks daily have a two- to threefold increased risk for postoperative complications when compared to patients who drink less than two drinks a day [1].

PREOPERATIVE EVALUATION

- Patients should be assessed for substance abuse or dependence. There are various screening tools, including the Audit-C questionnaire for alcohol abuse or dependence as shown in Table 35.1. In analyses adjusted for age, smoking, and days from screening to surgery, the estimated prevalence of postoperative complications increased from 5.6% (95% CI 4.8–6.6%) in patients with AUDIT-C scores 1–4, to 7.9% (6.3–9.7%) in patients with AUDIT-Cs 5–8, 9.7% (6.6–14.1%) in patients with AUDIT-Cs 9–10, and 14.0% (8.9–21.3%) in patients with AUDIT-Cs 11–12 [3].
- In heavy alcohol users (five or more drinks a day), one study showed that 4 weeks of preoperative abstinence decreases the risk of postoperative complications [4].
- Acute withdrawal may contribute to postoperative morbidity and should be avoided if possible.
- The use of illegal drugs is associated with pulmonary and cardiac complications that may affect management in the perioperative setting [5]. Identifying patients who abuse illegal

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TABLE 35.1 SCREENING ASSESSMENT: AUDIT-C QUESTIONNAIRE (3 QUESTIONS) [2]

Question 1: "How often did you have a drink containing alcohol in the past 12 months?"
Response (Score): Never (0), Monthly or less (1), 2–4 times a month (2), 2–3 times a week (3), 4 or more a week (4)
Question 2: "How many drinks containing alcohol did you have on a typical day when you were drinking in the past 12 months?"
Response (Score): 0 Drinks (0), 1–2 Drinks (0), 3–4 Drinks (1), 5–6 Drinks (2), 7–9 Drinks (3), and 10 or more (4)
Question 3: "How often did you have 6 or more drinks on an occasion in the past 12 months?"
Response (Score): Never (0), Less than monthly (1), Monthly (2), Weekly (3), and Daily (4)
AUDIT-C score is the sum of the points from each question (range 0–12 points)

drugs can be screened effectively using a single question: "How many times in the past year have you used an illegal drug or used a prescription medication for nonmedical reasons?" In an urban primary care setting, this single screening question was 100% sensitive (95% confidence interval [CI], 90.6–100%) and 73.5% specific (95% CI, 67.7–78.6%) for the detection of a drug use disorder [6].

- An injection drug use history should prompt investigation for infectious or other complications.
- Active substance abuse or dependence identified during preoperative evaluation is an indication for referral to primary care and counseling or rehabilitation resources. Other than for alcohol, there is limited data for interventions to improve perioperative outcomes, however.

POSTOPERATIVE MANAGEMENT

Patients at risk for withdrawal as identified during preoperative evaluation should have appropriate measures taken, including a symptom-triggered withdrawal management protocol. A high degree of suspicion is important in keeping substance problems in mind in patients who have postoperative complications. Withdrawal

syndromes are in the differential diagnosis of delirium in the postoperative setting (see Chap. 38). In some cases, patients have undergone emergency surgery and are unable to provide a history—additional information regarding substance use may need to be obtained from other sources. Patients identified with substance abuse or dependence should be referred to appropriate rehabilitation services.

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PART XIV

Postoperative Management: General Principles

Chapter 36
The Postoperative Evaluation

XIV

Nason P. Hamlin and Christopher J. Wong

Different hospitals have varying models regarding medical consultation. Some medicine consult services predominantly perform preoperative evaluations; others also work in the inpatient setting providing postoperative expertise. This section is for those medical consultants who provide care postoperatively.

POST ANESTHESIA CARE UNIT ASSESSMENT

Assessing patients in the Post Anesthesia Care Unit (PACU) following surgery provides a great opportunity to avert problems and enhance continuity of care.

CHART REVIEW

- Pre-op evaluation: Review the patient's preoperative evaluation.
- Surgery: Did the patient receive the surgery that was planned, or were there unanticipated changes or complications? Check the estimated blood loss (EBL)—typically found in the anesthesia record or the operating note, or directly from communication with the surgery or anesthesia teams.

HISTORY AND EXAM

Ask patients about chest pain, shortness of breath, nausea, and level of pain. Patients often have limited mobility immediately on recovery from surgery and the physical examination may be necessarily adjusted.

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VITAL SIGNS:

1. Temperature: Post-op patients are often hypothermic which increases their risk of complications. PACU nurses are usually attuned to this and will put a warming blanket (e.g., Bair Hugger®) on the patient.
2. Blood pressure: Patients may have transient hypertension due to pain. Make sure that the pain is acceptably controlled before aggressive BP management. Shivering or tremors can also lead to a spuriously elevated BP reading on the automatic BP cuff. When in doubt, check it manually.

MANAGEMENT

Remember that patients are still coming out of anesthesia, so a negative response does not necessarily mean that there is no problem. Do not let a lack of chest pain steer you away from ordering an ECG and cardiac enzymes on a patient at substantial risk for post-op MI. Check the surgeon's orders to make sure that the medications are correct. Ensure that the recommendations in the preoperative medical evaluation are being followed.

Common items to review:

- Diabetes management: Check insulin orders (see Chap. 21).
- Cardiovascular medications: Check for correct hold parameters for blood pressure meds and beta-blockers. Make sure that patients on beta-blockers pre-op for cardiovascular indications have them continued post-op (see Chap. 8).
- If you write orders (after discussion with the primary team), make sure to let the patient's nurse know. In hospitals that use paper chart orders, admission orders may already be sent to the nursing unit, and new orders may be missed. In hospitals that use computerized provider order entry (CPOE), orders may still be missed in transition and good communication remains essential during the transition from PACU to the nursing unit.

If the patient's condition warrants a change in post-PACU care (for example, requiring ICU or telemetry), make those recommendations and call the primary team.

DAILY POSTOPERATIVE EVALUATION

- Review interval history, examination, medication list, and labs/studies as you would for any medical patient.
- Review drains and catheters—these may not be as common in medical patients.
- What is the surgery team's plan? Discuss with the surgery team if in doubt.
- All patients: Is there appropriate VTE prophylaxis? (See Chap. 17.)
- Lung expansion maneuvers: Are they indicated, and, if so, being done?
- Pay attention to side effects of pain medications and sedatives.
- Comment on each problem you are asked to evaluate, especially the medical concerns.
- Know the patient's current and anticipated bowel function status and whether they are able to receive PO medications.

IF YOU HAVE NEVER SEEN THE PATIENT BEFORE:

For the new post-op consult, the above information still needs to be gathered. In addition, make sure of the following:

- Obtain the information for the requesting provider (name, service, contact number).
- Understand the clinical question clearly.
- Give the requesting provider a time frame in which you expect to see the patient and contact him or her.
- Review the surgery—Were there complications? What was the duration, EBL, and method of anesthesia?
- Post-op course to date—Have there been complications? Is the recovery going as expected? You should have a general sense of the length of stay, average blood loss, and recovery period for the procedure—see Chap. 40, Surgery Notes, and keep in mind that there may be site-specific and patient-specific differences, and of course, if in doubt—ask your surgical colleagues.
- You may need to seek other collateral information—the patient may have post-op delirium or still be recovering from anesthesia. If you need better history, you may need to seek out the patient's family, the surgeon, and nursing staff. The pre-op med list is not always correct if there was no formal medical consultation pre-op—you may need to double-check the patient's baseline meds.

Chapter 37
Postoperative Fever

XIV

Kara J. Mitchell

POSTOPERATIVE FEVER PEARLS

- There is no consensus on the definition of fever; many use a temperature of ≥38.3C/101.0F [1]. Consider using a cutoff of 38.0C/100.4F for immunocompromised patients.
- Axillary, temporal artery estimates and chemical dot measurements of temperature are unreliable and should not be used [1].
- Atelectasis does *not* cause fever; it can cause hypoxia and should still be treated [2,3].
- Remember, patients may have infection in the absence of fever, especially with advanced age, corticosteroid use, and other risk factors; infection may occasionally present with *hypo*thermia [1]. Most early fever is due to cytokine release and resolves spontaneously [3].
- Watch for life-threatening causes of early fever such as malignant hyperthermia, neuroleptic malignant syndrome, serotonin syndrome, necrotizing fasciitis, toxic shock syndrome, transfusion reaction, etc.

TIMING AFTER SURGERY IS KEY TO CORRECTLY IDENTIFYING THE CAUSE OF A FEVER

Immediate causes of fever include cytokine release, medications, and transfusion reactions. After 48 hours, but within the first week, important considerations include surgical site infections, pneumonia, urinary tract infections, catheter infections, and many noninfectious causes (see Table 37.1) [4].

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TABLE 37.1 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
Medications, including malignant hyperthermia	Pneumonia	Thrombophlebitis/ DVT/PE
Transfusion reaction	UTI	*C. difficile*
Necrotizing fasciitis	IV catheter infection	Drug reaction
Infection, thrombosis, or other noninfectious causes present prior to surgery	Noninfectious: MI, DVT/PE, CVA/SAH, thrombophlebitis, hematoma, pancreatitis, alcohol withdrawal, gout, bowel ischemia, TTP, hyperthyroidism, adrenal insufficiency, transfusion or medication reaction, inflammatory reaction to implanted hardware, etc.	Nosocomial or other infections: Pneumonia, UTI, IV catheter, intra-abdominal abscess, sinusitis, otitis media, osteomyelitis, endocarditis, cholecystitis (can be acalculous), etc.

Watch for surgery-specific causes: i.e. meningitis after neurosurgery, toxic shock after nasal or vaginal packing, parotitis after oral surgery, rejection after transplant surgery, fat emboli after orthopedic surgery, infected hardware or graft material, etc.
Less common causes of postoperative fever: Neoplastic, collagen-vascular disease.
Medications commonly implicated with causing fever: Betalactams, phenytoin, heparin [4].

EVALUATION: EXAMINE THE PATIENT CAREFULLY FOR POSSIBLE SOURCE

- Cultures have little utility in the first 48 hours after surgery, unless there is suspicion for antecedent infection.
- Fever occurring after postoperative day 3, multiple days of fever, and maximum temperature of greater than or equal to 39C are predictors of a positive fever evaluation [5].

- A brief bedside evaluation has the highest yield for determining the etiology of a fever [6].
- After 72 hours, consider ordering the following tests, using the bedside evaluation and the clinical context as a guide [1,4]:
  - CBC 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 urinary catheter present, ideally remove catheter and obtain a clean catch specimen; if unable to remove catheter, then obtain sample from the catheter port (not urine bag)
  - Chest X-ray ± sputum gram stain and culture if pneumonia suspected
  - Tap fluid collections, as appropriate (pleural, peritoneal, joint, CSF, etc.)
  - Appropriate imaging (i.e., CT or ultrasound for abdominal pain)
  - Stool for *C. difficile* if suspicious diarrhea and recent antibiotics
  - Test for noninfectious causes, as indicated (lower extremity duplex, CT pulmonary angiogram, ECG, etc.)

TREATMENT: IDENTIFY AND TREAT THE UNDERLYING CAUSE

- Avoid empiric antibiotics unless they are indicated (i.e., the patient is neutropenic or hemodynamically unstable, or for certain suspected diagnoses, such as hospital-acquired pneumonia or meningitis). If 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.
- Acetaminophen may be given for comfort (risk of hepatotoxicity with liver disease or starvation); use aspirin and NSAIDs only with caution (risk of renal failure, GI ulceration, or wound bleeding) [7].

FEVER PREVENTION

- Discontinue unnecessary medications, especially antibiotics. In many uncomplicated surgeries, prophylactic antibiotics should be discontinued within 24 hours of surgery.
- Discontinue catheters as soon as possible (Foley, NG tube, central lines, etc.). For example, guidelines for urethral catheters recommend discontinuing within 24 hours of surgery unless there are indications for it to remain in place: acute urinary retention, critically ill patients requiring accurate measurements, open sacral or perineal wounds in incontinent patients, prolonged immobilization, and end-of-life care [8].
- The femoral site should be avoided for central venous catheters. The subclavian site is recommended over internal jugular to minimize infection risk, but site placement considerations should also consider complication risk in addition to infection control [9].
- Implementation of a plan to reduce ventilator-associated pneumonia, including sedation vacations, weaning plan, and semi-upright head positioning.
- Use enteral nutrition, when possible, instead of total parenteral nutrition.

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Chapter 38
Postoperative Delirium

Andrew A. White

PREOPERATIVE EVALUATION

Although delirium will primarily manifest in the postoperative period, appreciating the definition, incidence, and risk factors for delirium will facilitate planning during the preoperative evaluation.

DEFINITION

Delirium is a common and serious altered mental state that may develop due to a wide variety of medical conditions or drug side effects. It is characterized by the following:

1. Acute onset and fluctuating course
2. Inattention
3. Disorganized thinking or a change in cognition
4. Altered level of consciousness

Using the confusion assessment method (CAM), delirium is most reliably diagnosed by the presence of the first two findings and at least one of the last two [1]. According to the DSM-IV definition, it may also be accompanied by sleep disturbance, lethargy, hypervigilance, agitation, hallucinations, illusions, or emotional disturbances, although these features are not necessary for diagnosis [2]. Hypoactive delirium may be missed due to subtle manifestations. The pathogenesis of delirium is poorly understood and most likely multifactorial [3].

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INCIDENCE

Delirium may occur in up to 70% of post-surgery patients [4], but the incidence varies widely with the type of surgery, the urgency of the surgery, and the patient's preoperative risk factors. Meta-analyses have produced the estimates of incidence shown in Table 38.1.

Cardiopulmonary bypass is a notable surgery-specific risk factor for delirium that may be associated with more protracted or even permanent cognitive dysfunction, but studies in this area are heterogeneous. If an off-pump surgery is possible, it may reduce the risk of post-op delirium.

RISK FACTORS

In addition to the type of surgery, certain patient populations are inherently vulnerable to developing delirium. Risk factors are shown in Table 38.2 [1, 2]:

PREOPERATIVE SCREENING

Identifying patients at risk for delirium should be a priority in the preoperative evaluation and during inpatient consults. Screening tools include the cardiac surgery delirium prediction score, utilizing risk factors of prior stroke or TIA, mini-mental status exam score, depression and low albumin [7], and general elective surgery delirium

TABLE 38.1 ESTIMATES OF INCIDENCE OF DELIRIUM IN INPATIENTS

Type of surgery/reason for admission	Incidence of delirium
Hip fracture [5]	21.7% (4–53%)
Elective hip or knee replacement [4]	12.1% (9–28%)
Cardiac surgery [6]	32% (0–73%)
Major elective surgery [1, 2]	10% (9–17%)
Elective vascular surgery [1, 2]	34.5% (29–39%)
ICU care (surgical and medical patients >65-year-old) [3]	70–87%

TABLE 38.2 PATIENT RISK FACTORS FOR DELIRIUM

Age > 65	Cognitive dysfunction, especially dementia
Prior stroke	Prior history of delirium
Depression	Reduced preoperative functional status
Vision and hearing impairment	Preoperative psychotropic drug use
HIV	Drug and alcohol abuse
Renal or liver disease	Male gender
Malnutrition	

prediction score, of which the components include age, dementia, functional dependence, aortic and thoracic surgery, and abnormal laboratory values [8].

It is worth noting that these prediction rules have relatively good specificity (80–90%), but mediocre sensitivity (~50%). Thus, they cannot be used to exclude the possibility of delirium developing after an operation.

POSTOPERATIVE MANAGEMENT

DIAGNOSIS

First confirm the diagnosis of delirium by excluding other neurologic and psychiatric conditions. Then, focus on identifying precipitants with history, medication review, physical exam (particularly neurologic and cognitive exam), and basic lab tests (CBC, Chem 7, UA). When appropriate, ECG, CXR, drug levels, or a toxin screen may confirm a suspected etiology. Remember that the etiology may be multifactorial. Head CT scan is often not helpful unless there is a risk factor for intracranial bleeding (e.g., history of fall, or anticoagulant medicines), or evidence of new focal neurologic impairment.

PRECIPITATING ETIOLOGIES

Many medications and medical conditions can contribute to the development of delirium. 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, alcohol, antidepressants, anticholinergics, opioid analgesics, antipsychotics, anticonvulsants, antihistamines, corticosteroids, fluoroquinolones, and anti-Parkinsonian agents. Also be wary of polypharmacy.

Acute medical conditions: Fluid and electrolyte abnormalities (sodium, glucose, calcium), uremia, uncontrolled pain, hypoxemia, hypercarbia, fever, hypotension, anemia, infections (UTI, pneumonia, line infections), myocardial infarction, alcohol and drug withdrawal, constipation, and urinary retention.

Iatrogenic: Sleep cycle disruption, catheters and other "tethers" (IV lines, ECG leads, and restraints), lack of access to hearing aids, interpreter services, glasses, food, and water.

PREVENTION

Prevention trials utilizing behavioral and environmental approaches have demonstrated a reduction in delirium incidence (absolute risk reduction 5–18%) [9, 10]. Pharmacologic prevention trials in high-risk patients have not consistently shown any reduction in delirium incidence, but may affect duration and severity. In the absence of better data, prophylactic antipsychotics are not warranted [11].

Effective prevention strategies are shown in Table 38.3.

TABLE 38.3 PREVENTION OF DELIRIUM IN POSTOPERATIVE PATIENTS

Providing visual and hearing aids when appropriate
Early mobilization
Avoid volume depletion and electrolyte abnormalities
Discontinue or substitute high-risk medications
Frequent reorientation
Maintain day/night cycle by limiting naps, opening blinds, avoiding nighttime interruptions
Adequate pain control without oversedation

TREATMENT

Delirium is typically reversible if the precipitating factors are addressed. Identifying and treating underlying causes of delirium are essential for recovery. Simultaneously, consider ways to provide supportive care and, if necessary, manage behavioral symptoms. Due to methodological limitations, existing studies do not support the use of antipsychotics in the treatment of delirium [12]. However, antipsychotics may play a limited role in the management of behavioral or emotional symptoms. Second-generation antipsychotics are not superior to haloperidol, except when there is concern for extrapyramidal symptoms [13]. Treatment recommendations are shown in Table 38.4.

TABLE 38.4 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 and hypoxia
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 Constant observer or wander guard Consider securing or protecting vulnerable lines, drains, and wounds from harmful manipulation

(continued)

TABLE 38.4 (CONTINUED)

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) Risperidone (0.5 mg PO q 12 h PRN) is an acceptable alternative 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 often worsen confusion and sedation and should typically be avoided for behavior management

DISCUSSION

Perioperative delirium is associated with greater cost, longer length of stay, greater morbidity, increased likelihood of subsequent institutionalization, prolonged functional decline, and mortality [14]. Delirium is common, frequently under-recognized, and typically requires a multifaceted and individualized treatment. Medical consult teams should address the harm associated with delirium by (1) identifying patients at high risk during the preoperative evaluation, (2) partnering with bedside nurses to screen for postoperative delirium, (3) detecting and treating reversible triggers for delirium, and (4) emphasizing multidisciplinary environmental and supportive interventions [15].

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Chapter 39
Postoperative Ileus

Lauge Sokol-Hessner

KEY POINTS

Postoperative ileus is when gut dysmotility persists beyond the expected period for a given surgery.

Differential diagnosis includes small bowel obstruction (SBO), acute colonic pseudo-obstruction, and other significant intra-abdominal pathology—imaging is required to distinguish these.

Treatment is supportive:

NPO, intravenous fluid (IVF), and nasogastric (NG) tube only if significant pain, distension, or vomiting
Attention to electrolytes and medications, minimizing opiates
Reimage only if clinically indicated

Consider prevention strategies such as epidural local anesthetics, avoidance of systemic opioids, early postoperative feeding, and chewing gum. Do not routinely place a nasogastric tube.

BACKGROUND

Some degree of postoperative gut dysmotility is normal—on the order of hours for the stomach and small intestine and days for the colon—and can even occur after non-abdominal procedures. Postoperative ileus (POI) is when the dysmotility is prolonged, causing discomfort and preventing oral intake. Inhibitory neural reflexes, inflammation from intestinal manipulation and trauma, neurohumoral peptides, and systemic opioids are all thought to contribute to POI [1].

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EVALUATION

HISTORY

Suspect POI when the symptoms of postoperative ileus—abdominal distension and pain, nausea and vomiting, and inability to pass flatus or stool or tolerate a normal diet—persist for several days beyond when they were expected to resolve (this varies by type of surgery). Note whether the patient has a history of constipation, diabetic neuropathy or gastroparesis, and prior surgeries (which may make SBO more likely), and review their medications (with attention to anticholinergics, opiates, and laxatives or suppositories).

EXAM

Decreased bowel sounds, distension, mild diffuse tenderness, and tympany are common. Severe pain or peritoneal signs suggest a more severe problem (see "Differential Diagnosis" below).

LABS

Complete blood count—elevated WBC suggests infection, hemoglobin/hematocrit drop may reflect intra-abdominal or retroperitoneal bleeding.

Basic metabolic panel and magnesium—looking for renal dysfunction and electrolyte imbalance.

Consider a liver injury panel, amylase and lipase based on history, exam, and other test results.

IMAGING

In general, begin with supine and upright plain abdominal radiographs (also known as an "obstruction series"), but recognize that SBO or other serious pathology may not be apparent on these images. If you have clinical suspicion for a more serious problem, or plain imaging is indeterminate, consider obtaining a CT abdomen/pelvis with oral contrast.

DIFFERENTIAL DIAGNOSIS

It is important to differentiate postoperative ileus from more serious intra-abdominal pathology. The presence of any of the following signs

or symptoms should prompt appropriate lab tests and imaging, and may require surgical evaluation:

Severe pain
Bilious or feculent vomiting
Fever
Tachycardia
High-pitched bowel sounds
Peritoneal signs
Air-fluid levels on radiographs

Consider the following differential:

SBO
Bowel perforation or anastomotic leak
Acute colonic pseudo-obstruction (dilation of the cecum and right hemicolon without an obstructing lesion, also known as Ogilvie's syndrome)
Sepsis or intra-abdominal infection (including appendicitis or cholecystitis)
Pancreatitis
Intra- or retroperitoneal hemorrhage
Constipation or stool impaction

TREATMENT

Treatment is supportive.

NPO except sips of clears.
IVF as needed.
Replete potassium and magnesium as needed.
Treat any constipation with appropriate agents.
Do not routinely place an 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).
Replace gastrointestinal fluid losses with attention to electrolytes.
Minimize opiates as tolerated, and consider standing acetaminophen and judicious NSAID use (avoiding gastrointestinal and renal toxicity).
Perform serial clinical evaluations and reimage for worsening or persistence.
Once bowel function returns, remove the NG tube and advance the diet as tolerated, beginning with clear liquids.

PREVENTION

Several strategies are commonly used in combination to prevent postoperative ileus:

Epidural local anesthetic—Thoracic infusion for several days postoperatively reduces spinal inhibitory signals to the gut [2].

Avoidance of systemic opioids—Acetaminophen, NSAIDs, 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.

Early postoperative feeding—Some patients may suffer nausea or vomiting, but overall, early feeding does not appear harmful and may reduce the length of the hospital stay, although its effects on return of bowel function are not clear [3].

Routine laxative use—Data are limited but suggest that some benefit with no obvious harm [4].

Chewing gum—Meta-analyses reveal shortened time to first flatus and stool, and decreased length of stay, with no increase in complications [5].

Surgical technique—Laparoscopic surgery is associated with a shorter time to recovery of bowel function although it is not clear if this is because of the technique itself or because patients need less opiate pain control postoperatively [6], and animal data shows that less intestinal manipulation is associated with less postoperative dysmotility [7].

UNPROVEN INTERVENTIONS

Peripherally acting mu-opioid receptor antagonists or PAM-ORs (including alvimopan and methylnaltrexone) hold some promise but studies have not consistently shown benefit.

INEFFECTIVE OR HARMFUL INTERVENTIONS

Promotility medications have been studied (including metoclopramide, erythromycin, and neostigmine) but the available evidence is limited and/or has shown no benefit [8].

Routine postoperative NG tube placement (i.e., in all patients, as opposed to only those with vomiting, abdominal pain, or distension) delays return of normal bowel function, and may increase pulmonary complications, discomfort, and length of stay [9].

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PART XV
Surgery Topics

Chapter 40
Surgical Procedures Overview

Kara J. Mitchell, Elizabeth Kaplan, Lauge Sokol-Hessner, and Molly Blackley Jackson

XV

The following sections represent typical, uncomplicated postoperative courses for surgical cases often encountered as a medicine consultant. The information is selected from a medical, rather than a surgical, point of view. Clearly, every postoperative course is different. It may have been years since an internist has seen a post-op surgical patient—therefore our goal is to give the internist a general sense of the typical postoperative course, and to highlight surgical issues that may impact other medical diagnoses and treatments. As always, there is no substitute for communicating with the surgery team.

ORTHOPEDIC SURGERY

TOTAL KNEE ARTHROPLASTY

2 h General Anesthesia (GA) or regional/EBL: Less than 100 mL during procedure but can be high (500 mL) over first post-op day into drains (or into the knee, if no drains).

POD 0: IVF, diet advanced. PCA and/or regional anesthesia (femoral block or catheter) and Foley. Usually able to restart PO meds.

POD 1: 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.

POD 2–3: D/C to home. Extended VTE prophylaxis on discharge.

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Tips

- Minimally invasive total knee arthroplasty (TKA) (MIS or quad sparing) may discharge earlier.
- Continuous passive motion (CPM) machine is sometimes used.
- Common issues to TKAs and THAs: See below.

TOTAL HIP ARTHROPLASTY

2 h/GA or regional/EBL 300 mL (varies).

POD 0: IVF, diet advanced. PCA and Foley. Usually able to restart PO meds.

POD 1: Diet advanced if not yet done. Stop IV fluids if doing well with oral intake. Remove drain (if used) and Foley catheter if possible. Consider transition to PO pain meds. VTE prophylaxis.

POD 2–3: Stop PCA, change to PO pain meds if not already done. Extended VTE prophylaxis.

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.
- Most primary (first-time) total hip arthroplasties (THAs) will be full weight bearing, but many revision THAs will be partial or protected weight bearing.

COMMON ISSUES TO TKAS AND THAS

- Patients with comorbidities, complications, or persistent drainage may have longer hospital courses.
- Revisions 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 intra-operatively or if indwelling epidural catheters are used; IV fluid boluses in appropriate patients typically support patients through this. For this reason, it is particularly important to write holding parameters for antihypertensive medications.
- Avoid 1/2 normal saline for IVF maintenance immediately postoperatively, which may contribute to hyponatremia in a patient who is slightly under-resuscitated; rather, normal saline or lactated ringers are appropriate.

- Commonly used drains include hemovac (round cylinder, uses springs to provide suction) and autovac (hemovac autotransfusion system—filters and reinfuses drained blood).
- DVT prophylaxis is typically the surgeon's choice. Know that there are differences between the American Academy of Orthopedic Surgeons (AAOS) and the Chest (ACCP) guidelines. Common agents are low-molecular-weight heparins, warfarin, and aspirin (in addition to TEDs and SCDs).
- 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.

HIP FRACTURE REPAIR

1–3 h/GA or regional/EBL 300 mL.

Tips

- There are various options for operative repair, including intramedullary 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

3 h/GA or regional/EBL 200 mL (varies).

POD 0: Advance diet. Stop IV fluids if doing well with oral intake. PCA for pain control.

POD 1: Transition from PCA to PO pain meds. Drain out. CPM machine commonly used.

POD 2: Discharge to home.

Tips

- Pharmacologic VTE prophylaxis is not used if patients are ambulating.
- Postoperative bleeding/hemarthrosis is not uncommon after total shoulder arthroplasty (TSA). 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 several days postoperatively unless the risk of clot is exceedingly high (e.g., mitral valve prosthesis).
- If a scalene block is used, adverse effects include hypotension, bradycardia, Horner's syndrome, and phrenic nerve involvement, causing diaphragmatic paralysis.

MAJOR SPINE SURGERY

10+ h/GA/EBL 3,000+ mL.

POD 0: ICU care until stabilized. Remain intubated for airway protection and pain control. Often require additional transfusions.

POD 1–2: Extubate when stable; transfer to floor.

POD 3–7: VTE prophylaxis when possible; mobilization using brace, drain care.

TIPS

- These are high-risk operations due to their blood loss and duration.
- EBL can reach as much as 10 L.
- Often operations are accomplished in 2–3 stages.
- Patients are at risk for multiple complications in addition to VTE/MI/PNA:
  - Disseminated Intravascular Coagulation (DIC)
  - Dilutional coagulopathy.
  - Posterior ischemic optic neuropathy (blindness—rare, but devastating).
  - Dural leak.
  - CSF 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.
  - Ileus.

- Occasionally patients receive pulse-dose steroids.
- Rehab/SNF is a common disposition.
- Spine precautions—Patients may require a brace.

OTHER SPINE SURGERY

Lumbar spine decompressions/fusions are of intermediate risk, typically involve a 3–4-day hospital stay, and patients are admitted directly to the floor.

- C-spine decompressions often have a shorter stay, e.g., 24–48 h.
- Microdecompressions are typically limited-stay procedures.

ORTHOPEDIC TUMOR SURGERY

4+ h/GA/EBL highly variable.

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.

TIPS

- Generally intermediate-risk operations, but can be of high risk depending on duration and blood loss.
- 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.
- Surgery service may be reluctant to initiate heparin-based VTE prophylaxis due to wound drainage—discuss with primary team.

GENERAL SURGERY

For bariatric procedures, see also Chap. 32.

GASTRIC BYPASS, LAPAROSCOPIC

2–3 h/GA/EBL 50–200 mL.

POD 0: ICU or step-down unit for patients with OSA.

POD 1: Start bariatric clear liquid diet and ADAT to full liquids. Start oral medications. Transfer to floor. Foley out.

POD 2: Discharge home.

GASTRIC BYPASS, OPEN

2–3 h/GA/EBL 100–400 mL (varies).

POD 0: ICU or step-down unit for patients with OSA.

POD 1: Start bariatric clear liquid diet and ADAT to full liquids. Start oral medications. Transfer to floor. Foley out.

POD 2–3: Transition to oral pain medications.

POD 4: Discharge home.

LAP BAND

1 h/GA/EBL minimal.

POD 0: Limited stay. Start bariatric clear liquid diet and ADAT to full liquids.

POD 1: Discharge home.

SLEEVE GASTRECTOMY

1–2 h/GA/EBL 50–100 mL.

POD 0: ICU or step-down unit for patients with OSA.

POD 1: Start bariatric clear liquid diet and ADAT to full liquids. Discharge home.

ESOPHAGECTOMY

6 h/GA + epidural/EBL varies.

POD 0: ICU. May have chest tubes.

POD 1–5: Mobilize; transfer to floor when possible. Strictly NPO until passes UGI series POD 5 or later. Usually not on TPN unless remains NPO past POD 5.

Tips

- Although of intermediate risk by ACC/AHA criteria, can have many serious complications, including ARDS, pericarditis, pneumothorax, PNA, and anastomotic leak. In our experience with the patients of higher medical risk, ICU stays are several days.
- Widened mediastinum on CXR may be due to postoperative changes; anastomosis may be at stomach vs. jejunum.
- Most patients have some degree of chest pain post-op due to the location of the surgery.

- 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; one of the main difficulties in treating it is the prolonged NPO status.
- Do not use CPAP initially after esophagectomy.
- Do not reposition or move NG tube.

HERNIA REPAIR

Varies greatly, from outpatient inguinal hernia repair under local anesthesia to major abdominal operation. Note that some lung diseases, e.g., severe COPD, may be worsened with repair of a ventral hernia due to increased intra-abdominal pressure.

WHIPPLE (PANCREATICODUODENECTOMY)

8–12 h/GA + epidural/EBL 500–1,000 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 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. Always wait for the surgeon to discuss this with the patient if you see the patient before the patient realizes this.
- Complications include line infection, PNA, ARDS, portal vein thrombosis, and lateral cutaneous nerve injury from retractors.

LIVER RESECTION

6 h/GA + epidural/EBL variable.

Tips

- Extent of resection varies; often patients are very ill at baseline due to underlying liver disease.
- ICU post-op; can have high EBL, hepatic dysfunction, ARDS.

GYNECOLOGY AND GYNECOLOGY–ONCOLOGY SURGERY

LAPAROSCOPIC HYSTERECTOMY-BSO: ROBOT ASSIST OR CONVENTIONAL

1–2 h/GA/EBL <100 mL.

POD 0: Can advance diet if no nausea/vomiting post-op.

POD 1: Diet advanced; PO pain medications; Foley out and discharge.

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.

VAGINAL HYSTERECTOMY WITH PELVIC ORGAN PROLAPSE REPAIR (E.G., ANTERIOR AND POSTERIOR REPAIR, VAGINAL VAULT SUSPENSION, SLING FOR URINARY INCONTINENCE)

2–3 h/GA or regional/EBL <200 mL.

POD 0: Advance diet if tolerated.

POD 1: Diet advanced; change to PO pain medications. Voiding trial done with checking of post-void residual volume.

Tips

Only about 1/3 of women void adequately on POD 1 after complex vaginal repairs. 2/3 go home with a catheter.

OPEN TAH-BSO (FOR BENIGN PATHOLOGY)

2 h/GA/EBL 100 mL.

POD 0: If there has been an anastomosis, then NPO until flatus; otherwise diet advanced.

POD 1–2: Diet advanced as above, Foley out, change to PO pain meds.

POD 2–3: Discharge to home.

Tips
Rarely done given rising prevalence of laparoscopic and robotic surgeries. These procedures tend to have earlier return of bowel function than general surgery cases that involve more of the GI tract, but slower compared with the minimally invasive procedures.

OPEN TAH-BSO (FOR MALIGNANCY)

2–4 h/GA/EBL 100–1,000 mL.

POD 0: If there has been an anastomosis, then NPO until flatus; otherwise diet advanced.

POD 1–2: Diet advanced as above; Foley out; change to PO pain meds.

POD 3: Discharge to home.

Tips
In some cases, it is unknown whether the tumor is benign or malignant pre-op. Depending on tumor burden, this operation may be longer and involve bowel resection, lymph node dissection, and omentectomy, with a higher EBL and duration. There may be delayed return of bowel function as a result. There is increased VTE risk because of malignancy, so VTE prophylaxis is often continued after discharge.

OVARIAN TUMOR DEBULKING OR CYTOREDUCTION (PELVIC EXENTERATION IS RARELY DONE)

7–10+ h/GA + epidural/EBL 1,000+ mL.
Often in the hospital 7–14 days.

Tips
Typically results in ileostomy/colostomy and urostomy. Usually go to ICU post-op. Often extensive blood loss and fluid shifts requiring additional resuscitation. May have prolonged ileus requiring parenteral nutrition. Complications include sepsis/ARDS, urinoma/ureter disruption, VTE, pelvic abscess, as well as atrial fibrillation on POD 2–3.

UROLOGIC SURGERY/ PROCEDURES

CYSTECTOMY, RADICAL

Removal of the bladder and prostate in men.

Removal of the bladder, possibly uterus and ovaries, possible vaginal strip in women.

Urinary diversion with ileal conduit, neobladder to the urethra, or cutaneous neobladder to the abdominal wall.

6+ h (varies, longer for robotic)/GA + epidural/EBL 500–1,000 (varies).

POD 0—NPO.

POD 1–3: NPO, follow drain output, some urologists give early clears.

POD 4–5: Bowel function usually returns.

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.

PROSTATECTOMY, RADICAL

2–5 h/GA/EBL 500–1,000 mL.

Typical length of stay is 1–2 days for robotic, 2–3 days for open.

Tips

Main issue is attention to blood loss; this is less of an issue now that many are done robotically.

TRANSURETHRAL RESECTION OF PROSTATE

1 h or less/GA or spinal/EBL minimal to 300 (varies, hard to quantify).

Many go home on the same day, especially if they had a Greenlight laser TURP.

Tips

Watch for obstructing clots, problematic on continuous bladder irrigation.

NEPHRECTOMY WITH IVC TUMOR THROMBECTOMY

4–8 h (depending on the height of the thrombus)/GA + epidural/EBL varies, often >1 L.

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 thoracotomy if thrombus extends above the diaphragm.

Tips

Watch for pneumothorax, pleural effusion, hemothorax, hepatic dysfunction, emboli from manipulation of thrombus, cancer-associated risk of thromboembolism, ileus (often greater bowel manipulation than radical nephrectomy); also, other ICU complications such as pneumonia, catheter-associated infections, etc.

OPEN NEPHRECTOMY, RADICAL

3–4 h/GA + epidural/300 mL.

POD 1–3 advance diet when bowel function returns.

Tips

- Anticipate increased creatinine/renal dosing of medications.
- Diet can usually be advanced expeditiously, if bowel is not manipulated.

LAPAROSCOPIC NEPHRECTOMY

4 h/GA/100 mL.

POD 0—Diet may be advanced.

In some cases, patients may be discharged on POD 1.

Tips

Anticipate increased creatinine/renal dosing of medications.

OPEN PARTIAL NEPHRECTOMY

3–4 h/GA + epidural/300 mL.

POD 1–3 advance diet when bowel function returns.

Tips

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 h with drain in place.

LAPAROSCOPIC/ROBOTIC PARTIAL NEPHRECTOMY

4–6 h/GA/100 mL.

POD 0—Diet may be advanced.

In some cases, patients may be discharged on POD 1.

Tips

- Almost always stay 2–3 days for drain/Foley management.
- 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 h with drain in place.

CYSTOSCOPY, TRANSURETHRAL RESECTION OF BLADDER TUMOR (TURBT), AND LITHOTRIPSY

Duration varies/moderate sedation vs. GA/EBL varies

These are typically outpatient or limited-stay procedures.

Tips

Note that cystoscopy may have risk of increased vagal tone, bradycardia, and hypotension, despite being considered a low-risk procedure.

VASCULAR SURGERY

OVERVIEW FOR VASCULAR SURGERY PATIENTS

General recommendations:

- Continue preoperative beta-blockade in the postoperative setting.
- Decisions about anticoagulants and antiplatelet agents are made at the discretion of the surgeon based on the magnitude of the procedure and the patients individualized risk of thrombotic and/or bleeding complications. Many patients undergoing vascular surgical procedures should continue their aspirin peri-operatively but this should be discussed with the surgeon.
- 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

SPECIFIC PROCEDURES

3–4 h/GA/150 mL.

POD 0: ICU.

POD 1: D/C Foley, advance diet. Transfer to floor. Possible D/C home.

POD 2: D/C to home.

Tips

- 1% risk of MI, 1% risk of stroke, 1% risk of permanent cranial nerve injury, 2–3% risk of temporary cranial nerve injury.
- Postoperative blood pressure control can require IV medications as endarterectomy can alter function of the baro-receptor in the carotid sinus, general goal is to keep within 20–30 mmHg of baseline.
- Postoperative BP control and need for close neurologic examinations are dependent on whether or not the patient is symptomatic (e.g. concern for hypoperfusion or hemorrhagic conversion after stroke).

AAA REPAIR, OPEN

6 h/GA/EBL 400–1,000 mL.

POD 0: ICU. May come out of OR still intubated.

POD 1–3: Stabilize, transfer to floor.

POD 4–6: Epidural out, then Foley out.

Tips

- Variation in length of ICU stay.
- Level of proximal aortic cross clamp predicts morbidity of the operation. Infra-renal is least stressful, suprarenal is more stressful, and supra-visceral (aka supra-celiac) is most stressful.
- Nonoliguric acute renal failure is common with suprarenal cross-clamping of the aorta. Reviewing the operative note is helpful.
- Most patients are on IV beta-blockers postoperatively for blood pressure control since almost all have hypertension at baseline.
- Other severe complications include bowel infarction and spinal cord infarct.

AAA REPAIR, ENDOVASCULAR

3 h/GA/EBL 50–200 mL.

POD 0: ICU. Short post-op hydration for IV contrast load, but rarely require resuscitation.

POD 1: Foley out in AM. Check renal function. Regular diet. Often go home.

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.
- Severe complications include groin hematoma, endoleak, kidney injury from embolization or contrast, bowel ischemia, and spinal cord infarct (rare).

PVD BYPASSES, SUPRAINGUINAL

4–6 h/GA/EBL 250–1,000 mL.

POD 0: ICU. May come out of OR intubated. Resuscitation.

POD 1–2: Stabilize, wean resuscitation by 48 h. To floor.

POD 3–5: Resume diet. Epidural and Foley out. Walking.

Tips

- Similar to open AAA repair, but usually reserved for healthier patients with PAD and clamp is most often below the renal arteries, so typically better tolerated than AAA repair.

PVD BYPASSES, INFRAINGUINAL

4–5 h/GA/EBL 200–400 mL.

POD 0: ICU for pulse checks. Do not need resuscitation.

POD 1–3: Floor. Wound care. Foley out.

Tips

- Length of stay is often a function of their mobility status and any foot wounds/ulcerations they have.

HEAD AND NECK SURGERY

NEW TRACHEOSTOMY

2 h/GA/EBL minute.

POD 0: ICU for airway monitoring.

POD 1: May be transferred to floor if doing well.

Tips

- May be straightforward or complex depending on the patient's anatomy and previous operations, if any.

LARYNGECTOMY/HEAD AND NECK CANCER SURGERY/FLAP

8+ h/GA/EBL variable.

Tips

- Can be extensive operations of long duration, although fluid shifts are typically minimal given the location.
- Most are in the ICU initially if a new tracheostomy is involved.
- Flaps from the thigh are common; you may see drains in multiple sites.
- Patients with prolonged or permanent inability to use oropharynx for nutrition will have a feeding tube or G-tube placed, often preoperatively.
- Alcohol withdrawal and COPD are common given the patient population's comorbid risk factors.

HEAD AND NECK DISSECTION/FLAP

4–12 h/GA/EBL variable.

Tips

- Can be extensive operations of long duration, although fluid shifts are typically minimal given the location.
- May be admitted to the floor if shorter duration of operation and no tracheostomy.
- Alcohol withdrawal and COPD are common given the patient population's comorbid risk factors.

NEUROSURGERY

CRANIOTOMY

6–24 h/GA/EBL variable.

Tips

- Variable course, depending on the extent of surgery.
- Initially admitted to ICU, may have ICP monitor, often still intubated.
- First few days post-op may have labile blood pressures, hyponatremia. Neurosurg team will often administer mannitol and salt tabs, and order serial CT scans.
- Watch for ICU complications such as VTE, line infections, and PNA.
- May have a great deal of facial swelling post-op.

OPHTHALMOLOGIC SURGERY

CATARACT SURGERY

2–3 h/GA or local/EBL minute.

Usually an outpatient procedure. A widely cited study (N Engl J Med 2000;342:168–75) randomized patients to ECG and lab tests vs. no standard preoperative tests and found no difference in complication rates. However, all patients did receive a pre-op H&P. We advocate an evaluation by a primary care provider and lab testing only as indicated preoperatively. Warfarin anticoagulation typically does not have to be held as long as the INR <3.0, but it is best to check with the surgeon. Note also that tamsulosin has been associated with "intraoperative floppy iris syndrome" and should be held for two weeks preop.

DENTAL SURGERY

Preoperative evaluation for patients with multiple medical comorbidities who are to undergo general anesthesia for dental extractions should focus on a complete H&P and ensuring that there is no active or decompensated medical problems. Patients on warfarin typically remain on anticoagulation as long as the INR is <3.0 and there is no greater than average bleeding risk for the surgery.

Appendix: Surgery Abbreviations

(not "official," but ones we have encountered)

AKA	Above knee amputation
APR	Abdomino-perineal resection (e.g., for rectal cancer in distal 1/3 of rectum, including anus will have permanent colostomy)
ARBF	Await return of bowel function
BKA	Below knee amputation
C/D/I	Clean, dry, and intact
CBI	Continuous bladder irrigation
CEA	Carotid endarterectomy
CPB	Cardiopulmonary bypass
CPM	Continuous passive motion (referring to machine that continuously slowly flexes a joint postoperatively, usually a knee or shoulder)
CBG	Capillary blood glucose (also CS, FSBG)
CS	Chemstick
ESWL (or ECSWL)	Extracorporeal shock wave lithotripsy
FSBG	Finger stick blood glucose
GETA	General endotracheal anesthesia
ICP	Intracranial pressure (monitor)
Inc.	Incision
IOR	Intraoperative radiation
IS	Incentive spirometry
JP	Jackson Pratt (bulb) drain

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LAR	Low anterior resection (e.g., for rectal cancer in proximal 2/3 of rectum can have primary anastomosis, unlike APR)
LD	Lumbar drain
LND	Lymph node dissection
MAC	Monitored anesthesia care. Care and monitoring of anesthesia without intubation
MAEs	Moves all extremities
MIS	Minimally invasive surgery
NWB	Non-weight bearing
OMFS	Oral and Maxillofacial Surgery
ORIF	Open Reduction and Internal Fixation
PCEA	Patient-controlled epidural analgesia
PPLND	Pelvic and paraaortic lymph node dissection
PROM	Passive range of motion (also premature rupture of membranes)
ROM	Range of motion
THA	Total hip arthroplasty
TKA	Total knee arthroplasty
TRAM	Trans-rectus abdominis muscle (flap-breast reconstruction)
TSA	Total shoulder arthroplasty
TTWB	Toe touch weight bearing
TURBT	Transurethral resection of bladder tumor
TURP	Transurethral resection of prostate
UPPP	Uvulopalatopharyngoplasty
VATS	Video-assisted thoracoscopic surgery
WBAT	Weight bearing as tolerated
WLE	Wide local excision
XLAP	Exploratory laparatomy (or “ex-lap”)

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