

# Preparing the Older Adult for Surgery

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**A**dults older than 65 years constitute more than 13% of the population in United States; this segment is expected to become a fifth of the population by 2030.<sup>1</sup> The rate of surgical interventions in this age group also has risen, with both emergency and elective surgical procedures being performed frequently, even in octogenarians and nonagenarians.<sup>2</sup> According to estimates from the National Hospital Discharge Survey Summary, more than 4.5 million elderly in the United States underwent inpatient surgery in 1996.<sup>3</sup>

Aging is associated with several physiologic changes that affect functional reserves, resulting in diminished ability to respond appropriately to stress. The additional presence of multisystem disease makes perioperative evaluation of older patients a challenge. Most perioperative deaths occur in the geriatric age group; in one series, up to 75% of all postoperative deaths occurred in elderly patients.<sup>4</sup> Several years ago, there was a tendency to postpone surgery in older adults unless the need for surgery was urgent<sup>5</sup>; as a result, procedures often became emergencies, with poorer outcomes. Better preoperative risk assessment and preparation of the patient have helped improve outcomes.<sup>4</sup> Deaths in geriatric patients with cardiac disease decreased from 18% in 1950 to below 2% in 1995, thanks to advances in medicine, surgery, and anesthesia.<sup>6</sup> This article reviews recommendations for the perioperative management of elderly patients, including preoperative cardiac assessment for noncardiac surgery. Patient-related and procedure-related risk factors are discussed. Perioperative management of certain specific medical conditions is briefly reviewed.

## **THE CONCEPT OF "CLEARANCE"**

The term "clearance for surgery" has been in use for a long time and continues to be used. The term is a misnomer, however, and misrepresents the process of medical evaluation.<sup>7</sup> In truth, the physician evaluates the status of the individual, assesses risks and benefits from surgery, offers corrective measures for those comorbid processes that are correctable, indicates the

presence of irreversible factors or disease, and offers a risk stratification based on several indices.<sup>7-9</sup> In short, the physician prepares the patient for surgery; perioperative management involves the presurgical, intraoperative (if requested), and postoperative periods.

## **PREOPERATIVE RISK ASSESSMENT**

A detailed history obtained from the patient or caregiver is an important initial step in the preoperative evaluation of an elderly surgical candidate. This includes a history of current and past illnesses; a review of prescribed, over-the-counter, and topical medications; tobacco and alcohol use; and prior surgery or anesthesia. For many patients, the evaluation prior to surgery is the first opportunity for a systematic physical examination.

Broadly, risk assessment involves patient-related and procedure-related factors. The most successful strategies for accurately assessing preoperative risk entail a team approach involving the primary care physician, surgeon, anesthesiologist, and any consulting specialists.

## **PATIENT-RELATED RISK FACTORS**

### **Age**

Advanced age traditionally has been considered a risk factor for surgery. Aging is associated with a decrease in functional reserves of organ systems and an increase in the presence of comorbid conditions. Early in the last century, persons older than 50 years were excluded from many procedures considered minor today (eg, inguinal hernia). It is now known that it is comorbidity, rather than age, that contributes significantly to perioperative morbidity and mortality and is a

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better predictor of outcome.<sup>4,6,10</sup> Although age is considered in several risk indices, age per se is not a contraindication for surgery.<sup>10,11</sup> In the past decade, the mortality for major surgical procedures was approximately 5% at age 80 years compared with 2% in younger adults.<sup>4</sup>

### **Functional, Cognitive, and Psychological Status**

Functional status, evaluated by the ability to perform activities of daily living or instrumental activities of daily living, contributes to the determination of a patient's level of risk for perioperative complications and morbidity.<sup>7,12</sup> The capability to leave home and return on one's own, at least twice weekly, is considered a favorable sign, as is the ability to exercise on a bicycle for 2 minutes or longer.<sup>4,6</sup> Those with better function and cognition are able to more meaningfully participate in postoperative rehabilitation.<sup>10</sup> In one study, a patient's capability for activities of daily living correlated with better survival at 1 year following hip surgery, and inactivity correlated with a poorer outcome.<sup>13</sup>

Preoperative mental status and cognitive capacity are predictors of surgical outcome.<sup>14</sup> Several instruments help to assess cognition; the Mini-Mental State Examination is commonly used. The presence of dementia predicts poor outcome and prolonged hospitalization. Preoperative mental status also predicts postoperative delirium.<sup>6,15</sup> Depression, which may be masked or overt, is common in the elderly and contributes to significant morbidity.<sup>15,16</sup> The Geriatric Depression Scale is a useful screening instrument.

The American Society of Anesthesiologists (ASA) classification uses a general evaluation of clinical status to assess perioperative risk. Introduced in 1941 and revised in 1962, this scale classifies patients into 5 groups based on general clinical status: ASA class I comprises healthy adults; class II, those with mild systemic disease; class III, those with nonincapacitating systemic disease; class IV, those with incapacitating, life-threatening illness. Class V subjects are moribund and expected to die within 24 hours regardless of surgical intervention. Although subjective and prone to observer differences, this scale has been successful in predicting risk. The ASA classification suggests that age by itself is not a strong predictor of adverse outcome.<sup>17</sup>

### **Preoperative Cardiac Assessment for Noncardiac Surgery**

Evaluation of the older adult for cardiovascular disease is made difficult by age-related cardiac changes, comorbidity, and atypical presentations. Aging results in a decrease in the compliance of the ventricles and blood

vessels, degenerative changes in the cardiac valves, and fibrocalcification of the conduction system.<sup>18</sup> Although the older heart maintains cardiac output at rest, a reduced  $\beta$ -adrenergic response impairs its ability to appropriately increase heart rate during exercise. Cardiac output during stress is maintained by an increase in stroke volume. Normal atrial contraction helps maintain adequate diastolic filling of the ventricles, which are stiffer and more prone to diastolic dysfunction.<sup>18</sup>

Cardiac disease is the primary basis for postoperative mortality in geriatric patients; optimizing cardiovascular risk factors and stabilizing cardiovascular function help prevent many postoperative complications. Several cardiac risk indices, though not uniformly adopted, are available.<sup>19–22</sup>

Preoperative coronary artery disease (CAD) is the most common etiology for postoperative ischemia. Contrary to common belief, the highest cardiac risk is not during surgery when the patient is optimally monitored, but 1 to 2 days postoperatively and later.<sup>8,10,23,24</sup> Myocardial ischemia may occur postoperatively as a result of excessive adrenergic activity, hemodynamic changes, fluid shifts, body temperature alterations, hypoxemia, pain, and alterations in blood coagulation associated with the perioperative state.<sup>25</sup> High-risk patients must be identified prior to surgery.

**Clinical predictors of increased cardiovascular risk.** Cardiac assessment begins with a thorough history and physical examination and an electrocardiogram (ECG). Several approaches to cardiovascular risk stratification are available, but no single method is considered optimal.<sup>26</sup> The landmark study published in 1977 by Goldman and colleagues<sup>19</sup> provided an approach that classified patients into 4 groups using clinical variables; this was modified and validated by Detsky and colleagues in 1986.<sup>19,20</sup> The American College of Cardiology/American Heart Association (ACC/AHA) guidelines, introduced in 1996<sup>27</sup> and updated in 2002,<sup>9,21</sup> follow a stepwise strategy based on clinical risk factors, prior cardiac evaluation or treatment, functional capacity, and surgical risks. Clinical risk predictors are divided into major, intermediate, and minor risk factors (**Table 1**). Noncardiac surgical procedures are stratified into high, intermediate, and low-risk categories (**Table 2**). Minor risk factors by themselves are not independent predictors, but may contribute to a clinical picture of increased risk. Intermediate risk factors may warrant noninvasive testing. The presence of a major risk factor warrants intensive management, with the functional status of the patient and the risks of surgery factored into decision making. An inability to attain a functional status of at least 4 metabolic equivalents (METs)

indicates a poor prognosis. The guidelines of the American College of Physicians (ACP), published in 1997,<sup>22</sup> in general parallel the recommendations of ACC/AHA; however, the ACP guidelines do not recommend evaluation of functional status or noninvasive testing with intermediate risks.<sup>12,26</sup>

All validated indices stress the importance of recent acute coronary syndrome, decompensated cardiac failure, and significant arrhythmias on ECG as major risk factors affecting surgical outcome. Myocardial infarction (MI) in the previous 6 months increases the risk of reinfarction, with the highest risk if the infarction occurred within 30 days.<sup>8,23,25</sup> If possible, elective surgery should be postponed for at least 6 months after an acute MI.<sup>28</sup> The recently updated ACC/AHA guidelines<sup>21</sup> note that if a recent stress test does not indicate the presence of residual myocardium at risk, the likelihood of reinfarction is low, and thus although clinical data is lacking, a 4- to 6-week waiting period prior to elective surgery is a reasonable option. Unstable angina is a major risk factor as well.<sup>25</sup> According to the ACC/AHA guidelines, patients who had successful coronary revascularization within 5 years or had cardiac testing with favorable results in the last 2 years are considered low risk if they have not had any cardiac events or symptoms since evaluation.<sup>21</sup>

Echocardiography helps assess left ventricular function, wall motion, and valvular function. A resting left ventricular ejection fraction lower than 35% increases perioperative risk for ischemia.<sup>21,25</sup> Poor left ventricular systolic or diastolic function predicts postoperative cardiac failure and death. Nevertheless, left ventricular function has not been a consistent predictor of postsurgical ischemic events.<sup>21</sup> Exercise stress testing can be used to assess preoperative functional capacity; this helps determine the presence and severity of coronary heart disease and arrhythmias.<sup>8</sup> As elderly patients are frequently limited in their ability to exercise, non-exercise stress testing is an available option. Dipyridamole thallium and adenosine myocardial perfusion scans have high sensitivity and specificity in predicting perioperative ischemic events; dobutamine stress echocardiography provides similar information.<sup>4,26</sup> The negative predictive value of stress testing is high; a negative test indicates low risk for postoperative cardiac events.<sup>8,25</sup> On the other hand, there is consensus that these tests should not be routinely used for preoperative evaluation because they have a high false-positive rate. An inability to attain 75% to 85% of the maximum predicted heart rate on stress testing or tolerate 4 METs in an assessment of functional capacity suggests risk for

**Table 1. Clinical Predictors of Increased Perioperative Cardiovascular Risk (Myocardial Infarction, Heart Failure, Death)**

**Major**

- Unstable coronary syndromes
  - Acute or recent MI\* with evidence of important ischemic risk by clinical symptoms or noninvasive study
  - Unstable or severe† angina (Canadian class III or IV)‡
- Decompensated heart failure
- Significant arrhythmias
  - High-grade atrioventricular block
  - Symptomatic ventricular arrhythmias in the presence of underlying heart disease
  - Supraventricular arrhythmias with uncontrolled ventricular rate
- Severe valvular disease

**Intermediate**

- Mild angina pectoris (Canadian class I or II)
- Previous MI by history or pathologic Q-waves
- Compensated or prior heart failure
- Diabetes mellitus (particularly insulin-dependent)
- Renal insufficiency

**Minor**

- Advanced age
- Abnormal ECG (left ventricular hypertrophy, left bundle-branch block, ST-T abnormalities)
- Rhythm other than sinus (eg, atrial fibrillation)
- Low functional capacity (eg, inability to climb 1 flight of stairs with a bag of groceries)
- History of stroke
- Uncontrolled systemic hypertension

ECG = electrocardiogram; MI = myocardial infarction.

\*The American College of Cardiology National Database Library defines recent MI as greater than 7 days but less than or equal to 1 month (30 days); acute MI is within 7 days.

†May include “stable” angina in patients who are unusually sedentary.

‡Campeau L. Grading of angina pectoris. *Circulation*. 1976;54:522–3.

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**Table 2.** Cardiac Risk\* Stratification for Noncardiac Surgical Procedures

<b>High</b> (reported cardiac risk often > 5%)
Emergent major operations, particularly in the elderly
Aortic and other major vascular surgery
Peripheral vascular surgery
Anticipated prolonged surgical procedures associated with large fluid shifts and/or blood loss
<b>Intermediate</b> (reported cardiac risk generally < 5%)
Carotid endarterectomy
Head and neck surgery
Intraperitoneal and intrathoracic surgery
Orthopaedic surgery
Prostate surgery
<b>Low</b> <sup>†</sup> (reported cardiac risk generally < 1%)
Endoscopic procedures
Superficial procedures
Cataract surgery
Breast surgery

\*Combined incidence of cardiac death and nonfatal myocardial infarction.

<sup>†</sup>Do not generally require further perioperative cardiac testing.

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postoperative cardiac events.<sup>8,21,24</sup> Poor functional capacity (determined to be less than 4 METs) and a positive pharmacologic stress test, with a high-risk surgical procedure, warrants further evaluation (eg, coronary angiography).<sup>21,24</sup>

Indications for coronary angiography as part of perioperative evaluation are available and are similar to those in the nonoperative setting.<sup>21,24</sup> In high-risk patients with suspected or proven CAD (especially left-main and 3-vessel disease), angiography is indicated. Indications for percutaneous transluminal coronary angioplasty and coronary artery bypass grafting are listed in the ACC/AHA guidelines and are the same as in the nonoperative setting.<sup>21</sup> Cancellation or postponement of surgery to follow treatment of the cardiac condi-

tion (eg, coronary vascularization) is the recommended route in only a small number of high-risk patients.<sup>21</sup>

In low-risk patients with good functional status, further testing is generally not needed. In high-risk patients requiring emergency surgery, proceeding with surgery may be reasonable and the only choice; alternatively, if surgery can be postponed, treatment of the cardiac condition may be attempted prior to surgery.

**Perioperative cardiac surveillance.** A baseline ECG must be obtained in all surgical candidates older than 40 years, especially patients with diabetes or hypertension. Approximately 30% of MIs are silent and are detected only on routine ECG.<sup>8</sup> For high-risk procedures in patients with known or suspected CAD, the ECG may be repeated after surgery and on the first 2 days after surgery.<sup>21</sup> Cardiac enzyme testing may be requested on suspicion of ischemia or in high-risk patients, rather than on a routine basis.<sup>21</sup> Pulmonary artery catheterization appears best suited for patients with severe CAD undergoing procedures that are associated with significant hemodynamic stress; those with congestive heart failure (CHF) and recent MI; and those with cardiomyopathy, significant systolic or diastolic left ventricular dysfunction, or valvular heart disease undergoing high-risk surgery.<sup>21</sup>

#### Optimum Hemoglobin-Hematocrit Levels

The optimum hemoglobin-hematocrit levels have not been ascertained by adequate studies, although generally, the “10/30 rule” (hemoglobin > 10 g/dL and hematocrit > 30%) has stood the test of time.<sup>29</sup> In general, a higher hematocrit is preferred for older patients likely to have cardiac or pulmonary disease, patients using  $\beta$ -blockers, and those undergoing surgical procedures with anticipated significant blood loss.<sup>29</sup> Based on expected blood loss, those with lower hematocrits are generally transfused to attain a value of approximately 30%. The use of transfusions may be individualized based on age, comorbid processes, life expectancy, and the nature of surgery.

#### Nutritional Status

Malnutrition is associated with poor outcome; hypoalbuminemia correlates with increased risk of complications and mortality.<sup>4</sup> Nutritional status is evaluated by assessing serial weights, oral intake, and biochemical parameters. Studies have failed to show a significant difference in mortality or morbidity with aggressive parenteral or enteral nutrition; sometimes therapy is associated with complications.<sup>30</sup> Postponement of surgery by weeks or months in order to improve nutritional status usually is not rewarding.

## **ASSESSMENT AND MANAGEMENT OF SPECIFIC MEDICAL CONDITIONS**

### **Congestive Heart Failure**

The presence of CHF increases perioperative cardiac morbidity, hence the need to treat pulmonary congestion prior to surgery.<sup>25</sup> It is important to determine the etiology of CHF and treat accordingly; for example, management of systolic dysfunction involves the use for diuretics and angiotensin-converting enzyme inhibitors.<sup>25</sup> Awareness of the fact that an infiltrative disorder such as amyloidosis is the basis for systolic or diastolic dysfunction may influence decisions regarding fluid administration in the perioperative period.<sup>21</sup>

### **Arrhythmias**

Supraventricular arrhythmias may cause ischemia by increasing oxygen demand in the presence of CAD. Premature ventricular contractions, complex ventricular ectopy, and nonsustained ventricular tachycardia require therapy only in the presence of myocardial ischemia.<sup>21</sup> Presence of arrhythmias in the perioperative phase should prompt evaluation for metabolic and electrolyte abnormalities, cardiopulmonary disease, and drug toxicity.<sup>21</sup> Rate control, optimization of fluid status, and need for anticoagulation (with heparin) need to be addressed.<sup>31</sup> The risk of perioperative arrhythmia should prompt institution of prophylactic  $\beta$ -blocker therapy.<sup>21</sup> Indications for temporary and permanent pacemaker implantation for those undergoing noncardiac surgery are similar to those in the nonoperative state.<sup>21</sup>

### **Valvular Heart Disease**

Regurgitant lesions are in general better tolerated than stenotic lesions.<sup>21</sup> Whereas regurgitant lesions may be stabilized medically, symptomatic stenotic lesions increase cardiac risk and thus warrant consideration for surgical correction.<sup>21</sup> Severe aortic stenosis carries the highest risk for noncardiac surgery; in those who refuse surgical correction or are not candidates for valve replacement, noncardiac surgery carries a mortality risk of approximately 10%.<sup>9</sup> Ventricular rate control is important in patients with mitral stenosis to minimize pulmonary congestion from poor diastolic filling. The presence of aortic regurgitation or severe mitral regurgitation warrants judicious fluid administration and afterload reduction.<sup>9</sup>

Superimposed arrhythmias may precipitate cardiac failure in the background of valvular heart disease and necessitate monitoring by pulmonary artery catheter to guide fluid administration.<sup>31</sup> Patients with prosthetic valves, damaged native valves from rheumatic or other

diseases, or prior endocarditis should receive antibiotics for infective endocarditis prophylaxis.<sup>23</sup>

### **Hypertension**

Increased perioperative morbidity is associated with uncontrolled hypertension and renovascular disease.<sup>32</sup> Patients with hypertension should be evaluated for control and evaluated for end-organ damage.<sup>31,32</sup> A blood pressure of 180/110 mm Hg or higher confers risk for ischemia and warrants delaying surgery until better control can be achieved.<sup>23,32,33</sup> The Joint National Committee VI guidelines<sup>33</sup> recommend  $\beta$ -blockers as initial therapy for preoperative hypertension; the benefit in declining mortality extends 6 to 8 weeks after surgery. If at least 7 days are available prior to surgery, the goal should be to titrate the dose of  $\beta$ -blockers to a resting heart rate of 60 bpm.<sup>34</sup> Abrupt discontinuation of  $\beta$ -blockers or clonidine can lead to rebound hypertension. Calcium channel blockers have been associated with increased surgical bleeding.<sup>33</sup> Antihypertensive medications should not be held prior to surgery; they may be given the previous night or the morning of the surgery with minimal water.<sup>35</sup>

### **Diabetes Mellitus**

Lack of glycemic control perioperatively is associated with postoperative infection, impaired wound healing, and cardiac complications. Blood sugar levels should be checked before, during, and after surgery. Patients on oral hypoglycemic agents may be preferably switched to insulin prior to surgery. Patients already on insulin may be given a half-dose of a long-acting insulin on the morning of surgery and placed on intravenous dextrose.<sup>12</sup> For blood sugar values above 250 mg/dL, regular insulin may be administered to attain blood glucose levels between 150 and 250 mg/dL.<sup>12,23,31</sup>

### **Pulmonary Disease**

The respiratory system undergoes several changes with aging. A decline in compliance of the thoracic cage occurs, associated with an increase in compliance of the lung.<sup>23</sup> Forced expiratory volume in 1 second (FEV<sub>1</sub>) and vital capacity decrease at a rate of 150 mL/decade; the PaO<sub>2</sub> declines, but the PaCO<sub>2</sub> remains normal. More important, closing volume increases, and as it approaches functional residual capacity, there is an increase in the risk of atelectasis.<sup>18,23,36</sup> A ventilation-perfusion mismatch occurs in the lower parts of the lung, particularly in the recumbent position; this is a basis for promoting early mobilization of older patients. Changes in pulmonary function are more prominent in smokers and from disease, rather than from age alone.<sup>37</sup> In addition, cough

reflex and antibody responses are diminished in the elderly, predisposing to pneumonia.<sup>36</sup>

Respiratory complications account for significant postoperative morbidity and mortality. Risk factors include smoking, poor exercise capacity, prior lung disease, prolonged surgery, and upper abdominal and thoracic operations.<sup>31,38</sup> Smoking accentuates the rate of decline in FEV<sub>1</sub> from aging and contributes to perioperative morbidity.<sup>6,39</sup> Every effort should be made to counsel the patient regarding smoking cessation; this is most beneficial if achieved 8 weeks prior to surgery.<sup>38</sup> Procedures in the chest or upper abdomen (close to the diaphragm) increase risk of pulmonary complications. Pulmonary function testing benefits high-risk patients such as smokers and those with clinical evidence of lung disease; however, routine preoperative pulmonary function testing for all patients is not recommended.<sup>4,10</sup> Markers for increased risk include vital capacity of less than 50% of the predicted value, FEV<sub>1</sub> less than 50% predicted or less than 2 L, presence of hypoxia, and carbon dioxide retention.<sup>4,6,40</sup>

Optimization of therapy for lung disease is important; judicious use of bronchodilators, antibiotics, and steroids is helpful. Patients can be taught breathing techniques, incentive spirometry and coughing in the preoperative phase to accelerate postoperative rehabilitation.

### **Renal Disease**

Changes with aging include a reduction in both glomerular filtration and tubular function at a rate of approximately 1% per year starting from the third decade of life, although variability has been documented.<sup>41</sup> This decline in renal function causes altered pharmacokinetics of anesthetic agents and medications.

Postoperative renal dysfunction is best predicted by preoperative renal status.<sup>4,23</sup> Impaired baseline renal function, a rising serum creatinine and left ventricular dysfunction are risk factors for renal failure.<sup>4</sup> Postoperative renal dysfunction may result from prerenal factors, but urinary obstruction and tubular damage from ischemia or medications also should be considered.<sup>23,31</sup>

### **SURGICAL PROCEDURE-RELATED RISKS**

#### **Emergency versus Elective Procedures**

Emergent procedures often are associated with poorer outcome, with a risk 3 to 10 times that of elective surgery, partly because of insufficient time to identify and correct potentially rectifiable problems.<sup>6,31,42</sup> In patients older than 70 years, emergency surgery is associated with a mortality rate of 20% compared with

1.9% for planned procedures.<sup>4</sup> Further, acute illness may present atypically in older adults, delaying the diagnosis. On occasion, conservative management is resorted to, leading to delay in surgery and increased mortality.<sup>6</sup>

### **Site and Type of Surgery**

The site of surgery affects outcome. Operations on body cavities carry significant risks in all ages.<sup>31</sup> It has been estimated that risks of thoracic or abdominal cavity surgery are 20 to 50 times greater than those of operations elsewhere.<sup>4</sup> Based on the type of surgery, risks have been stratified into high, intermediate, or low for noncardiac surgical procedures (Table 2), although classifications are not uniform.

### **PREOPERATIVE TESTING**

The extent of preoperative testing is individualized based on an adequate history and physical examination. In practice, testing profiles are frequently guided by the policies of each institution.<sup>24</sup> Laboratory tests routinely recommended prior to surgery include hematocrit/hemoglobin and renal function (serum creatinine and blood urea nitrogen). Additional tests (ordered on an individual basis) include serum electrolyte levels, blood glucose level, leukocyte count, urinalysis, bleeding and coagulation parameters (ie, platelet count, bleeding time, prothrombin time, activated partial thromboplastin time), specific organ function tests (eg, liver, thyroid), and drug levels.

Tests should not be ordered unless they are likely to influence patient management.<sup>7,24,27</sup> Blanket ordering of large profiles increases the likelihood of abnormal test results that would not affect surgical planning; medicolegal problems are more likely to result from ordering tests and not acting upon the (abnormal) result than from failing to order a test in the first place.<sup>43</sup> By the same token, needless repetition of tests over a short period of time should be avoided.

A chest radiograph and ECG generally are recommended in older adults because unsuspected abnormalities may be present in this age group with no indication on history or physical examination. Abnormalities might be found in up to 25% of routinely ordered ECGs in older adults.<sup>16</sup> Other specific diagnostic tests should be requested on the basis of comorbid conditions.

### **MEDICATION USE IN THE PERIOPERATIVE PERIOD**

Older adults frequently take numerous medications, incurring risks from polypharmacy. Alterations

**Table 3.** Perioperative Adjustment of Selected Medications\*

Antihypertensives	Administer on the morning of surgery with small amount of water. $\beta$ -Blockers are drug of choice; do not discontinue. <sup>32,40</sup> Withdrawal of $\beta$ -blockers, clonidine may cause rebound hypertension. <sup>9</sup>
Diabetic medications	Switch oral hypoglycemics to insulin 1 day prior to surgery. <sup>12,23,31</sup> Bolus doses or infusion of insulin are options. If on long-acting insulin, administer $1/3$ to $1/2$ of usual dose on morning of surgery. Initiate dextrose infusion. <sup>12,23,40</sup>
Diuretics	Preferably held for 48 hours prior to surgery. <sup>40</sup>
Medications for CAD	Continue $\beta$ -blockers, calcium channel blockers, and nitrates. <sup>9</sup>
Corticosteroids	Based on degree of surgical/medical stress, administer hydrocortisone 25 mg, 50–75 mg, or 100–150 mg on day of surgery (minor, moderate, severe stress, respectively). For moderate/severe stress, taper over 1–2 days. <sup>44,45</sup>
Antiplatelet medications	Discontinue aspirin 7 days and NSAIDs 3 days prior to procedure. <sup>8,40,46</sup> Discontinue ticlopidine 10–14 days prior to surgery <sup>†</sup> and clopidogrel 5 days before surgery. <sup>‡</sup>
Warfarin	Discontinue 3–5 days prior to surgery (4 doses) and confirm acceptable INR of 1.5 or less. <sup>46,47</sup> Switch to intravenous heparin if risk is high. Heparin should be stopped 6 hours prior to surgery and restarted 12–24 hours post-surgery. <sup>31</sup> Restart warfarin when oral intake resumes. <sup>8</sup>
Antiepileptics	Administer on morning of surgery
Benzodiazepines	Taper and discontinue several days prior to surgery. <sup>31</sup>
Meperidine	Minimize use, preferably avoid

\*An assessment of current medications should be performed at least 1 week prior to surgery.<sup>40</sup>

<sup>†</sup>Prolonged bleeding time caused by ticlopidine can be reversed by corticosteroid administration.

<sup>‡</sup>Source: product inserts: clopidogrel (Plavix), Bristol-Myers Squibb; ticlopidine (Ticlid), Roche Laboratories.

CAD = coronary artery disease; INR = international normalized ratio; IV = intravenous; NSAIDs = nonsteroidal anti-inflammatory drugs.

in renal and hepatic function, body composition, and body mass with advancing age affect metabolism and elimination of medications and anesthetic agents. A comprehensive review of prescribed, over-the-counter and topical medications, eye drops, and nutritional supplements is an important part of the preoperative evaluation. The use of selected medications during the perioperative period is summarized in **Table 3**.

### Antibiotic Prophylaxis

Antibiotics may be used as prophylaxis or therapy. The choice of antibiotic should be tailored to the wound (ie, clean, clean-contaminated, or contaminated); the final decision is often based on the surgeon's preferences. Older adults commonly have valvular heart disease, and bacteremia is a frequent occurrence during surgery; prophylaxis against endocarditis should be instituted based on standard AHA guidelines.<sup>40</sup>

### Perioperative Anticoagulation

**Long-term warfarin or aspirin therapy.** The chronic use of aspirin and warfarin is common in older adults with atrial fibrillation, for prevention of deep venous thrombosis (DVT), and for prevention of prosthetic

valve thrombosis.<sup>25,47</sup> The risk of temporarily discontinuing anticoagulation must be weighed against the benefit of diminished bleeding. Usually, holding 4 doses of warfarin is enough to normalize international normalized ratio (INR), when INR values range from 2 to 3.<sup>46,47</sup> Administration of vitamin K to reverse anticoagulation usually is not advised because of the long time needed to reattain therapeutic levels on resumption of anticoagulation. In patients at high risk for thromboembolism (recent deep vein thrombosis or pulmonary embolism), heparin is started when oral anticoagulation is stopped and discontinued 6 hours prior to surgery.<sup>47</sup> Anticoagulation is restarted 12 hours after major surgical procedures or later in the presence of bleeding.<sup>31,46,47</sup> For emergency surgery, reversal of warfarin effect is achieved by administration of vitamin K or fresh frozen plasma.<sup>46,47</sup> Prothrombin time and activated partial thromboplastin time should be checked prior to surgery to ensure acceptable values.<sup>46,47</sup> When contraindications for anticoagulation exist in patients with a high risk for DVT or pulmonary embolism, placement of a vena cava filter deserves consideration.<sup>46</sup>

Aspirin is usually discontinued 6 to 7 days prior to surgery.<sup>8,31</sup> Although aspirin increases risk of bleeding

by irreversible cyclooxygenase platelet inactivation, discontinuation must be weighed against the risk of CAD.<sup>40</sup>

**Anticoagulants for DVT prophylaxis.** Perioperative anticoagulation must be provided for all patients with risk for DVT. Risk factors include age over 40 years, recent DVT or pulmonary embolism, CHF, stroke, malignancy, hip and knee surgery, and high-risk procedures (eg, pelvic or abdominal surgery).<sup>46</sup> In these patients, heparin, low-molecular-weight heparin, or warfarin must be used to prevent DVT and pulmonary embolism.<sup>24,46</sup> In practice, the withholding of anticoagulants prior to surgery is based on the preferences of the surgeon and anesthesiologist. The fear of bleeding from spinal anesthesia attributed to anticoagulation may influence decision making.<sup>48</sup>

The risk of thromboembolism continues for several weeks after discharge. Anticoagulation may be initiated several days prior to elective procedures and continued postoperatively for 1 month or until the patient is sufficiently ambulatory. Intermittent pneumatic compression or elastic stockings may be used in high-risk situations in addition to anticoagulation therapy or as an alternative when anticoagulation is contraindicated.<sup>24,46</sup> Early ambulation is equally important.

### **Drug Therapy for Cardiac Disease**

$\beta$ -Blockers should be continued in the postoperative period if they were used prior to surgery.<sup>21</sup> Likewise, drugs used for the treatment of CHF (eg, angiotensin-converting enzyme inhibitors, diuretics) should be continued. Data regarding the role of prophylactic intraoperative intravenous nitroglycerin are conflicting.<sup>9</sup>

In patients with CAD,  $\beta$ -blockers may reduce cardiovascular complications; these agents tend to minimize blood pressure fluctuations and reduce perioperative ischemic episodes and postoperative atrial fibrillation.<sup>21,34</sup> Atenolol reduced the rate of cardiac events by 67% in 1 year compared with the placebo group and by nearly 50% in 2 years following surgery.<sup>49</sup> Following vascular surgery, the use of  $\beta$ -blockers was associated with a cardiac complication rate of 0.8% compared with 2.3% in those not on  $\beta$ -blockers.<sup>50</sup> The anti-ischemic effect of  $\beta$ -blockers appears to be related to a decrease in heart rate, increase in duration of diastole, and increased coronary perfusion; decreased myocardial contractility reduced myocardial oxygen demand.<sup>51</sup>

### **Other Medications**

In most instances, patients should continue antihypertensives, anti-epileptics, bronchodilators and car-

diovascular drugs until the day of surgery. When oral medications cannot be administered, corresponding medications in the intravenous forms are substituted. In particular,  $\beta$ -blockers and clonidine should not be discontinued prior to surgery.<sup>21,35</sup> Medications should be taken a few hours prior to surgery with a small quantity of water. Diuretics preferably are held on the day of surgery.<sup>7,10,40</sup>

For patients taking chronic corticosteroids, supplemental corticosteroid therapy during the perioperative period must be individualized based on the degree of surgical stress, the health of the patient, and the degree of suppression of the hypothalamic-pituitary-adrenal axis. If a patient has been on a corticosteroid regimen equal to a daily dose of 20 mg of prednisone or more for more than 1 week during the prior 6 months, stress-dose steroids may be considered. Typically, dosages range from 50 to 100 mg hydrocortisone every 6 to 8 hours for 2 to 3 days and then tapered.<sup>40</sup> Although optimal regimens continue to be debated, in general, more recent recommendations call for lower dosages and duration of therapy than have traditionally been used.<sup>44,45</sup> Based on whether the medical or surgical stress is minor, moderate, or severe, the stress dose of hydrocortisone may be 25 mg, 50 to 75 mg, or 100 to 150 mg daily, respectively.<sup>44</sup>

Both general and regional anesthesia have benefits and disadvantages; the choice of anesthesia is best left to the anesthesiologist based on nature of surgery and individual needs.

### **THE POSTOPERATIVE PERIOD**

The physician must continue to provide follow-up in the postoperative period, revise medications as indicated, and be alert to postoperative complications. Delirium is particularly frequent, especially following hip fracture; causes of delirium include metabolic and electrolyte abnormalities, sepsis, and alcohol or benzodiazepine withdrawal. Dementia is a predisposing factor for delirium.<sup>4,14,15,52</sup> Fever may be related to infection or the surgical procedure itself. Infection most commonly involves the urinary tract, especially following the use of an indwelling catheter. Other causes of fever include pneumonia, which carries a poor prognosis, and abdominal infection. The first 48 hours following surgery carry a high risk for cardiac events; postoperative MI may manifest as hypotension or rhythm abnormality and carries a poor prognosis.<sup>21</sup> Optimal pain control, considered humanitarian relief of suffering, must be achieved in all patients; this is coupled with early mobilization to accelerate postoperative rehabilitation.

## CONCLUSION

Living to age 100 years is no longer a rarity. More than 68,000 centenarians live in the United States today, a number projected to exceed 137,000 by 2011.<sup>1</sup> Surgical procedures on older adults, who typically have comorbid illnesses, are clearly on the increase. Surgeons are increasingly willing to electively operate on elderly patients; the complication rate is acceptable, and function may be improved to prior levels. Successful surgery may improve quality of life and allow many patients to perform independently at least some activities of daily living.<sup>53</sup>

Surgery should not be denied on the basis of age alone.<sup>40,42</sup> Age is a minor risk factor, but comorbidity confers far more risk.<sup>4</sup> Medical evaluation should focus on identification of risk factors, optimizing status, predicting complications and provide appropriate information to the surgeon and anesthesiologist. **HP**

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