CHAPTER 43

Geriatric Anesthesia

KEY CONCEPTS

1. In the absence of coexisting disease, resting systolic cardiac function seems to be preserved, even in octogenarians. Increased vagal tone and decreased sensitivity of adrenergic receptors lead to a decline in heart rate.
2. Elderly patients undergoing echocardiographic evaluation for surgery have an increased incidence of diastolic dysfunction compared with younger patients.
3. Diminished cardiac reserve in many elderly patients may be manifested as exaggerated drops in blood pressure during induction of general anesthesia. A prolonged circulation time delays the onset of intravenous drugs, but speeds induction with inhalational agents.
4. Aging decreases elasticity of lung tissue, allowing overdistention of alveoli and collapse of small airways. Residual volume and the functional residual capacity increase with aging. Airway collapse increases residual volume and closing capacity. Even in normal persons, closing capacity exceeds functional residual capacity at age 45 years in the supine position and age 65 years in the sitting position.
5. The neuroendocrine response to stress seems to be largely preserved, or, at most, only slightly decreased in healthy elderly patients. Aging is associated with a decreasing response to β-adrenergic agents.
6. Impairment of Na^+ handling, concentrating ability, and diluting capacity predispose elderly patients to both dehydration and fluid overload.
7. Liver mass and hepatic blood flow decline with aging. Hepatic function declines in proportion to the decrease in liver mass.
8. Dosage requirements for local and general (minimum alveolar concentration) anesthetics are reduced. Administration of a given volume of epidural local anesthetic tends to result in more extensive spread in elderly patients. A longer duration of action should be expected from a spinal anesthetic.
9. Aging produces both pharmacokinetic and pharmacodynamic changes. Disease-related changes and wide variations among individuals in similar populations prevent convenient generalizations.
10. Elderly patients display a lower dose requirement for propofol, etomidate, barbiturates, opioids, and benzodiazepines.

By the year 2040, persons aged 65 years or older are expected to comprise 24% of the population and account for 50% of health care expenditures. In Europe, persons aged 65 years or older are expected to comprise 30% of the population within the next 40 years. Of these individuals, many will require surgery. The elderly patient typically presents for surgery with multiple chronic medical conditions,

TABLE 43–1 Similarities between elderly people and infants, compared with the general population.

Decreased ability to increase heart rate in response to hypovolemia, hypotension, or hypoxia
Decreased lung compliance
Decreased arterial oxygen tension
Impaired ability to cough
Decreased renal tubular function
Increased susceptibility to hypothermia

in addition to the acute surgical illness. Age is not a contraindication to anesthesia and surgery; however, perioperative morbidity and mortality are greater in elderly than younger surgical patients.

As with pediatric patients, optimal anesthetic management of geriatric patients depends upon an understanding of the normal changes in physiology, anatomy, and response to pharmacological agents that accompany aging. In fact, there are many similarities between elderly and pediatric patients (Table 43–1). Individual genetic polymorphisms and lifestyle choices can modulate the inflammatory response, which contributes to the development of many systemic diseases. Consequently, chronologic age may not fully reflect an individual patient's true physical condition. The relatively high frequency of serious physiological abnormalities in elderly patients demands a particularly careful preoperative evaluation.

Elderly patients are frequently treated with β-blockers. β-Blockers should be continued perioperatively, if patients are taking such medications chronically, to avoid the effects of β-blocker withdrawal. A careful review of patients' often extensive medication lists can reveal the routine use of oral hypoglycemic agents, angiotensin-converting enzyme inhibitors or angiotensin receptor blockers, antiplatelet agents, statins, and anticoagulants. Because elderly patients frequently take multiple drugs for multiple conditions, they often benefit from an evaluation before the day of surgery, even when scheduled for outpatient surgery. Preoperative laboratory studies should be guided by patient condition and history. Patients who have cardiac stents requiring antiplatelet therapy present particularly vexing problems. Their management should be closely coordinated between the surgeon, cardiologist, and anesthesiologist. At no time should the anesthesia staff discontinue antiplatelet therapy without discussing the plan with the patient's primary physicians.

Age-Related Anatomic & Physiological Changes

CARDIOVASCULAR SYSTEM

Cardiovascular diseases are more prevalent in the geriatric than general population. Still, it is important to distinguish between changes in physiology that normally accompany aging and the pathophysiology of diseases common in the geriatric population (Table 43–2). For example, atherosclerosis is pathological—it is not present in healthy elderly patients. On the other hand, a reduction in arterial elasticity caused by fibrosis of the media is part of the normal aging process. Changes in the cardiovascular system that accompany aging include decreased vascular and myocardial compliance and autonomic responsiveness. In addition to myocardial fibrosis, calcification of the valves can occur. Elderly patients with systolic murmurs should be suspected of having aortic stenosis. However, in the absence of co-existing disease, resting systolic cardiac function seems to be preserved, even in octogenarians. Functional capacity of less than 4 metabolic equivalents (METS) is associated with potential adverse outcomes (see Table 21–2). Increased vagal tone and decreased sensitivity of adrenergic receptors lead to a decline in heart rate; maximal heart rate declines by approximately one beat per minute per year of age over 50. Fibrosis of the conduction system and loss of sinoatrial node cells increase the incidence of dysrhythmias, particularly atrial fibrillation and flutter. Preoperative risk assessment and evaluation of the patient with cardiac disease were previously reviewed in this text (see Chapters 18, 20, & 21). Age *per se* does not mandate any particular battery of tests or evaluative tools, although there is a long tradition of routinely requesting tests such as 12-lead electrocardiography

TABLE 43–2 Age-related physiological changes and common diseases of the elderly.

Normal Physiological Changes	Common Pathophysiology
Cardiovascular	
Decreased arterial elasticity	Atherosclerosis
Elevated afterload	Coronary artery disease
Elevated systolic blood pressure	Essential hypertension
Left ventricular hypertrophy	Congestive heart failure
Decreased adrenergic activity	Cardiac arrhythmias
Decreased resting heart rate	Aortic stenosis
Decreased maximal heart rate	
Decreased baroreceptor reflex	
Respiratory	
Decreased pulmonary elasticity	Emphysema
Decreased alveolar surface area	Chronic bronchitis
Increased residual volume	Pneumonia
Increased closing capacity	
Ventilation/perfusion mismatching	
Decreased arterial oxygen tension	
Increased chest wall rigidity	
Decreased muscle strength	
Decreased cough	
Decreased maximal breathing capacity	
Blunted response to hypercapnia and hypoxia	
Renal	
Decreased renal blood flow	Diabetic nephropathy
Decreased renal plasma flow	Hypertensive nephropathy
Decreased glomerular filtration rate	Prostatic obstruction
Decreased renal mass	Congestive heart failure
Decreased tubular function	
Impaired sodium handling	
Decreased concentrating ability	
Decreased diluting capacity	
Impaired fluid handling	
Decreased drug excretion	
Decreased renin–aldosterone responsiveness	
Impaired potassium excretion	

(ECG) in patients who are older than a defined age. Nonetheless, elderly individuals are more likely to present for surgery with previously undetected conditions that require an intervention, such as arrhythmias, congestive heart failure, or myocardial ischemia. Cardiovascular evaluation should be guided by American Heart Association guidelines.

2 Elderly patients undergoing echocardiographic evaluation for surgery have an increased incidence of diastolic dysfunction compared with younger patients. Diastolic dysfunction prevents the ventricle from relaxing and consequently inhibits diastolic ventricular filling at relatively low pressures. The ventricle becomes less compliant, and filling pressures are increased. Diastolic dysfunction is NOT equivalent to diastolic heart failure. In some patients, systolic ventricular function can be well preserved; however, the patient can have signs of congestion secondary to severe diastolic dysfunction. Diastolic heart failure most often coexists with systolic dysfunction.

Echocardiography is used to assess diastolic dysfunction. A ratio of greater than 15 between the peak E velocity of transmitral diastolic filling and the e' tissue Doppler wave is associated with elevated left ventricular end-diastolic pressure and diastolic dysfunction. Conversely, a ratio of less than 8 is consistent with normal diastolic function (see Figure 43–1).

Marked diastolic dysfunction may be seen with systemic hypertension, coronary artery disease, cardiomyopathies, and valvular heart disease, particularly aortic stenosis. Patients may be asymptomatic or complain of exercise intolerance, dyspnea, cough, or fatigue. Diastolic dysfunction results in relatively large increases in ventricular end-diastolic pressure, with small changes of left ventricular volume; the atrial contribution to ventricular filling becomes even more important than in younger patients. Atrial enlargement predisposes patients to atrial fibrillation and flutter. Patients are at increased risk of developing congestive heart failure. The elderly patient with diastolic dysfunction may poorly tolerate perioperative fluid administration, resulting in elevated left ventricular end-diastolic pressure and pulmonary congestion.

3 Diminished cardiac reserve in many elderly patients may be manifested as exaggerated drops in blood pressure during induction of general anesthesia. A prolonged circulation time delays

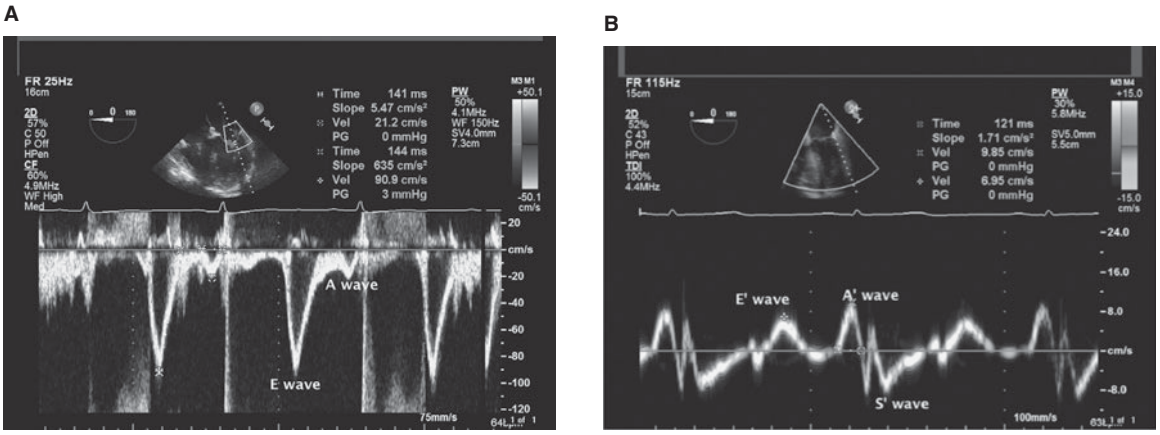

FIGURE 43–1 **A**: In this Doppler study of diastolic inflow, the E wave is seen with a peak velocity of 90.9 cm/sec. This Doppler study reflects the velocity of blood as it fills the left ventricle early in diastole. **B**: In tissue Doppler, the velocity of the movement of the lateral annulus of the mitral valve is measured. The e' wave in this image is 6.95 cm/sec. This corresponds to the movement of the myocardium during diastole. (Reproduced, with permission, from Wasnick J, Hillel Z, Kramer D, et al: *Cardiac Anesthesia & Transesophageal Echocardiography,* McGraw-Hill, 2011.)

the onset of intravenous drugs, but speeds induction with inhalational agents. Like infants, elderly patients have less ability to respond to hypovolemia, hypotension, or hypoxia with an increase in heart rate. Ultimately, cardiovascular diseases, including heart failure, stroke, arrhythmias, and hypertension contribute to an increased risk of morbidity, mortality, increased cost of care, and frailty in elderly patients.

Research is ongoing into the relationship between telomere biology and cardiovascular disease. Telomeres, which are located at the chromosome terminus, protect the DNA from degradation during cell division. With each cell division, there is progressive telomere loss. Cells with short telomeres undergo "replicative senescence" and apoptosis. Telomerase maintains telomere length, but has low activity in human cells. Indeed, telomere length varies among humans based upon inheritance and environmental factors. Telomerase activity is deficient in various early aging syndromes. Telomere shortening may be either a cause or a consequence of cardiovascular disease. Whatever the exact mechanism of cardiovascular aging, patient management should at all times be in accordance with American Heart Association/American College of Cardiology guidelines.

RESPIRATORY SYSTEM

4 Aging decreases the elasticity of lung tissue, allowing overdistention of alveoli and collapse of small airways. Residual volume and the functional residual capacity increase with aging. Airway collapse increases residual volume and closing capacity Even in normal persons, closing capacity exceeds functional residual capacity at age 45 years in the supine position and age 65 years in the sitting position. When this happens, some airways close during part of normal tidal breathing, resulting in a mismatch of ventilation and perfusion. The additive effect of these emphysema-like changes decreases arterial oxygen tension by an average rate of 0.35 mm Hg per year; however, there is a wide range of arterial oxygen tensions in elderly preoperative patients. Both anatomic and physiological dead space increase. Other pulmonary effects of aging are summarized in Table 43–2.

Decreased respiratory muscle function/mass, a less compliant chest wall, and intrinsic changes in lung function can increase the work of breathing and make it more difficult for elderly patients to muster a respiratory reserve in settings of acute illness (eg, infection). Many patients also present with obstructive or restrictive lung diseases. In patients who have

no intrinsic pulmonary disease, gas exchange is unaffected by aging.

Measures to prevent perioperative hypoxia in elderly patients include a longer preoxygenation period prior to induction, increased inspired oxygen concentrations during anesthesia, positive end-expiratory pressure, and pulmonary toilet. Aspiration pneumonia is a common and potentially life-threatening complication in elderly patients, possibly as a consequence of a progressive decrease in protective laryngeal reflexes and immunocompetence with age. Ventilatory impairment in the recovery room is more common in elderly than younger patients. Factors associated with an increased risk of postoperative pulmonary complications include age older than 64 years, chronic obstructive pulmonary disease, sleep apnea, malnutrition, and abdominal or thoracic surgical incisions.

METABOLIC & ENDOCRINE FUNCTION

Basal and maximal oxygen consumption declines with age. After reaching peak weight at about age 60 years, most men and women begin losing weight; the average elderly man and woman weigh less than their younger counterparts. Heat production decreases, heat loss increases, and hypothalamic temperature-regulating centers may reset at a lower level.

Diabetes affects approximately 15% of patients older than age 70 years. Its impact on numerous organ systems can complicate perioperative management. Diabetic neuropathy and autonomic dysfunction are particular problems for the elderly.

Increasing insulin resistance leads to a progressive decrease in the ability to avoid hyperglycemia with glucose loads. Institutions typically have their own protocols on how to manage increased blood glucose perioperatively, and these protocols reflect the changing literature on "tight" control. Attempts to maintain blood glucose within a strictly normal range during surgery, anesthesia, and/or critical illness may lead to hypoglycemia and adverse outcomes. Anesthesia practitioners are advised to determine what the "acceptable" perioperative blood glucose level is in their institution and to be aware of changing performance benchmarks related to this measure.

The neuroendocrine response to stress seems to be largely preserved, or, at most, only slightly decreased in healthy elderly patients. Aging is associated with a decreasing response to β-adrenergic agents.

RENAL FUNCTION

Renal blood flow and kidney mass (eg, glomerular number and tubular length) decrease with age. Renal function, as determined by glomerular filtration rate and creatinine clearance, is reduced (Table 43–2). The serum creatinine level is unchanged because of a decrease in muscle mass and creatinine production, whereas blood urea nitrogen gradually increases with aging. Impairment of Na^+ handling, concentrating ability, and diluting capacity predispose elderly patients to both dehydration and fluid overload. The response to antidiuretic hormone and aldosterone is reduced. The ability to reabsorb glucose is decreased. The combination of reduced renal blood flow and decreased nephron mass in elderly patients increases the risk of acute renal failure in the postoperative period, particularly when they are exposed to nephrotoxic drugs and techniques.

As renal function declines, so does the kidney's ability to excrete drugs. The decreased capacity to handle water and electrolyte loads makes proper fluid management more critical; elderly patients are more predisposed to developing hypokalemia and hyperkalemia. This is further complicated by the common use of diuretics in the elderly population. The search is ongoing for drugs that might protect the kidney perioperatively, as well as for specific genetic profiles of patients at greater risk of perioperative kidney injury.

GASTROINTESTINAL FUNCTION

Liver mass and hepatic blood flow decline with aging. Hepatic function declines in proportion to the decrease in liver mass. Thus, the rate of biotransformation and albumin production

decreases. Plasma cholinesterase levels are reduced in elderly men.

NERVOUS SYSTEM

Brain mass decreases with age; neuronal loss is prominent in the cerebral cortex, particularly the frontal lobes. Cerebral blood flow also decreases about 10% to 20% in proportion to neuronal losses. It remains tightly coupled to metabolic rate, and autoregulation is intact. Neurons lose complexity of their dendritic tree and the number of synapses. The synthesis of neurotransmitters, such as dopamine, and neurotransmitter receptors are reduced. Serotonergic, adrenergic, and gamma-aminobutyric acid (GABA) binding sites are also reduced. Astrocytes and microglial cells increase in number.

Aging is associated with an increasing threshold for nearly all sensory modalities, including touch, temperature sensation, proprioception, hearing, and vision. Dosage requirements for local and general (minimum alveolar concentration [MAC]) anesthetics are reduced. Administration of a given volume of epidural local anesthetic tends to result in more extensive spread in elderly patients. A longer duration of action should be expected from a given dose of spinal local anesthetic.

Currently, much work is being done to determine whether surgery and anesthesia harm the brain in some manner. Postoperative cognitive dysfunction (POCD) is diagnosed by neurobehavioral testing. Unlike delirium, which is a clinical diagnosis, cognitive dysfunction must be sought by using evaluative techniques. Up to 30% of elderly patients can demonstrate abnormal neurobehavioral testing within the first week after an operation; however, such testing may identify dysfunction already present in these individuals prior to any surgery or anesthesia exposure.

Ultimately, the question arises as to whether general anesthetic agents result in neurotoxicity in the aged brain. Some current investigations are attempting to determine whether anesthetic agents produce POCD through a mechanism similar to that underlying Alzheimer's disease.

It is also possible that side effects of illness (eg, inflammation) and the neuroendocrine stress response contribute to perioperative brain injury in some manner, independent of anesthesia. Indeed, patients presenting for surgery may present with cognitive dysfunction. In one study, 20% of elderly patients presenting for elective total joint arthroplasty demonstrated preoperative cognitive impairment; furthermore, POCD was independent of type of anesthesia or surgery at 3 months postoperatively. Postoperative delirium is common in elderly patients, especially those with reduced preoperative neurocognitive test scores and reduced functional status. Preoperative frailty is also associated with postoperative delirium. Frailty is common in preoperative elderly patients awaiting surgery and predicts postoperative delirium. Delirium has a particularly frequent incidence following hip surgery. Factors associated with postoperative delirium in the elderly and ways to avoid it are presented in **Tables 43–3** and **43–4**.

Elderly patients often take more time to recover completely from the central nervous system effects of general anesthesia, especially if they were confused or disoriented preoperatively. This is important in geriatric outpatient surgery, where socioeconomic factors, such as the lack of a caretaker at home, necessitate that patients may need to assume a higher level of self care.

In the absence of disease, any perioperative decrease in cognitive function is normally modest. Short-term memory seems to be most affected. Continued physical and intellectual activity seems to have a positive effect on preservation of cognitive functions.

The etiology of POCD is likely multifactorial and includes drug effects, pain, underlying dysfunction, hypothermia, and metabolic disturbances. Elderly patients are particularly sensitive to centrally acting anticholinergic agents, such as scopolamine and atropine. Some patients suffer from prolonged or permanent POCD after surgery and anesthesia. Some studies suggest that POCD can be detected in 10% to 15% of patients older than age 60 years up to 3 months following major surgery. In some settings (eg, following cardiac and major orthopedic procedures), intraoperative arterial emboli may be contributory. Animal studies suggest that anesthesia without surgery can impair learning for weeks,

TABLE 43–3 Predisposing and precipitating factors for delirium after surgery.

	Precipitating Factors	
Predisposing Factors, Preoperative	**Intraoperative**	**Postoperative**
Demographics	Type of operation	Early complications of operation
Increasing age	Hip fracture	Low hematocrit
Male gender	Cardiac surgery	Cardiogenic shock
Comorbidities	Vascular surgery	Hypoxemia
Impaired cognition	Complexity of operation	Prolonged intubation
Dementia	Operation time	Sedation management
Mild cognitive impairment	Shock/hypotension	Pain
Preoperative memory complaint	Arrhythmia	Later complications of operation
Atherosclerosis	Decreased cardiac output	Low albumin
Intracranial stenosis	Emergency surgery	Abnormal electrolytes
Carotid stenosis	Operative factors	Latrogenic complications
Peripheral vascular disease	Intraoperative temperature	Pain
Prior stroke/transient ischemic attack	Benzodiazepine administration	Infection
Diabetes	Propofol administration	Liver failure
Hypertension	Blood transfusion	Renal failure
Atrial fibrillation	Anesthesia factors	Sleep-wake disturbance
Low albumin	Type of anesthesia	Alcohol withdrawal
Electrolyte abnormalities	Duration of anesthesia	
Psychiatric disease	Cognitively active medications	
Anxiety		
Depression		
Benzodiazepine use		
Function		
Impaired functional status		
Sensory impairment		
Lifestyle factors		
Alcohol use		
Sleep deprivation		
Smoking		

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particularly in older animals. Elderly inpatients seem to have a significantly higher risk of POCD than elderly outpatients. Anesthetic neurotoxicity is also a potential risk for the developing brain. Progress in research in this area is documented on the Smart Tots™ website (see http://www.smarttots.org/).

MUSCULOSKELETAL

Muscle mass is reduced in elderly patients. Skin atrophies with age and is susceptible to trauma from removal of adhesive tape, electrocautery pads, and electrocardiographic electrodes. Veins are often frail and easily ruptured by intravenous infusions. Arthritic joints may interfere with positioning or regional anesthesia. Degenerative cervical spine disease can limit neck extension, potentially making intubation difficult.

Age-Related Pharmacological Changes

9 Aging produces both pharmacokinetic (the relationship between drug dose and plasma concentration) and pharmacodynamic (the relationship between plasma concentration and clinical effect) changes. Disease-related changes and wide variations among individuals in similar populations prevent generalizations.

TABLE 43–4 Prevention of delirium after surgery.

Module	Postoperative Intervention
Cognitive stimulation	Orientation (clock, calendar, orientation board) Avoid cognitively active medications
Improve sensory input	Glasses Hearing aids/amplifiers
Mobilization	Early mobilization and rehabilitation
Avoidance of psychoactive medication	Elimination of unnecessary medications Pain management protocol
Fluid and nutrition	Fluid management Electrolyte monitoring and repletion Adequate nutrition protocol
Avoidance of hospital complications	Bowel protocol Early removal of urinary catheters Adequate central nervous system O_2 delivery, including supplemental oxygen and transfusion for very low hematocrit Postoperative complication monitoring protocol

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A progressive decrease in muscle mass and increase in body fat (particularly in older women) results in decreased total body water. The reduced volume of distribution for water-soluble drugs can lead to greater plasma concentrations; conversely, an increased volume of distribution for lipid-soluble drugs could theoretically reduce their plasma concentration. Any change in volume of distribution sufficient to significantly change concentrations will influence the elimination time. Because renal and hepatic functions decline with age, reductions in clearance prolong the duration of action of many drugs.

Distribution and elimination are also affected by altered plasma protein binding. Albumin, which binds acidic drugs (eg, barbiturates, benzodiazepines, opioid agonists), typically decreases with age. α_1-Acid glycoprotein, which binds basic drugs (eg, local anesthetics), is increased.

The principal pharmacodynamic change associated with aging is a reduced anesthetic requirement, represented by a reduced MAC. Careful titration of anesthetic agents helps to avoid adverse side effects and unexpected, prolonged duration; short-acting agents, such as propofol, desflurane, remifentanil, and succinylcholine, may be particularly useful in elderly patients. Drugs that are not significantly dependent on hepatic or renal function or blood flow, such as atracurium or cisatracurium, are useful.

INHALATIONAL ANESTHETICS

The MAC for inhalational agents is reduced by 4% per decade of age over 40 years. Onset of action is faster if cardiac output is depressed, whereas it is delayed if there is a significant ventilation/perfusion abnormality. Recovery from anesthesia with a volatile anesthetic may be prolonged because of an increased volume of distribution (increased body fat) and decreased pulmonary gas exchange. Decreased hepatic function is of less importance, even for halothane. Agents that are rapidly eliminated (eg, desflurane) are good choices for speeding emergence in the elderly patient.

NONVOLATILE ANESTHETIC AGENTS

10 In general, elderly patients display a lower dose requirement for propofol, etomidate, barbiturates, opioids, and benzodiazepines. The typical octogenarian will require a smaller induction dose of propofol than that required by a 20-year-old patient.

Although propofol may be close to an ideal induction agent in elderly patients because of its rapid elimination, it is more likely to cause apnea and hypotension than in younger patients. Both pharmacokinetic and pharmacodynamic factors are responsible for this enhanced sensitivity. Elderly patients require nearly 50% lower blood

levels of propofol for anesthesia than do younger patients. Moreover, both the rapidly equilibrating peripheral compartment and systemic clearance for propofol are significantly reduced in elderly patients. The initial volume of distribution for etomidate significantly decreases with aging: lower doses are required to achieve the same electroencephalographic endpoint in elderly patients (compared with young patients).

Enhanced sensitivity to fentanyl, alfentanil, and sufentanil is primarily pharmacodynamic. Pharmacokinetics for these opioids are not significantly affected by age. Dose requirements for the same EEG endpoint using fentanyl and alfentanil are 50% lower in elderly patients. In contrast, the volume of the central compartment and clearance are reduced for remifentanil; thus, both pharmacodynamic and pharmacokinetic factors are important.

Use of sedative and antinausea agents with anticholinergic and antidopaminergic properties may produce adverse effects in patients with Parkinson's disease.

Aging increases the volume of distribution for all benzodiazepines, which effectively prolongs their elimination half-lives. Enhanced pharmacodynamic sensitivity to benzodiazepines is also observed. Midazolam requirements are generally 50% less in elderly patients, and its elimination half-life is prolonged by about 50%.

MUSCLE RELAXANTS

The response to succinylcholine and other neuromuscular blockers is unaltered by aging. Decreased cardiac output and slow muscle blood flow, however, may cause up to a 2-fold prolongation in the onset of neuromuscular blockade in elderly patients. Recovery from nondepolarizing muscle relaxants that depend on renal excretion (eg, pancuronium) may be delayed due to decreased drug clearance. Likewise, decreased hepatic excretion from a loss of liver mass prolongs the elimination half-life and duration of action of rocuronium and vecuronium. The pharmacological profile of atracurium is not significantly affected by age.

CASE DISCUSSION

The Elderly Patient with a Fractured Hip

An 86-year-old nursing home patient is scheduled for open reduction and internal fixation of a subtrochanteric fracture of the femur.

How should this patient be evaluated for the risk of perioperative morbidity?

Anesthetic risk correlates much better with the presence of coexisting disease than chronological age. Therefore, preanesthetic evaluation should concentrate on the identification of age-related diseases (Table 43–2) and an estimation of physiological reserve. There is a tremendous physiological difference between a patient who walks three blocks to a grocery store on a regular basis and one who is bedridden, even though both may be the same age. Obviously, any condition that may be amenable to preoperative therapy (eg, bronchodilator administration) must be identified and addressed. At the same time, lengthy delays may compromise surgical repair and increase overall morbidity.

What are some of the considerations in selection of premedication for this patient?

In general, elderly patients require lower doses of premedication. Nonetheless, hip fractures are painful, particularly during movement to the operating room. Unless contraindicated by severe concomitant disease, an opioid premedication may be valuable. Anticholinergic medication is rarely needed, as aging is accompanied by atrophy of the salivary glands. These patients may be at risk for aspiration, as opioid premedication and pain from the injury will decrease gastric emptying. Therefore, pretreatment with an H_2 antagonist or proton pump inhibitor should be considered.

What factors might influence the choice between regional and general anesthesia?

Advancing age is not a contraindication for either regional or general anesthesia. Each technique, however, has its advantages and disadvantages in the elderly population. For hip surgery,

regional anesthesia can be achieved with a subarachnoid or epidural block extending to the T8 sensory level. Both of these blocks require patient cooperation and the ability to lie still for the duration of the surgery. A paramedian approach may be helpful when optimal positioning is not possible Unless regional anesthesia is accompanied by heavy sedation, postoperative confusion and disorientation are less troublesome than after general anesthesia. Cardiovascular changes are usually limited to a decrease in arterial blood pressure as sympathetic block is established. Although this decrease can be minimized by prophylactic fluid loading, a patient with borderline heart function may develop congestive heart failure when the block dissipates and sympathetic tone returns. Reduced afterload can result in profound hypotension and cardiac arrest in patients with aortic stenosis, a common valvular lesion in the elderly population. Patients with coronary artery disease may experience an increase in myocardial oxygen demand as a result of reflex tachycardia or a decrease in supply caused by lower coronary artery perfusion. Invasive arterial pressure monitoring is useful when taking the elderly patient to surgery. Monitors of hemodynamic function using pulse contour analysis that estimate stroke volume variation in addition to transesophageal echocardiography can all be employed to guide fluid therapy. The benefits of transesophageal echocardiography must be considered in the context of the risks of esophageal rupture and mediastinitis in the elderly.

Are there any specific advantages or disadvantages to a regional technique in elderly patients having hip surgery?

A major advantage in regional anesthesia—particularly for hip surgery—is a lower incidence of postoperative thromboembolism. This is presumably due to peripheral vasodilation and maintenance of venous blood flow in the lower extremities. In addition, local anesthetics inhibit platelet aggregation and stabilize endothelial cells. Many anesthesiologists believe that regional anesthesia maintains respiratory function better than general anesthesia. Unless the anesthetic level involves the intercostal musculature, ventilation and the cough reflex are well maintained.

Technical problems associated with regional anesthesia in the elderly include altered landmarks as a result of degeneration of the vertebral column and the difficulty of obtaining adequate patient positioning secondary to pain related to the fracture. To avoid having the patient lie on the fracture, a hypobaric or isobaric solution can be injected intrathecally. Postpuncture headache is less of a problem in the elderly population.

If the patient refuses regional anesthesia, is general anesthesia acceptable?

General anesthesia is an acceptable alternative to regional block. One advantage is that the patient can be induced in bed and moved to the operating room table after intubation, avoiding the pain of positioning. A disadvantage is that the patient is unable to provide feedback regarding pressure points on the unpadded orthopedic table.

What specific factors should be considered during induction and maintenance of general anesthesia with this patient?

It is important to remember that because a subtrochanteric fracture can be associated with more than 1 L of occult blood loss, induction with propofol may lead to an exaggerated decrease in arterial blood pressure. Initial hypotension may be replaced by hypertension and tachycardia during laryngoscopy and intubation. This rollercoaster volatility in blood pressure increases the risk of myocardial ischemia and can be avoided by preceding airway instrumentation with lidocaine (1.5 mg/kg), esmolol (0.3 mg/kg), or alfentanil (5–15mcg/kg). Elderly patients often have poor vascular compliance and wide pulse pressures, leading to dramatic swings in both systolic and diastolic blood pressure during anesthesia.

Intraoperative paralysis with a nondepolarizing muscle relaxant improves surgical conditions and allows maintenance of a lighter plane of anesthesia. Monitoring for anesthetic awareness is suggested if the patient's hemodynamics dictate reliance on muscle relaxants to prevent movement intraoperatively.

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