PERIOPERATIVE CARE

Understanding the principles of pre- and post-operative care is critical in ensuring high quality outcomes in surgical patients. Each surgical patient presents with his/her own unique set of risk factors and comorbidities. In addition to the risks of surgery and anesthesia common to all patients, every procedure that a surgeon performs carries its own set of specific management issues and potential complications. This module cannot cover specific risks for all procedures, but will provide the student with a basic understanding of the issues that must be addressed to optimize the perioperative care of our patients.

PREOPERATIVE EVALUATION AND OPTIMIZATION

There is no "standard" preoperative workup that fits all patients. Each procedure and each patient have their own unique needs with regard to preoperative preparation. Not every patient should be sent for the same set of (or sometimes any) tests such as laboratories, imaging, or other studies prior to surgery. Preoperative evaluation of the surgical patient begins with a thorough history and physical examination. In addition to findings pertinent to the primary diagnosis, careful attention should be paid to comorbidities that may affect surgical risk and/or require additional preoperative workup.

Risk stratification tools can be utilized to better estimate the risk of morbidity and mortality, identify patients that require further preoperative evaluation, and guide discussions regarding informed consent. There are a number of models that have been utilized in an attempt to stratify surgical risk (1). The American Society of Anesthesiologists' physical status classification (ASA-PS, Table 1) is a commonly used tool that assesses a patient's fitness for surgery (2). It does not, however, take into account many factors specific to the patient or the procedure that is being performed, and therefore, may not be very useful for optimizing preoperative preparation. A more recent update of the system does provide examples of some of the major comorbidities that may affect operative risk and helps to ensure more accurate classification.

Table 1 - ASA-PS Classification

I	Healthy person	Healthy, non-smoking, no or minimal alcohol use
II	Mild systemic disease	No substantive functional limitations: current smoker, social alcohol drinker, pregnancy, obesity (30<BMI<40), controlled DM/HTN, mild lung disease
III	Severe systemic disease	Substantive functional limitations: poorly controlled DM /HTN, COPD, BMI ≥40, active hepatitis, alcohol abuse, pacemaker, moderate reduction of ejection fraction, ESRD on dialysis, premature infant, PCA < 60 weeks, history (>3 months) of MI, CVA, TIA, or CAD/stents.

IV	Severe systemic disease that is a constant threat to life	Recent (<3 months) MI, CVA, TIA, or CAD/stents, ongoing cardiac ischemia or severe valve dysfunction, severe reduction of ejection fraction, sepsis, DIC, ARD or ESRD not undergoing regularly scheduled dialysis
V	A moribund patient who is not expected to survive without the operation	Ruptured abdominal/thoracic aneurysm, massive trauma, intracranial bleed with mass effect, ischemic bowel in the face of significant cardiac pathology or multiple organ/system dysfunction
VI	A declared brain-dead patient whose organs are being removed for donor purposes	

Guidelines for routine preoperative laboratory testing based on ASA classification have recently been published in JAMA (3). These include indications for CBC, renal function testing, coagulation studies, and pregnancy testing. CBC is recommended in all patients undergoing high-risk procedures and in ASA class 3 or 4 patients with cardiovascular or renal disease and recent symptoms undergoing intermediate-risk procedures. Renal function testing is recommended in low-risk procedures for class 3 or 4 patients at risk for acute kidney injury (AKI), in intermediate-risk procedures for all class 3 or 4 patients and class 2 patients with risk of AKI and in all high-risk procedures except for class 1 patients at low risk for AKI. Routine coagulation testing with INR or platelet count has not been shown to predict the risk of surgical bleeding. Therefore, coagulation testing is recommended only for ASA class 3 or 4 patients undergoing intermediate or high-risk procedures who have a history of chronic liver disease or are on anticoagulants. With regard to pregnancy testing, the guidelines recommend discussing the possibility of pregnancy and potential risks of surgery to the fetus. The authors do acknowledge a lack of efficacy data supporting these guidelines.

One particularly critical aspect of preoperative evaluation is the assessment of cardiac risk in patients undergoing non-cardiac surgery. Patients who are at low cardiac risk are generally not required to undergo any additional cardiac evaluation. However, a number of factors may be identified in the patient's H&P that are associated with increased cardiac risk. These include a history of ischemic or valvular heart disease, congestive heart failure, cardiomyopathy, arrhythmias, pulmonary vascular disease, diabetes mellitus or renal insufficiency, as well as poor functional status or those undergoing higher-risk surgeries. Patients with major or multiple such risk factors are often recommended to undergo additional preoperative testing or optimization.

The Goldman cardiac risk index was originally proposed in the 1970's as a means to use some of the above risk factors to assess cardiovascular risk in patients undergoing non-cardiac surgery. Subsequently, several other cardiac risk indices have been developed and validated for these patients. The American College of Cardiology, in cooperation with several other

organizations, has developed a series of guidelines for the evaluation and management of perioperative cardiac risk (4). Patients presenting with significant cardiac risk factors, poor functional status, or undergoing high risk surgeries such as intraperitoneal, intrathoracic, or suprainguinal vascular procedures should be considered for preoperative cardiac evaluation.

Recommendations may range from no workup in stable patients undergoing low risk surgery, to ECG, assessment of left ventricular function, and exercise or pharmacologic stress testing, and may even include angiography and coronary revascularization in select patients. Recommendations may also include continuation or initiation of treatment with pharmacologic therapy such as beta blockers, statins, anti-platelet or other agents.

Risk of perioperative events is calculated using tools such as the Revised Cardiac Risk Index (RCRI) (5) or the American College of Surgeons NSQIP Risk Calculator. The RCRI incorporates several risk factors, including high-risk surgery, history of ischemic heart disease, history of congestive heart failure, history of cerebrovascular disease, preoperative treatment with insulin, and preoperative serum creatinine > 2 mg/dL. Risk of major cardiac complications increases substantially as the number of risk factors that the patient presents with increases. The NSQIP risk calculator (6) is a powerful tool that can be used to estimate the risk of a number of perioperative complications. These include not only cardiac complications, but other events such as postoperative infections including pneumonia or wound infections, venous thromboembolism, readmission, reoperation and death.

Assessing and optimizing pulmonary function may also be an issue in patients with COPD, obstructive sleep apnea (OSA), active smoking and other pulmonary issues, as well as those undergoing extensive abdominal or thoracic procedures (7). Preoperative testing is rarely indicated. However, perioperative management may be tailored to minimize pulmonary complications. These interventions may include intraoperative techniques such as lung-protective ventilation and regional anesthesia. Pre- and post-operative methods may include smoking cessation, preoperative respiratory conditioning, and epidural or patient controlled analgesia. OSA has become a common comorbidity and should be routinely screened for in preoperative patients. Interventions to address the pulmonary issues associated with OSA may include more intensive postoperative monitoring with continuous pulse oximetry, limiting use of sedatives, and continuing positive airway pressure therapy if used before surgery.

End stage liver disease (ESLD) and end stage renal disease (ESRD) also have a significant impact on perioperative morbidity and mortality. Both of these disease processes often require modifications to medication dosages and avoidance of certain medications due to alterations in hepatic and renal metabolism. Substances that are hepato- or nephro-toxic must be avoided in these patient populations. ESRD also adds additional perioperative management issues due to the timing and tolerance of dialysis and difficulties with electrolyte and fluid management.

For patients with ESLD or ESRD, the NSQIP risk calculator does include the presence of ascites, dialysis dependence and acute renal failure as specific risk factors, but does not include liver failure as an independent category. Patients with ESLD often present with anemia, coagulopathy, varices, and other issues that may contribute to perioperative complications. ESLD patients are also at risk for worsening hepatic function after surgery and anesthesia.

Model of end-stage liver disease (MELD) score is another risk assessment that may be used in patients with ESLD. The score is based on the patient's creatinine, bilirubin, and INR. This system can determine mortality risk in cirrhotic patients and is used for organ allocation in liver transplantation. MELD score has also been shown to be predictive of the risk for complications after non-transplant surgery in cirrhotic patients.

PERIOPERATIVE NUTRITIONAL MANAGEMENT

Preoperative malnutrition increases the risk of complications after surgery, particularly related to wound healing and development of post-operative infections and increases length of stay. Malnutrition is a common issue in cancer patients, the elderly, those with recent weight loss and other debilitated patients. This is exacerbated in the postoperative period due to a variety of factors, including the postoperative catabolic state, increased nutritional needs for wound healing, gastrointestinal tract dysfunction, and a number of others. Preoperative nutritional evaluation should be considered in patients at risk for malnutrition. This is particularly true in patients undergoing high-risk surgery. In addition to evaluation of risk factors, other testing may be considered. Serum albumin level is often obtained as low levels (<3 mg/dl) are associated with poor wound healing and increased postoperative morbidity. Serum transferrin and prealbumin are better short term markers and may be used to assess ongoing nutritional status postoperatively.

Enteral nutrition is generally considered the preferred route for nutritional support in patients with functioning GI tracts. There have been a number of proposed advantages for enteral nutrition, but there is often little data to support their role in improving outcomes. These include preservation of gut mucosa, decreased leakage of gut bacterial antigens, reduction of inflammation, maintenance of immune function, and decreased hyperglycemia. Improvements in outcome that have been consistently demonstrated for enteral over parenteral nutrition include fewer infectious complications, reduced cost, earlier gut function, and reduced length of stay (8).

Nutritional support may be considered for patients who are malnourished, but is not recommended for all patients. Patients with low or intermediate levels of malnutrition can be considered for preoperative nutritional supplements. Preoperative full nutritional support remains controversial and is generally only considered in patients with severe malnutrition. These patients should receive 7 or more days of enteral or parenteral nutrition prior to surgery. Preoperative fasting for a prolonged period of time (NPO post-Midnight, for example) is often recommended to decrease the risk of aspiration during induction or maintenance of anesthesia. Recent literature, however, has shown that it may be safe to eat up to 6 hours and take clear liquids up to 2 hours preoperatively.

Postoperatively, oral nutrition should begin as soon as possible, depending on the type of surgery. Patients who may not be able to tolerate oral intake for prolonged periods of time postoperatively should be considered for pre- or intraoperatively placed feeding tubes to provide early enteral nutrition. Patients with poor GI function may require parenteral nutrition. In non-malnourished patients nutritional support is generally not initiated unless it is anticipated to be needed for 7 or more days. Malnourished patients should receive nutritional support as soon as

possible postoperatively. Diabetic patients should have tight glycemic control initiated along with nutritional management postoperatively to decrease complications.

TOBACCO, ALCOHOL, AND DRUG USE

Abuse of tobacco, alcohol, and illicit drugs is frequently identified in surgical patients. Although, ideally, all patients should be enrolled in smoking cessation or detoxification programs, this is clearly not possible in the preoperative setting. An understanding of the risks of substance abuse is critical to prevent certain complications. Active smoking remains a major contributor to postoperative morbidity and is considered a chronic disease in the ASA classification, as mentioned above. Smokers may suffer from postoperative nicotine withdrawal that requires treatment with nicotine replacement and may also have poor wound healing. Smoking cessation for at least 4 weeks preoperatively may mitigate the effects of smoking.

Patients who abuse alcohol are at risk for postoperative delirium and alcohol withdrawal, as well as other postoperative morbidities such as infectious, cardiac and pulmonary complications. Patients known to abuse alcohol may be treated with alcohol administration postoperatively. More commonly, though, they are administered benzodiazepines, as well as thiamine to prevent Wernicke's encephalopathy and multivitamins to address potential nutritional deficiencies.

Acute cocaine toxicity increases the risk of cardiovascular complications such as cardiac ischemia, arrhythmias and stroke. Cocaine users are frequently required to undergo toxicity screening prior to surgery. Positive toxicity screens for cocaine lead to cancellation of procedures, even in asymptomatic patients. It remains unclear, however, if patients who are not acutely toxic are at increased risk. Opioid abuse leads to difficulty in postoperative pain management and may lead to complications such as respiratory suppression and prolonged ileus. Patients with a history of opioid abuse may benefit from the use of regional anesthesia or other non-opioid anesthetics.

SPECIAL CIRCUMSTANCES

Emergency Surgery

There are significant differences in morbidity and mortality rates between non-elective (emergent and urgent) and elective surgical procedures. These have been demonstrated in a variety of surgical specialties, such as general, cardiac and colorectal surgery. Factors influencing this difference may include an inability to fully evaluate patients' comorbidities preoperatively, as well as physiologic derangements resulting from the underlying disease process in urgent and emergent situations. This has led to attempts at better understanding risk in patients undergoing non-elective surgical procedures. Factors that can influence operative risk in these patients include preoperative comorbidities, obesity, rising ASA classification, age greater than 65 years, contaminated surgical wounds, and current smoking (9). A group in Japan was able to predict postoperative mortality in emergency surgery with a scoring system using five variables (10). These include the JCS (Japan Coma Scale), ASA class, white blood

cell count, platelet count, and blood urea nitrogen. Further studies are needed to better develop a useful system for risk stratification in these patients.

Elderly Patients

As the population ages, surgical intervention will be considered in more and more elderly patients. In addition to known risk factors such as cardiac disease and diabetes, elderly patients often lack the physiologic reserve seen in younger patients. Frailty is a measure of this physiologic reserve or lack thereof. Frailty is often discussed in the geriatrics literature and may be used to gauge surgical risk in elderly or infirm patients. Full assessment of frailty is often considered too onerous to complete as part of preoperative assessment. A simplified measure of frailty has been proposed (11) that when combined with ASA score and serum hemoglobin can be used to classify operative risk. This includes 2 components of the full frailty assessment, grip strength and shrinkage (weight loss > 10 pounds in the past year) and allows patients to be stratified into 3 categories of risk for postoperative complications.

Children

Risk stratification in children carries the additional burden of not only providing the risk of complications for specific procedures, but also guiding the discussion of informed consent with the child's family. A pediatric-specific NSQIP risk calculator has been developed to address these issues (12). This tool covers multiple age groups, from neonate to age 18, as well as multiple different procedures relevant to this population. Risk factors are tailored to include common pediatric issues such as neuromuscular, hematologic, and cardiac issues and exclude those that are infrequent in children, such as hypertension, COPD, and smoking. Special consideration should be given to infants, as the risk for post-operative apnea is significantly greater in infants < 60 weeks post conception.

Pregnancy

In pregnant patients, elective non-obstetric procedures should generally be postponed until after delivery. These patients may, however, require urgent or emergent non-obstetric surgical interventions, most commonly appendectomy or cholecystectomy. Overall, maternal morbidity and mortality are not increased in pregnant patients compared to the general population (13). These patients are, however, at risk for obstetrical complications, including preterm labor or delivery and miscarriage. In general, procedures performed during the second trimester are associated with the lowest rate of these complications, and laparoscopic approaches are preferred to open. A recent study identified several additional risk factors for obstetrical complications, including cervical incompetence, preterm labor during current pregnancy, vaginitis or vulvovaginitis, and sepsis (14).

PREOPERATIVE PREPARATION

Preoperative preparation of the patient includes a number of factors related to the avoidance of complications such as surgical site infections (SSI) and deep venous thrombosis (DVT). Bowel preparation decreases bacterial load in the colon and may decrease the risk of wound infection and other complications such as anastomotic leak, as well as increasing the ease of intraoperative manipulation of the bowel. Mechanical bowel preparations utilize stimulant or osmotic laxatives and may lead to patient discomfort, electrolyte abnormalities, and renal failure, and also contribute to postoperative ileus in certain patients. Combined mechanical and antibiotic bowel preparation with Neomycin and Erythromycin has been routinely used in abdominal surgery, particularly for colorectal procedures, since the concept was first studied by Nichols and Condon and others in the 1970's. Interestingly, they did not advocate the routine use of systemic antibiotics. More recently, intravenous antibiotics have become standard, while the necessity of mechanical and antibiotic bowel preparation has come into question. At this point, mechanical and antibiotic bowel preparation are given at the discretion of the surgeon in colorectal procedures as there is conflicting data in the literature regarding the utility of one or both of these modalities. For non-colorectal abdominal procedures mechanical bowel preparation may also be considered, again at the discretion of the surgeon.

Prophylactic systemic antibiotics are given prior to surgery to decrease the risk of infectious complications. Their use is generally dictated by the wound classification and potential organisms that may cause infection after the specific procedure. Antibiotics are generally not indicated for elective, clean cases due to the low risk of infection. For clean-contaminated cases, where organs such as those of the genitourinary or gastrointestinal tracts may be entered, or in emergency cases, prophylactic antibiotics are routinely administered. For contaminated or dirty cases antibiotics may also be continued postoperatively. It is generally recommended that prophylactic antibiotics be given no more than 30-60 minutes prior to the time of incision to be fully effective. Appropriate administration of perioperative antibiotics, including timing, choice of medication, and dosing are considered quality measures for hospitals and surgeons.

Prevention of DVT is a critical consideration in the perioperative management of surgical patients. The American College of Chest Physicians has published a series of guidelines for the prevention and management of DVT's, including recommendations for DVT prophylaxis in non-orthopedic surgical patients (15). These consider not only the risks, benefits, and contraindications, but also the associated costs. A full discussion of the guidelines is beyond the scope of this module. The recommendations for patients undergoing General, Abdominal-Pelvic, Bariatric, Vascular, and Plastic and Reconstructive Surgery are listed in table 2. The guidelines also recommend continuing treatment for 4 weeks in patients at high risk of thrombosis such as cancer patients.

Table 2		
DVT risk	**Bleeding risk**	**Prophylaxis**
very low		Early ambulation
low		Mechanical prophylaxis (intermittent pneumatic compression (IPC))
Moderate	low	Low molecular weight (LMWH) or low dose unfractionated (LDUH) heparin or IPC
	high	IPC
High	low	LMWH or LDUH with IPC
	high	IPC until bleeding risk diminishes, then LMWH or LDUH

INTRAOPERATIVE ISSUES

Skin preparation

Skin preparation is another major component in the prevention of SSI. The patient is often asked to shower with an antiseptic agent such as chlorhexidine (CHG) preoperatively. There is some debate over hair removal and its role in preventing SSI. If the area is shaved it should be done in the preoperative holding area with clippers rather than a razor. The skin is routinely prepared with an antiseptic agent in the OR immediately prior to draping. The optimal agent for skin preparation remains to be determined. Commonly used antiseptic agents include povidone-iodine, CHG, and iodine-povacrylex. Contaminated areas are prepared last to avoid contamination of clean tissue.

Use of Blood Products

Transfusion of blood and blood products remains a major consideration in the management of surgical patients. Transfusions may be associated with serious complications, including febrile and allergic reactions, fluid overload, lung injury (TRALI), and infections such as viral hepatitis and HIV. Massive RBC transfusions of over one blood volume are associated with coagulopathy and should be accompanied by transfusions of platelets and fresh frozen plasma. Preoperative anemia is a risk factor for poor surgical outcomes, with studies consistently showing higher morbidity and mortality in these patients. Therefore, despite the risks, patients with preoperative anemia and/or significant blood loss may require blood transfusions. There is currently a focus on patient blood management rather than simply relying on transfusion of blood products to treat anemia. This includes recognition and management of preoperative anemia, avoidance of blood loss, and transfusing blood products only when absolutely necessary (16).

The use of alternatives to blood transfusion is recommended whenever possible. When preoperative anemia is recognized, patients should be evaluated for treatable causes, such as nutritional deficiencies of vitamin B12 or ongoing gastrointestinal bleeding. Treatment may be initiated preoperatively with iron supplementation, vitamin B12/folate, and even the use of erythropoietin analogues. Intraoperatively, blood loss should be minimized with meticulous surgical technique and optimization of conditions for hemostasis such as temperature and pH, as well as careful management of anticoagulation. High risk patients may benefit from intensive hemodynamic monitoring and use of cell-salvage systems.

Plasma and platelet transfusions carry similar risks to PRBC transfusions. As discussed previously, routine patient screening for coagulopathy is not indicated in patients without a known risk for coagulopathy. Patients with known coagulopathy, thrombocytopenia, or those on anticoagulants or anti-platelet agents may require perioperative transfusion of these blood products. The simplest way to treat patients with medication-induced coagulopathy is to stop their medications at the appropriate interval prior to surgery when possible. Some patients may require bridging with shorter acting agents until their surgery is completed. If emergency or urgent surgery is needed, the coagulopathy may need to be reversed with blood products or other agents.

Patients with thrombocytopenia, particularly those with platelet counts below 50,000, are at increased risk for bleeding and have an overall increased risk of complications, as well as increased requirements for blood transfusion. Preoperative platelet transfusions, however, have not been consistently shown to decrease the need for PRBC transfusion. Patients with coagulopathy, as indicated by an increased INR, may also be at an increased risk for bleeding. There is general agreement that coagulation is only impaired clinically once the INR exceeds 1.5. At that point, correction of the coagulopathy with FFP is often considered. Vitamin K is also used frequently in patients who are not taking warfarin. Again, correction of INR has not consistently been shown to reduce blood loss or transfusion requirement.

MONITORING PATIENTS IN THE OR

Physiologic monitoring is a critical component of the safe conduct of surgical procedures under anesthesia. The Association of Anaesthetists of Great Britain and Ireland, for example, has published a series of guidelines concerning the standards of patient monitoring during anesthesia (17). Obviously, the presence of qualified anesthesia personnel to clinically assess the patient is essential. Minimum recommendations for the use of monitoring devices include the following: pulse oximeter, non-invasive blood pressure, ECG, inspired and expired gases (oxygen, carbon dioxide, nitrous oxide and volatile anesthetic agent if used), airway pressure, peripheral nerve stimulator if neuromuscular blocking drugs are being used, and temperature for any procedure > 30 minutes duration. Monitoring should continue until the patient is fully recovered from anesthesia.

Critically ill patients may require more intensive monitoring regimens. These are used at the discretion of the surgical and anesthesia teams and may include fluid balance (I&O's), cardiac output, intravascular pressures, and laboratory values such as blood gases, electrolytes or

hematologic values. Traditionally, invasive monitoring techniques were routinely used for measuring intravascular pressures and cardiac function. These include arterial and central venous lines that may be used to monitor intravascular pressure and draw blood for laboratory studies, and Swan-Ganz, or pulmonary artery (PA) catheters that can be used to indirectly measure preload and calculate cardiac output.

Currently, there is a trend towards less invasive monitoring techniques to replace PA catheters. Several different devices have been developed to monitor cardiac output and preload without placing a PA catheter. These devices typically utilize algorithms that can calculate cardiac output and preload from pressure waveforms or temperature differential. Other techniques utilize trans-esophageal echocardiography or Doppler to directly image cardiac contraction or measure flow in the aorta. Trans-esophageal echocardiography can also be used to directly visualize cardiac filling and estimate left ventricular end-diastolic volume as a surrogate for preload.

ENHANCED RECOVERY AFTER SURGERY (ERAS) PROTOCOLS

The use of ERAS protocols has dramatically changed perioperative management in certain subsets of patients. In ERAS, evidence-based guidelines are used to direct pre-, intra- and post-operative management of the patient. These guidelines are typically developed through a multidisciplinary collaboration of different specialties involved in the care of the patient. These protocols are designed to streamline perioperative management and lead to shorter hospital stays and other improved outcomes, as well as reduce cost. Each protocol is designed for a specific class of procedures, and was first implemented for colorectal surgery. As ERAS continues to expand to other surgical disciplines, data will need to continue to be collected to ensure that outcomes are optimized.

SUMMARY

Perioperative management of surgical patients is an incredibly complex undertaking. Each patient must be carefully evaluated for risks. Each test and intervention must be carefully weighed for benefits, complications, and cost. Recent data often contradicts surgical dogma regarding patient management. New guidelines and protocols may streamline perioperative management of patients and truly improve outcomes.

QUESTIONS

1. A patient with severe systemic disease such as poorly controlled diabetes or COPD would fall under which ASA class?

    a. I
    b. II
    c. III
    d. IV

2. Frailty is a measure of which of the following?

    a. Severe cardiac disease
    b. Physiologic reserve
    c. Procedural risk
    d. Advanced age

3. Outcomes associated with enteral vs parenteral nutrition include all of the following except:

    a. Reduced infectious complications
    b. Reduced cost
    c. Earlier return of gut function
    d. Increased length of stay

4. Recommendations for routine intraoperative monitoring include all of the following except:

    a. Non-invasive blood pressure
    b. Central venous pressure
    c. Pulse oximetry
    d. Expired CO_2

5. Current concepts in patient blood management mandate which of the following to help guide transfusion practices:

    a. Unlimited transfusion of blood products
    b. Measurement of blood loss
    c. Recognition and management of preoperative anemia
    d. Avoidance of alternatives to transfusion of blood products

ANSWERS

1. A patient with severe systemic disease such as poorly controlled diabetes or COPD would fall under which ASA class?

    a. I
    b. II
    c. III
    d. IV

2. Frailty is a measure of which of the following?

    a. Severe cardiac disease
    b. Physiologic reserve
    c. Procedural risk
    d. Advanced age

3. Outcomes associated with enteral vs parenteral nutrition include all of the following except:

    a. Reduced infectious complications
    b. Reduced cost
    c. Earlier return of gut function
    d. Increased length of stay

4. Recommendations for routine intraoperative monitoring include all of the following except:

    a. Non-invasive blood pressure
    b. Central venous pressure
    c. Pulse oximetry
    d. Expired CO_2

5. Current concepts in patient blood management mandate which of the following to help guide transfusion practices:

    a. Unlimited transfusion of blood products
    b. Measurement of blood loss
    c. Recognition and management of preoperative anemia
    d. Avoidance of alternatives to transfusion of blood products

REFERENCES

1. Barnett S, Moonesinghe SR. Clinical risk scores to guide perioperative management. *Postgraduate medical journal*. 2011;87:535-541.
2. http://www.asahq.org/quality-and-practice-management/practice-guidance-resource-documents/asa-physical-status-classification-system#
3. Martin SK, Cifu AS. Routine Preoperative Laboratory Tests for Elective Surgery. *JAMA*. 2017;318:567-568.
4. Fleisher LA, Fleischmann KE, Auerbach AD, et al. 2014 ACC/AHA Guideline on Perioperative Cardiovascular Evaluation and Management of Patients Undergoing Noncardiac Surgery. *Journal of the American College of Cardiology*. 2014;64:e77-e137.
5. Lee TH, Marcantonio ER, Mangione CM, et al. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. *Circulation*. 1999;100:1043-1049.
6. Bilimoria KY, Liu Y, Paruch JL, et al. Development and evaluation of the universal ACS NSQIP surgical risk calculator: a decision aid and informed consent tool for patients and surgeons. *Journal of the American College of Surgeons*. 2013;217:833.
7. Pfeifer KJ, Smetana GW. Pulmonary Risk Assessment and Optimization. *Hospital Medicine* Clinics. 2016;5:176-188.
8. Seres DS, Valcarcel M, Guillaume A. Advantages of enteral nutrition over parenteral nutrition. *Therapeutic Advances in Gastroenterology*. 2013;6:157-167.
9. Mullen MG, Michaels AD, Mehaffey JH, et al. Risk Associated With Complications and Mortality After Urgent Surgery vs Elective and Emergency Surgery: Implications for Defining “Quality” and Reporting Outcomes for Urgent Surgery. *JAMA Surgery*. 2017;152:768-774.
10. Miyazaki N, Haga Y, Matsukawa H, et al. The development and validation of the Calculation of post-Operative Risk in Emergency Surgery (CORES) model. *Surgery Today*. 2014;44:1443-1456.
11. Revenig LM, Canter DJ, Kim S, et al. Report of a Simplified Frailty Score Predictive of Short-Term Postoperative Morbidity and Mortality. *Journal of the American College of Surgeons*. 2015;220:904-911.e1.
12. Kraemer K, Cohen ME, Liu Y, et al. Development and Evaluation of the American College of Surgeons NSQIP Pediatric Surgical Risk Calculator. *Journal of the American College of Surgeons*. 2016;223:685-693.
13. Moore HB, Juarez-Colunga E, Bronsert M, Hammermeister KE, Henderson WG, Moore EE, Meguid RA. Effect of Pregnancy on Adverse Outcomes After General Surgery. JAMA Surg. 2015 Jul;150(7):637-43.
14. Sachs A, Guglielminotti J, Miller R, Landau R, Smiley R, Li G. Risk Factors and Risk Stratification for Adverse Obstetrical Outcomes After Appendectomy or Cholecystectomy During Pregnancy. JAMA Surg. 2017 May 1;152(5):436-441.
15. Gould MK, Garcia DA, Wren SM, et al. Prevention of VTE in nonorthopedic surgical patients: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest*. 2012;141:e227S.

16. Butcher A, Richards T. Cornerstones of patient blood management in surgery. *Transfus Med*. 2017; Sep 22, Epub.
17. Checketts MR, Alladi R, Ferguson K, et al. Recommendations for standards of monitoring during anaesthesia and recovery 2015: Association of Anaesthetists of Great Britain and Ireland.

AUTHORS/CONTRIBUTORS

Andre R. Campbell, MD, FACS (Section Editor)
San Francisco General Hospital, San Francisco, CA

Roger Tatum, MD (Goals and Objectives Author)
University of Washington School of Medicine, Seattle, WA

Bruce M. Brenner, MD, FACS (Content Author)
Boca Raton Regional Hospital, Boca Raton, FL

Emil R. Petrusa, PhD (Assessment Consultant)
Massachusetts General Hospital, Boston, MA