INTRODUCTION
Similar to most other health care providers, surgeons are seeing an ever-increasing proportion of elderly patients in their practices. Furthermore, this patient population is more likely to require operations. Patients age 65 and older currently account for approximately 60% of the average general surgeon’s work.1 The growth in general surgery over the next decade is expected to outpace the population growth due to a large increase in the number of older Americans. In specialties that care for a greater proportion of elderly patients, such as ophthalmology, urology, and cardiothoracic surgery, this growth is projected to increase 35-47%. This growth is driven by the post-war “baby boom” coupled with greater longevity. Given this increase, it is important for surgeons and practitioners who refer to surgeons to understand the appropriate perioperative evaluation and management of older patients.

In a study by Manku and Bacchetti,2 21% of patients age 70 and older undergoing noncardiac surgery experienced postoperative complications. Elderly patients suffering postoperative complications had greater than twice the risk of death in the first 3 months when compared with elderly patients undergoing an operation but not suffering a complication. Postoperative renal and pulmonary complications have been found to have the greatest impact on survival.3 In addition, another study reported that quality of life and functional status were worse among the elderly patients who suffered postoperative complications.4 These studies reinforce the need for optimal perioperative care to avoid complications in this at-risk population.

The physiologic impact of surgery and implications of postoperative complications differ among procedures. They also vary depending on whether the procedure is performed as an emergency or as an elective operation. Many elderly patients tolerate elective operations quite well, with postoperative complication and death rates of 6.8% and 1.9%, respectively.5 In contrast, the morbidity and mortality rates associated with emergency operations are much higher, at 31% and 20%, respectively. For elective operations, the focus of this review, preoperative evaluation is aimed at identifying and reducing factors that lead to postoperative complications. In certain instances, factors can be identified but cannot be modified. Age, in and of itself, is not a risk factor for postoperative complications. The underlying comorbidities that develop as part of the aging process are risk factors.

This two-part article outlines current strategies to identify and modify these factors, and highlights important points in the preparation of elderly patients for surgery. Part I discusses factors, includ-
ing cardiac, pulmonary, and renal, that can lead to postoperative complications.

**FACTORS AFFECTING OUTCOME**

**Cardiac factors**

Cardiovascular decline has been one of the most studied effects of aging. The most common cardiac complication in older patients is myocardial ischemia. The prevalence of coronary artery disease increases with age and is present at autopsy in more than 50% of individuals over age 70 years. With aging, there is also a decreased arterial elasticity and diminished relaxation to normal stimuli. This can lead to a chronic elevation of systolic pressure and eventual aortic dilatation. This increased aortic impedance can progress to ventricular hypertrophy, which increases both wall stress and myocardial oxygen demand and makes the ventricle more prone to ischemia. The reduction in ventricular compliance, coupled with a blunted response to catecholamines, compromises the heart’s ability to respond to significant changes in circulatory volume. This predisposes to congestive heart failure (CHF) when there are modest increases in circulatory volume and hypotension, and when there are modest decreases in circulatory volume.

Studies have demonstrated that there is a strong association between clinical signs of CHF and postoperative complications, including neurological, pulmonary, and cardiac complications. Preoperative optimization of heart function and aggressive management in the postoperative period with regard to fluid management, monitoring, and pharmacological therapy in the patient with either a history or clinical signs of CHF is important.

Arrhythmias are common in older patients, although ventricular arrhythmias and all degrees of heart block are not associated with a significant increase in perioperative risk to the patient. Atrial fibrillation is a significant issue due to the complications of thromboembolic events and anticoagulation management. The prevalence of atrial fibrillation in the older population has been estimated to be as high as 5% in persons age 60-70 years, 13% in persons age 71-90 years, and as high as 22% in persons age 91 years or older. Perioperative stroke is more common in patients with atrial fibrillation. In one study, the relative risk of stroke in patients with non-valvular atrial fibrillation compared with patients with sinus rhythm was increased 2.6 times in patients age 60-69 years, increased 3.3 times in patients age 70-79 years, and increased 4.5 times in patients age 80-89 years. Adequate anticoagulation is sometimes difficult in the immediate postoperative period. Patients who have had a previous arterial thromboembolism are at increased risk of a second event. Preoperative heparin is indicated for patients within 1 month of an initial arterial thromboembolism. If a patient is on warfarin preoperatively, it can be stopped 4 days prior to admission, and hospital administration of IV heparin should be initiated and continued postoperatively. A patient with atrial fibrillation without a previous embolus does not warrant the risk of immediate postoperative anticoagulation.

**Pulmonary factors**

Postoperative respiratory complications, including pneumonia, hypoxemia, hypoventilation, and atelectasis, occur in 2.1-10.2% of elderly patients. These complications increase hospital length of stay and mortality. Aging causes several changes in the upper and lower airways of the respiratory system. Protective reflexes such as coughing and swallowing are diminished in aging and lead to increased risk of aspiration. The increased frequency of pneumonia in older persons and incidence of colonization with gram-negative organisms is attributed to these factors. Declining lower respiratory function is a
result of changes in both the chest wall and the lung. The chest wall has decreased compliance due to atrophy of the intercostal muscles and calcification of the costal cartilage, causing decreased mobility. Morphologic changes in the alveolar ducts and the alveoli lead to changes similar to emphysema; however, they lack inflammatory cells, so it is termed senile emphysema. These changes result in decreased static recoil of the lung, increased closing capacity, and a forced expiratory volume in 1 second (FEV1) that declines 8-10% each decade. The total lung capacity remains unchanged, with an increase in residual volume resulting in a decrease in vital capacity. A decrease in the ratio of FEV1/total vital capacity has been found to be a risk factor for pulmonary complications.

Aging diminishes the respiratory system reserve in acute disease. Elderly patients have decreased sensitivity to hypoxia and hypercapnia, which results in a diminished ventilatory response to CHF, infection, or exacerbation of underlying lung disease.

Renal factors

Aging leads to progressive decrease in renal blood flow and loss of renal parenchyma. There is a 20-40% decrease in renal size from the third to eighth decades of life. Renal cortical atrophy results in a significant decrease in nephrons. Declining renal tubular function leads to an inability to conserve or excrete sodium and hydrogen ions, resulting in a diminished capacity to regulate fluid and acid-base balance. There is also an associated decrease in glomerular filtration rate, so older patients are more susceptible to fluid overload. Fluid balance is further complicated by alteration in the normal thirst mechanism. This decline in the subjective feeling of thirst is not well understood, but is thought to be due to alteration in the osmoreceptor function in the hypothalamus and decreased end organ response to antidiuretic hormone, leading to dehydration.

Cognitive factors

Dementia occurs in as many as 8% of patients 65 years of age, and increases in prevalence with age. Patients with end-stage dementia have a fourfold increase in 6-month mortality when compared to patients who are cognitively intact. The effects of postoperative delirium in elderly patients are evident in increased morbidity, delayed functional recovery, and prolonged hospital stay. Risk factors for postoperative delirium include preexisting dementia, visual impairment, alcohol use, postoperative infection, duration of anesthesia, narcotic use, lack of pain control, and need for reoperation.

Malnutrition

Nutrition is an important predictor of surgical outcomes. The adverse effects of malnutrition include delayed wound healing, greater risk of sepsis, wound infections, and increased mortality. It is estimated that 9-15% of persons over the age of 65 years are found to be malnourished in the outpatient clinic setting, 12-50% in the acute hospital setting, and as many as 25-60% or more in the chronic institutional setting. The risk factors for malnutrition in the older patient include social isolation, limited financial resources, poor dentition, alcohol consumption, depression, and chronic medical diseases. Most alteration in the desire to eat is controlled through the central nervous system. Stroke dementia or delirium may limit the desire or physical ability to feed oneself. The social stimulation to eat may be altered by depression, isolation, and loneliness. There is also a decline in appetite and an increased sensitivity of the satiety centers, mediated by a variety of hormones.
**Functional status**

The evaluation of the resting patient does not indicate how the patient will respond to the cardiac, pulmonary, and metabolic demands of the perioperative period. The ability to perform the activities of daily living (ADLs) such as feeding, dressing, bathing, and toileting have been correlated with postoperative morbidity and mortality. In one study, patients identified as inactive were shown to have a higher incidence of all major surgical complications. In another study, better preoperative physical performance, as measured by the Hand Grip Strength, Timed Up and Go, and Functional Reach tests, nearly always independently predicted better recovery and shorter time to recovery in ADLs, and instrumental activities of daily living (IADLs) after major abdominal surgery. These tests provide an assessment of the patients’ muscle mass, nutritional status, coordination, balance, gait speed, and mobility. This study also found that preoperative depression, as measured by the Geriatric Depression Scale, was an independent predictor of recovery and longer time to recovery in IADLs. The success of an operation must be questioned if the procedure is technically adequate but the patient suffers loss of preoperative functional status and independence.

**Type of operation**

Operations are generally divided into cardiac and noncardiac operations. The noncardiac operations can further be divided into high-risk, intermediate-risk, and low-risk procedures (Table). The high-risk procedures consist of emergent operations, aortic or other major vascular operations, and prolonged surgical procedures with a significant blood loss and large fluid shifts. The intermediate operations include carotid endarterectomy, head and neck, intraperitoneal, intrathoracic, orthopedic, and prostate procedures. The low-risk operations include endoscopic procedures, superficial operations, cataract surgery, and breast operations. High-risk procedures ordinarily carry a risk of nonfatal myocardial infarction or cardiac death of 5% or higher; intermediate-risk procedures carry a combined risk of 1-2%, and low-risk procedures carry a combined risk of lower than 1%.

**Elective/urgent/emergent operations**

The aging patient often has comorbidities that require assessment and optimization prior to operation. This may be impossible in the emergency setting. The preoperative assessment in the emergent setting may be complicated by an elderly patient who does not know what his or her medical history may be, or is too acutely ill to effectively communicate. In the older patient, abdominal pathology more often presents acutely, and mortality is greater than that of the younger patient. Patients over age 65...
years account for up to 50% of all emergency operations. In one study, authors found that 86% of perioperative deaths reported to a national database were in patients over age 60, and 57% of these reported deaths were after urgent or emergent operations.27

Emergency hernia repairs are one of the most common procedures performed in the older population. Up to 40% of hernia repairs, mainly inguinal and femoral, are performed for incarceration or bowel obstruction in patients over age 65.28 The emergency repair of hernias is associated with a morbidity of 50% and a mortality rate of 8-14%.29 This is compared to an elective repair rate of lower than 2%.30 A delay in diagnosis as well as a reluctance of surgeons to perform elective repair of reducible hernias in older patients can often lead to these emergent situations.31

SUMMARY

Preoperative assessment and management of geriatric patients undergoing noncardiac surgery is based upon the factors known to affect their outcomes. These factors include physiologic, functional, cognitive, and nutritional status, as well as the urgency and type of operation. Part II, to be published in a future issue of Clinical Geriatrics, will discuss preoperative assessment in the older patient, which includes physiologic, cognitive, nutritional, and functional assessment.

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REFERENCES