Preoperative Evaluation Before Noncardiac Surgery

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Abstract

The medical complexity of surgical patients is increasing and medical specialties are frequently asked to assist with the perioperative management surgical patients. Effective pre-anesthetic medical evaluations are a valuable tool in providing high-value, patient-centered surgical care and should systematically address risk assessment and identify areas for risk modification. This review outlines a structured approach to the pre-anesthetic medical evaluation, focusing on the asymptomatic patient. It discusses the evidence supporting the use of perioperative risk calculation tools and focused preoperative testing. We also introduce important key topics that will be explored in greater detail in upcoming reviews in this series.

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This article is the first in a series of review articles on perioperative medical evaluation and management. We review perioperative physiology and introduce our approach to a pre-anesthetic medical evaluation, focusing on the asymptomatic patient. Subsequent articles will discuss specific topics relevant to perioperative management of the surgical patient.

THE SURGICAL STRESS RESPONSE AND THE PHYSIOLOGY OF ANESTHESIA

Understanding the physiologic changes due to surgical stress and anesthesia are necessary for perioperative risk assessment and management. The surgical stress response is activated by afferent input to the hypothalamus from the site of tissue injury, which results in endocrine, metabolic, and inflammatory responses.[1,2] The endocrine stress response includes increases in levels of cortisol, adrenocorticotropic hormone, growth hormone, catecholamines, renin, and antidiuretic hormone (ADH). Metabolic changes such as catabolism of carbohydrates, fat, and protein provide increased energy needed for the production of glucose and acute-phase proteins. Salt and water metabolism is influenced by ADH (which promotes free water retention and the production of concentrated urine) and renin/aldosterone (which promotes sodium and water reabsorption). The inflammatory response to surgery is predominantly driven by the release of cytokines (interleukin-1, interlukin-6, and tumor necrosis factor-α) from the leukocytes, fibroblasts, and endothelial cells from the site of the injured tissue. These cytokines initiate a local response, but also initiate a more systemic acute-phase response with the production of acute-phase proteins from the liver. The magnitude of the surgical stress response is proportional to the degree of surgical injury. Its duration also varies; the effect of ADH lasts for 3 to 5 days postoperatively, whereas the effects of cytokines last 48 to 72 hours.[1]

Anesthetics contribute to many perioperative physiologic changes. Two major classes of anesthesia are available: general and neuraxial anesthesia. Multiple factors contribute to selecting the most appropriate anesthetic, and this choice is best left the anesthesiologist. General anesthesia (GA) is comprised of a triad of hypnosis, analgesia, and muscle relaxation.[3] During the induction phase, an intravenous combination of a sedative-hypnotic (such as propofol, etomidate, or

ketamine), an adjuvant (such as midazolam, opioid, or lidocaine), and a neuromuscular blocking agent (such as rocuronium, vecuronium, or cisatracurium) are used. An inhalation agent (sevoflurane, desflurane, isoflurane, or nitric oxide) may be added once initial loss of consciousness is achieved.[4] Maintenance of anesthesia is achieved by using an inhalation agent, intravenous anesthesia, or, most commonly, a combination of both.[4] GA leads to multisystem physiologic changes, particularly during induction and emergence.[4] The most important effects are hypotension due to vasodilatation, decreased heart rate and decreased stroke volume, and respiratory impairment due to loss of respiratory muscle tone, reduced lung volume, and airway closure.[4,5]

Neuraxial anesthesia, including spinal and epidural techniques, creates unique physiologic effects due to a blockade of the sympathetic nervous system and unopposed parasympathetic tone. This sympathectomy occurs above the sensory level (unmyelinated nerves are more sensitive to anesthetics) and causes hypotension and bradycardia. Patients with hypovolemia or pre-load dependent cardiac disease (such as aortic stenosis or hypertrophic cardiomyopathy) are at significant risk of complications, including cardiac arrest and death. Respiratory effects include a sense of dyspnea and a reduction in expiratory effort and cough strength. Paralysis of the accessory muscles and diaphragm can occur if a high spinal level is achieved. Finally, afferent and efferent nerve signals to the bladder are blocked, resulting in urinary retention.[6]

In summary, the surgical stress response and anesthesia affect multiple organ systems and awareness of these important physiologic changes is vital to understanding how best to manage them in the perioperative setting.

PERIOPERATIVE RISK ASSESSMENT

Effective pre-anesthetic medical evaluations should systematically address risk assessment and risk modification. Risk assessment requires an analysis of surgical urgency, surgery-specific risk, patient-specific risk, and the status of relevant comorbidities. This information can then be integrated to formulate preoperative and postoperative risk modification recommendations.

Surgical Urgency

Surgical urgency is one of the most important determinants of perioperative risk and management. Many guidelines, including those from American, European, and Canadian cardiovascular societies, recommend assessing surgical urgency as the first step in a pre-anesthetic medical evaluation.[7-9] Urgent or emergent status has been shown to increase the risk of complications over similar procedures performed electively.[10]

Several classification schemes for surgical urgency have been published. The most recent American College of Cardiology (ACC)/American Heart Association (AHA) guidelines include formal definitions based on expert consensus[8]: (1) emergency surgery: life or limb threatened without intervention within 6 hours; (2) urgent surgery: life or limb threatened without intervention within 24 hours; (3) time-sensitive surgery: medically necessary to operate within 1 to 6 weeks; and (4) elective: can be deferred for up to 1 year.

The Canadian Cardiology Society outlines a three-tiered system of emergency, urgent/semi-urgent, and elective surgeries in their most recent guidelines.[7] The European Heart Rhythm Association uses a similar scheme for unplanned surgery in patients receiving therapeutic anticoagulation.[11] The common urgency classification scheme is used by many institutions to optimize surgical scheduling, but it does not include categories beyond 24 hours.[12,13] We prefer the classification scheme outlined by the ACC/AHA as it better approximates the clinical decisions in practice.

Surgery-Specific Risk

The intrinsic risk of a surgical procedure depends on the amount and location of tissue disruption, blood loss, fluid shifts, and

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hemodynamic effects, among other variables.[10] An evaluation of surgery-specific risk is formally included in American, European, and Canadian guidelines for preoperative cardiac evaluation.[7-9] Other societies recommend similar approaches for other organ systems.[14-17]

The risk of major adverse cardiac events was historically separated into low- (<1%), intermediate- (1% to 5%) and high- (>5%) risk categories.[18] More recent guidelines recommend a binary approach, using low risk (<1%) and elevated risk (≥1%) to better integrate with the clinical decision-making process.[8] Low-risk procedures, such as cataract or dermatologic surgeries, have fewer hemodynamic shifts and a smaller surgical stress response.[8]

Patient-Specific Risk

Patient-specific risk is attributable to medical comorbidities that impact the overall risk of a surgical procedure. The history and physical exam are key components in identifying these risk factors. This assessment should build on the procedure-specific risk; the preferred risk assessment tools incorporate both patient and procedural elements when possible. A limitation of many risk assessment tools is the assumption that patients are medically stable and are therefore not accurate in patients with acute or progressive symptoms.[19] When these symptoms are identified, they should be evaluated as would be done in a non-perioperative setting.[8]

Perioperative risk assessment tools have several additional limitations. They are derived from populations where high-risk conditions with low prevalence such as pulmonary hypertension and cirrhosis are often not accounted for in the models, underestimating the risk in affected patients. There is also the possibility that the absolute risk estimates may not be accurate. For example, the validation and derivation cohorts used to construct the Revised Cardiac Risk Index showed significant differences in cardiovascular complication rates, particularly with scores greater than 1.[19] The use of large databases such as the National Surgery Quality Improvement Program (NSQIP) database may improve this calibration, although the variables and outcomes are limited to only those collected by NSQIP. This can lead to differences in the outcomes predicted by different calculators, complicating direct comparisons between calculators.

Table 1 outlines several commonly used risk assessment tools categorized by organ system. There are no prospective trials directly comparing perioperative risk assessment tools, but the strength and weaknesses have been shown in observational studies. Understanding the strengths and limitations of the tools preferred at one's practice location is crucial to effective use.

COMBINED RISK ASSESSMENT

We recommend assessing risk by organ system, and outline a structured approach below. Surgical urgency, surgical risk, and patient-specific risk factors are necessary inputs for clinical decision algorithms and society guidelines. The combined medical and surgical risk for cardiac complications, pulmonary complications, venous thromboembolism, postoperative nausea, vomiting, and delirium should be assessed on all patients.[8,14-17] Additional risks should be assessed on an individualized basis.

Cardiac

The 2014 ACC/AHA guidelines for perioperative cardiac evaluation created an easy-to-follow algorithm to identify patients for whom stress testing can be considered.[8] Key decisions are based on identifying patients with acute coronary syndrome, elevated perioperative risk of major adverse cardiac events based on a validated risk assessment (see Table 1), and poor functional capacity (<4 Measurement of Exercise Tolerance Before Surgery [METS]). The Canadian Cardiovascular Society recommends formally evaluating only patients with known cardiovascular disease or aged 45 years or older who are undergoing surgery requiring at least an overnight hospital stay. They recommend against stress testing and prefer postoperative troponin monitoring guided by B-naturetic peptide levels over functional capacity assessment.[7] These

TABLE 1. Perioperative Risk Assessment Tools[a]

Tool	Outcomes	Advantages	Limitations
Cardiac risk calculators			
Revised Cardiac Risk index[19]	Myocardial infarction, pulmonary edema, ventricular fibrillation, cardiac arrest, or complete heart block	Simple, well-validated	Moderate performance, derived in elective surgeries with hospitalization for at least 2 days
Gupta MICA[20]	Myocardial infarction, cardiac arrest	Adjusts for type of surgery	Limited patient-specific variables, does not account for variability within each surgery type, variables and outcomes limited to data collected by NSQIP
ACS NSQIP[10]	Myocardial infarction, cardiac arrest	Specific data for each procedure	Single set of variables for all outcomes, variables and outcomes limited to data collected by NSQIP
Pulmonary risk calculators			
Gupta Respiratory Failure[21]	Mechanical ventilation >48 hours after surgery or unplanned intubation within 30 days of surgery	Validated across wide range of surgeries and clinical settings	Limited patient-specific variables, does not account for variability within each surgery type
Gupta Postoperative Pneumonia[22]	Pneumonia within 30 days of surgery	Validated across wide range of surgeries and clinical settings	Limited patient-specific variables, does not account for variability within each surgery type
ARISCAT[23]	Respiratory infection, respiratory failure, pleural effusion, atelectasis, pneumothorax, bronchospasm, aspiration pneumonitis	Includes objective variables rather than general classifications	Includes complications of questionable clinical relevance, valid for inpatient surgery only
ACS NSQIP[10]	Respiratory failure, pneumonia	Surgery specific	Variables and outcomes limited to data collected by NSQIP
STOP-BANG[24]	Moderate or severe OSA	Validated in perioperative setting	Nonspecific at intermediate scores
Sleep apnea clinical score[25]	Moderate or severe OSA	Score >15 predicts postoperative respiratory events, especially in combination with postoperative assessment	Lacks specificity when used alone
VTE risk calculators			
Caprini[26]	VTE within 30 days of surgery	Accounts for many patient and surgical factors	Not validated in neurosurgery, cardiac, thoracic, or trauma surgery
ACCP[14]	VTE within 30 days of surgery	Addresses different surgeries specifically	Complex to implement with subjective components
ACS NSQIP[10]	VTE within 30 days of surgery	Procedure specific	Variables and outcomes limited to data collected by NSQIP
Geriatric risk calculators			
Risk analysis index[27]	Death, surgical complications	Short survey or documentation review to collect data	Not externally validated, stronger predictor at 6 months than 30 days, optimal cut points unknown

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TABLE 1. Continued

Tool	Outcomes	Advantages	Limitations
Geriatric risk calculators, continued			
Frailty score[28]	30-day surgical complications, length of stay, and discharge disposition	Components validated in perioperative and general populations	Specific equipment required, time-consuming
Modified frailty index[29]	Death, surgical complications, unplanned 30 day readmission	Simple to calculate	Not validated in a clinical setting due to NSQIP changes
Mini-Cog[30,31]	Dementia risk	Simple, assesses multiple cognitive domain, abnormal test predicts complications	
Hepatic risk calculators			
MELD[32]	Death	Higher scores correlate with worse outcomes (>10)	Most studies done with older versions of MELD equations than what is used for transplant
Child-Pugh[33]	Death	Higher scores correlate with worse outcomes (>7)	Performance similar to MELD, which is more widely used for transplant
Postoperative nausea/ vomiting risk calculators			
Apfel score[34]	Postoperative nausea and vomiting	Simple, can guide intervention	Moderate predictive power
Koivuranta score[35]	Postoperative nausea and vomiting	Simple, prospectively developed	Moderate predictive power
Other risk calculators			
CAGE[36]	Alcohol use disorder	Score >2 increases risk of delirium	Prospective interventional studies not available
AUDIT-C[37]	Alcohol use disorder	Higher scores (9-12) associated with increased complication rates	Prospective interventional studies not available
Duke Activity Status Index[38]	Functional status in METs	Incorporates common household activities	Relies on patient recall, decision thresholds not established

[a]ACCP = American College of Clinical Pharmacy; ACS = American College of Surgeons; ARISCAT = Assess Respiratory Risk in Surgical Patients in Catalonia; AUDIT-C = Alcohol Use Disorders Identification Test; MELD = Model for End-stage Liver Disease; MET = metabolic equivalent; MICA = Myocardial Infarction and Cardiac Arrest; NSQIP = National Surgical Quality Improvement Project; OSA = obstructive sleep apnea; VTE = venous thromboembolism.

algorithms have not been prospectively compared, but the METS trial, discussed below, does compare several different methods of assessing functional capacity.[39]

Patients needing emergency surgery should undergo clinical risk stratification and proceed to surgery with monitoring intraoperatively and postoperatively as indicated. Patients not needing emergency surgery should be assessed for signs and symptoms of acute coronary syndrome. Although not specifically mentioned in the guideline, our practice is to extend this to other acute or unstable cardiac conditions. If an unstable acute cardiac condition is identified, it should be managed per standard clinical practice guidelines. For medically stable patients, the next step is to assess the risk of major adverse cardiac events using a combination of medical and surgical risk. The calculators contained in Table 1 all meet this requirement. For patients with a risk of less than 1%, no further testing is indicated and the patient may proceed with surgery. Patients with a risk of greater than 1% benefit from a functional capacity assessment. If the functional capacity is greater than or equal to 4 METs, the patient may proceed to surgery. If the functional

capacity is less than 4 METs, pharmacologic stress testing is reasonable if the results would affect management.[8]

The ACC/AHA algorithm does not include noncoronary cardiac conditions, but the guidelines do recommend patients be evaluated if there is clinical evidence of heart failure, valvular heart disease, arrhythmia, or other cardiac disorders. Patients with established cardiovascular disease also require additional considerations. Those with a history of myocardial infarction or stroke within the past year deserve careful review due to a variety of factors, including antiplatelet medications and risk of subsequent events.[40,41]

Pulmonary

Pulmonary complications contribute to perioperative morbidity and mortality in similar magnitude to cardiac complications.[15] Pulmonary complication rates are higher in upper abdominal, thoracic, and head and neck surgeries due to their impacts on respiratory mechanics.[42,43] Patients should undergo a clinical assessment for new or progressive pulmonary disorders, including the impact on functional status. This includes assessing for obstructive sleep apnea (OSA) and hypoventilation syndromes using a validated screening instrument.[17,24,44] Patients with symptoms or exam findings suggestive of function-limiting pulmonary disease should be evaluated if the surgical urgency permits. The calculators in Table 1 provide risk estimates based on surgical and patient factors, but do not predict the risk of OSA.

Venous Thromboembolism and Bleeding

All surgical patients should undergo risk assessment for venous thromboembolism (VTE) and bleeding.[14] Factors contributing to a higher risk of VTE include tissue injury, pro-inflammatory states such as cancer, location and duration of the procedure, and immobilization. The Caprini risk assessment tool can be applied to several different types of surgery, but is best validated in general and abdomino-pelvic populations.[26] Specific guidelines for total joint arthroplasty, hip fracture, spine surgery, and ambulatory surgery are available from the American College of Chest Physicians; these guidelines should be followed over more generalized tools.[14] Bleeding risk assessment includes the rate of bleeding inherent to the procedure, the consequences of bleeding (such as the potentially devastating consequences in neurosurgical or reconstructive procedures) and patient factors such as medications or comorbidities. The risk of clotting should be balanced with the risk of bleeding to determine the type and duration of prophylaxis recommended.

Delirium

Delirium is a major contributor to postoperative morbidity and mortality in elderly patients. Delirium risk should be assessed in all patients, with special attention to those with known or suspected preoperative cognitive dysfunction.[16] A mini-cog score of 2 or less is associated with an increased risk of delirium.[31] Assessing baseline cognition, identifying surrogate decision makers, documenting risk factors, and identifying alternatives to provoking medications in high-risk patients are recommended.[16]

Postoperative Nausea and Vomiting

Postoperative nausea and vomiting is a common complication that affects patient comfort, risk of pulmonary complications, and resource use.[45] Multiple risk factors have been identified, and several models to predict symptoms within the first 24 hours have been published (see Table 1). Overall performance of these models is similar.[46]

Other Risks

Many disorders identified by a comprehensive evaluation may require additional consideration and should be assessed as indicated in non-perioperative settings. Conditions affecting hemodynamics, fluid balance, wound healing, infection, and bleeding deserve special attention. Medications and endocrine, renal, gastrointestinal, and nutritional disorders will be discussed later in this series. Preoperative involvement of subspecialists can be considered, particularly when structured management

approaches are not readily available or optimization is desired.

PREOPERATIVE HISTORY AND PHYSICAL EXAMINATION

The goal of the preoperative history and physical examination is to identify elements needed for preoperative risk assessment and reduction, anesthetic management, and optimization of medical comorbidities. A thorough medical, surgical, family, and social history should be obtained. It is also important to document the severity and stability of chronic medical conditions. Expected benefits include the safety of perioperative care, optimal resource use, improved outcomes, and patient satisfaction.[17] Table 2 summarizes our suggested approach.

The preoperative history should assess functional capacity in metabolic equivalents (METs), including whether the patient is able to meet 4 METs regularly and without significant symptoms. Examples of 4 METs of activity include walking on a flat surface at a 4-mph pace, walking up a hill or flight of stairs without stopping or performing heavy housework such as vacuuming. Patients may not accurately self-report METs. A large prospective cohort study recently compared preoperative subjective assessment of METs with other preoperative

TABLE 2. Preoperative History and Physical Exam by System

System	History	Physical exam
General	Serious illness or hospitalization in past 6 months Weight, cognitive, or functional changes	Vital signs, body mass index, sarcopenia, cognition Wounds, pressure ulcers
Ear, nose and throat	Airway tumor, obstruction or history of previous oropharyngeal surgery History of head and neck radiation	Mallampati classification Dentition Removable oral appliances
Neck	Pain Previous injury or surgery History of rheumatoid arthritis, Down syndrome	Range of motion Thyromental distance Neck circumference
Cardiac	Recent chest pain, exertional dyspnea, dizziness, peripheral edema, orthopnea, paroxysmal nocturnal dyspnea	Auscultation Jugular venous pressure Hepatojugular reflex Peripheral edema
Hematologic	Excessive bleeding (personal and family) Blood clotting (personal and family) Blood thinner exposure	Petechiae Ecchymoses Peripheral edema
Pulmonary	Dyspnea Snoring, apneic episodes, snort arousals Features of chronic obstructive pulmonary disease or asthma exacerbation if patient has these conditions	Trachea Auscultation Work of breathing Chest wall abnormalities
Gastrointestinal	Abdominal pain, constipation, diarrhea, history of liver disease, postoperative ileus, or nausea/vomiting	Findings of cirrhosis Surgical scars Distention
Musculoskeletal	Falls Range of motion Pain	Synovitis Gait Deformities such as kyphosis or scoliosis
Neurologic	Symptoms of stroke (new or residual) Seizures	Focal neurologic deficits Pupil symmetry
Other	Menstrual/pregnancy Medications, including over the counter Tobacco, alcohol, illicit drugs Corticosteroid exposure (including injections) Reactions to general anesthesia (personal and family)	Implanted medical devices

markers of fitness, including cardiopulmonary exercise testing, the Duke Activity Status Index (DASI) questionnaire, and serum N-terminal pro-B-type natriuretic peptide (NT pro-BNP).[39] Preoperative subjective assessment of METS was only approximately 20% sensitive for identifying patients who were unable to achieve 4 METs during cardiopulmonary exercise testing. However, the DASI questionnaire was positively correlated to peak oxygen consumption and negatively correlated with NT pro-BNP concentrations, suggesting the DASI may be superior to subjective assessment. This study has prompted us to begin incorporating the DASI into our practice.

Several risk calculators require the patient's preoperative functional status as defined by NSQIP. This classifies the patient as independent, partially dependent, or dependent based on the level of assistance needed from another person or device to accomplish activities of daily living.[10]

PREOPERATIVE TESTING

Thoughtful consideration to what testing is indicated ensures safe, cost-effective care. Preoperative testing is generally limited to those things that have a high likelihood to change management. For most patients undergoing surgery, minimal testing is indicated. This approach reduces the impact of false-positive testing and prevents unnecessary delays for surgeries. Subsequent reviews in this series address disease-specific management, so we focus on the management

TABLE 3. Summary of Preoperative Testing Recommendations for Asymptomatic Patients[a]

Test	Indicated for routine testing?	Special considerations
Electrocardiogram	No	Known CVD Severe obesity (BMI > 40 kg/m^2) with CVD risk factors
Stress testing	No	Known CVD High-risk patients with poor functional capacity
B-natriuretic peptide	Yes/no	May be helpful for borderline or unknown functional capacity
Hemoglobin and hematocrit	No	Known hemoglobinopathies Advanced age Surgeries likely to have significant blood loss
Platelets	No	Hematologic or liver disease
Creatinine	No	Known renal disease Medications that affect renal function Advanced age or elevated-risk procedure
Electrolytes	No	Medications that alter electrolytes
Fasting glucose and hemoglobin A1c	No	Diabetes Vascular and orthopedic surgeries
Liver enzymes	No	Liver disease
Coagulation studies	No	Known coagulopathies
Albumin, pre-albumin, transferrin	No	History or physical exam create concern
Pregnancy testing	Yes	None
Urinalysis	No	Urologic, gynecological surgery
MRSA screening	No	MRSA characteristics of local institution
Chest x-ray	No	Patients older than 50 years with abdominal aortic aneurysm surgery or upper abdominal and thoracic surgery Severe obesity (BMI > 40 kg/m^2)
Pulmonary Function Test	No	Indicated in pulmonary resection
Sleep Study	No	Clinical screening indicated routinely

[a]BMI = body mass index; CVD = cardiovascular disease; MRSA = methicillin-resistant staphylococcus aureus.

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of asymptomatic individuals. Suggestions are summarized in Table 3.

Cardiovascular

Routine electrocardiograms (ECGs) are not indicated for asymptomatic individuals who are undergoing low-risk surgeries. ECG is recommended for patients undergoing an elevated-risk surgical procedure or patients with known cardiovascular disease not undergoing a low-risk procedure.[8] It is reasonable to obtain a preoperative ECG for severely obese patients (body mass index [BMI] >40 kg/m^2) who have at least one additional cardiovascular disease risk factor, such as diabetes, hypertension, hyperlipidemia, smoking, or poor exercise tolerance.[47]

Stress testing can be considered in specific situations, such as elevated risk patients with a poor functional capacity (<4 METs).[8] BNP is an evolving tool, but its role remains unclear. Routine echocardiography is not recommended in asymptomatic individuals; it is reasonable in patients with known valvular disease or decreased left ventricular function. [8]

Pulmonary

Routine chest x-rays are not needed for asymptomatic patients, but the American College of Physicians recommends one "for patients with known cardiopulmonary disease and those older than 50 years of age who are undergoing upper abdominal, thoracic, or abdominal aortic aneurysm surgery."[15] The ACC/AHA recommends a chest x-ray for patients with severe obesity (BMI >40 kg/m^2) to assess for potentially "undiagnosed heart failure, cardiac chamber enlargement, or abnormal pulmonary vascularity suggestive of pulmonary hypertension."[47] Pulmonary function testing is not recommended routinely because clinical evaluation is more predictive of pulmonary complications after surgery.[48] Screening for OSA risk is accomplished using a validated tool such as the snoring, tiredness, observed apnea, high blood pressure, BMI, age, neck circumference, and male gender (STOP-Bang) score.

Hematologic

Routine hemoglobin and hematocrit levels are not indicated preoperatively for most asymptomatic patients without known anemia. The American Society of Anesthesiologists recommends these lab tests in selected patients of advanced age and in those who will be undergoing surgeries that are likely to result in severe blood loss.[17] Routine white blood cell counts and platelets levels are not indicated in patients without symptoms or known abnormalities.[49] Platelets would be indicated in patients with known hematologic or hepatic disease.

Routine coagulation testing is not recommended as coagulopathies are rare in asymptomatic individuals and most who have dysregulation of hemostasis will present with symptoms before evaluation for a preoperative exam.[50] Questions regarding perioperative management of patients who are on anticoagulants are common. It is worth a brief review here, although a comprehensive review will follow. Warfarin can be effectively monitored by the prothrombin time (PT) and this should be measured preoperatively in patients who receive warfarin. The novel anticoagulants do not require routine labs for monitoring therapy, but residual activity may need to be assessed preoperatively. Dabigatran is preferentially monitored with an ecarin clotting time, but significant activity is unlikely if a dilute thrombin time or activated partial thromboplastin time is normal. Apixaban, edoxaban, and rivaroxaban are factor Xa inhibitors that are monitored with a drug-specific anti-Xa assay. An uncalibrated anti-Xa assay that is normal excludes significant active anticoagulant effect. PT and activated partial thromboplastin time are less reliable in this situation.[51]

Chemistries

The American Geriatrics Society recommends that all elderly patients have a creatinine test before surgery.[16] It is also reasonable to consider this in patients who have underlying kidney disease, are taking medications that alter electrolytes, have exposure to nephrotoxic agents, or require cardiac risk stratification as the Revised

Cardiac Risk Index and Gupta myocardial infarction or cardiac arrest calculator use creatinine as one of the risk factors. Specifics regarding management of patients with kidney disease will be discussed in detail in a subsequent review. Routine electrolytes are not indicated in the asymptomatic patient. The incidence of asymptomatic abnormalities is very low.[49] Situations that would require electrolyte analysis should be easily predictable from a good history, that is, use of diuretics for hypertension.

Routine fasting glucose levels are also not recommended in asymptomatic populations. A meta-analysis studying the association between hemoglobin A1c levels in non-diabetics and surgical complications did not show any association except in vascular and orthopedic surgeries.[52] For patients undergoing these types of surgeries, the authors believed it was reasonable to use hemoglobin A1c as screening tool. Patients who have diabetes should have hemoglobin A1c levels to monitor the management of their diabetes before surgery.

Routine liver enzyme tests are not recommended in asymptomatic individuals. Significant abnormalities are uncommon[53] and analysis of the NSQIP database showed no risk difference between patients who had preoperative liver testing and those who did not.[54] Patients with liver disease should have laboratory studies performed so that either a Model for End-stage Liver Disease (MELD) score or a Child-Pugh score can be calculated (creatinine, bilirubin, PT, and albumin).

NUTRITION

Routinely obtaining albumin, prealbumin, and transferrin levels is not recommended for asymptomatic patients, with the possible exception of geriatric patients.[16] These are reasonable tests if there is concern for nutritional status based on history, physical exam finding, or underlying medical conditions. Low albumin levels (<2.2 g/dL) suggest malnutrition and correlate with poor surgical outcomes.[55] However, albumin has a half-life of approximately 20 days and may not reflect recent poor nutrition or recent recovery from malnutrition. In addition, other conditions such a renal disease and hepatic disease can affect albumin levels. Prealbumin has a half-life of approximately 2 days but it can be difficult to interpret in the presence of inflammation, renal disease, and hepatic disease. Transferrin has a half-life of approximately 10 days. It also represents the iron status of a patient and therefore must be interpreted in conjunction with iron levels (ie, a low transferrin in the setting of a low serum iron is more indicative of iron deficiency than protein malnutrition).

INFECTION

Routine urinalysis and culture to screen for asymptomatic bacteriuria is not recommended. There does not appear to be any significant difference in wound infections for those who had or did not have urinalysis before most surgeries, including orthopedic surgeries.[56,57] Exceptions to this would be high-risk surgeries, such as urologic and gynecological surgeries.[58]

Methicillin-resistant staphylococcus aureus (MRSA) infections are a risk to the hospitalized patient and may represent an even greater risk to the surgical patient. Practices regarding MRSA screening vary widely. A meta-analysis from 2010 concluded that evidence is currently inconclusive to recommend routine preoperative screening for MRSA colonization.[59]

PREGNANCY

Pregnancy cannot be excluded by history alone and knowing someone is pregnant may change the surgical plan. Pregnancy testing in women of child-bearing age is recommended by the American Society of Anesthesiologists.[17]

SPECIAL POPULATIONS

Geriatric

Geriatric patients have a higher rate of medical comorbidities including cardiovascular disease, cerebrovascular disease, chronic kidney disease, hypertension, and diabetes.[16] Management of these conditions does not differ from the nongeriatric population.

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Issues specific to the geriatric population include cognitive deficits and delirium, malnutrition, frailty, and falls. Current guidelines recommend screening for cognitive deficits which are a risk factor for postoperative delirium and a history of falls.[60] Geriatric patients should be assessed for frailty and malnutrition using standard assessment tools (see Table 1). Recent studies suggest that addressing malnutrition and frailty preoperatively with a program of "prehabilitation" improves postoperative outcomes.[61] In the case of urgent surgery, increased attention to postoperative rehabilitation and nutrition has also been shown to be beneficial.[60] Patient's wishes regarding advanced directives should be noted, particularly regarding the issue of intraoperative resuscitation. The Beers criteria should be used when prescribing medications postoperatively.[62]

Pregnancy

The most common nonobstetric conditions requiring surgery during pregnancy are appendicitis, biliary disease, ovarian torsion or neoplasm, and trauma. The preanesthetic medical evaluation should include an obstetrician and medications should be screened for teratogenicity.[63] Elective surgeries are recommended to be postponed until after delivery. Time-sensitive surgery is recommended to be performed during the second trimester when the risk of spontaneous abortion is lowest.[63] Urgent surgery can generally be performed safely, although the risks may be higher than non-pregnant patients and mechanical effects of late-stage pregnancy have perioperative implications.[64,65] Delaying urgent surgery is associated with higher complication rates, and patients should not be deprived of an indicated surgery due to pregnancy alone.[63]

Human Immunodeficiency Virus

The preoperative evaluation of patients with human immunodeficiency virus (HIV) is similar to that of patients without HIV, with special attention towards conditions that are more prevalent in patients with HIV.[66] These include hepatic and renal dysfunction, coronary artery disease, coagulopathy, thrombocytopenia, neutropenia, substance use disorders, and infection/colonization with MRSA.[66] Although some studies have noted a slight increase in morbidity and mortality in HIV patients with either high viral loads or low CD4 counts, organ dysfunction and nutritional status are superior risk predictors.[67,68] Optimization of antiretroviral therapy (ART) before elective surgery is recommended, and pharmacy oversight for antiretroviral drug interaction checking is recommended. Clinicians should continue ART in the perioperative period with as little interruption as possible. When ART interruption is necessary, all components of the regimen should be stopped simultaneously, and clinicians should consult with a provider who has experience in management of ART.[66] Patients who require prophylaxis for *Pneumocystis jirovecii* and are unable to receive oral medications for more than 1 week can receive trimethoprim/sulfamethoxazole intravenously or pentamidine intravenously or by inhalation.[69] Patients with a history of *P. jirovecii* are at increased risk of spontaneous pneumothorax, which could manifest as postoperative dyspnea.[70]

Chronic Liver Disease

Patients with cirrhosis are at increased risk for surgical and anesthesia related complications.[71] The MELD and Child-Pugh scores predict postoperative risk in cirrhotic patients.[72] Patients with a MELD score of less than 10 are at low risk during elective surgery, whereas those with a MELD score greater than 10 are at elevated risk.[73] This risk increases with an increasing MELD, and special consideration should be given to those with MELD scores of 15 or greater.[74] Ninety-day postoperative mortality rates in patients with MELD scores of 15 or higher are greater than 50%, and greater than 85% for patients with MELD scores over 25.[32]

Patients with nonalcoholic steatohepatitis are at increased risk for coronary disease due to the likelihood of significant dyslipidemia.[75] Patients with hemochromatosis

should be considered for screening for cardiomyopathy.[72] Patients with ascites are at increased risk for wound dehiscence and incisional hernia; these patients should be treated with diuretics and sodium restriction to reduce the ascites burden preoperatively if possible.[72] Hepatic encephalopathy can be brought on or aggravated by narcotic-induced constipation and the use of benzodiazepine medications; the use of these drugs should be minimized when possible.[71]

Refusal of Blood Products

Patients may refuse blood products due to religious beliefs or concerns regarding blood product safety. The most well-known refusal comes from the religious group known as Jehovah's Witnesses. In general, Witnesses believe that voluntarily accepting blood transfusions may affect their eternal salvation. However, there is variation among beliefs, with some individuals accepting blood subtractions such as albumin or coagulation factor concentrates. Often, autologous transfusion involving storage of autologous blood is unacceptable, whereas circulating blood back into the patient such as during cardiopulmonary bypass, is acceptable. Perioperative evaluation should focus on careful and granular delineation of the patient's wishes, including potential life-threatening situations. Correcting any coagulopathy using factors as acceptable to the patient, and optimizing red cell production with iron, B12 and folate supplements as appropriate, may improve outcomes.[76,77]

Obesity

Otherwise healthy overweight (BMI, 25 to 30 kg/m^2) and class 1 obese patients (BMI, 30 to 35 kg/m^2) are not at increased risk of adverse outcome following noncardiac surgery.[78] However, there is an increased risk of comorbidities that do adversely affect postoperative outcomes, including OSA, obesity hypoventilation syndrome, hypertension, heart disease, diabetes mellitus, metabolic syndrome, and chronic kidney disease.[79] These patients should have a perioperative evaluation with attention to the possibility of these conditions being undiagnosed.

Class 2 and 3 obesity (BMI, $\geq$35 kg/m^2) even in otherwise healthy patients, is an independent risk factor for specific adverse perioperative outcomes including pneumonia, respiratory failure, and postoperative wound infections.[79] The perioperative management of comorbid medical conditions does not differ in the obese versus nonobese patient.

WHEN TO DELAY SURGERY

Delaying or cancelling a surgery should be considered when risk unacceptably outweighs the expected benefit. Although testing and risk assessment tools can be helpful, this is ultimately a clinical decision that should incorporate the surgical team, medical team, and patient values. Preoperative medical optimization should focus on meaningfully reducing modifiable perioperative risk. Major limitations in the literature are the absence of optimization targets and distinction of which risks are modifiable. This is reflected in guidelines on coronary revascularization and sleep apnea treatment.[8,44] Unmodifiable risk is best managed through enhanced monitoring or postoperative prevention strategies. Studies have shown that postoperative mortality correlates more with the way complications are managed than with the incidence.[80]

The surgical urgency significantly contributes to the decision to delay a surgery. It is very rarely appropriate to delay emergency surgery. However, unstable or progressive symptoms, particularly those affecting the cardiac or respiratory systems, should prompt evaluation even in urgent surgeries.[8] Elective or time-sensitive surgeries should only be delayed for testing that would potentially alter management. If confirmatory testing is not able to be performed preoperatively, patients should be managed as if they have the suspected condition.[44]

Perioperative hypertension is common, but has not been shown to influence complication rates when less than 180/110 mm Hg.[81] Patients in need of urgent surgery with blood pressures greater than this may

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TABLE 4. Example Documentation[a]

System-based risk assessment/disease-specific management	Example documentation
Overall summary of risk	A 71-year-old male is scheduled for a total hip arthroplasty. He is at acceptable risk to proceed with the planned surgical procedure without additional testing. His chronic diseases are medically optimized. Details and recommendations as follows.
Cardiac risk assessment	Patient has stable coronary artery disease and diabetes mellitus on insulin. His estimated functional capacity is 4 METs; he ambulates without the use of a gait aid. His RCRI score is 2. His Gupta risk is 1.4%. The estimated risk of cardiac death, nonfatal MI, or cardiac arrest is approximately 1.5% to 2.5%. He has adequate functional capacity and the electrocardiogram reveals no worrisome findings. No additional cardiac testing is indicated at this time. Metoprolol should be taken the morning of surgery.
Pulmonary risk assessment	Risk factors for postoperative pulmonary complications include age, moderate COPD, and OSA. His COPD is adequately controlled with tiotropium inhaler; he is able to walk 1 to 2 miles without respiratory limitation. Lungs are clear on exam. He is compliant with his CPAP. No additional pulmonary testing is indicated. Would recommend postoperative incentive spirometry, aspiration precautions, and early mobilization. If needed, Duonebs may be provided postoperatively. Patient advised to bring his CPAP with him for use in the recovery room and postoperatively.
VTE risk assessment	Patient is at high risk for perioperative VTE given this surgical procedure and his advanced age. He is not at significant increased risk for postoperative bleeding. Would recommend prophylaxis with both mechanical (pneumatic compression) and pharmacologic methods. Because of the increased risk of VTE after hospital discharge, recommend consideration of extending anticoagulant prophylaxis for at least 10 to 14 days, and ideally, up to 35 days postoperatively. The specific prophylactic regimen is to be determined by the surgical team.
Delirium risk assessment	His estimated risk of postoperative delirium is approximately 12% given the type of surgery; he has additional risk factors of age, male sex, and decreased hearing. Recommend careful attention to maintaining day/night activities, early mobilization, frequent reorientation, and having the patient wear his hearing aids postoperatively. Avoidance of as-needed medications with anticholinergic or sedative side effects (ie, diphenhydramine, benzodiazepines) is also recommended. Multimodal approach to pain management to minimize the need for opiates is encouraged. Having family present as much as possible postoperatively can be helpful with reorientation.
Disease-specific management Diabetes Stress dose steroids Hypothyroidism	Hemoglobin A1C was well controlled at 7.5%. The patient is advised to hold his morning short acting insulin. He should take 50% of his usual glargine dose the night before surgery (15 units). Corrective scale insulin can be used as needed until the patient resumes normal dietary intake. Because the patient has received >5 mg of prednisone for >3 weeks in the past 3 months, I recommend stress dose steroids; hydrocortisone 25 mg every 8 hours for 2 days. Patient is on a stable dose of levothyroxine. His last TSH was normal 6 months ago. His gout, gastroesophageal reflux, and hypertension are clinically stable.
Laboratory review	I have reviewed his blood count, electrolytes and creatinine; all were normal. Type and screen has been completed per surgical service.
Medication management	I have reviewed the fasting guidelines with the patient and have recommended that he take the following medications on the morning of surgery: omeprazole, metoprolol, tiotropium, levothyroxine, and allopurinol. He was advised to hold hydrochlorothiazide, lisinopril, and multivitamin on the morning of surgery. He can take his atorvastatin the evening before surgery as usual. Insulin recommendations as above. Medications can be resumed postoperatively once diet is resumed as blood pressure and fluid status tolerates. I have confirmed his current active medication list in the electronic record.

[a]COPD = chronic obstructive pulmonary disease; CPAP = continuous positive airway pressure; MET = metabolic equivalent of task; MI = myocardial infarction; OSA = obstructive sleep apnea; RCRI = revised cardiac risk index; TSH = thyroid stimulating hormone; VTE = venous thromboembolism.

require parenteral antihypertensive therapy.[82] Upper respiratory infection has been associated with an increased risk in minor pulmonary complications in children, but there is no established major morbidity in adults.[83]

Smoking and substance use disorders increase perioperative risk directly through effects from the substances themselves and indirectly through an increased risk of comorbidities such as coronary artery disease.[84] Smoking cessation can have benefits

within as little as 2 weeks, although the largest benefit is seen after at least 8 weeks.[85] Patients undergoing elective or time-sensitive surgeries should be referred for substance use counseling.

Preoperative anemia is associated with a variety of complications.[86] Some studies have shown a reduction in transfusions with iron repletion in iron-deficiency anemia. It is reasonable to delay elective surgery to correct a significant anemia with a treatable cause.[87]

DOCUMENTATION

Communication and documentation is the key portion of the preoperative risk assessment. A standardized approach to this documentation can ensure all important perioperative risks and disease-related management issues are addressed. This can improve communication with surgical colleagues, reduce unnecessary delays, and reduce complication rates in high-risk patients.[61,88-90] A system-based risk assessment method along with disease-specific recommendations can be very helpful in achieving this goal (see Table 4).

CONCLUSION

Pre-anesthetic medical evaluations should consist of a comprehensive evaluation to provide both risk stratification and modification appropriate for the combined medical and surgical risk. Preoperative interventions and postoperative monitoring should receive equal emphasis. A structured, collaborative approach is beneficial for both medical and surgical teams.

Abbreviations and Acronyms: **ACC** = American College of Cardiology; **ADH** = anti-diuretic hormone; **AHA** = American Heart Association; **ART** = antiretroviral therapy; **BMI** = body mass index; **DASI** = Duke Activity Status Index; **ECG** = electrocardiogram; **GA** = general anesthesia; **MELD** = Model for End-Stage Liver Disease; **MRSA** = methicillin-resistant staphylococcus aureus; **NSQIP** = National Surgical Quality Improvement Program; **NT pro-BNP** = N-terminal pro-brain natriuretic peptide; **OSA** = obstructive sleep apnea; **PT** = prothrombin time

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