Preoperative Evaluation for Non-Cardiac Surgery

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Abstract
Internists are frequently consulted to perform preoperative risk assessments on patients undergoing non-cardiac surgery. Physicians need to assess the cardiac risk associated with the surgery, identify the patient’s unique risk profile, recommend appropriate preoperative testing and make suitable recommendations. By a focused history-taking, physical examination, and application of current evidence-based guidelines in cardiac risk assessments, patients at high risk for complications at surgery can be identified and additional work-up suggested. Effective preoperative recommendation includes an assessment of risk (cardiac and non-cardiac), recommendations on medication adjustment, thrombo-embolic prophylaxis, and use of perioperative $\beta$ blockers. Prompt communication with the surgeon often enhances the quality of medical consultation and ensures compliance.

INTRODUCTION
Each year 10% of the adult population undergoes a non-cardiac surgery. A third of these surgeries are performed in the geriatric population who are at increased risk for a cardiac event. The overall mortality rate of all surgeries is 0.3%. For major surgeries, the mortality rate is less than 1% in patients younger than 65 years, but increases to 5% for patients between 65 and 80 years. Death in the postoperative period in the first 48 hours is mainly due to cardiac causes, while death between 48 hours and 6 weeks is often due to pneumonia, sepsis, pulmonary embolism, cardiac arrest, and renal failure.

Internists are frequently consulted to perform preoperative evaluation of patients. Evaluation of the surgical patient often starts with a systematic approach to history-taking and performing a focused clinical examination. An essential skill is the identification of high-risk patients, whose medical condition needs to be optimized considerably prior to surgery, as well as the identification of those patients who need to be excluded from an elective surgery. With improvements in risk assessment and recent advances in anesthesia and surgical techniques, the latter group of patients are rare these days. Preoperative evaluation is a part of the core curriculum in Internal Medicine training in the US and several hospitals now have specialized preoperative clinics to assess patients prior to surgery. In the current article, we will review the current evidence for assessment of cardiac risk prior to non-cardiac surgical procedures, identification of individual risk predictors (cardiac and non-cardiac), determine appropriate preoperative testing and measures to tailor the perioperative recommendation to the patient’s medical status.

Cardiac risks associated with Noncardiac surgery:
Cardiac risks of surgery include nonfatal myocardial infarctions and fatal cardiac events. The incidence of postoperative myocardial infarction (MI) in male general surgery patients over 50 years is 0.7%, and is as high as 3.1% in vascular surgery patients. The risk of postoperative cardiac complication depends on the functional capacity, presence of co-morbid conditions, the age of the patient and the type of surgery.

The American Society of Anesthesiologist (ASA) have stratified the surgical risk based on patient’s functional state, co-morbid diseases, and urgency of surgery (Table 1). The surgeries that are associated with high (> 5%) cardiac risks include emergency major surgeries in elderly, aortic and major vascular surgeries, peripheral arterial procedures and surgeries of prolonged duration. Intermediate risk surgeries (<5%) include carotid endarterectomy, head and neck surgery, abdominal surgery, intrathoracic surgeries, prostate surgery and orthopedic surgery. Low risk surgeries (<1%) include endoscopic procedures, breast surgery, cataract surgeries and superficial procedures.

The risk of mortality associated with anesthesia and surgery has decreased from 1:1500 in 1950 to 1:250,000 more recently. The risk of perioperative myocardial infarction is maximum 24 to 48 hours after surgery. Interestingly, 60% of perioperative myocardial infarctions are not associated with chest pain. The predictors of postoperative ischemia in patients...
undergoing non-cardiac surgery includes left ventricular hypertrophy on EKG, history of hypertension, definite coronary artery disease, diabetes mellitus and use of digoxin. Hence postoperative monitoring should be recommended in patients at high risk for ischemia.

Assessment of Cardiovascular risk

A focused history and physical examination is essential to determine if the patient has any of the five cardiac risks factors. These include ischemic heart disease, valvular heart disease, congestive heart disease, arrhythmias and hypertension.

A history of recent ischemic cardiovascular events is associated with a dramatic increase in perioperative myocardial infarctions (MI). In patients undergoing surgery, the risk of perioperative MI is 37%, 16% and 5% in patients with history of suffering from MI in the last 3 months, 3-6 months and over 6 months, respectively. Hence, routine surgeries must be delayed for at least 6 months after a MI. Recent advancement in anesthetic delivery, post operative care, have allowed surgeries to be performed as early as 4 to 6 weeks after an acute myocardial infarction if preoperative stress testing reveals an absence of myocardial ischemia. In high risk patients, treatment with B-blockers started a few days prior to surgery to achieve a heart rate of 50 to 60 beats/ min, reduces the risk of subsequent cardiac events.

Patients with valvular heart disease especially severe aortic stenosis (AS), increases the risk of surgery. Patient with severe AS have a fixed cardiac output and do not tolerate either general or spinal anesthesia as they are associated with vasodilatation. Patients with moderate to severe mitral stenosis also tolerate surgery poorly. On the other hand, patients with aortic and mitral regurgitation with preserved left ventricular function are less likely to have an adverse cardiac event due to the valve dysfunction. Patients with valvular heart disease will require appropriate infective endocarditis prophylaxis.

History of preoperative congestive heart failure (CHF) increases the risk of pulmonary edema from 3% in New York Heart Association Class 1 to 25% in patients with Class IV CHF. However, in 50% of patients who develop postoperative CHF, there is no prior history of CHF. Most of these patients develop CHF within an hour of completion of surgery and need aggressive postoperative care with diuretics and medical co-management. Elective surgery should be postponed for at least 1 week after optimizing the signs of heart failure. On the contrary dehydration should be avoided as hypovolemia can result in hypotension during anesthesia.

Patients with arrhythmias may tolerate surgery poorly. Patient with supra-ventricular arrhythmias need to be rate controlled prior to surgery. Patients with ventricular arrhythmias need to be evaluated by a cardiologist prior to surgery. Those with first-degree heart block and Mobitz Type I heart block tolerate surgery well, though patients with Mobitz type II, third degree heart blocking might require intraoperative pacing.

Hypertension should be well controlled prior to surgery. Studies have shown that if diastolic blood pressure (BP) is maintained below 110 mm Hg, surgeries can be performed without increased risk. The general consensus is to have the systolic BP below 180 mm Hg prior to induction of anesthesia. Antihypertensive agents must be continued in the perioperative period and occasionally parenteral anti-hypertensive medication may be required if patient is unable to tolerate medication by mouth or through a nasogastric tube.

Numerous risk assessment tools including the American Society of Anesthesiologist score (ASA index), Goldman’s cardiac risk index, Detsky’s criteria have been used to assess cardiac risks. Recent recommendations by the American College of Cardiology/ American Heart Association (ACC/AHA) regarding perioperative cardiac evaluation is based on clinical risk predictors, the functional status of the patient, and risk of the surgical procedure (high, intermediate or low risk). The clinical predictors of risk are defined as major, intermediate, or minor, depending on the severity of the ischemic heart disease and other factors (Table 2). Functional status of a patient can be determined by the ability of the patient to perform household tasks and exercise activities. A patient who is unable to climb a flight of stairs (estimated energy requirement of < 4 METs) has a poor functional status. Patients with moderate functional capacity (4-7 METs) can climb a flight of stairs but are unable to participate in moderate activities such as bowling, dancing, or playing golf. Patients with good functional activities (> 7 METs) are able to participate in moderate recreational activities.

Patients who have had coronary revascularization procedure in the last 5 years or have had a favorable coronary angiogram 2 years prior to surgery usually do not require any further testing. Noninvasive (stress test) and/or invasive cardiac evaluations (coronary angiogram

### Table 1: American Society of Anesthesiologists classification of anesthetic risk

<table>
<thead>
<tr>
<th>Class</th>
<th>Physical status</th>
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<tbody>
<tr>
<td>I</td>
<td>Normal healthy person &lt; 80 years old</td>
</tr>
<tr>
<td>II</td>
<td>Mild systemic disease</td>
</tr>
<tr>
<td>III</td>
<td>Severe but not incapacitating systemic illness</td>
</tr>
<tr>
<td>IV</td>
<td>Incapacitating systemic illness that is constant threat to life</td>
</tr>
<tr>
<td>V</td>
<td>Moribund patient unlikely to live &gt; 24 hours, regardless of surgery</td>
</tr>
<tr>
<td>E</td>
<td>Emergency surgery, add suffix to any Class, i.e., IE, IIE, etc.</td>
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</table>

48 hour mortality rate Class I-0.07%, Class II- 0.24%, Class III- 1.4%, Class IV- 7.5%, Class V- 8.1%, E- double risk at any class, modified from reference 5.
Table 2: Clinical predictors of risk for surgery

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Examples</th>
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<tbody>
<tr>
<td>Major</td>
<td>Decompensated CHF</td>
</tr>
<tr>
<td></td>
<td>Unstable coronary syndromes</td>
</tr>
<tr>
<td></td>
<td>Significant arrhythmias</td>
</tr>
<tr>
<td></td>
<td>Severe valvular diseases</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Mild angina pectoris (Class I/II)</td>
</tr>
<tr>
<td></td>
<td>Compensated or prior CHF</td>
</tr>
<tr>
<td></td>
<td>Prior MI by history and Q waves</td>
</tr>
<tr>
<td></td>
<td>Diabetes mellitus</td>
</tr>
<tr>
<td></td>
<td>Renal insufficiency</td>
</tr>
<tr>
<td>Minor</td>
<td>Advanced age</td>
</tr>
<tr>
<td></td>
<td>Abnormal EKG (RBBB, LVH, ST-T abnormalities)</td>
</tr>
<tr>
<td></td>
<td>Rhythm other than sinus</td>
</tr>
<tr>
<td></td>
<td>Low functional capacity</td>
</tr>
<tr>
<td></td>
<td>History of CVA</td>
</tr>
<tr>
<td></td>
<td>Uncontrolled blood pressure</td>
</tr>
</tbody>
</table>

Abbreviations- CVA- cerebrovascular accidents, CHF- congestive heart failure, RBBB- right bundle branch block, MI- myocardial infarction, LVH- left ventricular hypertrophy, Modified from reference 6.

angiogram) is required in patients with major clinical predictors, those with intermediate clinical predictors and poor functional capacity (4 METs) or undergoing high surgical risk procedures, and in patients with minor clinical predictors and poor functional capacity undergoing high risk procedure (Fig. 1).

Assessment of Pulmonary risks

Pulmonary complications (pneumonia, hypoventilation and atelectasis) occur in about one-third patients postoperatively, and account for 50% of overall mortality 15. Preoperative pulmonary testing is indicated in patients with suspected lung disease, patients with over 10 pack-year history of smoking, patients with chronic obstructive lung disease (COPD). Forced expiratory volume in 1 second (FEV1) is probably the best indicator of surgical risk. Patients with FEV1 > 2 can safely undergo surgery while patients with FEV1 of < 1 are at high risk of postoperative pulmonary complication. Chest X-ray is recommended for patients suspected of chronic lung disease, pulmonary tuberculosis and those undergoing thoracic or abdominal surgery. Arterial blood gas evaluation maybe reserved for patients with severe COPD.

Preoperative precautions to decrease pulmonary risks include smoking cessation, preferably several weeks prior to surgery, use of bronchodilators and treatment of chronic bronchitis. Postoperatively, for patients with chronic lung disease, incentive spirometry, bronchodilators, chest physiotherapy and early mobilization are encouraged.

Preoperative Hematologic Risk Assessment

Patients should be assessed for increased bleeding risks (use of non-steroidal anti-inflammatory agents, hereditary or platelet factor disorders, clotting factors deficiency, or on anticoagulants). NSAIDs like aspirin should be discontinued one week prior to elective procedures. Warfarin should be discontinued 5 days prior to elective procedures. Most surgeries can be performed safely at an INR (international normalized ratio) of < 1.5. Patient with mechanical prosthetic valves undergoing surgery should discontinue Warfarin several days prior to the procedure and managed with low-molecular weight heparin (LMWH). LMWH can be discontinued 12 to 24 hours prior to surgery and restarted postoperatively along with warfarin when it is considered safe. A hematologist must be involved in the care of the care of patients with hereditary or platelet factor disorders, clotting factors deficiency.

Surgical patients at high risk for venous thromboembolism (TE) include those who are obese, elderly, undergoing prolonged operations or hip surgery, history of malignancy, previous TEs, hereditary disorders of thrombosis, or use estrogen. These patients require TE prophylaxis with measure such as the use of LMWH, unfractionated heparin, or warfarin, early mobilization and intermittent pneumatic compression devices.16

Endocrine aspects of risk assessment

Common endocrine conditions that impact perioperative risk includes diabetes mellitus, thyroid disorders and secondary adrenal insufficiency due to prior corticosteroid use.

Patients with poorly controlled diabetes are more prone to developing wound infections. Hence, it is desirable to have at least moderate blood sugar control preoperatively. Patients on oral hypoglycemic agents should hold their medication on the morning of surgery. Metformin should be held 48 hours prior to surgery and Chlorpropamide (due to prolonged half-life) should be


Patients with chronic liver disease are at high risk of mortality from <1% to 29%, and increase in morbidity less than 2.1 g/dl was associated with an increase in adverse outcome. A decrease of serum albumin from greater 4.6 g/dl to 2.1 g/dl increase in mean glucose level was associated with a 30% increase in postoperative complications.17 Serum glucose should be maintained below 150 mg/dl in the postoperative period.

Patient with hypothyroidism present low surgical risk and should continue on their regular thyroid replacement dosage. Uncontrolled hypothyroidism may result in delayed clearance of anesthetic agents. Patients with uncontrolled thyrotoxicosis are at high surgical risk of thyroid storm, hence elective surgery should be postponed for at least 3 months or until the patient is euthyroid. In case of emergency surgery in a patient with thyrotoxicosis, pretreatment with propranolol and propylthiouracil is recommended.

Secondary adrenal insufficiency must be suspected in patients who have received long-term steroid therapy, or those that have received at least 2 weeks of steroids in the previous year. These individuals should be covered with replacement doses of corticosteroids in the perioperative period.18

Nutritional Status and Surgical outcome

Malnutrition and hypoalbuminemia has been associated with postoperative morbidity and mortality. A decrease of serum albumin from greater 4.6 g/dl to less than 2.1 g/dl was associated with an increase in mortality from <1% to 29%, and increase in morbidity from 10% to 65%. Patients who are severely malnourished (> 15% loss of body weight), might benefit from preoperative nutritional intervention.19

Risk assessment of other organ systems

Patients with chronic liver disease are at high risk of delayed clearance of anesthetics and prolonged intubation. These patients require a baseline assessment of prothrombin time and partial thromboplastin time assays and need to be monitored for bleeding complications.

Patients with renal insufficiency require close monitoring to prevent hypotension, fluid and electrolyte imbalances and antibiotic nephrotoxicity. Patients with end-stage renal failure undergoing surgery may need dialysis 12 hours preoperatively and 12-24 hours postoperatively, to optimize fluid and electrolyte balance.

E elective surgery should be postponed in patients with severe acute infections.

Role of routine pre-operative laboratory testing

Laboratory testing is rarely indicated in patients under the age of 50 years. For patients over 50 years, minor abnormality of laboratory tests rarely delays surgery.20 When indicated, specific tests should be planned based on the clinical history of the patients. In the past, chest X-rays were done on all patients undergoing surgery due to the high prevalence of undetected pulmonary tuberculosis. However, current day indication of chest X-ray is limited to patients over 60 years, or those with known pulmonary symptoms or with cardiac disease. The current recommendation of routine laboratory testing is summarized in Table 3.

Management of chronic outpatient medications

Elderly patients account for one-third of all surgeries, and half of all emergency procedures. Most elderly patients have one or more concomitant chronic medical disorder and are on numerous medications. Physicians have to be aware of the medication adjustments and suggest appropriate medication modifications to avoid perioperative complications.21 Table 4 outlines the appropriate management of commonly prescribed medications.

Preoperative templates and recommendations

The purpose of preoperative evaluation by internists includes an assessment of the cardiac and noncardiac risk factors for surgery, recommendation for appropriate testing, assessment of fitness for surgery and recommendations for perioperative medication such as â blockers and venous thromboembolism prophylaxis. The mnemonic (A to I) could be helpful in summarizing the history of a preoperative evaluation. A: allergies, B: bleeding tendencies, C: coronary artery disease, CHF, COPD, D: list of drugs, E: endocrine including thyroid

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Table 4: Medication adjustments and recommendations—prior to elective surgery

<table>
<thead>
<tr>
<th>Medication</th>
<th>Perioperative modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antihypertensives</td>
<td>Take on the morning of surgery (exception of diuretics)</td>
</tr>
<tr>
<td>Digoxin</td>
<td>Check digoxin level. Take on morning of surgery</td>
</tr>
<tr>
<td>HMG CoA reduction and Gemfibrozil</td>
<td>Hold prior to surgery. Increase risk of rhabdomyolysis</td>
</tr>
<tr>
<td>NSAIDs –</td>
<td>Aspirin, NSAIDs Hold 1 week prior to surgery</td>
</tr>
<tr>
<td>Clopidogrel</td>
<td>Hold 5 days prior to surgery</td>
</tr>
<tr>
<td>Warfarin</td>
<td>Hold 3-5 days prior to surgery</td>
</tr>
<tr>
<td>Oral hypoglycemic agents</td>
<td>Metformin Hold 2 days prior to surgery</td>
</tr>
<tr>
<td>Newer oral hypoglycemic</td>
<td>Chlorpropamide Hold 2-3 days prior to surgery</td>
</tr>
<tr>
<td>Insulin- Regular</td>
<td>Newer oral insulin Hold on the morning of surgery</td>
</tr>
<tr>
<td>NPH</td>
<td>Bronchodilators Take prior to surgery</td>
</tr>
<tr>
<td>Sedatives</td>
<td>Thyroid replacement Take prior to surgery</td>
</tr>
<tr>
<td>Hypnotics</td>
<td>Hold on morning of surgery, reassess further use in postoperative period</td>
</tr>
<tr>
<td>Estrogen</td>
<td>Discontinue prior to surgery</td>
</tr>
<tr>
<td>Herbal medication</td>
<td>Discontinue prior to surgery</td>
</tr>
</tbody>
</table>

Table 5: Template for preoperative assessment and recommendations

1) Type of surgery planned: elective, emergency
2) History of presenting illness
   a) History of CAD: None, Class I, Class II, Class III, Class IV
   b) History of CHF: None, Class I, Class II, Class III, Class IV
   c) Pulmonary disease: None, COPD, asthma, smoking, pulmonary tuberculosis
   d) Diabetes mellitus: None, Type I, Type II
   e) Renal disease: None, Yes
   f) Functional status: Poor, Moderate, Good
   i) Bleeding risk: None, Yes
   j) Prior hepatitis or blood transfusion: Yes, None
   k) Venous thromboembolism risk: None, Yes
   l) Prior anesthesia complications: Yes, None
   m) History of aspirin use: Yes, None
   n) History of recent steroid use: None, Yes
   o) History of alcohol dependence: None, Yes
3) Medication and allergy list
4) Focused review of systems: prior CABG, cardiac stress test (last 2 years)
5) Vitals signs and focused examination: BP, Pulse, JVP, carotid bruits, S₃, severe aortic stenosis, lung sounds, active infection
6) Impression, Recommendations and Plan:
   a) Cardiac risk for noncardiac surgery: Low risk (<1%), intermediate risk (5%), high risk procedure (>5%)
   b) Patients Clinical risk predictors: None, minor, intermediate, major
   c) Results of laboratory test- summarize
   d) Fitness for surgery: Yes, No (require additional evaluation)
   e) If fit for surgery, additional recommendations: β blockers, DVT prophylaxis, medication adjustments, delirium risk

status, diabetes mellitus and corticosteroid use, F-family history of malignant hyperthermia, G-glaucoma, H–hepatitis, HIV and I–infections (Tuberculosis or active infection). Internist should avoid using the term, ’okay for surgery’. The plans regarding the type and mode of anesthesia, and the decision to proceed with surgery is a shared decision, to be made by the surgeon, the anesthetist and the patient.

Several hospitals use templates to perform a preoperative evaluation. We have summarized a template for preoperative assessment in Table 5. High risk patients requiring additional evaluations, i.e. stress testing or coronary angiogram can be identified quite easily using this format. It is important to note that patient is never subjected to coronary angiogram and coronary bypass surgeries just to ‘get through the surgery’. These procedures are often indicated independent of the elective surgical procedure. Additionally, in patients who have undergone coronary artery stenting, surgery is deferred for several months as the risk of postoperative mortality and morbidity is higher in this group of patients in the months immediately following the coronary artery stenting procedure. Often these patients are on Clopidogrel (Plavix), which can increase the risk of postoperative bleeding.

Recent studies have demonstrated that in select patients at high risk for coronary artery disease, use of β blockers can reduce the incidence of preoperative mortality and myocardial infarction by 50%. Patients who are likely to benefit from β blockade include those with history of known coronary artery disease (history of myocardial infarction, angina, positive exercise stress test) and suspected coronary artery disease (having 2 or more of these risk factors, age > 65 yrs, hypertension, nicotine dependence, diabetes mellitus, cholesterol ≥240 mg/dl). These patients would benefit from the initiation of Atenolol 50 mg on the day of surgery and continued up to one week postoperatively, or until discharge. The benefit from the use of β blockade on reduction in cardiac risk has been noted to last for at least 2 years postoperatively.

Hence, by adhering to structured history taking and performing a patient focused examination, an efficacious preoperative evaluations can be performed in a reasonable and timely fashion. Internists can provide valuable assistance to their surgical and anesthesia colleagues by evaluating and coordinating the care of patients scheduled to undergo surgery. The internist must communicate effectively to their referring...
physicians in a summary statement that comprises the patient’s risk assessment, and appropriate perioperative recommendations.

**REFERENCES**

11. Auerbach AD, Goldman L. Beta-Blockers and reduction of cardiac events in noncardiac surgery: scientific review. *JAMA* 2002;287:1435-44.