Chapter

35 ELDERLY PATIENTS

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The change in demographics of the U.S. and world population has led to a significant shift in the age of the population and the absolute numbers of geriatric patients. Between 2005 and 2030, the percentage of individuals over 65 years of age is expected to increase from 12% to 20% of the U.S. population. This is an increase of almost 30 million: from 37 million to over 70 million individuals. The "oldest old" age group, over 80 years of age, represents the fastest growing segment of the population. At present there are approximately 11 million, and this number is expected to increase to over 20 million in the next 20 years. The increase in population is due to the combined effect of the aging baby boomers and the increase in longevity. The average life expectancy in the United States is now estimated at 78 years old.[1,2] The increase in population of older patients will place a burden on health care systems, and this will be reflected in an increase in the proportion of older patients with multiple comorbid conditions undergoing surgery and invasive procedures. Anesthesia providers must have a clear understanding of fundamental geriatric issues and the challenges inherent in caring for this segment of the population.[3-5]

WHY GERIATRIC ANESTHESIOLOGY IS IMPORTANT

About one third of geriatric patients undergo at least one surgery with anesthesia prior to death, and this number is likely to increase given the frequent number of new procedures requiring anesthesia. In the United States, over 30% of inpatient surgeries are performed in patients older than 65 years of age, and when considering all procedures and surgeries, this increases to 50%. In addition, anesthetic and surgical morbidity and mortality rates in the elderly are also increased.[6,7]

Despite multiple population studies demonstrating that advanced age predicts adverse outcomes, prediction of how well a very elderly individual patient will tolerate a surgery can be challenging.[3,7] Numerous studies support surgery

in the oldest old individuals, and advanced age by itself should not be considered a contraindication for surgery. A reduction in physiologic reserve associated with normal aging can be accelerated by certain disease conditions that may render older patients more vulnerable from complications and increase the risk of severe morbidity and death. Certain conditions are associated with increased risk from anesthesia and surgery and include emergency surgery, a high American Society of Anesthesiologists (ASA) physical status (classification greater than II), low functional capacity, intracavitary surgery, congestive heart failure, and trauma. Overall the presence of significant medical conditions indicated by a high ASA score is more important than chronologic age (Box 35.1) (Fig. 35.1).[5-9] More recently, frailty has also been identified as an important predictor of postoperative outcomes. Frailty is a state of reduced physiologic reserve beyond what would be expected with normal aging, associated multisystem impairment, and subsequent diminished homeostatic reserve.[8,9] Diminished cognitive function in older patients can also be an important predictor of postoperative cognitive decline and morbidity.[10,11]

Box 35.1 Challenges in Management of the Geriatric Patient

- Population is heterogeneous.
- Wide disparity between physiologic and chronologic age is common.
- Advancing age is associated with a steady decline in organ function.
- Preoperative reserve organ function is unknown.
- Multiple acute and chronic comorbid conditions are typical.
- Common conditions may have atypical clinical presentations.
- Emergency procedures are associated with increased mortality and morbidity rates.
- Patients often have complex medication regimens.
- Potential diminished mental capacity makes history taking difficult.

MORBIDITY AND MORTALITY RATES

Morbidity and mortality rates in older patients range from 3% to 10% following noncardiac surgery. The higher mortality rate follows emergency surgery; the lower mortality rate accordingly reflects nonemergent, less invasive procedures. In a retrospective study using data from the American College of Surgeons National Surgical Quality Improvement Program database, authors found that postoperative fatality, overall morbidity, and postoperative complications all increased with age.[12] In individuals older than 80 years of age who developed cardiovascular, pulmonary, or renal complications, mortality rate was especially high—43% in patients developing renal insufficiency, 36% with a stroke, and 36% following a myocardial infarction. These results are similar to earlier studies by Hamel and associates,[13] who found that for elective noninvasive surgeries such as transurethral resection of the prostate (TURP), hernia repair, knee replacement, and carotid endarterectomy, the mortality rate in older patients was less than 2%. However, in patients over 80

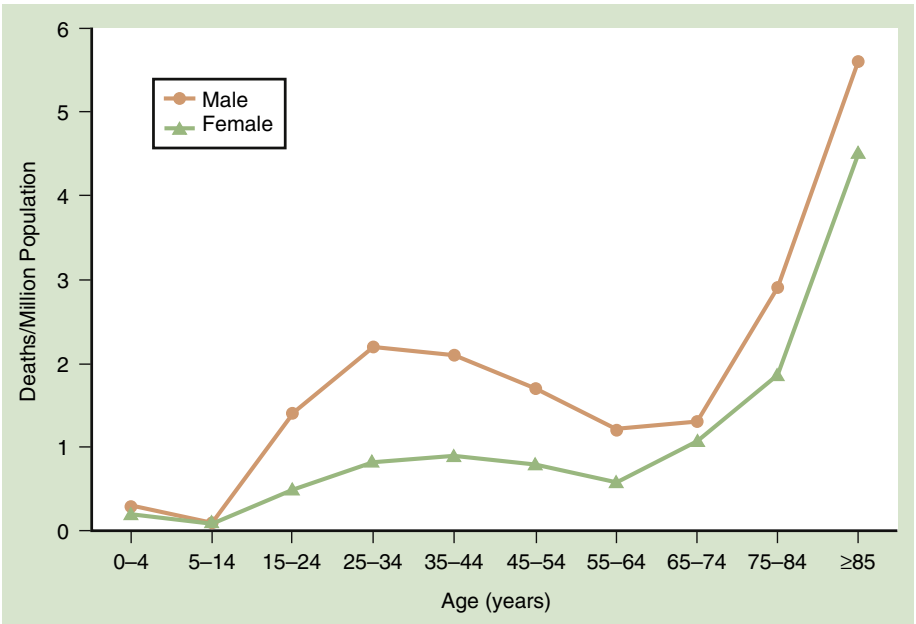

Fig. 35.1 Mortality rates. (Redrawn from Li G, Warner M, Lang BH, et al. Epidemiology of anesthesia-related mortality in the United States, 1999-2005. *Anesthesiology.* 2009;110:759-765.)

Table 35.1 Age-Related Changes in Selected Organ Systems

Organ System	Structural Changes	Functional Changes
Body composition	Decreased skeletal muscle mass Increased percentage of body fat Decreased total body water	Increased storage size for lipid-soluble drugs Decreased O_2 consumption and heat production
Central nervous system	Loss of neural tissue Decreased number of serotonin, acetylcholine, and dopamine receptors	Reduction in cerebral blood flow Decline in memory, reasoning, perception Disturbed sleep/wake cycle
Cardiovascular system	LV hypertrophy and decreased compliance Increase in vascular rigidity Decreased compliance of venous vessels	Decreased parasympathetic nervous system tone Increased sympathetic neuronal activity Desensitization of β-adrenergic receptors Increase in SVR and SBP Decrease in stroke volume and cardiac output Diastolic LV dysfunction Decreased maximally attainable HR
Pulmonary system	Increase in central airway size Decrease in small airway diameter Decrease in elastic tissue, reorientation of elastic fibers, increased amount of collagen Decrease in respiratory muscle strength Increased chest wall stiffness Decrease in chest wall height and increase in AP diameter	Decreased respiratory center sensitivity Decreased effectiveness of coughing and swallowing Increase in lung compliance and decrease in chest wall compliance Decreased functional alveolar surface area Decrease in D_{LCO} Decrease in $P_{I_{max}}$ and $P_{E_{max}}$ Decrease in ERV and VC Increase in RV and FRC with no change in TLC Increase in RV/TLC and FRC/TLC ratios Increase in closing volume and closing capacity Decrease in FVC, FEV_1, FEV_1/VC, and FEF at low lung volumes Increased A-a gradient and decrease in Pao_2
Renal system	Loss of tissue mass Decreased perfusion	Decreased GFR Reduced ability to dilute and concentrate urine and conserve sodium Decreased drug clearance
Hepatic system	Decrease in tissue mass Decrease in blood flow	Possible decrease in affinity for substrate Possible decrease in intrinsic activity Decreased first-pass metabolism of some drugs

A-a, Alveolar-arterial; *AP,* anteroposterior; D_{LCO_2}, single-breath carbon monoxide diffusion capacity; *ERV,* expiratory reserve volume; *FEF,* peak expiratory flow rate—the peak flow rate during expiration; FEV_1, the amount that can be forcefully exhaled in the first second from a full inspiration; *FRC,* functional residual capacity; *FVC,* forced vital capacity; *GFR,* glomerular filtration rate; *HR,* heart rate; *LV,* left ventricle; *RV,* residual volume; *SBP,* systolic blood pressure; *SVR,* systemic vascular resistance; *TLC,* total lung capacity; *VC,* vital capacity.

years of age who developed one or more complications, the 30-day mortality rate was 26% versus 4% in patients without a complication. Death occurred most frequently following a cardiac arrest (88%), acute renal failure (52%), and myocardial infarction (48%). In an analysis of surgical outcomes for patients 80 years of age and older, for every year above 80 years there is an associated 5% increase in mortality rate; thus, a 90-year-old had a 50% higher risk of death compared to an 80-year-old.[14]

Total knee and hip arthroplasty are common elective surgeries performed in elderly patients. In a retrospective study of 46,322 patients, including 12% over the age of 80 years, overall cardiac complications were relatively uncommon (<1%), but significant risk factors for a cardiac event included age over 80 years, hypertension treated with medication, and a history of cardiac disease.[15]

AGE-RELATED PHYSIOLOGIC CHANGES

Aging is associated with predictable decline in organ function in all body systems, which is estimated at 1% per year after the age of 40 years. This decline leads to overall reduced physiologic reserve capacity and a limited ability to respond to acute stress, for example, during surgery and anesthesia. The addition of multiple comorbid conditions further reduces reserve capacity, increasing the risks from anesthesia and surgery (Table 35.1).[1,16,17]

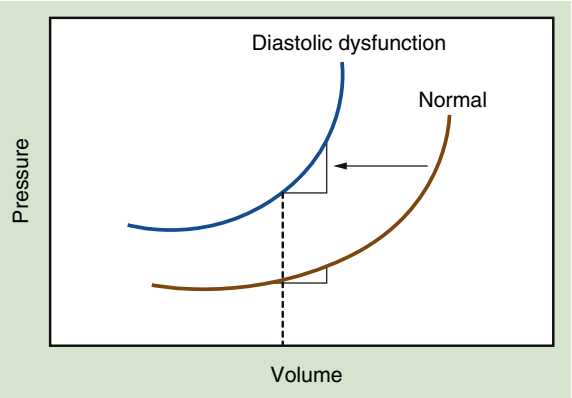

Fig. 35.2 Depiction of the diastolic function.

Cardiovascular Changes

Cardiovascular functional capacity is one of the most significant factors influencing perioperative outcome in elderly patients. Aging leads to progressive stiffening and loss of compliance in the vasculature and the myocardium. This results from the collective effects of a gradual loss of elastin, increases in collagen, and damage to collagen through glycosylation and the deposition of free radicals in connective tissue. Systolic arterial blood pressure and pulse wave velocity increase, and the left ventricle faces greater impedance to outflow and subsequent myocardial hypertrophy, further reducing ventricular compliance. Diastolic dysfunction refers to the reduction of left ventricular relaxation during diastole. The impaired relaxation of the ventricle leads to a decrease in early diastolic filling. In the elderly this may be reduced as much as 50% compared to younger patients. These alterations render the older patient very dependent on adequate atrial pressures and active atrial contraction to complete diastolic filling. Preoperatively diastolic dysfunction may be underestimated because patients frequently have vague symptoms, and studies suggest that one third or more of patients with normal preoperative left ventricular function may also have diastolic dysfunction. Older patients with diastolic dysfunction may not tolerate even brief periods of atrial fibrillation and readily develop congestive heart failure in the setting of intravascular volume overload (Fig. 35.2).[18,19]

Aging also alters cardiovascular autonomic function. Vagal or parasympathetic tone is decreased, and at the same time there is an increase in sympathetic nerve activity and plasma levels of noradrenaline. β-Adrenergic receptors are less responsive to stimulation with a lesser increase in heart rate and less arterial and venous relaxation with direct stimulation. α-Adrenergic receptor activity appears largely preserved. The reduction in baroreflex function and overall vascular stiffening leads to more labile arterial blood pressure and predisposes elderly patients to orthostatic hypotension. This condition may be exaggerated during anesthesia, especially in intravascularly volume-depleted patients. The impaired β-adrenergic receptor responsiveness reduces an older patient's ability to respond to an increase in demand through increased heart rate alone, and the elderly patient becomes very reliant on vascular tone and preload.

Myocardial fibrosis and fatty infiltration of pacemaker cells lead to conduction abnormalities such as sick sinus syndrome, atrial fibrillation, and frequent premature atrial contractions. The changes in the conduction system may lead to exaggerated bradycardia following the administration of opioids, such as remifentanil.

Cardiac function in the older patient is frequently compromised further by the development of cardiac disease. Cardiovascular disease occurs in over 75% of the U.S. population over the age of 75 years. The incidence of hypertension increases dramatically in older individuals and is a leading cause of congestive heart failure. Congestive heart failure is one of the most significant risk factors for death following anesthesia and surgery.

Pulmonary Changes

In the perioperative period, 40% of deaths in patients older than 65 years are due to postoperative pulmonary complications. Postoperative pneumonia can be slow to evolve but is associated with increased 30-day mortality rate as well as increased length of hospital stay. The increased susceptibility reflects both loss of physiologic reserve and a diminished immune capacity. In addition, there is often increased colonization of the upper respiratory tract with gram-negative organisms.[20,21]

As with other organ systems, there are certain predictable changes that occur during aging, including a reduction in respiratory muscle strength, a decrease in chest wall compliance, and a decrease in the elastic recoil.

With aging the chest wall becomes stiffer, and at the same time muscle strength is diminished, leading to an increase in the work of breathing. The aging chest is more barrel-shaped, and the diaphragm can become flattened, negatively impacting chest wall dynamics. The combined impact of these changes can lead to diaphragmatic fatigue and a predisposition to respiratory failure in the postoperative period and difficulty weaning from a ventilator, especially in frail older patients. Pulmonary changes with aging are similar to those that occur with smoking-induced emphysema. They both have increased size of central airways and anatomic-physiologic dead space. The lack of elastic recoil in smaller airways can result in air-trapping with positive-pressure ventilation. Closing capacity is increased, and by the age of 65 years it exceeds functional residual capacity (FRC), leading to closure of small airways and increase in shunt fraction, predisposing older patients to hypoxemia.

In addition to structural changes with the lungs, alveolar gas exchange is also impacted by an age-related

increase in ventilation-perfusion mismatch, decreased diffusing capacity, and an increase in dead space. There is a gradual decrease in resting arterial oxygen tension, leaving the older patient vulnerable to the development of significant hypoxemia with even minimal residual weakness or sedation.

Respiratory-related central nervous system changes also occur, leading to a decrease in hypoxemic and hypercapnic ventilatory drive by 50% or more. The elderly patient has an increased susceptibility to narcotic-induced apnea, potentially leading to hypoxemia and hypercapnia.

Metabolic and Renal Changes

Metabolic and renal changes lead to significant changes in pharmacokinetics of anesthetic and analgesic drugs. Overall there is a decrease in the total body water and an increase in percentage of body fat, accompanied by a reduction of protein and muscle mass. Both plasma volume and intracellular water decline by 20% to 30% by the age of 75 years. Then the initial volume of distribution and plasma concentration of an anesthetic drug increase. This can have important hemodynamic consequences. For example, following the administration of propofol, older patients have an exaggerated and prolonged hypotensive reaction. This is due to the combined effect of a higher initial plasma concentration and probably to an age-related delay in the redistribution of propofol from the central compartment. These and other age-related changes have led to the broad recommendation to reduce the initial drug dose and increase the intervals between boluses in elderly patients. As total body water declines, the percentage of fat increases, which can lead to increases in drug deposition of lipid-soluble drugs and delayed elimination.

Renal changes include a 20% to 25% decrease in renal cortical mass by the age of 80 years that may be exacerbated by comorbid conditions such as hypertension and diabetes mellitus. Other renal changes include a decrease in renal blood flow with the number of functioning glomeruli and remaining glomeruli exhibiting an increase in sclerosis. There is a progressive reduction in glomerular filtration rate (GFR), from an average of 125 mL/min in a young adult to only 60 mL/min by age 80 years. As aging leads to significant reduction in muscle mass, the serum creatinine in the older patient will not accurately reflect the degree of renal insufficiency in the geriatric patient.

Several changes predispose the older patient to fluid and electrolyte abnormalities. These changes include a reduction in tubular function and limited ability to concentrate urine appropriately and a reduction in the renin-angiotensin system and the secretion of antidiuretic hormone (ADH). As a result, older patients are more likely to develop hyponatremia (e.g., in combination with diuretics) and hypernatremia (e.g., with reduced thirst perception). Renal failure accounts for 20% of all perioperative deaths, and acute renal failure in elderly patients in the postoperative period has a significant mortality rate.

Hepatic blood flow decreases and the sizes of the liver and enzyme systems decrease in elderly patients. Both qualitative and quantitative reductions in protein binding occur, potentially leading to an increase in free fraction of protein-bound drugs. Owing to the significant hepatic reserve, the impact on metabolism is less than on other systems, and hepatic aging has less clinical impact compared to age-related changes in renal function (Fig. 35.3).[22]

Changes in Basal Metabolic Rate

Metabolic rate and the effectiveness of peripheral vasoconstriction decrease in the elderly, making it more difficult for them to maintain body temperature during surgery and anesthesia. Hypothermia can lead to significant negative effects such as slowed metabolism of medications, shivering with subsequent increased oxygen demand, and potential myocardial ischemia, as well as impaired coagulation. Active warming is an important component for most patients, especially for geriatric patients undergoing procedures.[23]

Central Nervous System Changes

A gradual decrease in brain size occurs in aging, most likely secondary to a decrease in neuronal size. The loss in brain size is associated with an increase in ventricular volume and widening of sulci. The number of neuroreceptors and neurotransmitters decreases even in the absence of dementia or recognized neurodegenerative diseases. The most significant declines are observed in acetylcholine and serotonin receptors in the cortex, dopamine receptors in the neostriata, and dopamine levels in the substantia nigra and neostriata. Normal aging can be accompanied by cognitive changes such as memory difficulty and a decrease in speed of processing; however, the extent of these changes among individuals is widely variable.[24] Alzheimer disease is the most common dementia, accounting for 60% to 80% of cases, followed by vascular dementia, dementia associated with Parkinson disease, dementia with Lewy bodies, and frontotemporal dementia. The incidence of Alzheimer dementia increases significantly in aging patients and is estimated to affect 45% of people over 85 years of age. Mild cognitive impairment (MCI) may represent a precursor of Alzheimer disease. Cognitive impairment (with or without a formal dementia diagnosis) is a major risk factor for postoperative cognitive complications.[11,25]

PERIOPERATIVE CARE IN THE ELDERLY

The preoperative evaluation (also see Chapter 13) in the older patient is challenging but remains an important aspect of the anesthetic.[16,17,26] In addition to certain

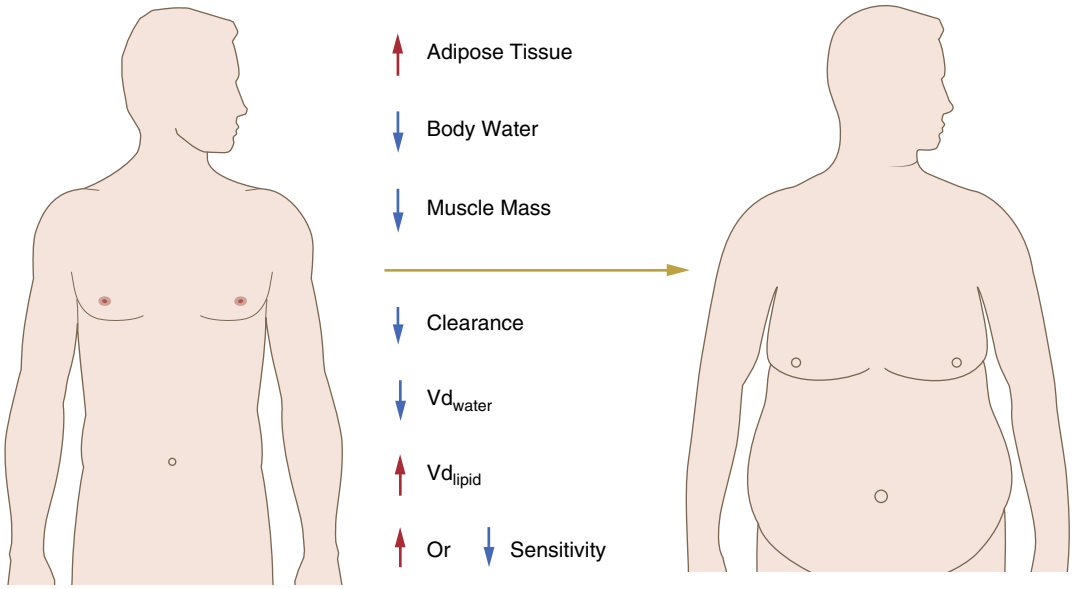

Fig. 35.3 Changes in body composition in elderly patients. *Vd*, Volume of distribution. (From Rivera R, Antognini JF. Perioperative drug therapy in elderly patients. *Anesthesiology.* 2009;110(5):1176-1181.)

geriatric-specific elements described later, older patients should undergo standard risk stratification for cardiopulmonary risk prior to surgery. The 2014 American College of Cardiology/American Heart Association (ACC/AHA) Guideline on Perioperative Cardiovascular Evaluation and Management of Patients Undergoing Noncardiac Surgery provides an algorithmic approach for further cardiac testing and evaluation.[27] Laboratory testing[16,26,28] in older patients should be performed if clinically indicated, acknowledging that as a result of the increased number of comorbid conditions, older patients will often need more testing for surgeries and procedures in general. For the elderly patient the functional assessment is one of the most important aspects of the preoperative evaluation. Excellent medical fitness, as described by activity level, is associated with a reduction in postoperative complications.[29] In addition, the identification of significant geriatric syndromes, such as frailty and cognitive impairment, can identify "at risk" patients and potentially direct risk-reduction strategies as well as prepare patients and caregivers more realistically about the postoperative course. As stated, routine laboratory testing should not be performed based on advanced age alone. All laboratory testing should be based on the patient's medical history and the invasiveness of the anticipated surgery. Age-based criteria for electrocardiograms (ECGs) and other testing are no longer recommended. Instead, elderly patients with a cardiac history, hypertension, or a history of active cardiac disease may need a preoperative ECG if the surgery is more than a minimal risk and no recent ECG is available. The preoperative ECG may reveal significant abnormalities and confirm the presence of preexisting cardiac disease such as left ventricular hypertrophy and prior myocardial infarction. Comparison with a prior ECG is recommended to establish the timing of a possible cardiac event, yet preoperative abnormalities on ECGs have a low specificity for predicting postoperative complications. Furthermore, an older patient may have a normal ECG and still have significant occult cardiac dysfunction. A routine chest radiograph is not indicated preoperatively in the absence of pulmonary symptoms or abnormalities on physical examination. A chest radiograph may be indicated to assess cardiopulmonary status such as pulmonary congestion or the presence of pneumonia.

The preoperative evaluation of an elderly patient who resides in a skilled nursing facility ("nursing home") or rehabilitation facility can be especially challenging. These patients often have significant comorbid conditions that may make the preoperative interview challenging. In addition, a separate trip to a hospital for a preoperative evaluation may not be feasible. In these patients a history and list of medications may be reviewed prior to the day of surgery and anesthesia. This approach may also be useful for patients who have cataracts and carry an intense burden of disease but are undergoing a very low risk, noninvasive procedure. For all patients with cognitive dysfunction from dementia or neurologic disease, it is important to identify the person who can provide consent for the patient as well as how that person can be reached. Although sometimes uncomfortable, a discussion of advanced health care directives can be initiated during the preoperative assessment of these patients.

Functional assessment is another important component of the preoperative evaluation. In addition to the standard preoperative questions about the patient's past medical history, an assessment of function using activity scores, activities of daily living (ADLs), and instrumental activities of daily living (IADLs) is recommended for frail older patients (Box 35.2).[16,26]

Malnutrition in elderly patients occurs in 13% of community dwelling elders, and increases to 39% and 50% for elders in the hospital or rehabilitation facility. Poor nutrition is associated with an increased risk of wound complications such as wound infection or anastomotic leak that increase postoperative length of stay. Recommended nutritional assessments include calculating body mass index (BMI), measuring baseline serum albumin and prealbumin levels, and inquiring about unintended weight loss in the prior 12 months. A BMI of less than 18.5 kg/m^2, serum albumin of less than 3.0 g/dL, and a weight loss of more than 10% in 6 months indicate severe nutritional risk, and appropriate referral for supplemental nutrition may be indicated, especially for elective surgeries that can be delayed or postponed. In addition, malnutrition is a frequent indicator of overall frailty.[17,26]

Frailty is characterized by a decrease in physiologic reserve across multiple systems in excess of normal age-related decline in function. The underlying cause of frailty is not totally understood, but frailty appears to be related to an inflammatory state and autonomic and immune dysregulation. Frailty impacts 7% to 10% of community dwelling elders, increasing with age to 25% in individuals over age 85 years. It appears to be particularly high in patients undergoing surgery—estimated between 25% and 56%.[8,30,31] Frailty is independently associated with increased postoperative mortality rate, morbidity, and delirium, and all contribute to an increased length of stay, readmission, and discharge to an institution as opposed to home.

Several tools and approaches can be employed to identify frailty preoperatively.[8,32,33] The clinical phenotype model, first described in 2001, identifies five observable conditions[9,33]: unintended weight loss (>10 lb in the past year), weakness (assessed by grip strength), self-reported exhaustion, slow walking speed, and low physical activity. Robinson identified additional "traits" to characterize susceptible frail individuals undergoing colorectal surgery.[34] These traits included (1) measures of daily function such as ADL or IADL (see Box 35.2), (2) a Timed Up and Go (TUG) test greater or equal to 15 seconds (Box 35.3),[35] (3) an assessment of cognitive function (e.g., the Mini-Cog test with a score < 3) (Box 35.4), (4) a measure of comorbid condition burden, (5) anemia defined as hematocrit less than 35%, (6) poor nutrition assessed as an albumin level less than 3.4 g/dL, and (7) a history of falls within 6 months. Patients were considered as frail if they had four or more traits, nonfrail if they had none or one trait, and intermediate with two to three traits. Researchers found that frailty was associated with increased complications and length of stay postoperatively.[30,36] In general, higher frailty scores defined using the phenotype model and adaptations are associated with poor outcomes following surgery, and frailty assessment is becoming a more accepted risk assessment tool. This is particularly valuable for older patients in whom the benefits of surgery need to be balanced with realistic expectations about postoperative complications and outcomes (Fig. 35.4).[17]

Although the phenotype frailty score provides an excellent assessment of an individual patient, such assessment is not always practical in the preoperative clinic or surgeon's office.[37] An alternative approach to identify frailty is to calculate a Frailty Index,[9,33] a multidimensional score that measures the number of deficits an individual has accumulated divided by the total number of preidentified deficits. The higher the score, the more frail

Box 35.2 Activities of Daily Living and Instrumental Activities of Daily Living

Activities of Daily Living
Bathing
Dressing
Toileting
Transferring
Eating

Instrumental Activities of Daily Living
Use of telephone
Use of public transportation
Shopping
Preparation of meals
Housekeeping
Taking medications properly
Managing personal finances

[a]The ability of the patient to perform the listed tasks independently, partially independently, or with complete assistance required is recorded.

Box 35.3 Assessment of Gait and Mobility Limitations With the Timed Up and Go (TUG) Test

Patients should sit in a standard armchair with a line 10 feet in length in front of the chair. They should use standard footwear and walking aids and should not receive any assistance.
Have the patient perform the following commands:
1. Rise from the chair (if possible, without using the armrests)
2. Walk to the line on the floor (10 feet)
3. Turn
4. Return to the chair
5. Sit down again

From Centers for Disease Control and Prevention. The Timed Up and Go (TUG) Test. http://www.cdc.gov/steadi/pdf/tug_test-a.pdf/. Accessed June 1, 2016.

the individual is considered to be. The number of deficits identified ranges from 10 (the modified Frailty Index) to 30 or 70 and includes multiple variables: comorbid conditions, laboratory values, assessment of function (e.g., ADLs), and other physical traits such as weakness and cognitive function. These indices may provide better discrimination of outcome compared to the phenotype classification.

The Comprehensive Geriatric Assessment (CGA) is a systematic multidimensional assessment that includes a medical evaluation (usually by a geriatrician), an assessment of the patient's cognitive and functional status, social support, and disability. Most CGAs include a screen for frailty. The CGA generally includes multidisciplinary recommendations for preoperative optimization of comorbid conditions and also postoperative recommendations, for example, to prevent and manage postoperative delirium. The CGA has been shown to provide a valuable predictive assessment of the risk of surgery for older patients.[38,39]

Cognitive assessment is an important aspect of the preoperative assessment in elderly patients. Patients with preexisting preoperative cognitive difficulties carry an increased risk of postoperative morbidity and complications such as delirium and postoperative cognitive dysfunction (POCD).[10,40,41] In addition, older patients with multiple comorbid conditions including cognitive disorders and disability may have limited decision-making ability, impacting their ability to appropriately participate in a discussion regarding recommendations for treatment. A review of decision-making capacity in elders found that 2.8% of healthy older patients lacked decision-making capacity. In comparison, 20% of these patients had MCI and 54% had Alzheimer disease. The American College of Surgeons and the American Geriatrics Society (ACS/AGS) preoperative guidelines recommend a simple cognitive assessment tool such as the

Box 35.4 Cognitive Assessment With the Mini-Cog Test: Three-Item Recall and Clock Draw

1. Get the patient's attention, then say:
   "I am going to say three words that I want you to remember now and later. The words are: *banana, sunrise, chair.* Please say them for me now."
   Give the patient three tries to repeat the words. If unable after three tries, go to the next item.
2. Say all the following phrases in the order indicated:
   "Please draw a clock in the space below. Start by drawing a large circle. Put all the numbers in the circle and set the hands to show 11:10 (10 past 11)."
   If the subject has not finished clock drawing in 3 minutes, discontinue and ask for recall items.
3. Say:
   "What were the three words I asked you to remember?"

Scoring

Three-item recall (0 to 3 points); Clock draw (0 or 2 points)

- 1 point for each correct word; 0 points for abnormal clock; 2 points for normal clock
- A normal clock has all of the following elements:
  - All numbers 1 to 12, each only once, are present in the correct order and direction (clockwise) inside the circle.
  - Two hands are present, one pointing to 11 and one pointing to 2.
  - Any clock missing any of these elements is scored abnormal. Refusal to draw a clock is scored abnormal.
- Total score of 0, 1, or 2 suggests possible impairment.
- Total score of 3, 4, or 5 suggests no impairment.

From Mini-Cog.com. Copyright S. Borson (soob@uw.edu), used with permission.

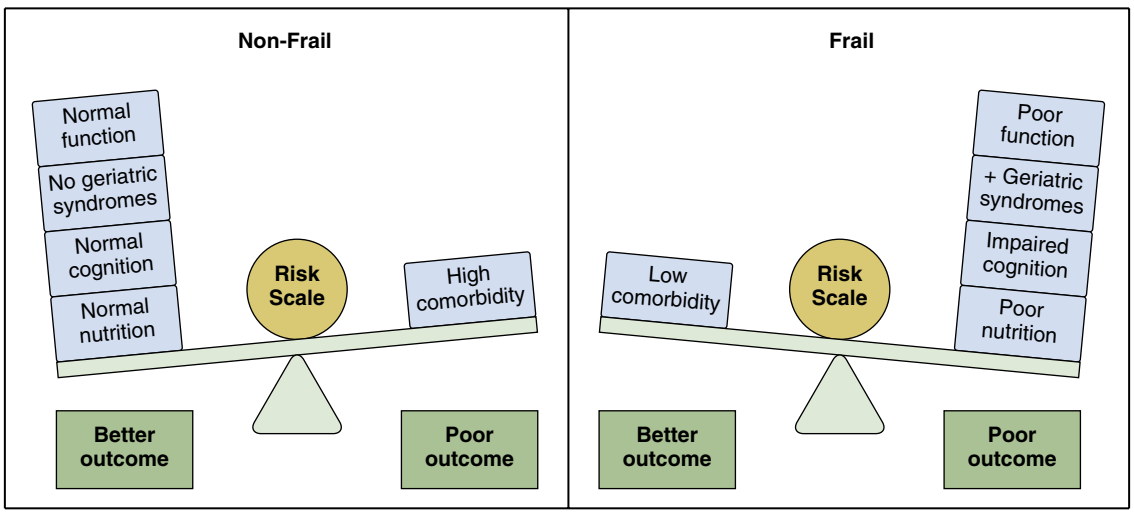

Fig. 35.4 Frailty score as a predictor of complications after surgery in elderly patients. Simple frailty score predicts postoperative complications across surgical specialties. (From Robinson TN, Wu DS, Pointer L, et al. Simple frailty score predicts postoperative complications across surgical specialties. *Am J Surg.* 2013;206(4):544-550.)

Mini-Cog test (see Box 35.4). This simple test assesses several cognitive domains including memory, language, visual-motor skills, and executive function. Impaired cognitive function in surgical patients between age 60 and 90 years identified using the Mini-Cog test ranges from 17% to 100%, with an average of 44%.[11]

Medications

The preoperative examination should include a complete history of all medications including over-the-counter drugs. More than 90% of persons older than 65 years of age use at least one drug, 40% take five or more drugs per week, and 12% use 10 or more drugs per week on average.[42]

These numbers increase in very old patients, especially those who are hospitalized. In general, most medications, especially cardiac and antihypertensive medications, should be continued through the morning of surgery, with the exception of angiotensin-converting enzyme (ACE) inhibitors and angiotensin II receptor blockers (ARBs). Continuation of ACE inhibitors has been associated with increased hypotension immediately following induction of anesthesia, which means that these drugs should not be taken for at least 12 hours prior to general anesthesia. Decisions regarding platelet antagonists and anticoagulants should be made with the patient's primary care doctor and the surgeon (Table 35.2).

Intraoperative Monitoring

Standard ASA monitoring is required during the administration of any anesthetic. In the older patient additional hemodynamic monitoring is often required for invasive and prolonged surgeries and in patients with significant comorbid conditions (see Chapter 20).

Choice of Anesthesia

As with all anesthetics, the choice of general versus regional anesthesia or sedation will depend on the surgical requirements, the patient's physical status, and the patient's preferences. In elderly patients, there is no evidence that one type of anesthesia is safer than another, although regional anesthesia may confer certain benefits such as improved postoperative pain control, decreased blood intraoperative loss during hip surgery, and decreased postoperative venous thrombosis.[43]

General Anesthesia

Elderly patients are more likely to be edentulous compared with young patients. Thus, laryngoscopy may be easier, but difficulty during ventilation via a mask may necessitate the use of an oral or nasopharyngeal airway to maintain a patent airway (also see Chapter 16). Reduced extension of the neck secondary to advanced arthritis may limit head and neck manipulation during laryngoscopy, and vertebrobasilar disease may predispose older patients to cerebral ischemia with neck manipulation. Older patients present in more advanced stages of disease (for example, with end-stage rheumatoid arthritis), which may increase the frequency of a difficult airway. Elderly patients frequently exhibit exaggerated hemodynamic responses to laryngoscopy, which is an obvious concern in patients with underlying cardiac conditions. A small dose of lidocaine (e.g., 50 mg) intravenously or short-acting β-adrenergic blockade with induction of anesthesia can attenuate this response. An age-related decrease in pharyngeal reflexes predisposes older patients to pulmonary aspiration of gastric contents. Prolonged periods of intraoperative hypotension may lead to an increase in postoperative morbidity in older patients. Hypotension should be avoided in older patients, and arterial blood pressure probably should arbitrarily be maintained within 10% of starting levels.

Table 35.2 Drugs Often Taken by Elderly Patients That May Contribute to Adverse Effects or Drug Interactions

Drug/Drug Class	Response
Diuretics	Hypokalemia
	Hypovolemia
Centrally acting antihypertensives	Decreased autonomic nervous system activity
β-Adrenergic antagonists	Decreased autonomic nervous system activity
	Decreased anesthetic requirements
	Bronchospasm
	Bradycardia
Cardiac antidysrhythmics	Potentiation of neuromuscular blocking drugs
Digitalis	Cardiac dysrhythmias
	Cardiac conduction disturbances
Tricyclic antidepressants	Anticholinergic effects
Antibiotics	Potentiation of neuromuscular blocking drugs
Oral hypoglycemics	Hypoglycemia
Alcohol	Increased anesthetic requirements Delirium tremens

Anesthetic Drugs

Pharmacokinetic and pharmacodynamic changes with aging necessitate dosing adjustments for most anesthetic drugs.[22] In general, "start low, go slow" remains a valid axiom when taking care of elderly patients (Table 35.3).

Intravenous Anesthetics (Also See Chapter 8)

Propofol is commonly used to induce general anesthesia. The mechanism of action appears to be mediated through the central γ-aminobutyric acid A ($GABA_A$) receptors. Propofol produces a rapid loss of consciousness, apnea in sufficient doses, and a dose-dependent reduction in vascular resistance and preload. The hemodynamic effects of propofol can be greatly exaggerated in older patients, especially if their intravascular volumes are depleted, possibly leading to significant cardiac or cerebral ischemia. The initial dose of propofol should be reduced and the time interval between repeated doses increased to prevent an exaggerated and potentially prolonged hypotension. Propofol does allow for rapid recovery with minimal delayed cognitive effects. Given in smaller total doses than in younger adults, propofol infusions probably provide a more stable hemodynamic course, but the dose required for sedation should be reduced.

Table 35.3 Adjustments to Anesthetic and Adjuvant Drug Administration in Elderly Patients

Drug/Drug Class	Adjustment
Volatile anesthetics	Decrease inspired concentration
Intravenous induction drugs (thiopental, propofol)	Small to moderate decreases in initial dose Decreased maintenance infusion
Opioids	Decrease initial dose[a] Increased incidence of skeletal muscle rigidity Increased duration of systemic and neuraxial effects Increased incidence of depression of ventilation
Local anesthetics (spinal and epidural)	Small to moderate decrease in segmental dose requirements Anticipate prolonged effects
Benzodiazepines	Modest decrease in initial dose Anticipate marked increase in duration of action
Atropine	Increased dose needed for comparable heart rate response Anticipate possible central anticholinergic syndrome
Isoproterenol	Increased dose needed for comparable heart rate response

[a]Supportive data not available.

Etomidate, a carboxylated imidazole ring, has the disadvantage of producing some disinhibitory effects leading to development of myoclonus, which has been observed in 30% to 60% of patients. Yet its minimal cardiovascular effects make it preferred in patients in whom a decrease in arterial blood pressure may not be tolerated. It is an excellent anesthetic for an emergency situation. The volume of distribution for etomidate is reduced with aging, and a 50% reduction in dose is recommended in patients 80 years of age or older.

The anxiolytic and sedative properties of midazolam make it an excellent premedication for anesthesia, and its short duration and absence of significant active metabolites or cardiovascular effects increase the utility in the elderly population. Although pharmacokinetic changes can prolong elimination, especially in obese elderly patients, the increase in sensitivity observed in geriatric patients appears to be due mainly to a pharmacodynamic change within the benzodiazepine GABA receptor unit.[43a] In general the dose of midazolam should be reduced by 50% and repeat doses administered in increments of 0.5 mg or less. Older patients are susceptible to midazolam-induced apnea, and when administered during spinal anesthesia there may be an increased risk of respiratory depression. Unwanted effects of midazolam can be reversed with flumazenil. Long-acting benzodiazepines have been associated with delirium in the elderly owing to prolonged clearance and active metabolites. For these reasons, diazepam and lorazepam are not recommended in elderly patients.

Inhaled Anesthetics (Also See Chapter 7)

The minimum alveolar concentration (MAC) of inhaled anesthetics decreases predictably by 6% every decade after age 20 years. Thus, the MAC at age 90 years is reduced by 30% compared to the MAC for a 40-year-old. This change most likely reflects a combination of age-related cerebral atrophy and alterations in neurotransmitter balance.

Muscle Relaxants (Also See Chapter 11)

Aging does not increase sensitivity to muscle relaxants at the neuromuscular junction. Of course, age-related diseases (e.g., kidney dysfunction) may increase sensitivity but more likely prolong the action of muscle relaxants. Furthermore, decreases in hepatic metabolism and renal clearance may lead to delayed elimination of nondepolarizing neuromuscular blocking drugs. This is most prominent for pancuronium, which is 85% eliminated through renal clearance, and the drug probably should be avoided in elderly patients. Vecuronium and rocuronium are less dependent on renal excretion, and their effects are less likely to be significantly prolonged. Cisatracurium and atracurium are dependent on Hoffman elimination that is not impacted by aging or renal or hepatic function. To ensure complete recovery from neuromuscular blockade, monitoring of neuromuscular blockade should be done to assure that successive doses are appropriate and complete

reversal from neostigmine or sugammadex has occurred prior to extubation of the trachea. Actually, monitoring of neuromuscular blockade is becoming a requirement in most or all patients, but especially with the elderly. In the older patient, even a small degree of weakness can result in a clinically significant respiratory incident during transport to and while in the postanesthesia care unit (PACU).

Opioids (Also See Chapter 9)

Pharmacodynamic changes in elderly patients account for the increase in the sensitivity of the brain to opioids, and pharmacokinetic changes impacting elimination and distribution of opioids are less significant. Opioid doses should be reduced by 50% in older patients. Interindividual variability of opioid response is common among older patients, and it is important to titrate these drugs to desired effect. Fentanyl is a popular short-acting lipid-soluble opioid with a large volume of distribution. The dose should be reduced by 50%, largely as a result of pharmacodynamic changes. Remifentanil is an ultrashort-acting mu-receptor agonist that is metabolized by plasma esterases. The bolus dose and the infusion rates should be reduced in the elderly and titrated to effect. Morphine is one of the most popular postoperative analgesics administered. In elderly patients there is a reduction in the volume of distribution and a potential accumulation of active metabolites morphine 3-glucuronide and morphine 6-glucuronide that are eliminated via the kidneys.[9,37,38]

Meperidine has been a popular opioid for sedation and analgesia with nonanesthesia providers. In older patients, administration of meperidine causes delirium, possibly through anticholinergic mechanism and accumulation of active metabolite normeperidine. It is not recommended for elderly patients for sedation or analgesia.

Monitored Anesthesia Care

Assistance from anesthesiology is more frequently requested for nonsurgical procedures such as endoscopic retrograde cholangiopancreatography (ERCP), advanced gastrointestinal procedures, bronchoscopy, and radiologic interventions (also see Chapters 14, 37, and 38). Elderly patients with complex medical conditions are frequent candidates for these noninvasive procedures, and administration of anesthesia can be especially challenging. In general, geriatric principles should be applied, and reduction of the dose, infusion, and an increase in bolus interval are recommended. Because of an age-related increase in sensitivity to narcotics and benzodiazepines, as well as pulmonary changes, older patients are particularly susceptible to developing hypoventilation and apnea during procedures. Supplemental oxygen and monitoring of ventilation through end-tidal CO_2 is recommended. Standard intravenously administered anesthetics that can be used for MAC include midazolam and the short-acting opioids (e.g., fentanyl and remifentanil). In addition, small doses of ketamine, 10 mg to 30 mg intravenously, can be a valuable adjunct for procedures, especially if associated with painful stimuli. At these small doses the positive hemodynamic effects of ketamine are less pronounced and can be treated with small doses of labetalol. Dexmedetomidine has no adverse respiratory effects and can provide both analgesia and sedation. Side effects that may preclude its use are prolonged sedation, bradycardia, and hypotension.

Neuraxial Anesthesia

Spinal and epidural anesthesia compared to general anesthesia do not alter the 30-day mortality rate in elderly patients (also see Chapter 17). However, these techniques may be particularly useful for a wide range of orthopedic procedures such as hip fracture repair, lower extremity joint replacement, TURP, and gynecologic and lower extremity vascular procedures.[43-45] Age-related changes including calcification of the interspinous ligaments and ligamentum flavum and narrowing of the intervertebral foramina, combined with a reduction in flexibility and difficulty positioning, may make the placement of the needle for a spinal or epidural block more challenging. Age-related changes can also lead to exaggerated spread of the local anesthetic within the epidural space and a higher than expected anesthetic level. Similarly for spinal anesthesia, the cephalad spread may be wider than expected and the dose of local anesthetic should be reduced in older patients. Hypotension is the most significant hemodynamic consequence of neuraxial anesthesia. Hypotension occurs when the sympathetic blockade leads to significant vasodilatation, causing a decrease in systemic vascular resistance and central venous pressure and a redistribution of blood volume to the extremities from central splanchnic and mesenteric vascular beds. Hypotension is of particular concern in very elderly patients with limited cardiac reserve and may be exaggerated in patients with baseline hypertension. Pretreatment with crystalloid does not consistently offset the hypotension following a spinal block. Treatment of hypotension with vasopressors, such as ephedrine and phenylephrine, is frequently required.

POSTOPERATIVE CARE

Pain

The treatment of intraoperative and postoperative pain in the elderly patient is an important part of the anesthetic plan.[46,47] Age-related reduction in nerve conductivity and receptors may lead older patients to experience less pain following surgery, but untreated pain can have significant adverse consequences. Postoperative pain is associated with increased length of

stay, increased morbidity, pulmonary complications, and delirium. The longer a patient stays in the hospital, the greater the risk of complications. Generational and cultural issues may lead older patients to complain less about pain, and elderly patients frequently have lower expectations for successful treatment. For cognitively intact elders patient-controlled analgesia (PCA) is the preferred method for administering postoperative intravenous (IV) narcotics. Treatment of pain in patients with significant dementia or delirium is challenging both to assess and treat. If possible, pain should be assessed using a specially designed nonverbal pain scale such as the Pain Assessment IN Advanced Dementia (PAINAD), which is an observational scale of five items: breathing, vocalization, facial expression, body language, and consolability. For nonverbal elders and those with a diagnosis of dementia, pain medication should be offered on a regularly scheduled interval as opposed to an as-needed basis (also see Chapter 39).

Opioid use can be reduced by concomitant administration of acetaminophen. Nonsteroidal antiinflammatory drugs (NSAIDs) in older patients cause renal failure and gastrointestinal hemorrhage, and medications such as ibuprofen and ketorolac should be administered cautiously. When administered, the IV dose of ketorolac should be reduced to 15 mg IV every 6 hours, with a 60 mg 24-hour dose maximum.

Gabapentin, originally released for its antiepileptic properties, is another useful opioid adjunct for postoperative pain control. Although most commonly used to treat chronic neuropathic pain, it has been used preemptively before surgery as well as following surgery. It is an oral medication excreted via the kidneys, and in elderly patients a reduction in dose is recommended; larger doses are associated with sedation.

The role of nerve blocks for postoperative pain control in elderly patients is increasingly important (see Chapter 40). Adequate, but safe, postoperative analgesia is very important in the elderly. The total dose of local anesthetic should be reduced as the metabolism and clearance of local anesthetics are delayed in advanced age. Postoperative epidural analgesia with local anesthetics or opioids probably improves postoperative pulmonary outcomes including (1) improved postoperative pain control, (2) decline in atelectasis, (3) improved tracheal extubation variables, and (4) shorter intensive care unit stays.[43,44]

Postoperative Neurologic Events

The most common postoperative neurologic events in the elderly are postoperative delirium and POCD.[40,48,49] Delirium refers to an acute state of confusion that generally occurs within 1 to 3 days following surgery. It can persist for weeks or months after surgery. Delirium is not unique to surgery patients; it also commonly develops in hospitalized elderly patients, especially those admitted to the intensive care unit. Delirium is a significant source of morbidity and occurs in 15% to 60% of elderly patients who have a hip fracture.[40,50]

POCD can increase length of hospital stay and require discharge to rehabilitation facilities as opposed to home and is associated with an increased mortality rate. There are multiple causes of delirium in the postoperative patient. The more common ones include acute metabolic derangements such as hypo- or hypernatremia, hypoxemia, anemia, uremia, sepsis, uncontrolled pain, disorientation, depression, residual effects of anticholinergic medications, and alcohol withdrawal. Treatment of delirium should start with a search for an underlying reversible condition such as hypoxemia or pain; unfortunately, often there is no single factor that is easily reversed. Agitated patients may benefit from intravenously administered small doses of haloperidol.[51]

POCD is a distinct cognitive disorder found in patients after anesthesia.[10,49,52] It is diagnosed through neuropsychological testing and results in subtle changes in mental ability. Unlike patients with delirium, POCD patients are not acutely confused or agitated. In some studies 10% of older patients developed POCD 3 months after major noncardiac surgery. In most cases it resolved by 6 to 12 months, although its occurrence has been associated with an increased mortality rate. The role of anesthetics in the development of POCD is a current focus of significant research.

Perioperative stroke is an uncommon event following general surgery; it occurs more frequently after head and neck, vascular, and cardiac surgery. Risk factors for a postoperative stroke include advanced age and predisposing comorbid conditions such as hypertension and reduced ejection fraction of less than 40%. The most frequent incidence of stroke occurs after cardiac and aortic surgery. Most perioperative strokes are embolic and ischemic. A perioperative stroke is associated with prolonged hospitalization, increased disability, and death following surgery.[50]

REDUCTION OF PERIOPERATIVE RISK

Elderly patients have high mortality and morbidity rates after surgery, especially after major and emergent surgery. Reduction of risk should be aimed at avoiding complications and limiting risk. The patient should be in optimal condition preoperatively. Unfortunately it is not always possible to delay surgery, especially in emergent situations. Administration of perioperative β-adrenergic blockers may reduce postoperative cardiac events through a reduction in sympathetic tone, improved myocardial oxygen supply/demand, and reduction in ventricular arrhythmias as well as decreasing shear stress surrounding

Box 35.5 Guidelines for Treating Geriatric Patients

1. Advanced chronologic age is not a contraindication to surgery.
2. Clinical presentation of disease may have been atypical, leading to delays and errors in diagnosis.
3. Assume interindividual variability and titrate medications to physiologic effect when possible.
4. Expect complexity: Multiple medications and illnesses are common, and persons older than 65 years of age have on average 3.5 medical diseases.
5. Diminished organ reserve can be unpredictable and difficult to measure preoperatively; limitations may become apparent only during stress.
6. A disproportionate increase in perioperative risk may occur without adequate preoperative optimization—for example, after emergent procedures.
7. Meticulous attention to detail can help avoid minor complications, which in elderly patients can rapidly escalate into major adverse events.
8. Impact of extrinsic factors, such as smoking or those related to the environment or socioeconomic status, is difficult to quantify.

atherosclerotic plaque. If a patient is already receiving chronic β-adrenergic blockade, it should be continued for the entire perioperative period; abrupt discontinuation can increase the incidence of adverse events. Patients with American Heart Association class I or IIa indications should receive β-adrenergic blockers (also see Chapter 13, Table 13.10). More data are still needed to establish the most effective use of perioperative β-adrenergic blockade for elderly patients.[27,53]

As mentioned previously, appropriate pain control is also important, and epidural analgesia may have a significant role in preventing pulmonary complications. Other measures that may be used to limit pulmonary complications include using positive end-expiratory pressure (5 to 10 cm H_2O) to maintain FRC above closing capacity. Maintaining a higher inspired oxygen concentration (60%-90%) during surgery has been evaluated for potential benefit in reducing surgical site infections and postoperative nausea and vomiting, but meta-analyses have not clearly demonstrated efficacy.[55,56]

MEDICATIONS TO AVOID IN THE GERIATRIC POPULATION

An important aspect of risk reduction in geriatric patients is the avoidance of iatrogenic complications from medication side effects. Geriatric patients have decreased cholinergic reserve and are at risk from developing side effects from central anticholinergic medications.[10]

The most prominent side effects include cognitive decline and delirium, and patients with Alzheimer dementia or other types of dementia, such as multi-infarct and vascular dementia, are particularly sensitive. Perioperatively, antihistamines such as chlorpheniramine, promethazine, and the antiemetic scopolamine are the most commonly encountered anticholinergic medications to be avoided. Haloperidol also has anticholinergic properties but is well tolerated in the small doses typically prescribed for agitation or nausea. Tools available to screen patients for potentially inappropriate medications include both the 2012 AGS Beers Criteria for Potentially Inappropriate Medication Use in Older Adults and the Screening Tool of Older People's Prescriptions or STOPP criteria.[17,54]

SUMMARY

In summary, aging is associated with significant physiologic changes and an increase in comorbid conditions that influence the administration and choice of anesthetics. In the future there will be even larger numbers of elderly patients undergoing surgical procedures. Anesthetic plans must be designed to reduce or minimize postoperative complications.

QUESTIONS OF THE DAY

1. How does aging alter cardiovascular autonomic function? What are the implications for evaluation of intraoperative hypotension in an elderly patient?
2. What is frailty, and how can it be assessed using the clinical phenotype model? What measures of frailty can be used to predict postoperative complications after surgery?
3. What postoperative risks are increased in a patient with preoperative cognitive impairment? What are the elements included in the Mini-Cog test?
4. What are the expected changes in the minimum alveolar concentration (MAC) of inhaled anesthetics for each decade after 20 years of age?
5. What is the incidence of delirium in elderly postoperative patients? What factors can contribute to the development of delirium?
6. What medications should be avoided in the elderly patient undergoing surgery? What screening tools can be used to evaluate for potentially inappropriate medications?

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