Chapter 1.1

Medical Management and Preoperative Patient Assessment

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It is imperative to obtain a comprehensive medical, surgical, and social history prior to any surgical procedure, as these are key to identifying medical comorbidities. The essentials of the history taking include the chief complaint, history of the chief complaint, other complaints, and the medical history. It remains important to review the patient's allergies, medications, social history, family history, surgical history and functional status.

The physical examination is focused based on the history. All systems should be reviewed, although the cardiovascular and respiratory systems are probably the most important. Patients who will undergo surgery—whether under local anesthesia, sedation, or general anesthesia—also require risk stratification and medical optimization in order to identify and mitigate the risk of surgery- and anesthesia-related complications. Ultimately, this requires an understanding of the surgical stress and the patient's medical condition(s).

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Oral and maxillofacial procedures performed in an ambulatory setting are considered low risk. However, some oral and maxillofacial surgery procedures, such as head and neck surgery, are considered to be intermediate in risk. The patient's medical condition(s) impart additional risk factors that are best evaluated using one or more of the following four risk stratification tools.

The American Society of Anesthesiologists Physical Status (ASA-PS) classification remains one of the most commonly utilized tools, although it tends to be somewhat subjective and is designed to assess and communicate pre-anesthesia medical comorbidities, but it cannot predict perioperative risk when used in isolation (Table 1.1.1).[1]

Functional status is best assessed using the metabolic equivalent of tasks (METs). The assessment is based on a patient's ability to perform specific physical activities and the oxygen consumption required to perform those tasks. One MET is arbitrarily set at 3.5 mL of oxygen per kilogram per minute. The functional capacity provides insight into a patient's cardiovascular and respiratory capacity which are likely to be similarly stressed during surgery and anesthesia. The greater the functional capacity, the lower the risk. A MET of 4 is considered to be the minimum value above which risk is relatively low. The Duke Activity Status Index (DASI) is particularly useful to classify patients according to functional status (Table 1.1.2).[2]

The DASI can be easily calculated using an online calculator, which asks 12 specific (yes/no) questions and calculates the DASI score, METs, and peak VO_2 consumption. A DASI score of 34 or less suggests an increased risk for myocardial injury, myocardial infarction (MI), moderate complications, and new disability. Access the calculator at https://www.omnicalculator.com/health/dasi.

The Revised Cardiac Risk Index (RCRI) for preoperative risk is the third tool that can be used to assess the risk of adverse cardiac events during noncardiac surgery. The original cardiac risk index was developed in 1977 and later revised in 1999 to become the RCRI.[3] The tool solicits for the presence of one or more of the following: ischemic heart disease, congestive heart failure (CHF), cerebrovascular disease, insulin-dependent diabetes mellitus (DM), chronic kidney disease (CKD), and type of surgery. The RCRI was further evaluated with additional patient cohorts, and the risk was adjusted based on new data.[4–6] Scores of 0, 1, 2, and ≥3 are associated with a risk of 3.9%, 6%, 10.1%, and 15%, respectively. These numbers are higher than those originally reported (Table 1.1.3). The calculator can be assessed at https://www.mdcalc.com/revised-cardiac-risk-index-pre-operative-risk.

The fourth risk assessment tool is the American College of Surgeons National Surgical Quality Improvement Program (NSQIP). This program uses clinical data to predict 30-day patient morbidity and mortality. The data is risk- and case-mix adjusted to account for more complicated cases and patients with greater comorbidities. It remains the most comprehensive tool that includes all of the following data:

- Surgical procedure
- Age

Table 1.1.1 American society of anesthesiology physical status classification.

Classification	Description
I	Healthy patient
II	Mild systemic disease with no functional limitation
III	Severe systemic disease with functional limitation
IV	Severe systemic disease that is a threat to life
V	Moribund patient
VI	Brain-dead patient awaiting organ transplantation

Source: Adapted from American Society of Anesthesiologists.[1]

Table 1.1.2 Duke Activity Status Index.

Activity	METs	Functional Capacity
Walk around house	1.75	Poor
Walk two blocks on level ground	2.75	Poor
Activities of daily living	2.75	Poor
Light housework (dishwashing)	2.7	Poor
Moderate housework (vacuuming)	3.5	Poor
Yard work	4.5	Moderate
Sexual relations	5.25	Moderate
Climb stairs	5.5	Moderate
Golf	6	Moderate
Swimming, basketball	7.5	Excellent
Running	8.0	Excellent

MET = metabolic equivalent (1 MET = 3.5 mL/kg/min O_2 use).
Source: Adapted from Hlatky MA, et al.[2]

Table 1.1.3 Revised cardiac risk index.

Condition	No (0) or Yes (1)
Coronary artery disease	
Congestive heart failure	
Cerebrovascular disease	
Insulin dependent diabetes mellitus	
Renal insufficiency and creatinine >2mg/dL	
High risk surgery	

Source: Adapted from Lee T, et al.[3]

- Sex
- Functional status
- Emergent surgery
- American Society of Anesthesiologists status
- Steroid use
- Ascites
- Sepsis
- Ventilator use
- Malignancy
- Diabetes mellitus
- Hypertension
- CHF
- Acute renal failure
- Dialysis
- Chronic obstructive pulmonary disease
- Dyspnea
- Tobacco use
- Body mass index

The NSQIP is based on more than 5 million surgical records and has excellent calibration. The online NSQIP risk calculator tool allows for easy determination of risk to facilitate decision-making. Access it at https://riskcalculator.facs.org/.

Cardiovascular disease

Mitigating risk requires recognition of cardiovascular disease, further assessment/investigation, and patient optimization. A focused history and cardiovascular examination will generally identify cardiovascular conditions that are associated with Major Adverse Cardiac Events (MACE), including coronary artery disease (CAD), congestive heart failure (CHF), arrhythmia, valvular heart disease, and hypertension (HTN).[7] Useful tests to help identify and quantify disease severity include the following:

- Chest radiograph to evaluate for cardiomegaly, pulmonary edema, or pleural effusion.
- ECG to evaluate for left ventricular hypertrophy (LVH), ST-segment changes, inverted T waves, Q waves, and arrhythmias.
- Transthoracic Doppler echocardiography for wall motion abnormalities, ejection fraction, chamber pressures, and valvular disease.
- Stress test to assess for functional cardiac ischemia. This can be combined with echocardiography.
- Perfusion nuclear imaging (thallium, technetium sestamibi, technetium tetrofosmin, N-13 ammonia, and fluorodeoxyglucose [FDG]) to assess cardiac perfusion at rest and during function.
- Cardiac angiography.

Coronary artery disease

Asymptomatic and symptomatic patients with CAD may develop symptoms in the perioperative period. Risk factors for CAD include DM, HTN, smoking, hypercholesterolemia, and a family history of the disease. CAD may result in stable angina or one of the acute coronary syndromes (ACSs). Stable angina often presents with precordial pain radiating to the left arm, neck, and jaw upon exertion. It is relieved by rest or the use of sublingual nitroglycerin. ACSs include unstable angina, non–ST-elevated MI, and ST-elevated MI. Symptoms differ from stable angina in that they occur with less exertion than usual, or at rest, and do not abate with further rest. The diagnosis is best made with a 12-lead ECG (ST elevation, inverted T waves, or Q waves) and cardiac enzymes (CK-MB and troponins).

The initial treatment for suspected ACS or MI includes aspirin and nitroglycerin, which impede platelet aggregation and reduce preload and pain, respectively. Oxygen should only be used when oxygen saturation is less than 90%, as it has the potential to increase infarct size.[8] The use of fibrinolytics and percutaneous coronary angioplasty (PCA), particularly within the first 90 minutes of onset of symptoms, has reduced the mortality significantly. The American College of Cardiology (ACC) recommends waiting a minimum period of six weeks after an MI before proceeding with elective surgery.[9] Furthermore, the longer the time period from the MI to the elective surgery, the greater the risk reduction.

Patients who have had PCA are typically treated with DAPT, which involves the use of aspirin and a glycoprotein IIb/IIIa inhibitor (e.g., abciximab or eptifibatide) or an adenosine diphosphate (ADP) antagonist (e.g., clopidogrel, etc.). "It is recommended that in the event that a patient requires non cardiac surgery the aspirin should be continued. The glycoprotein IIb/IIIa inhibitor or ADP antagonist should be continued for a minimum period of 14 days, 30 days and 3 months for balloon angioplasty, bare metal stents and drug eluting stents, respectively."[10,11]

Congestive heart failure

Compensated CHF is considered an intermediate predictor of morbidity, while decompensated CHF is considered a major predictor and a contraindication to elective surgery. The New York Heart Association (NYHA) classification may also be used to help stratify surgical patients with the perioperative risk of complications depending on the assigned class and ranging from 3% (Class I) to 25% (Class IV) (Table 1.1.4).[12]

Table 1.1.4 New York Heart Association classification.

Class	Symptoms
I	Asymptomatic
II	Symptomatic with moderate activity, comfortable at rest
III	Symptomatic with minimal activity, comfortable at rest
IV	Symptomatic at rest

Signs and symptoms of CHF may include exertional dyspnea, orthopnea, paroxysmal nocturnal dyspnea, cardiomegaly, rales, a third heart sound (S_3) gallop, elevated jugular venous pressure, peripheral edema (especially in the lower extremities), and atrial fibrillation (AF). The diagnosis is readily made with a transthoracic echocardiogram. Brain natriuretic peptide (BNP) can also be used to help diagnose and monitor CHF progression. Treatment goals are to reduce afterload and increase cardiac output, which can be achieved with the use of angiotensin-converting enzyme inhibitors (ACEIs), angiotensin receptor blockers (ARBs), diuretics, beta-blockers, and digoxin.

Patients with CHF should maintain their medications in the perioperative period. Fluid replacement should be judicious, and potassium levels should be monitored with replacement as needed, given the potential for hypokalemia.

Valvular heart disease

Valvular heart disease includes conditions that result in valvular stenosis or regurgitation. This predisposes some patients to CHF, arrhythmias, and fluctuations in heart rate and blood pressure (BP). As with most medical comorbidities, functional status can provide insight into the severity of the disease.

Aortic stenosis (AS) may result in syncope, angina, and exertional dyspnea. Auscultation of a high-pitched, midsystolic, crescendo-decrescendo murmur at the right upper sternal border is consistent with AS. It is often associated with LVH, which can be recognized by the presence of a fourth heart sound (S_4 gallop) at the cardiac apex. Patients with AS are intolerant to tachycardia and a reduction in peripheral vascular resistance.

Aortic regurgitation (AR) may present with pulmonary edema, hypotension, and CHF. Auscultation of a diastolic decrescendo murmur, a high-pitched crescendo-decrescendo murmur, and a diastolic rumble is consistent with AR. It is also often associated with LVH. It remains important to control BP during the perioperative period.

Mitral stenosis (MS) may present with dyspnea, orthopnea, pulmonary edema, AF, and a right ventricular heave. Auscultation of an opening snap and a mid-diastolic, low-pitched rumble at the apex is consistent with MS. An ECG may reveal notched or enlarged P waves when atrial enlargement has developed. Increases in heart rate should be avoided given the potential for reduced cardiac output.

Mitral regurgitation (MR) may present with pulmonary edema, hypotension, dyspnea on exertion, and a holosystolic, high-pitched murmur at the cardiac apex.

Prosthetic valve replacement and infective endocarditis

Patients with prosthetic valves pose perioperative risk that is related to the potential for infective endocarditis and hemorrhage secondary to anticoagulation. Antibiotic prophylaxis is required in patients with prosthetic heart valves or those with a history of endocarditis, unrepaired cyanotic congenital heart disease, or repaired congenital heart disease during the first six postoperative months. The antibiotic of choice is amoxicillin 2 gms PO one hour before the procedure. If allergic to penicillin, then either cephalexin 2 gms, azithromycin 500 mg, or clarithromycin 500 mg should be taken. When antibiotics are to be given parenterally, ampicillin 2 gms is the drug of choice. If allergic to penicillin, consider either cefazolin or ceftriaxone 1 gm.

Anticoagulation

Life-long anticoagulation is always required with alloplastic valve replacement, while biological valves typically only require three months of anticoagulation following implantation. In addition to prosthetic heart valves, indications for anticoagulation also include cerebrovascular accident (CVA), deep venous thrombosis (DVT), pulmonary embolism (PE), cardiac stent, and AF. Oral anticoagulation may involve the use of aspirin, warfarin, antiplatelet drugs (adenosine diphosphate and IIb/IIIa inhibitors), or factor IIa or factor Xa inhibitors (direct oral anticoagulation (DOAC)). Aspirin may also be combined with DOACs when needed and is referred to as "dual antiplatelet therapy" (DAPT).

Maintaining anticoagulation during surgery significantly reduces the risk of thromboembolic events (TEE) but may increase the risk of surgical bleeding. When the risk of surgical bleeding is low, such as during minor oral surgical procedures, maintaining anticoagulation is generally recommended, although it will be dependent on many factors, including the number of teeth to be extracted, the need for bone removal, and the ability to use local hemostatic measures. More significant oral and maxillofacial surgical procedures

will often require anticoagulation to be discontinued despite the increased risk of TEE.

Aspirin is rarely a concern regarding bleeding, and it should typically be continued, depending on the surgical procedure and the risk of TEE. Warfarin should also be maintained for minor oral surgery procedures when the international normalized ratio (INR) is less than 3, as the risk of bleeding is less than the risk of TEE. Surgical bleeding that occurs or persists while on warfarin despite local hemostatic measures can be managed with fresh frozen plasma (FFP), prothrombin complex concentrates (PCC), recombinant factor VIIa, factor eight inhibitor bypassing activity (FEIBA), or vitamin K (oral or intravenous). DOACs should also typically be maintained for minor oral surgery if local hemostatic measures are feasible. Reversal of DOACs (Apixaban, Dabigatran, Rivaroxiban, Edoxaban, Betrixaban) when bleeding is anticipated or occurs can be achieved with the use of Idarucizumab and andexanet alfa for factor IIa and Xa inhibitors, respectively. Alternatively, FFP, PCC, and FEIBA can also be used. Antiplatelet drugs such as clopidogrel inhibit platelet function for the lifespan of the platelet (7–9 days) and cannot be reversed.

Major surgery will require the cessation of anticoagulation. This should be done in conjunction with the patient's physician to ensure the risk of TEE is minimized. The plan for cessation will depend on the drug. Patients on warfarin can effectively be bridged by withholding warfarin for 5–6 days prior to surgery and administering low molecular weight heparin (LMWH) at 1 mg/kg subcutaneously twice daily. The LMWH is also held 24 hours prior to surgery and resumed following surgery, as is the warfarin. Patients on DOACs do not require bridging due to the short half-life of these drugs (approximately 12 hours). They should be stopped 1–2 days prior to surgery and resumed 1–3 days following surgery. Antiplatelet drugs should be stopped 7–9 days prior to the surgery and can be resumed one week after surgery.

Arrhythmia

Tachyarrhythmias are generally classified as supraventricular or ventricular. Supraventricular arrhythmias include supraventricular tachycardia (SVT), AF, and atrial flutter, with each having the potential to reduce cardiac output, leading to palpitations, shortness of breath, and dizziness. Diagnosis is based on the history, supported by a rhythm strip from an ECG or Holter monitor. Supraventricular arrhythmias are paroxysmal and often self-limiting. If symptoms are significant or the SVT is persistent, treatment is required. Carotid massage and the Valsalva maneuver may terminate the episode. Intravenous adenosine can also be given. Beta-blockers remain the mainstay for the prevention of SVT. AF is relatively common, resulting in an irregular heart rate. It can also be associated with a rapid ventricular response (RVR), resulting in more profound symptoms. Atrial flutter is less common but often results in similar symptoms. Treatment of both includes beta-blockers, calcium channel blockers (CCBs), and antiarrhythmic medications such as amiodarone. Cardioversion and cardiac ablation may also be appropriate in select cases. All patients with AF are treated with oral anticoagulation given the risk of TEE.

Ventricular arrhythmias have the potential to deteriorate into a nonperfusion rhythm. Premature ventricular contractions (PVCs) are common, but they may reflect myocardial ischemia, MI, or electrolyte abnormalities and should be investigated preoperatively.[13,14] Ventricular tachycardia may be perfusing or nonperfusing, and it may require immediate attention, including basic life support (BLS) and advanced cardiac life support (ACLS). Long-term therapy may involve the use of antiarrhythmic drugs, radiofrequency ablation, or implantable cardiac defibrillators.

Bradyarrhythmias may be associated with fatigue, dizziness, shortness of breath, and syncope. The most important consideration is the location of the heart block and the presence of underlying structural abnormalities. *First-degree blocks* are associated with a prolonged PR interval, although atrial and ventricular contractions occur consistently. No treatment is required. *Second-degree blocks* can be classified as Mobitz type I or Mobitz type II. A progressive increase in the PR interval over several beats until one atrial impulse fails to be conducted through the AV node is consistent with a Mobitz type I second-degree heart block. No treatment is required. A constant but prolonged PR interval with the loss of conduction through the AV node after several beats is consistent with a Mobitz type II second-degree heart block. The loss of a ventricular contraction typically occurs after a specified number of atrial contractions. This allows the Mobitz type II to be described as a 2:1, 3:1, or 4:1 heart block, depending on how many atrial contractions precede the lost ventricular contraction. Mobitz type II requires treatment given the symptoms and the potential to deteriorate into a third-degree heart block. *Third-degree heart block* has no conduction through the AV node, resulting in a heart rate that is often in the 30s and producing symptoms due to a reduction in cardiac output and BP. Treatment of a Mobitz type II second-degree heart block or third-degree heart block may require immediate external pacing and long-term internal pacing with a pacemaker. The occurrence of any heart block in the perioperative period requires

further investigation to determine the causes, particularly electrolyte abnormalities, drug toxicity, and myocardial ischemia. The development of second-degree Mobitz type II and third-degree heart block will most often require perioperative pacing.[15]

Hypertension

Current guidelines from the Eighth Joint National Committee (JNC 8) classify HTN into several categories (Table 1.1.5).[16]

Most often, HTN is idiopathic. HTN can also be secondary to kidney disease, hyperthyroidism, AR, medications, or adrenal gland pathology, including Cushing's syndrome, Conn's syndrome, and pheochromocytoma. Antihypertensive medications, including beta-blockers, CCBs, diuretics, angiotensin-converting enzyme inhibitors (ACEIs), angiotensin receptor blockers (ARBs), and clonidine, should be continued in the perioperative period. General anesthesia agents, including inhalational agents and propofol, tend to cause systemic hypotension, which, on rare occasions, may require ACEI, ARB and diuretics to be held immediately prior to a general anesthesia.

Hypertensive urgency and emergency are both defined by elevated BP, with a systolic pressure above 180 mmHg and/or a diastolic pressure above 120 mmHg. The difference between the two lies in the presence of end-organ damage (e.g. CVA, cardiac ischemia, pulmonary edema, and renal failure), which is associated with hypertensive emergency. Elective surgery should be postponed for hypertensive urgency and emergency.[17]

The Eight Joint National Committee (JNC 8) recommends the following treatment strategies for HTN:

- In the general population aged ≥60 years, initiate pharmacologic treatment to lower BP at systolic blood pressure (SBP) ≥150 mmHg or diastolic blood pressure (DBP) ≥90 mmHg, and treat to a goal SBP <150 mmHg and goal DBP <90 mmHg.
- In the general population <60 years, initiate pharmacologic treatment to lower BP at DBP ≥90 mmHg and treat to a goal DBP <90 mmHg.
- In the general population <60 years, initiate pharmacologic treatment to lower BP at SBP ≥140 mmHg and treat to a goal SBP <140 mmHg.
- In the population aged ≥18 years with CKD, initiate pharmacologic treatment to lower BP at SBP ≥140 mmHg or DBP ≥90 mmHg, and treat to a goal SBP <140 mmHg and goal DBP <90 mmHg.
- In the population aged ≥18 years with diabetes, initiate pharmacologic treatment to lower BP at SBP ≥140 mmHg or DBP ≥90 mmHg, and treat to a goal SBP <140 mmHg and goal DBP <90 mmHg.
- In the general non-Black population, including those with diabetes, initial antihypertensive treatment should include a thiazide-type diuretic, CCB, ACEI, or ARB.
- In the general Black population, including those with diabetes, initial antihypertensive treatment should include a thiazide-type diuretic or CCB.
- In the population aged ≥18 years with CKD, initial (or add-on) antihypertensive treatment should include an ACEI or angiotensin receptor inhibitor (ARB) to improve kidney outcomes. This applies to all CKD patients with HTN, regardless of race or diabetes status.
- The main objective of HTN treatment is to attain and maintain goal BP. If goal BP is not reached within a month of treatment, increase the dose of the initial drug or add a second drug from one of the classes in Recommendation 6 (thiazide-type diuretic, CCB, ACEI, or ARB). The clinician should continue to assess BP and adjust the treatment regimen until goal BP is reached. If goal BP cannot be reached with two drugs, add and titrate a third drug from the list provided. Do not use an ACEI and an ARB together in the same patient. If goal BP cannot be reached using only the drugs in Recommendation 6 because of a contraindication or the need to use more than three drugs to reach goal BP, antihypertensive drugs from other classes can be used. Referral to a HTN specialist may be indicated for patients in whom goal BP cannot be attained using the above strategy or for the management of complicated patients for whom additional clinical consultation is needed.

Table 1.1.5 Hypertension.

Class	Systolic (mmHg)	Diastolic (mmHg)
Normal	<120	<80
Pre-HTN	120–139	80–89
Stage I HTN	140–159	90–99
Stage II HTN	160–179	100–109
Hypertensive urgency	>180	>110

HTN = hypertension.

Automatic implantable cardioverter defibrillators and pacemakers

Some patients who present for surgery will have an automatic implantable cardioverter-defibrillator (AICD) or cardiac pacemaker. These devices can monitor cardiac rhythm, pace, and defibrillate. Patients with an AICD or pacemaker who require surgery will require an ECG, which will be able to show if the

patient is being paced by virtue of the pacing spike and subsequent QRS complex. The decision to reset the AICD or pacemaker should be made by the cardiologist and/or the anesthesiologist. Most defibrillators should be turned off prior to inducing the general anesthesia to prevent accidental discharge or damage to the device. An AICD can have the defibrillator turned off while maintaining the pacing. Electrocautery devices can damage an AICD or pacemaker. Bipolar electrocautery is the least likely to adversely affect the devices and is generally safe. Monopolar devices should be avoided.

Respiratory disease

Respiratory function and reserve are critical factors in the perioperative period. A thorough history and assessing functional status will provide some insight into a patient's respiratory capacity. Current smoking also increases the likelihood of perioperative pulmonary complications.[18] This risk can be substantially reduced with smoking cessation, provided it is begun eight weeks prior to the planned surgical procedure.[19] Evaluation of pulmonary function using a chest X-ray is generally not helpful, as its sensitivity is too low. Peak flow can be helpful in patients with known asthma or chronic obstructive pulmonary disease, particularly for evaluating for any exacerbations. Pulmonary function testing (PFT), although rarely indicated, remains the most comprehensive test to evaluate lung volumes, lung dynamics, and oxygen/carbon dioxide diffusion. Disease severity can be measured using the ratio of the forced expiratory volume in one second (FEV_1) to the forced vital capacity (FVC).

Perioperative pulmonary complications can be classified into one of four basic states, which include hypoventilation, diffusion impairment, ventilation-perfusion mismatching, and shunting. There are several potential causes of hypoventilation, including asthma exacerbations, poorly controlled COPD, obstructive sleep apnea (OSA), excessive narcotics, pulmonary fibrosis, myasthenia gravis (MG), and multiple sclerosis. Diffusion impairment is most often the result of acute respiratory distress syndrome or pulmonary fibrosis. The most common cause for a ventilation-perfusion mismatch is pulmonary embolism. Shunting can be seen in many settings, including postoperative atelectasis, pulmonary edema, atrial or ventricular septal defects, and chronic liver disease.

Perioperative treatment of respiratory distress aims to increase oxygenation, reduce hypoxemia, and decrease the work of breathing. Treatment may include any of the following.

- Nasal cannula (maximum FiO_2 40% at 6 L/min)
- Rebreathing facemask (maximum FiO_2 60% at 10 L/min)
- Non-rebreathing facemask (maximum FiO_2 90% at 10 L/min)
- CPAP/BiPAP (maximum FiO_2 80%)
- Endotracheal intubation/tracheostomy (maximum FiO_2 100%)

Asthma

Asthma is commonly encountered and may result in bronchoconstriction. This leads to reduced minute ventilation with resultant hypoxemia. The latter results in shortness of breath, nighttime symptoms, interference with activity, wheezing, coughing, and chest pain. In severe cases, the asthma exacerbation may result in life-threatening status asthmaticus (Table 1.1.6).

The treatment of asthma involves the use of medications that can reduce symptom severity and the likelihood of perioperative exacerbations. The most current

Table 1.1.6 Classification of asthma severity.

Severity	Symptom Frequency	Nighttime Symptoms	% FEV_1 of Predicted	SABA Use*	Interference with activity	Use of oral steroids in the prior 12 months
Intermittent	≤ 2/week	≤ 2/month	≥ 80%	≤ 2 days/week	None	0–1
Mild persistent	> 2/week	3–4/month	≥ 80%	> 2 days/week	Minor	*2 or more
Moderate persistent	Daily	> 1/week	60–80%	Daily	Some	*2 or more
Severe persistent	Continuously	> 7/week	< 60%	≥ 2/day	Extremely limited	*2 or more

FEV_1 = forced expiratory volume in 1 second; SABA: short-acting β agonist; *not including prevention of exercise induced bronchospasm.
Source: Adapted from Global Initiative for Asthma. Global Strategy for Asthma Management and Prevention, 2020. Available from www.ginasthma.org

Table 1.1.7 Asthma stepwise therapy.

	Step 1	Step 2	Step 3	Step 4	Step 5
Rapid-acting β_2-agonists as needed					
Controller options		*Select one*	*Select one*	*Do one or more*	*Add one or many*
		Low-dose ICS	Low-dose ICS + LABA	Medium ICS dose +/- LABA	High dose ICS + LABA
		LTRA	Med/high-dose ICS	Add LTRA Add LAMA	Add LTRA Add LAMA Monoclonal biologic therapy* Add oral steroids (at lowest possible dose)
			Low-dose ICS + LTRA		

ICS: inhaled corticosteroid; LTRA: leukotriene receptor antagonist; LABA: long-acting inhaled β_2-agonist; LAMA: long-acting anti-muscarinic.
Source: Adapted from Global Initiative for Asthma. Global Strategy for Asthma Management and Prevention, 2020. Available from www.ginasthma.org

recommendation suggests a sequential approach to medication (Table 1.1.7).

Perioperative exacerbations should be anticipated despite appropriate preventive medication. The use of a SABA metered-dose inhaler (MDI) or nebulizer may be needed to alleviate symptoms. Children present a unique challenge and may require continuous nebulization. Anticholinergic medication is less commonly used but may also be administered by MDI or nebulizer. Systemic corticosteroid should be considered for a severe exacerbation.[20]

Chronic obstructive pulmonary disease

The hallmark of COPD is dilated and collapsed small airways, secondary to smoking or alpha-1 antitrypsin deficiency. The signs and symptoms of COPD include chronic cough with sputum production, variable shortness of breath, reduced functional status, and wheezing. A chest X-ray often reveals hyperinflation with a flattened diaphragm. A reduction in the FEV_1/FVC ratio with PFT is typical with COPD.

Elective surgery should be avoided when a COPD exacerbation or an upper respiratory tract infection is present. The patient may also require a course of inhaled or systemic steroids to help optimize the perioperative health.[21] Maintenance of the patient's usual bronchodilator, anticholinergic, and steroid medication in the perioperative period is important. Nitrous oxide poses a theoretical risk of pulmonary bullae rupture due to its blood/gas coefficient and its tendency to accumulate in the bullae. Intubation will require that ventilator peak flow pressures increase to allow for a short inspiratory and prolonged expiratory time, which are all secondary to the obstructive process. If a postoperative exacerbation occurs, treatment should be instituted immediately and may include the following:

- Supplemental oxygen
- SABA MDI or nebulized
- Anticholinergic medication MDI or nebulized
- Systemic corticosteroid (prednisolone 1 mg/kg/day over 5–7 days)

Pneumonia

Pneumonia may develop in the perioperative period due to aspiration or prolonged intubation. Most cases are nosocomial and involve *Streptococcus pneumoniae*. However, several other, more pathogenic bacteria, including *Acinetobacter* species, *Pseudomonas aeruginosa,* and *Staphylococcus aureus,* may also result in pneumonia. The signs and symptoms of pneumonia include shortness of breath, high fever, dyspnea, chest pain, and decreased or absent breath sounds. The presence of fever and increased ventilatory support (increased pressure support and FiO2) in an intubated patient should be considered suggestive of pneumonia. Infiltrations, loss of lung markings, and a pleural effusion will be seen on a chest X-ray. Broad-spectrum antibiotics should be instituted early, with the choice of antibiotic determined by a bronchoalveolar lavage and culture. The need to perform a tracheotomy to facilitate recovery remains controversial.[22]

Pulmonary embolus

Most pulmonary emboli arise from the deep veins of the legs. Risk factors include anything that results in pro-coagulable state. This includes smoking, contraceptives, pregnancy, reduced mobility, malignancy, and hereditary coagulation disorders. The latter

include antithrombin III deficiency, factor V Leiden, and protein C and S deficiencies, which may not have been previously diagnosed. Mitigation strategies to reduce the risk of PE include early ambulation, sequential calf compressors during surgery and the early postoperative period, thromboembolic deterrent stockings (TEDs), and postoperative LMWH.

The signs and symptoms of PE are nonspecific and include chest pain, dyspnea, and shortness of breath. Sinus tachycardia is common, while hemoptysis and a swollen calf are less common findings. Pain on dorsiflexion of the foot (positive Homan's sign) is not common, and the absence of this sign should be anticipated. If PE is considered a possibility, blood tests to measure D-dimer and an ABG to evaluate for an elevated alveolar-arterial (A-a) gradient should be performed. Additionally, a chest CT with contrast and a duplex ultrasound scan of the lower extremity veins should be conducted to identify subsegmental pulmonary thrombosis and DVT, respectively. An ECG is not generally helpful but will often reveal a simple sinus tachycardia. The classic findings of an S wave in lead I, a Q wave, and an inverted T wave in lead III are rarely seen.

The treatment of PE includes weight-based heparin (bolus and infusion), warfarin, or direct thrombin or factor Xa inhibitors. A large PE may require surgical thrombectomy due to the significant right ventricular strain. Recurrent PE despite anticoagulation may necessitate an inferior vena cava filter to limit the likelihood of PE.

Atelectasis

Atelectasis is common following general anesthesia and can lead to reduction in lung compliance, impaired minute ventilation, and reduced functional residual capacity (FRC). The signs of atelectasis may include decreased breath sounds, inspiratory crackles at the bases, and increased work of breathing. Incentive spirometry and early ambulation remain the mainstays of treatment.

Pulmonary edema

Pulmonary edema can be the result of both cardiac and noncardiac causes. Assuming normal cardiac function, causes of pulmonary edema can develop as a result of fluid overload, renal disease, or negative-pressure pulmonary edema (NPPE). The signs and symptoms are similar to many other pulmonary conditions with increased work of breathing, dyspnea, shortness of breath, decreased breath sounds, and bilateral crackles. A chest X-ray will often show diffuse infiltrates which are consistent with pulmonary edema.

The acute management requires supplemental oxygen with or without diuretics, although a short period of mechanical ventilation with PEEP may also be required in severe cases.

Airway

Difficulty in establishing an airway and maintaining ventilation are potentially serious complications that may result in significant morbidity and mortality. Prior difficulties with a sedation or general anesthesia are highly suggestive of a potential airway issue. The physical examination should include an assessment of the body mass index (BMI), cervical range of motion, maximum incisal opening (MIO), the presence of a retrognathic mandible, and the Mallampati score (Table 1.1.8).[23]

Patients with significant odontogenic infections, a history of head and neck cancer, head and neck radiation, OSA, and trismus are poor candidates for sedation and are best treated under local anesthesia or in a hospital setting where a difficult airway can be more easily managed. It is prudent to consider a variety of techniques to secure the airway rather than relying on a single technique. Basic techniques to support ventilation should be implemented early and include head tilt-chin lift, jaw thrust, oral airway, nasal airway, positive-pressure bag-valve-mask ventilation, or a combination of these. The surgeon should also be prepared to insert a supraglottic airway or endotracheal tube if needed. Although a last resort, cricothyroidotomy should be considered when all else fails.

Renal disease

A decline in renal function may result in electrolyte abnormalities. The ability to regulate sodium, potassium, anion gap, calcium, magnesium, phosphorus, and other electrolytes is compromised. The regulation of metabolic waste and urea is also impaired, which may result in uremia and platelet dysfunction. A basic metabolic panel and complete blood count (CBC) provide adequate information to determine renal

Table 1.1.8 Mallampati classification.

Class	Anatomy
I	Visualized entire tonsillar pillars, uvula, soft palate, hard palate
II	Visualized upper tonsillar pillars, base of uvula, soft palate, hard palate
III	Visualized base of uvula, soft palate, hard palate
IV	Visualized hard palate

function. The most robust assessment of renal function is the glomerular filtration rate (GFR). The GFR is estimated as part of the metabolic panel but can also be more accurately calculated using equations that incorporate age, sex, weight, and serum creatinine. Urinalysis with microscopy also allows the presence of crystals, red and white blood cells, and protein to be recognized.

Renal impairment or failure is often divided into three categories: prerenal, renal, or postrenal. Determining which category of impairment is present is important. The prerenal causes include hypovolemia and shock, significant hypotension, and heart failure. Renal causes include acute tubular necrosis (ATN), interstitial nephritis (IN), glomerulonephritis (GN), and pyelonephritis. ATN may be secondary to renal ischemia and can be seen in the setting of hypotension, intravenous contrast media, and massive rhabdomyolysis. It is recognized by the presence of muddy brown casts in the urinalysis/microscopy. IN is most commonly associated with nephrotoxic drugs and drug overdosing and leads to eosinophilia within the urine. GN is most often autoimmune related and can be recognized by RBC casts in the urine. Postrenal causes are obstructive in nature and often suggest benign prostate hypertrophy and renal stones.

Acute renal failure results in reduced urine output, increased serum creatinine, and electrolyte abnormalities. New-onset renal failure should require evaluation to determine the cause. This will include serum electrolytes, urea, creatinine, and urinalysis with microscopy. The fractional excretion of sodium (FENa) should also be determined, as this allows prerenal, renal, and postrenal causes to be distinguished. The FENa is calculated as follows:

$$\text{FENa} = \frac{[\text{Urine Na}]/[\text{Plasma Na}]}{[\text{Urine Cr}]/[\text{Plasma Cr}]}$$

A FENa <1% suggests prerenal causes, a FENa >2% suggests renal causes, and a FENa above 4% is most suggestive of a postrenal cause.

Perioperative management of renal disease should focus on the volume status and electrolyte imbalance, particularly hypokalemia. As hyperkalemia increases above 5.5 mEq/L, the potential for cardiac arrhythmia increases. Initial electrocardiograph changes that may occur include a wide QRS complex, loss of P waves, and peaked T waves. This mandates treatment with calcium gluconate to stabilize the cardiac membrane and reduce the risk of arrhythmia, kayexalate to reduce gastrointestinal (GI) absorption of potassium, and on occasion, a dextrose/insulin infusion. Significant hyperkalemia may require dialysis.

Nephrotoxic drugs should be stopped or renally dosed. Dialysis may be required in the short term until renal function improves. It may be performed with continuous renal dialysis, peritoneal dialysis, or traditional dialysis, depending on the status of the patient.

Liver disease

Liver disease is often conspicuous by the absence of signs and symptoms. As the severity of the disease increases, signs of jaundice, telangiectasia, splenomegaly, and generalized pruritus may become apparent. Liver disease may also affect other organ systems resulting in pleural effusion and renal dysfunction. Spontaneous and excessive bleeding may develop secondary to the reduced synthesis of coagulation factors II, VII, IX, and X all of which are vitamin K-dependent.

The model for end-stage liver disease (MELD) system has generally replaced the child's classification for evaluating liver function.[24] The MELD score is calculated based on the patient's serum creatinine, bilirubin, and INR. A simple calculator is available online to facilitate the process (www.unos.org/resources/meldcalculator.asp). Patients can be stratified based on the MELD score, with a MELD <10 considered adequate for elective surgery, a MELD score of 10–15 posing additional risk, and a MELD score >15 being a contraindication to elective surgery.

Liver function is easily evaluated by measuring liver enzymes (gamma-glutamyl transpeptidase, aspartate aminotransferase, and alanine aminotransferase), as well as serum bilirubin, coagulation times (prothrombin time, partial thromboplastin time), and the INR. The degree of hepatic fibrosis, if present, can be estimated using the aspartate aminotransferase to platelet ratio (APRI).[25] A ratio that is >0.7 is highly suggestive of liver dysfunction.

The INR should be one, with increasing values reflecting more severe liver dysfunction. When the INR needs correction and there is no urgency, vitamin K can be administered either orally (PO) or intravenously (IV), and will result in a decrease in the INR over 24 hours. Fresh frozen plasma and activated factor VII will result in a more rapid reduction in the INR and are optimal for acute bleeding. Desmopressin (DDAVP) may also be beneficial for less severe liver disease and will reduce the INR by increasing von Willebrand's factor (vWF) and factor VIII. Hyperammonemia, secondary to protein metabolism, can be managed with lactulose to reduce GI reabsorption and dietary modification to reduce intake. Liver disease increases the risk of bacterial translocation across the GI tract, which can lead to

peritoneal infection. It is, therefore, recommended that patients with liver disease receive antibiotic prophylaxis to reduce the risk. Portal HTN also increases the risk of gastroesophageal varicosities and bleeding, and this risk can be reduced with the use of histamine (H_2) antagonists.

Blood disorders

Anemias

A decrease in RBC production or an increase in RBC destruction will both result in anemia. Elective surgery should be deferred for most patients with moderate to severe anemia until the etiology of the anemia is determined. The evaluation of patients with anemia can be complex. The initial workup includes a CBC, hemoglobin, and hematocrit as well as mean corpuscular volume (MCV) and mean corpuscular hemoglobin concentration (MCHC). This allows for the determination of whether the anemia is microcytic, normocytic, or macrocytic. The reticulocyte count (RC) will also differentiate between decreased RBC production (decreased RC) or increased destruction (increased RC). Additional tests include serum iron, total iron-binding capacity, vitamin B12, ferritin, folate, methylmalonic acid, and homocysteine, which can further identify the underlying problem.

Consideration for performing a blood smear with both direct and indirect Coomb's test is appropriate when disseminated intravascular coagulation (DIC), thrombotic thrombocytopenic purpura (TTP), or hemolytic-uremic syndrome (HUS) are potential diagnoses.

Iron supplementation for iron deficiency anemia will improve the anemia over several months. Vitamin B_{12} or folate supplementation should also be instituted when they are deficient.

Sickle cell anemia is relatively common. It can lead to recurrent vaso-occlusive crises, which often lead to ischemia with resultant pain. The heart, lungs, kidneys, and bones are often affected. The treatment requires aggressive hydration, supplemental oxygen to reduce sickling, hydroxyurea, and opioids to mitigate the severe pain.

Lymphoma and multiple myeloma

Lymphoma is a malignancy of lymphoid tissue. It can be classified as Hodgkin's lymphoma (Reed-Sternberg cells) and non-Hodgkin's lymphoma (NHL). Furthermore, Waldenström's macroglobulinemia, a low-grade form of NHL, increases the risk of hyperviscosity syndrome, which can lead to Raynaud's phenomenon and peripheral neuropathy.

Malignant proliferation of plasma cells results in multiple myeloma (MM) and leads to the production of a monoclonal antibody (M-protein). Although the disease progresses slowly, it can result in bone pain, hypercalcemia, hyperviscosity syndrome, and renal disease (nephrotic syndrome).

Treatment may include chemotherapy and/or bone marrow transplantation (BMT). The latter has the potential to be curative. Radiation may also be used to reduce symptoms. One of the mainstays of management is the use of antiresorptive medications. These limit bone resorption but may result in medication-related osteonecrosis of the jaws (MRONJ).

Thrombocytopenia

Thrombocytopenia may lead to spontaneous bleeding when the platelet count falls below 50,000 cells/mm.[3] There are multiple causes of thrombocytopenia, including idiopathic thrombocytopenic purpura (ITP), thrombotic thrombocytopenic purpura (TTP), hemolytic-uremia syndrome (HUS), and disseminated intravascular coagulation (DIC). ITP is an autoimmune state secondary to some viral respiratory illness. It is self-limiting and typically is best treated with steroids. Recurrent ITP may necessitate splenectomy. TTP and HUS are relatively similar and often present with hemolytic anemia, thrombocytopenia, and renal dysfunction. TTP differs from HUS in that it may also be associated with seizures. DIC is a serious condition that tends to occur with polytrauma and in patients that are septic. Despite the coagulopathy and thrombus formation, patients are at risk of bleeding secondary to the consumption of coagulation factors. It may also be seen in the perioperative period, particularly in polytrauma and septic patients. Platelet transfusion for thrombocytopenia is often beneficial, but the increase in platelet count may be limited by autoantibodies following multiple platelet transfusions.

Coagulopathy

A history of spontaneous bleeding or bleeding with any prior surgical procedures (including extractions) is highly suggestive of coagulopathy.

Thrombasthenia results in defective platelets and is seen with Bernard-Soulier thrombasthenia and Glanzmann's thrombasthenia. Platelet transfusion may be required depending on the severity of the planned surgical procedure. Medications may also result in defective platelet function. This is mild with NSAIDs but can be more pronounced when ADP or glycoprotein IIb/IIIa receptor inhibitors are administered. These include common medications such as clopidogrel, ticlopidine, abciximab, tirofiban, and eptifibatide. Perioperative

management may include discontinuing the medication, depending on the nature of the planned surgery and the initial reason for its use of the medication. Platelet transfusion may also be required.

Von Willebrand's disease (vWD) can be divided into types I, II, and III. It is characterized by a quantitative and/or qualitative reduction in vWF and factor VIII. Type I vWD is the most common form, resulting from low levels of vWF, and is treated with medications to increase vWF levels. These include desmopressin acetate (DDAVP), which can be administered intranasally or intravenously to increase vWF and factor VIII levels. Recombinant vWF or antihemophilic factor/vWF complexes can also be used and are particularly helpful for more severe disease and when major surgery is indicated.

Hemophilia A and B

Hemophilia A is a common X-linked recessive inherited disorder. It is characterized by a deficiency in factor VIII, leading to the potential for excessive bleeding. Hemophilia A can be classified based on the factor VIII level:

- Mild hemophilia (factor VIII level of >5%).
- Moderate hemophilia (factor VIII level 1% to 5%).
- Severe hemophilia (factor VIII level < 1%).

The factor VIII level will need to be increased prior to any surgical procedure. Minor surgical procedures typically only require a factor VIII level of at least 50% of the normal value. A factor VIII level that is normal is typically required for major surgical procedures. Mild cases of hemophilia often respond to DDAVP alone.

Recombinant factor VIII (rFVIII) and FFP remain the mainstays of treatment. The short half-life of rFVIII has typically required multiple injections, although the recent development of extended plasma life products has greatly reduced the frequency of FVIII administration. This has been made possible by linking an immunoglobulin Fc domain or polyethylene glycol (PEG) to FVIII. Cryoprecipitate, which contains fibrinogen, FVIII, FXIII, and vWF, is no longer used to treat hemophilia. Unfortunately, some patients will develop alloantibodies (inhibitors) against many forms of exogenous recombinant FVIII, making management challenging. Activated prothrombin complex concentrates (aPCCs) and recombinant activated factor VII (rFVIIa) remain the mainstays for treating patients with acute bleeding and those with inhibitors.

Hemophilia B is a deficiency of factor IX and can also be classified as mild, moderate, or severe in a similar fashion to hemophilia A. Treatment requires recombinant FIX or FFP.

The diagnosis of hemophilia A or B requires the measurement of factor VIII and IX levels, respectively. In addition, the level of vWF also requires measurement to ensure normal levels are present (as opposed to vWD). The partial thromboplastin time (PTT) is elevated in hemophilia, while the prothrombin time (PT) remains normal.

States of coagulopathy

Thrombosis can develop as a result of inherited disorders or secondary to acquired conditions. Antithrombin III deficiency, factor V Leiden, and protein C and S deficiencies are the most frequently encountered inherited disorders. Systemic lupus erythematosus, malignancy, and nephritic syndrome are the most common acquired disorders. In addition, prolonged immobilization, smoking, pregnancy, and contraception all increase the risk of thrombosis. The risk of thrombosis can be mitigated with the following:

- Early postoperative ambulation
- Sequential calf compressors during and immediately following surgery
- Thromboembolic deterrent stockings (TEDS)
- Unfractionated heparin (5,000 units SQ TID) or low molecular weight heparin (30 mg subcutaneously BID)

Endocrine

Diabetes mellitus

Physiological stress in the perioperative period is common and is secondary to the surgical procedure, anesthesia, psychological factors, and the disease process itself. Stress results in the secretion of antidiuretic hormone (ADH), cortisol, catecholamines, glucagon, and growth hormone. This leads to decreased insulin secretion, insulin resistance, lipolysis, proteolysis, and hyperglycemia. The latter results in ketogenesis, increased proinflammatory cytokines, endothelial dysfunction, immune dysregulation, and diuresis. The goal of therapy is to maintain the blood glucose level between 140 and 180 mg/dL while avoiding hypoglycemia (<70mg/dL) or hyperglycemia (>180 mg/dL).

Management can be divided into preoperative, operative, and postoperative phases.[26] The important preoperative aspects include obtaining a detailed history to identify DM-related nephropathy, neuropathy, retinopathy, and cardiovascular disease. The history should also seek to identify the current treatments,

including diet modification, oral hypoglycemic medications, and insulin use. The hemoglobin A1c (HbA1c) should be checked to assess the glycemic control over the preceding three months.

Oral hypoglycemic medications and non-insulin injectables, including metformin, sulfonylureas, thiazolidinediones, glinides, alpha-glucosidase inhibitors, dipeptidyl peptidase-4 (DPP-4) inhibitors, and sodium-glucose cotransporter-2 (SGCT-2) inhibitors, should be held in the perioperative period. Glucagon-like-peptide-1 (GLP-1) receptor agonists have recently flooded the market and should also be held before surgery, although some of these drugs are administered daily and others weekly, which may require discontinuation for an extended period of time leading to poorly controlled blood glucose levels in the perioperative period.

Patients on long-acting insulin (e.g., glargine, detemir) should decrease their long-acting basal dose by 25% on the evening prior to surgery or the morning of surgery, depending on when they take their usual dose. Patients taking intermediate-acting insulin, such as neutral protamine Hagedorn (NPH), should take their usual dose the night before surgery and reduce the morning dose by 50% on the day of surgery. The same regime applies to patients taking premixed insulin such as NPH/Regular 70/30 or aspart protamine/aspart 75/25. Short-acting prandial insulin should be held during the fasting period (Table 1.1.9).

The intraoperative management of DM requires blood sugar checks every two hours and the administration of subcutaneous (SC) short-acting insulin for hyperglycemia exceeding 180mg/dL. In rare cases, when the surgery is anticipated to last beyond four to five hours, the use of an intravenous insulin infusion should be considered. The dose of short-acting insulin can be calculated as follows:

$$\text{Units regular insulin} = \frac{\text{Blood sugar level} - 140}{40}$$

Postoperative patients who are ambulatory and tolerating PO intake should resume their normal antihyperglycemic regime. Patients who require hospitalization will need management with basal, prandial (when taking PO), and correctional insulin. Basal insulin should consist of long-acting insulin once or, occasionally, twice a day. Prandial (short-acting) insulin should be taken before meals when PO intake has resumed. Correctional insulin should be administered based on the blood sugar level (BSL) when they exceed 180mg/dL.

The postoperative insulin doses can be determined using the patient's usual preoperative insulin dose, or it can be calculated empirically. The initial total daily insulin (TDI) requirement and basal insulin needs can be calculated as follows:

- TDI units = weight in pounds divided by 4 or weight in kilograms divided by 0.55
- Basal long-acting insulin units = 50% of TDI
- Prandial short-acting insulin units = $\frac{\textbf{50\% of TDI}}{\textbf{3}}$ for each of the three standard meals per day
- Correctional insulin – use the SSI shown above

Individual response to insulin depends on many factors, including the relative insulin sensitivity or resistance of any given patient. Initially, it is prudent to treat all patients as insulin-sensitive to avoid hypoglycemia. A single unit of short-acting correctional insulin will typically reduce the BSL by about 40 mg/dL in most patients.

Many patients may have an insulin pump that delivers short-acting insulin continuously to provide a basal level. The use of an insulin pump in the perioperative period is challenging, particularly during longer surgical procedures. Ideally, the use of the pump should be discontinued and replaced with long-acting basal insulin. The basal insulin dose can be calculated by determining the total dose of the short-acting insulin within the pump used in 24 hours.

Table 1.1.9 Preoperative insulin dosing.

Insulin type	Evening before surgery	Morning of surgery
Long acting	75% usual dose	75% usual dose
Intermediate acting	Usual dose	50% usual dose
Premixed	Usual dose	50% usual dose
Short-acting	Usual dose	Hold dose

Thyroid disease

The thyroid gland produces triiodothyronine (T3) and thyroxine (T4). These hormones influence the basic metabolic rate (BMR), protein synthesis, and growth and facilitate responses to catecholamines through permissiveness. Signs and symptoms of hypothyroidism include weight gain, cold intolerance, hair loss, fatigue, dry skin, constipation, bradycardia, narrow pulse pressure, and sexual dysfunction. The constellation of signs and symptoms is often referred to as "myxedema." Causes of hypothyroidism include insufficient iodine resulting in goiter and surgical thyroidectomy. Signs and

symptoms of hyperthyroidism include weight loss, heat intolerance, irritability, hair loss, diarrhea, exophthalmos, tachycardia, palpitations, AF, and insomnia. Causes of hyperthyroidism include Graves' disease, thyroid nodules, and thyroiditis. The most concerning perioperative consideration for patients with thyroid disease is the development of thyrotoxicosis or thyroid storm.

Preoperative screening for hypothyroidism and hyperthyroidism includes thyroid-stimulating hormone (TSH).[27] Additionally, T3 and T4 should also be measured, particularly when hyperthyroidism is suspected. Hypothyroidism is treated with levothyroxine, with the adequacy of treatment evidenced by a normalized TSH level. Hyperthyroidism can be treated with propylthiouracil (PTU) or methimazole, combined with a beta-blocker. Thyroid storm is the most severe form of hyperthyroidism, resulting from a sudden and profound increase in thyroid hormones, leading to fever, profuse sweating, vomiting, diarrhea, delirium, weakness, seizures, irregular heartbeat, and coma. Mortality approaches 75% if not treated. The storm can be precipitated by a surgical procedure, infection, or trauma. Treatment is a medical emergency consisting of PTU or methimazole. Iodine may be administered to reduce the release of additional T3 and T4, although the beneficial effect is transient and limited to 7–10 days. Corticosteroids can also be administered to immediately reduce the conversion of T4 to active T3. Cholestyramine can also be administered to help bind intestinal hormones and reduce overall hormone levels relatively quickly. Thyroid storm usually resolves over 1–2 days with treatment.

Adrenal function

Excessive cortisol production is the key feature of Cushing's syndrome. Adrenal hyperplasia, pituitary adenoma, ectopic adrenocorticotropic hormone (ACTH) production secondary to malignancy, or exogenous corticosteroid administration remain the four major causes of excessive cortisol. The most common signs and symptoms include central obesity, moon facies, abdominal striae, hyperglycemia, hirsutism, HTN, and purpura. If considering Cushing's syndrome, the ACTH level and 24-hour urine free cortisol levels should be measured. The dexamethasone suppression test can be further used to make the diagnosis. An increase in aldosterone production is the key feature of Conn's syndrome, which is secondary to adrenal hyperplasia or adenoma. The classic presentation includes hypernatremia, hypokalemia, hyperchloremia, and metabolic alkalosis. Elevated serum aldosterone levels confirm the diagnosis. Fluid balance and electrolyte abnormalities are the main concerns in the perioperative period.

Adrenal insufficiency, or Addison's disease, is primary when it results from adrenal gland destruction due to autoimmune disease, infection, or infarction. It is characterized by hyperpigmentation and an elevated ACTH level. It can also be secondary when caused by decreased pituitary ACTH production. The cosyntropin stimulation test will identify secondary adrenal deficiency by resulting in an elevated cortisol level. Addison's disease results in both a reduced cortisol and aldosterone production.

Inadequate levels of adrenal cortisol, often with stress and surgery, result in an adrenal crisis characterized by severe hypotension, nausea and emesis, abdominal pain, lethargy, altered mental status, and electrolyte abnormalities. The prevention and treatment of an adrenal crisis require perioperative steroid administration. The dose and duration will depend on the magnitude of the surgical insult and the patients' postoperative course. Minor surgical procedures, such as extractions, may not require an increase in the patient's usual daily corticosteroid dose, although pre- and post-procedure BP should be closely monitored. Major office- and hospital-based surgical procedures require an increase in the usual steroid dose, which can be given orally or parenterally. This can be achieved by asking the patient to double or triple their usual daily dose or by administering hydrocortisone or a more potent and longer-acting corticosteroid (Table 1.1.10).

Pituitary disease

Diabetes insipidus (DI) may be central or nephrogenic, depending on whether the pituitary gland production of ADH is low or the kidneys are poorly responsive to ADH, respectively. The net result of DI is the urinary

Table 1.1.10 Corticosteroid dosing.

Drug	Relative Glucocorticoid Potency	Relative Mineralocorticoid Potency
Cortisone	0.8	1
Prednisolone	1	1
Methylprednisolone	4	0.8
Triamcinolone	5	0
Betamethasone	30	0
Dexamethasone	30	0
Fludrocortisone	15	150
Aldosterone	0	500

loss of free water resulting in increased serum osmolality and hypernatremia. The water deprivation test when associated with continued urine production can help make the diagnosis. It is important to distinguish central and nephrogenic DI. Administering DDAVP results in a decrease in free water urinary loss and correction of serum osmolality and hypernatremia when central DI is present. Fluid balance and correcting electrolytes are the mainstays of management.

Neurological disease

Trauma

Head trauma may result in an acute deterioration of neurological function. The severity of the neurological injury is best determined during the secondary survey after the patient is stabilized following the primary survey. The Glasgow coma scale (GCS) remains the most common system to classify the severity, treatment, and prognosis of head-injured patients (Table 1.1.11).[28]

Patients can be classified as having a mild, moderate, and severe head injury depending on the GCS score. The scores can be mild (13–15), moderate (9–12), or severe (<9). Patients with a GCS of 8 typically require intubation.

Seizures

Patients with a known seizure disorder require little additional perioperative management other than maintaining their anti-seizure medication throughout the perioperative period. The occurrence of perioperative seizures is possible, and patients may require treatment if the seizure is not self-limiting. New-onset seizures in the perioperative period mandate a thorough evaluation to determine the etiology, which may include fever, electrolyte abnormalities, CVA, or medication-induced causes. Benzodiazepines are useful in terminating seizures. Seizures that are persistent or recurrent may require intravenous loading and maintenance with phenytoin or fosphenytoin. Immediate neurology consultation is highly suggested. A head CT should be considered for an acute intracranial bleeding episode. Patients will typically require prolonged anti-seizure medication in the perioperative and postoperative periods.

The use of general anesthesia medications in the perioperative period will reduce the likelihood of seizures. Local anesthetics may result in seizures with a moderate overdosage due to suppression of inhibitory interneurons. Appropriate weight-based dosing of all local anesthetics is critical to avoid this risk, as is aspiration before injection.

Myasthenia gravis

Myasthenia gravis, an autoimmune condition, is characterized by the presence of autoantibodies against acetylcholine (Ach) receptors. This leads to generalized muscle weakness, resulting in fatigue, eyelid ptosis, and diplopia, dysarthria, dysphonia, dysphagia, and even respiratory distress or failure. Some medications are known to increase the risk of an MG crisis, including aminoglycosides, meperidine, and phenytoin. The diagnosis of MG is based on generalized and progressive muscle weakness, electromyographic studies (EMG) confirming reduced amplitude with repetitive nerve stimulation, and the edrophonium test, which usually results in an improvement in the patients' symptoms. An acute or subacute MG crisis may necessitate the use of intravenous immunoglobulin (IVIG) or plasmapheresis.

Substance abuse

Patients with substance abuse present several challenges related to the diagnosis and management. As many as 9% of patients have a substance abuse problem.[29] The most common drugs include alcohol, benzodiazepines, cocaine, methamphetamine, heroin, methadone, prescription opioids, marijuana, ecstasy, lysergic acid diethylamide (LSD), ketamine, phencyclidine (PCP),

Table 1.1.11 Glasgow coma scale.

Eye Opening and Score		Verbal Response		Motor Response	
Spontaneously	4	Orientated	5	Obeys commands	6
To speech	3	Confused	4	Localizes pain	5
To pain	2	Inappropriate words	3	Withdraws to pain	4
No response	1	Incomprehensible	2	Flexes to pain	3
		No response	1	Extends to pain	2
				No response	1

Table 1.1.12 CAGE criteria.

Question	Score
Have you felt the need to **cut down** on your drinking?	0 or 1
Have people **annoyed** you by criticizing your drinking?	0 or 1
Have you ever felt bad or **guilty** about your drinking?	0 or 1
Eye-opener: Have you ever had a drink in the morning to alleviate the hangover?	0 or 1

Score ≥2 is clinically significant.

and gamma-hydroxybutyrate (GHB). There are multiple tools for screening substance abuse, while confirmation requires urine tests or a blood test for alcohol. All patients should be screened as part of their history and physical examination. Perioperative risks are best considered for each drug independently.

- *Alcohol:* Screening can be completed using the CAGE questionnaire (Table 1.1.12). Risks include aspiration, pneumonia, poor wound healing, liver cirrhosis, and acute withdrawal. The latter is the most concerning given the potential morbidity and mortality. Patients should receive thiamine supplementation to reduce the likelihood of Wernicke's encephalopathy and, ultimately, Korsakoff syndrome. The former is characterized by ophthalmoplegia, ataxia, and confusion. Acute alcohol withdrawal syndrome (AWS) is characterized by anxiety, sweating, vomiting, tachycardia, delirium tremens, hallucinations, and seizures. It can be both prevented and treated with benzodiazepines such as chlordiazepoxide and lorazepam. The former is typically used as a fixed tapering dose to prevent withdrawal with 50 mg PO four times per day on day 1, 50 mg PO three times a day on day 2, 25 mg PO four times a day on day 3, and 25 mg PO three times a day on day 4. Current evidence suggests that a symptom-triggered approach (STA) is more ideal, with use of 1–2 mg lorazepam PO every 2 hours PRN or clonazepam 0.5–1.0 mg IV every 4–6 hours PRN. Ultimately, the PO or IV dose must be titrated to alleviate the signs and symptoms of the alcohol withdrawal. Furthermore, the concomitant administration of opioids will influence the required dose and the potential for respiratory compromise.
- *Benzodiazepines:* The concern regarding this class of medications relates to the possibility of overdose and respiratory suppression. Overdose can be effectively treated with flumazenil. Another concern relates to the potential for withdrawal in the postoperative setting. This can be avoided by continuing a therapeutic dose of benzodiazepines during the perioperative period or by using a STA following the algorithm listed above.
- *Cocaine:* Cocaine may result in psychosis, paranoia, systemic HTN, pulmonary HTN, CVA, and ACS. Intraoperative hypotension (secondary to catecholamine depletion) and HTN can be challenging to manage. Phenylephrine can be used to manage hypotension while nitroprusside, nitroglycerin, or dexmedetomidine can be used for HTN. Ketamine is best avoided due to its sympathomimetic action. Withdrawal is exceedingly uncommon.
- *Amphetamine and Methamphetamine:* These drugs are often used to treat attention deficit hyperactivity disorder (ADHD) and narcolepsy. Abuse may result in cardiac arrhythmias, ACS, cardiomyopathy, and aortic dissection. Pulmonary HTN may develop if the drug is inhaled or smoked. Intraoperative manifestations are like cocaine with the potential for both hypotension and HTN. Treatment is also similar.
- *Opioids:* Abuse may be the result of prescription or non-prescription opioids. The latter includes heroin and synthetic drugs such as fentanyl. The potential effect of all opioids is respiratory depression, although chronic use may also result in an increased sensitivity to pain, making perioperative pain management challenging. Overdose can be reversed with naloxone, while surgical pain can be mitigated with the use of NSAIDs, acetaminophen, gabapentin, pregabalin, and long-acting local anesthesia. Patients with a prior history of opioid abuse or those who are being treated with a partial agonist/antagonist combination, such as buprenorphine/naloxone (e.g., Suboxone®) will require consultation with the acute pain service to help manage postoperative pain.
- *Marijuana:* Perioperative concerns are mild and are most often limited to respiratory irritation (similar to tobacco) and the potential for HTN and cardiac arrhythmias.

Obesity

Obesity is best quantitated using the BMI (mass in kilograms / square of height in meters) (Table 1.1.13).

Table 1.1.13 Body mass index.

Category	BMI Range
Severely underweight	<16.5
Underweight	16.5–18.4
Normal	18.4–24.9
Overweight	25.0–30.0
Obese	30.1–40.0
Morbidly obese	>40.0

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The perioperative risk increases as BMI increases. The most concerning issues are airway and pulmonary, with the later related to a reduced FRC. A combined short neck, increased neck circumference, higher Mallampati score, and enlarged tongue make intubation more difficult. The reduced FRC further reduces the time to desaturation during induction. Extubation may also result in airway compromise for similar reasons. It remains prudent to ensure adjunct airways are available, as well as video laryngoscopy and fiberoptic equipment, should they be needed. Increased abdominal girth also increases intra-abdominal pressure, which increases the risk of esophageal reflux and aspiration. Comorbid conditions that are often associated with increasing BMI include OSA, HTN, CAD, and CVA.

Postoperative issues include pulmonary function and the risk of DVT, particularly when ambulation is delayed. As with all patients, measures to reduce the risk of DVT should include the use of TEDs, prophylactic unfractionated or fractionated heparin, and early mobilization. The possibility of undiagnosed OSA should also be considered, as this influences the need and duration of postoperative monitoring, as well as the potential need for continuous positive airway pressure (CPAP).

Geriatric patients

Advancing age increases perioperative complications and length of stay.[30] Myocardial infarction, ACS, and arrhythmia account for the majority of cardiac events, while respiratory failure, pneumonia, and acute renal failure account for the majority of noncardiac causes. However, the NSQIP remains the only tool with age as a variable included in risk calculation.

Cardiac reserve declines with age and is often related to diastolic dysfunction, CAD, valvular dysfunction (stenosis and regurgitation), and the propensity for arrhythmias. These issues are further complicated by the presence of autonomic dysfunction. Carotid stenosis also increases with age, as does the perioperative risk of CVA.

Pulmonary reserve also declines because of a reduction in lung diffusion capacity and ventilation-perfusion mismatching. A concomitant reduction in the FRC with age compounds the problem and increases the risk of respiratory failure and pneumonia. Early ambulation, incentive spirometry, and the avoidance of prolonged intubation remain the only tools to mitigate risk.

Renal function declines with age, as measured by serum creatinine levels as an indirect measure of GFR. This creates the potential for electrolyte abnormalities and fluid shifts that must be corrected in the perioperative period.

Pediatric patients

The pediatric patient provides several challenges based on differences in anatomy and physiology when compared to an adult. Establishing an airway is more difficult given the relatively large tongue, floppy epiglottis, and anterior location of the vocal cords. This may necessitate the use of a straight Miller blade or video laryngoscopy to facilitate intubation. The FRC is lower than that of an adult, which will lead to rapid desaturation. The main cardiac issue is the dependence on heart rate to maintain cardiac output.

Fluid administration and resuscitation should be weight based, with careful attention to ensure the urine output is adequate (2 to 3 mL/kg/h for pediatrics). Medication doses should also be weight based in infants and toddlers. Certain medications, including tetracyclines and fluoroquinolones, should be avoided as they may result in deposition within mineralized tissues, including teeth, bones, and cartilage.

Pregnancy

Pregnancy will result in changes in cardiac output and minute ventilation. A decrease in cardiac output and hypotension may result from compression of the inferior vena cava by the gravid uterus. Using a lateral decubitus position when supine will help reduce these issues. The FRC is also reduced as the pregnancy progresses leading to the potential for rapid desaturation during intubation while the elevated intra-abdominal pressure increases the likelihood of gastroesophageal reflux disease (GERD) and the risk of aspiration.

Hypertension, proteinuria, headache, and edema are all features of preeclampsia. Without appropriate treatment, this may progress to eclampsia, characterized by tonic-clonic seizures. Hemolysis, elevated liver enzymes, and low platelets (HELLP syndrome) may also develop with either condition.

The choice of medications for a pregnant patient must include careful consideration of the potential for teratogenesis (Table 1.1.14). Only category A, B, or C should be used during pregnancy.

Table 1.1.14 Drug classification in pregnancy.

Class A	Adequate and well-controlled studies have failed to demonstrate a risk to the fetus in the first trimester of pregnancy.
Class B	Animal reproduction studies have failed to demonstrate a risk to the fetus, and there are no adequate and well-controlled studies in pregnant women, OR animal studies have shown an adverse effect, but adequate and well-controlled studies in pregnant women have failed to demonstrate a risk to the fetus in any trimester.
Class C	Animal reproduction studies have shown an adverse effect on the fetus, and there are no adequate and well-controlled studies in humans, but potential benefits may warrant use of the drug in pregnant women despite potential risks.
Class D	There is positive evidence of human fetal risk based on adverse reaction data from investigational or marketing experience or studies in humans, but potential benefits may warrant the use of the drug in pregnant women despite potential risks.
Class X	Studies in animals or humans have demonstrated fetal abnormalities and/or there is positive evidence of human fetal risk based on adverse reaction data from investigational or marketing experience, and the risks involved in the use of the drug in pregnant women clearly outweigh potential benefits.

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