Review Article

Postanesthesia Care for the Elderly Patient

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ABSTRACT

Purpose: As the general population lives longer, the perioperative physician is more likely to encounter disease states that increase in incidence in an aging population. This review focuses on anesthetic considerations for rational drug choices during the perioperative care of elderly patients. The primary aim of the review was to identify intraoperative and postanesthetic considerations for diseases associated with advancing age; it includes highlights of the commonly impaired major organs (eg, cardiovascular, pulmonary, neurologic, renal, hepatic systems). We also outline an approach to frequent issues that arise in the immediate postsurgical period while caring for these patients.

Methods: A systematic review was performed on aspects of the perioperative and postoperative periods that relate to the elderly. A list of pertinent key words was derived from the authors, and a PubMed database search was performed.

Findings: The anesthesiologist must account for changes in various organ systems that affect perioperative care, including the cardiovascular, pulmonary, renal, hepatic, and central nervous systems. The pharmacokinetic principles frequently differ and are often unpredictable because of anatomic changes and decreased renal and hepatic function. The most important pharmacodynamic consideration is that elderly patients tend to exhibit an exaggerated hypoactivity after anesthesia.

Implications: Before surgery, it is essential to identify those patients at risk for delirium and other commonly encountered postanesthesia scenarios. Failure to manage these conditions appropriately can lead to an escalation of care and prolonged hospitalization. (*Clin Ther.* 2015;37:2651–2665) Published by Elsevier HS Journals, Inc.

Key words: elderly, recovery, delirium, polypharmacy, anesthesia, surgery.

INTRODUCTION

As the general population lives longer, the perioperative physician is more likely to encounter disease states that increase in incidence in an aging population. The preoperative evaluation of elderly patients undergoing surgery is considered elsewhere. The primary aim of the present review was to identify intraoperative and postanesthetic considerations for diseases associated with advancing age; it includes highlights of the commonly impaired major organs (eg, cardiovascular, pulmonary, neurologic, renal, hepatic systems). We also outline frequent issues that arise in the immediate postsurgical period in these patients. Finally, we present our anesthetic techniques that may be of clinical benefit for surgeries and procedures often performed in the elderly population.

MATERIALS AND METHODS

Although most clinical research involves an arbitrary age threshold at which one is considered to be aged or elderly, most practitioners understand that there is great heterogeneity in co-morbid conditions, disease

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severity, and functional independence among patients who are aged >60 years. Although the literature search was not limited to a particular age range, the National Library of Medicine notes elderly (or aged) as a person aged 65 through 79 years (Medical Subject Headings Descriptor Data).

We performed a systematic review of aspects of the perioperative and postoperative period that relate to the elderly. A list of pertinent key words was derived from the authors, and a PubMed database search was performed. Search terms (Medical Subject Headings) were: (((Elderly) OR (Aged, 80 and Over)) AND ((Surgery) OR (Anesthesia) OR (PACU) OR (Recovery))) AND (keyword). The key words used were as follows: complications, myocardial infarction, stroke, delirium, anemia, COPD, diabetes, dysphagia, hip fracture, hypotension, hypertension, dementia, POCD, sleep, cancer, polypharmacy, endocrine, pain, nausea, vomiting, and hypothermia. The focus was on recently published, highly cited, randomized controlled trials, human studies, translational animal models, articles pertaining to the perioperative period, and reporting of adverse outcomes. Articles in languages other than English were excluded from the search.

ANESTHETIC CONSIDERATIONS FOR DISEASES THAT INCREASE IN PREVALENCE WITH AGE

Cardiovascular Disease

The lifetime risk of developing coronary artery disease after 40 years of age is 49% for men and 32% for women.[1] Preoperative risk stratification is well outlined by the American Heart Association guidelines, and we refer to this document for preoperative consideration. In patients of any age with coronary artery disease, a key anesthetic goal is maintenance of the balance between oxygen supply and demand in the perioperative period. Although hypertension (increased cardiac work) and hypotension (decreased coronary blood flow) can negatively affect patients with coronary artery disease, tachycardia (increased work and decreased coronary filling time) has the greatest adverse effect. The 2014 American Heart Association guidelines on perioperative evaluation and management recommend continuing β-blocker therapy in the perioperative period.[2] Acute withdrawal of β-blockade was shown to increase both 30-day and 1-year mortality.[3] Although initiating β-blocker therapy on the day of surgery is associated with a decreased incidence of perioperative myocardial infarction, there is a subsequent increase in the risk of death and stroke.[4] Intraoperative hypotension in 2 different studies was found to be an independent risk factor for major cardiac events in noncardiac surgery.[5,6] The study by Sabate et al[5] specifically defines intraoperative hypotension as a >20 mm Hg decrease or a drop of 20% in mean arterial pressure lasting for >1 hour. Given these results, keeping the mean arterial pressure within 20% of baseline would be recommended. The accompanying table summarizes anesthetic considerations for specific cases commonly encountered in the elderly population.

Atrial fibrillation also increases in frequency with age. Five percent of patients aged >70 years have a diagnosis of atrial fibrillation, and it is increased to 10% in patients aged >80 years.[7] Patients with chronic atrial fibrillation do not require additional evaluation before surgery if their heart rate is pharmacologically controlled at <80 beats/min.[8] The 2014 American Heart Association guidelines on perioperative management recommend no changes in medication management under these circumstances.[2] Age reduces arterial compliance; recently, the role of atrial stretch in arrhythmogenesis has received much scientific attention.[9,10] This focus has prompted clinicians to carefully consider fluid strategies when managing patients at risk for developing atrial fibrillation, especially during cardiac surgery.[11] Despite the potential risk of abnormal atrial stretch leading to new-onset atrial fibrillation, no fluid strategy is currently recommended for the prevention of atrial fibrillation. In addition, no recommendations can currently be made for the fluid management of patients undergoing surgery who have existing long-standing or paroxysmal atrial fibrillation.

Historically, inhaled anesthetics (halothane and nitrous oxide) dominated the anesthesia market as potent, nonflammable agents suitable for a wide variety of surgeries. However, their use has declined somewhat with the introduction of newer volatile agents (sevoflurane, isoflurane, and desflurane) with more favorable cardiovascular profiles. Halothane (no longer in use in the United States) has been considered to increase the risk of arrhythmias,[12] and nitrous oxide may increase the incidence of myocardial infarction even without a significant increase in the risk of morbidity from that infarction.[13] Although cardiac arrhythmias and

perioperative myocardial infarction are still identified and treated, much of the cardiovascular concerns have shifted toward avoiding perioperative hypotension in patients to preserve cerebral perfusion.

The prevalence of hypertension in adults aged ≥60 years is 66.7%.[1] A meta-analysis of 30 observational studies examining perioperative cardiac risk reported no significant increase in this condition in patients with preoperative arterial pressures of <180/110 mm Hg.[14] A study in the *Canadian Journal of Anesthesia* found that those with isolated systolic hypertension exhibited no increased risk of perioperative myocardial ischemia compared with a normotensive control group.[15]

Although the trend is to maintain blood pressure at usual values for patients with hypertension and for those without hypertension, antihypertensive medications should be continued in the perioperative period, especially β-blockade.[16] β-blockade for patients with known cardiac risk factors has become a quality metric for most hospitals despite some controversy over the risks of stroke.[4] It should be noted that the specific β-blocker studied was metoprolol succinate, a B_1-selective blocker. A less selective β-blocker with some α-blockade (i.e., carvedilol) is also commonly used in patients with depressed ejection fractions. In a recent Danish study, both medications produced equal efficacy in patients with heart failure in terms of mortality.[17] It remains controversial if diuretics, angiotensin-converting enzyme (ACE) inhibitors, and angiotensin receptor blockers should be continued on the day of surgery due to the risk of postinduction hypotension. A study by Turan et al[18] showed that ACE inhibitor use did not increase the risk of 30-day mortality, although it did result in an increase in intraoperative medications for vasoconstriction. Postoperatively, early reinstitution of maintenance antihypertensive medication is recommended. In a retrospective study in the Veterans Affairs system, early reinstitution of ACE inhibitors produced a decrease in 30-day mortality risk.[19]

Anemia is another disease state with a substantial presence in the elderly. The disease prevalence in men aged >65 years is estimated to be 11%, and in women, 10.2%.[20] Unexplained anemia should be evaluated before surgery, given the possible potential for malignant process or other correctible process as the cause.[21] An appropriate baseline hemoglobin level for proceeding with elective surgery has not been determined. However, an observational study from the Department of Veterans Affairs found increased 30-day mortality in patients with a preoperative hematocrit level <39%.[22] Intraoperatively, it is well accepted that patients with symptomatic anemia should undergo transfusion. In the asymptomatic patient, a clinical decision should be based on the underlying systemic disease states that could be worsened by anemia. Although there is an increased prevalence of coronary artery disease in the elderly population, these patients may not benefit from a liberal transfusion strategy. Grover et al[23] examined a conservative versus liberal hemoglobin threshold for transfusion (8 vs 10 gm/dL) but observed no significant difference in cardiac ischemic events during total knee replacement or hip arthroplasty. However, both groups averaged <1 unit per patient (208 units transfused in a total of 217 patients). No clear recommendations can be made for a specific hemoglobin level as a transfusion point based on this review.

Pulmonary Disease

In 2012, a total of 15 million adults (6.3%) in the United States reported they were told by a health care provider that they have chronic obstructive pulmonary disease (COPD).[24] The same Centers for Disease Control and Prevention report lists the incidence of COPD as 12.1% of patients aged 65 to 74 years and 11.6% in those aged >75 years. In California in 1965, 23.2% of patients smoked ≥20 cigarettes per day, which was a consistent reflection of the US population at that time (22.9% of all Americans smoking >20 cigarettes per day).[25] Medium-intensity smoking was defined as 10 to 19 cigarettes per day and had a prevalence in 1965 of 11.1% in California and 10.5% in the rest of the United States. In a study by Gupta et al,[26] COPD was independently linked with postoperative pneumonia and respiratory failure. Patients with severe disease may be taking chronic steroids; these doses should be continued preoperatively and may require "stress dosing" (in the form of intravenous [IV] hydrocortisone or methylprednisolone) at the time of surgery. Maintenance inhalers should also be continued in the preoperative period.

Pulmonary function tests (if available) are useful in determining the patient's response to B_2-agonist therapy. Adequate analgesia in the postoperative period

carries additional considerations in patients with COPD. Regional analgesia has been assessed as a method of providing postoperative analgesia with fewer adverse effects compared with systemic opioids. In a study by Panaretou et al,[27] significantly better results on pulmonary function testing (ie, forced expiratory volume in 1 second, forced vital capacity) were reported in patients receiving epidural analgesia rather than IV analgesia after open abdominal aortic aneurysm repair. However, they found no difference in pulmonary-related morbidity, although the small sample size (30 patients) may have played a role in this result. A larger study of patients after major abdominal surgery reported a decrease in postoperative pneumonia and 30-day mortality, mostly in patients with severe COPD.[28]

Intraoperative thoracic epidural analgesia is useful as an adjunct to the anesthetic for elderly patients undergoing lung cancer resection. A more general discussion of epidurals for postoperative analgesia is discussed later (in the section entitled "Postanesthesia Recovery and the Postanesthesia Care Unit"). Nonpharmacologic methods to ensure lung expansion postoperatively have been examined; however, the data are not conclusive. A Cochrane review demonstrated no defined benefit of incentive spirometry in terms of mortality in the perioperative period.[29] In contrast, the American College of Physicians have suggested that lung expansion modalities may be superior to no lung expansion but did not recommend a particular method.[30]

Neurologic Disease

Elderly surgical patients are at increased risk for several acute neurologic complications such as delirium and stroke in the perioperative period.[31,32] Advanced age is a predisposing factor for adverse outcomes and may increase the trajectory of their underlying neurodegenerative disease.[33]

Delirium complicates the postoperative course of 15% to 53% of patients aged >65 years; it predicts an escalation of care and increased length of hospitalization.[31,34] Moreover, postoperative delirium has been shown to increase the severity of underlying neurodegenerative disease.[33] Delirium cab be categorized on the basis of accompanying motor activity. The subtypes are hyperactive and hypoactive, as well as mixed, which includes elements of both within a short period.[35] It is imperative that all modifiable risk factors for postoperative delirium be addressed to improve patient outcomes. Hypoglycemia should be avoided, and maintaining normoglycemia perioperatively has been shown to enhance postoperative cognitive functioning.[36] Anticholinergic medications and benzodiazepines may precipitate delirium in elderly patients. Because pain can be a precipitating factor for causing delirium, pain medications should not be withheld in the elderly surgical patient.[37] However, some pain medications (eg, opioids) can contribute to sedation, nausea, and hypercarbia, which in turn can contribute to delirium. Ketamine, long known to inhibit *N*-methyl-D-aspartate receptors, has recently been shown to inhibit hyperpolarization-activated cyclic nucleotide-gated receptors, which are important for regulating levels of consciousness and neuroinflammation.[38,39] Hudetz et al[40] conducted a 58-patient, randomized controlled trial showing that low-dose ketamine reduces postoperative delirium from 31% to 3% after major cardiac surgery. The PODCAST (Prevention of Delirium and Complications Associated With Surgical Treatments Multi-Center Clinical Trial), a larger multicenter study, is underway to further investigate ketamine's effect on postoperative delirium after major surgery.[41]

Perioperative stroke in an elderly patient is associated with an 8-fold increase in 30-day mortality.[42] Elderly patients with a history of stroke are more likely to sustain a subsequent perioperative stroke.[32] The increased perioperative stroke rate among elderly patients is not isolated to cardiovascular procedures. Independent of other risk factors, elderly patients are more likely to sustain a perioperative stroke in many commonly performed surgeries.[42] A primary consideration should be to maintain cerebral perfusion pressure. Among patients who have known cerebrovascular insufficiency or chronic hypertension, it is best to maintain a cerebral perfusion pressure at or slightly above the patient's baseline.[43] In addition, patients should be kept normoglycemic because hyperglycemia has been shown to worsen ischemic injury.

Neurodegenerative diseases such as Parkinson's disease (PD) and Alzheimer's disease are most prevalent in the elderly.[44] Both diseases are associated with loss of cholinergic neurons. There is a growing body of scientific literature that mechanistically links drugs of the perioperative period to adverse reactions to neuronal health.[45–47] The effects of inhaled anesthetic

agents share 2 major pathologic mechanisms with Alzheimer's disease: they increase production and aggregation of Aβ peptides, and precipitate hyperphosphorylation and accumulation of tau protein.[48,49] Currently, no specific anesthetic regimen is recommended for the prevention or mitigation of the enhanced hypoactivity after general anesthesia in patients at risk or susceptible to neurodegenerative disease. One feature of patients with PD is their dependence on pharmacotherapeutic agents with relatively short half-lives. For this reason, when patients with PD undergo general anesthesia, it is vital that they receive their PD medications preoperatively and as quickly as possible postoperatively to minimize PD symptoms during recovery. If a dose of oral medications must be missed, dopaminergic agents such as transdermal rotigotine or subcutaneous apomorphine should be considered.[50,51]

PHARMACOLOGY IN THE ELDERLY

Advancing age alters the pharmacodynamics and pharmacokinetics of commonly used anesthetic and postoperative medications. The clinical effect of a given drug may be more profound and/or have prolonged effect in the geriatric patient. The increased potency and prolonged action time put elderly patients at increased vulnerability to drug adverse effects.

Chronologic age does not accurately predict physiologic changes in the elderly; patients' bodies "age" at different rates. There are, however, age-specific shifts in body mass and body water that can be used to project altered drug pharmacokinetics. As patients age, total body water decreases, the proportion of fat increases, and the volume of distribution for lipophilic drugs is subsequently increased. Most IV and inhaled agents used by anesthesiologists are lipophilic (eg, fentanyl, propofol, sevoflurane); therefore, due to extensive redistribution, a longer elimination phase is likely in the elderly.[52]

Although redistribution plays a major role in the cessation of some anesthetic drug effects, metabolic changes in the elderly due to organ system changes in both the kidney and liver can influence drug pharmacokinetics that manifest as clinically appreciable pharmacodynamic differences. Kidney mass decreases with age, resulting in up to a 60% loss of glomeruli.[53] Both glomerular filtration rate and renal blood flow are reduced with age. This finding may be in the setting of normal serum creatinine levels due to the decreases in muscle mass and creatinine production that occur in aging. Evaluating glomerular filtration rate and creatinine clearance are more predictive of drug metabolism and renal elimination than serum creatinine levels alone. Presence of co-morbidities that affect renal health (eg, diabetes, congestive heart failure, hypertension) will additionally make the kidney more susceptible to injury and decrease its functional capacity. In addition, renal failure has been linked to prolonged neuromuscular blockade after administration of nondepolarizing neuromuscular blocking agents, including rocuronium.[54]

Liver mass also decreases with age and is accompanied by a resultant decrease in hepatic blood flow. These physiologic changes may not significantly affect hepatic function, and commonly assessed laboratory values to determine liver health (serum albumin and bilirubin) are often normal.[53] Conversely, hepatic clearance of drugs may be changed. Drugs with high liver extraction (morphine) may have increased plasma concentrations due to decreased blood flow limiting drug delivery to the organ.[55] For drugs that do not rely on blood flow–limited metabolism, the clinical significance of hepatic age–related changes is less clear. Phase I reactions (principally based on the cytochrome P450 system) alter drugs via oxidation, reduction, or hydrolysis and are likely affected by the decreased liver mass.[56,57] In addition, the daily use of opioids or other drugs (eg, antidepressant agents, antiepileptic agents) to treat common conditions can alter the activity of specific cytochrome P450 enzymes, leading to an unpredictable metabolic profile. Kharasch et al[58] noted that the opioid alfentanil is an excellent probe of hepatic cytochrome P450 system activity. Phase II reactions that metabolize drugs via conjugation do not appear to be reduced with age.[55]

DRUG–DRUG INTERACTIONS/ POLYPHARMACY

Given the unpredictable pharmacodynamics and pharmacokinetics in elderly patients, extra care must be afforded to these patients to prevent drug–drug interactions. In addition to the induction of hepatic enzymes, many drug–drug interactions can potentially affect the perioperative period. Each patient's home medications should be reviewed when planning his or her anesthetic and postoperative care. Elderly patients account for 30% of the drug prescriptions in the United States.[59] The typical anesthetic may require the

administration of a dozen medications. One interpretation is that the perioperative period should be considered similarly to the Beers Criteria established by the American Geriatric Society for identifying inappropriate or extraordinary prescriptions.[60] Medications commonly used in the perioperative period that have been shown to be of concern in the elderly, particularly when combined with other therapies, are benzodiazepines,[61] insulin, first-generation antihistamines,[3] NSAIDs,[62] metoclopramide,[63] methylene blue,[64,65] and anticholinergic agents.[66]

POSTANESTHESIA RECOVERY AND THE POSTANESTHESIA CARE UNIT

Pain

Postoperative pain management in the elderly provides a number of challenges. Appropriate analgesia is necessary to prevent complications from underlying systemic issues (as mentioned earlier), but pain medication selection must take into account possible adverse effects. The current focus of management is to use a multimodal approach (rather than relying on systemic opioids alone) to limit the risk of respiratory depression and, in some cases, even delirium. Multimodal techniques and medications include regional anesthetic techniques, acetaminophen, NSAIDs, systemic opioids, and other therapeutics.

Regional Anesthetic Techniques

Neuraxial blocks such as epidurals, peripheral nerve blocks (either single or continuous catheter), or local injection at the site of surgery are excellent options for managing postoperative pain. Using local anesthetics, these techniques can often provide adequate postoperative analgesia without the need for supplemental parenteral medications, including opioids. Epidural analgesia is commonly used for upper abdominal and thoracic surgery to provide postoperative pain relief. A Cochrane review from 2012 concluded that epidural analgesia provided better relief for the first 3 postoperative days, and reduced the need for postoperative mechanical ventilation, in patients who underwent open abdominal aortic surgery.[67] Common local anesthetics used include bupivacaine and ropivacaine with or without opioids. Low concentrations allow for less motor blockade and earlier ambulation. Peripheral nerve blocks are typically used for surgery on the extremities or abdomen (eg, transversus abdominis plane blocks). Perineurial catheters can be used for longer durations of pain relief, and patients can be sent home with them in place (assuming appropriate home care support is available). Several adjuncts to the injected medication (ie, dexamethasone or epinephrine) can be added to augment efficacy and prolong duration. A longer acting liposomal encapsulated formulation of bupivacaine is available but is not yet approved by the US Food and Drug Administration for either epidural or peripheral nerve block use.

Nonopioid Systemic Pain Relief

Acetaminophen and NSAIDs are excellent nonsedating choices for surgical pain. Acetaminophen is available in 3 formulations: oral, rectal, and IV. It is a centrally acting antipyretic and analgesic. The recent advent of an IV form allows for ease of use in postoperative patients who retain a "nothing by mouth" status. IV dosing is typically 1 g per dose with a maximum of 4 g/d to prevent toxicity and potential liver failure. The dosing may need to be adjusted in patients with hepatic insufficiency, and it should not be used in patients with significant hepatic impairment. An efficacy study in geriatric patients with hip fracture found that scheduled use of acetaminophen resulted in decreased opioid requirements.[68] Ketorolac, ibuprofen, and diclofenac have been used for many years as an adjunct for postoperative analgesia in the postanesthesia care unit (PACU) and can be given orally, intravenously, or intramuscularly. A meta-analysis by De Oliveira et al[69] found a greater reduction in opioid use with a 60-mg ketorolac dose given intramuscularly. IV ibuprofen was introduced in 2009 for postoperative analgesia. There is evidence that a combination of both acetaminophen and NSAIDs offers improved analgesia compared with either agent alone.[70] Ketorolac (like all NSAIDs) inhibits platelet aggregation and should be used in consultation with the surgical team because they may wish to avoid this effect in certain procedures. Impaired renal function (which is particularly important in the elderly population) can limit or preclude the administration of ketorolac. Similarly, the risk of gastrointestinal complications should also be considered in elderly patients receiving NSAIDs.

Opioids

Systemic opioids retain a prominent role in postoperative analgesia. However, care must be taken in the

elderly population given the effects of these opioids on respiration and sedation. Opioids can interfere with sleep architecture and, in some cases, contribute to postoperative delirium in the elderly.[71] In addition, the physiologic changes associated with respiratory depression (eg, hypoxia, hypercarbia) can worsen myocardial ischemia and increase the pressure in the pulmonary circulation. Pain can also be a cause of postoperative delirium in elderly patients.[72] The use of opioids should therefore not be avoided but should be part of a deliberate, multimodal approach for postoperative analgesia.

Mental Status Evaluation

Mental status is an important part of the postoperative assessment and should be "periodically" evaluated according to recommendations of the American Society of Anesthesiologists.[73] Currently, there is no standard criteria for specifically evaluating the cognitive status of an individual after general anesthesia. Delirium is associated with an escalation in care and increased hospital costs. Because the incidence of delirium (postoperative or otherwise) is higher in hospitalized elderly patients, there is great interest in identifying at-risk populations and avoiding delays in diagnosis. Screening tools have been used to detect postoperative delirium, such as the Confusion Assessment Method, most often used in the ICU along with the Richmond Agitation and Sedation Score.[74] Physostigmine, a reversible cholinesterase inhibitor, alleviates some of the symptoms caused by anticholinergic drugs and has demonstrated some benefit in management of delirium even if the patient has not received anticholinergic drugs.[75] In addition, antipsychotic agents (eg, haloperidol) have been shown to reduce the occurrence of postoperative delirium, in addition to being effective options for reducing postoperative nausea and vomiting (PONV).[76] There is concern among some anesthesia providers regarding the potential for adverse long-term cognitive consequences after anesthesia for elderly patients.[77]

Pulmonary Complications during Anesthetic Recovery

Age changes lung volumes by decreasing vital capacity, with a corresponding increase in residual volume, closing capacity, and dead space.[78] As a result, hypoventilation and the potential for ventilation–perfusion mismatch increases, placing elderly patients at risk for developing hypoxia and hypercarbia. In addition, geriatric patients have been shown to have an elevated risk of developing pneumonia and atelectasis.[79] The use of deep breathing exercises, noninvasive positive pressure, or incentive spirometry after thoracic and upper abdominal surgery may confer further benefits for the elderly population more so than for a younger cohort.[80] The prevalence of COPD in patients >65 years old is estimated to be up to 18%[81] and has been shown to be an independent predictor of mortality in octogenarians undergoing cardiac surgery.[82] Optimizing COPD with β-agonists and inhaled corticosteroids before surgery may improve pulmonary mechanics postoperatively and prevent PACU complications. Neuromuscular-blocking drugs (NMBD) (ie, rocuronium, cisatracurium) are of moderate lipophilicity and, due to an overall decrease in total body water, bolus dosing may result in higher than expected blood concentrations.[52] A recent study examining postoperative pulmonary complications associated with neuromuscular blockade found that 6% of patients aged 66 to 75 years and 8% of those aged >75 years experienced a postoperative pulmonary complication.[83] Even in the setting of high-dose NMBD administration, younger patients (ie, those aged <55 years) had pulmonary complications as a result of NMBD administration less than one half as frequently as their elderly counterparts (0.97%–2.6%).

The prevalence of obstructive sleep apnea (OSA) in an older population (age >65 years) has been estimated to be between 24% and 44%.[84] Studies in the elderly have shown that typical features associated with OSA in the middle-aged population, such as snoring[85] and obesity,[86] do not always herald the presence of OSA in the geriatric population. It may be more difficult to preoperatively identify older patients with undiagnosed OSA.[87] In addition, postmenopausal women are as likely as men to have OSA. Using the STOPBang Questionnaire may be helpful for preoperative assessment of the geriatric patient; anesthesiologists should also be suspicious of the disease in patients with a medical history of nocturia, frequent falls,[88] cognitive changes,[89] and decreasing attention/vigilance.[90] An anesthetic with carefully titrated doses of opioids and neuromuscular blockade, in addition to close observation in the postoperative period, is needed for patients with known or suspected sleep apnea.

Temperature Monitoring

Temperature assessment and management are particularly important in the geriatric patient, as multiple

studies have shown this population to be at higher risk for postoperative hypothermia.[59] The response to thermoregulatory vasoconstriction at cooler temperatures is reduced in anesthetized elderly patients (aged 60–80 years).[91] Peripheral integumentary sympathetic receptors demonstrate a decreased response to hypothermia.[92] Aging limits the patient's visceral sympathetic response to cooling while anesthetized.[93] Shivering is less effective at correcting hypothermia in the geriatric population compared with younger patients, likely a result of decreased muscle mas.[94] Older patients are thus less able to compensate for core heat loss caused by redistributive effects under anesthesia and peripheral loss caused by radiation, conduction, and evaporation. Shivering related to hypothermia in the PACU increases oxygen demand, heart rate, and blood pressure. All of these factors can result in myocardial ischemia. Maintenance of normothermia in the PACU, with active warming as required to keep the patient's core temperature $>36^{\circ}$ C, may decrease the risk of ischemic events and ventricular dysrrhthmias.

Dysphagia

Approximately 15% of elderly patients are affected by dysphagia.[95] However, in those with concomitant neurologic disease, the incidence of oropharyngeal dysphagia may increase to 50%.[96] Dysphagia can be the result of structural disease (tumor, prior surgery, or trauma) or impaired physiology (motility dysfunction or sensory impairment). Muscle mass is diminished in elderly patients and can cause the swallow reflex to lose strength, particularly when these patients are exposed to illness and have diminished reserve.[97] This places elderly patients at risk of malnutrition and dehydration before surgery, conditions that can affect their surgical and healing course. Postoperatively, dysphagia predisposes elderly patients at risk for aspiration pneumonia.[98] Elderly patients with prolonged hospitalizations, living in nursing homes/care facilities, patients with Alzheimer's disease/dementia, and patients with prior stroke should be given special consideration in the PACU as high risk for aspiration. The incidence of dysphagia in these groups is increased compared with older patients who live independently.[95] Patients with neuromuscular disease such as myasthenia, amyotrophic lateral sclerosis, and PD are also at risk of poor swallow function. Patients in the PACU at high risk for aspiration should have the head of the bed elevated to 30 degrees. In addition, minimizing sedatives and cautious use of opioids will help limit pharyngeal dysfunction and aid in the mobilization of oral secretions. Testing patients for dysphagia by use of a 3 oz liquid swallow challenge has been performed at the bedside to evaluate swallowing function. The test exhibits good sensitivity for predicting aspiration risk.[99]

Postoperative Nausea and Vomiting

A primary risk factor for PONV includes younger age (ie, <50 years). However, patient factors alone do not accurately predict the risk of PONV; surgical factors and anesthetic techniques also increase the incidence of PONV, even in low-risk populations. Nausea and vomiting produce significant patient dissatisfaction and can cause surgical complications after the following procedures: esophageal/gastric; ear, nose, and throat; oral and maxillofacial; facial plastic; and neurosurgical. The Society for Ambulatory Anesthesia 2013 guidelines[100] assess risk on the basis of current data and are an evolution of the original scoring system developed by Apfel et al.[101] For older patients with ≥ 1 risk factor, especially those undergoing surgeries associated with a high risk of emesis (eg, cholecystectomy, laparoscopic surgery, gynecologic surgery), anti-nausea medications should be prophylactically administered. Medications such as aprepitant,[102] ondansetron, and dexamethasone[103] have shown to be of benefit. Among elderly patients, the benefits of dexamethasone should be weighed carefully against potential complications such as impaired wound healing and the potential for exacerbating underlying conditions such as diabetes. A reduction in dose is therefore appropriate in many instances. The transdermal scopolamine patch has also proven to be an efficacious prophylactic agent; however, its anticholinergic activity may cause adverse effects in elderly patients taking multiple anticholinergic drugs. IV anesthesia with propofol also decreases the risk of immediate PONV compared with volatile agents. Postoperative opioids contribute to nausea and vomiting; alternative nonopioid analgesics may aid in pain control without exacerbating nausea.

Postoperative Urinary Retention

Postoperative urinary retention (POUR) has been estimated to occur in $\sim 2\%$ of surgical patients being tracked by the Surgical Care Improvement Project (SCIP).[104] POUR is defined as the inability to void in the presence of a full bladder.[105] This condition results

Table 1. Summary of anesthetic considerations for specific cases commonly encountered in the elderly population.

Procedure	Special Considerations for Elderly Patients	Recommendations	Reference
Carotid endarterectomy	Stroke is the most common cause of disability in adults and the third leading cause of death 50% narrowing found in 6% of men aged 70–79 years and 3.6% of women of the same age CEA is the procedure of choice for symptomatic high-grade stenosis NASCET study showed a decreased incidence of CVA, from 26% with medical therapy alone to 9% with CEA for stenosis >70%	Avoid intraoperative hypotension, maintain blood pressure, and cerebral perfusion Consider regional anesthesia (cervical plexus block) because it allows the patient to remain awake, while continuing to assess the neurologic status Regional anesthesia decreases the incidence of hypotension and use of vasopressors. Postoperative risks are hyperperfusion and bleeding	96–102
Laparoscopic surgery	CV effects include: compression of the inferior vena cava, leading to decreased preload, stroke volume, and cardiac output Many elderly patients are taking antihypertensive agents such as β-blockers, and their natural physiologic response to decreased CO may be attenuated	Careful consideration of patient position; optimal positioning for surgery usually involves a steep Trendelenburg position, which can increase blood pressure and decrease cardiac output (caution is needed in patients with heart failure and/or pulmonary hypertension) Quality postoperative respiratory management for early identification and treatment of atelectasis, hypoventilation, pneumonia, hypercarbia, and respiratory acidosis. Including incentive spirometry, continuous positive airway pressure, physiotherapy, early ambulation, and good pain control	103–104
Herniorrhaphy	Hernia repair is the most common procedure in patients aged >65 years	TAP block is a safe alternative to general anesthesia for hernia repair at T10 dermatome or lower. TAP block has a superior recovery and analgesic profile Regional/neuraxial techniques (TAP or spinal) can be used to decrease the need for systemic narcotics intraoperatively and postoperatively	105–107

(continued)

Table 1. (continued).

Procedure	Special Considerations for Elderly Patients	Recommendations	Reference
Transurethral resection of the prostate or bladder	Prostate cancer is the second leading cause of cancer-related death in the United States. Nine of 10 affected are aged ≥55 years; mean age of diagnosis is 73 years The elderly are especially susceptible to physiologic derangements, and care should be made to limit resection time, the pressure of irrigation fluid, and type of irrigation fluid	Potential complications include dilutional hyponatremia, hypothermia, coagulopathy, bleeding, anemia, glycine toxicity, ammonia toxicity, bacteremia, and bladder perforation Careful management of intraoperative fluids and electrolytes. Watch for transurethral resection of the prostate syndrome caused by excessive fluid absorption. Symptoms include HTN, bradycardia, hypotension, dysrhythmias, pulmonary edema, hypoxemia, hyperglycemia, hypo-osmolality, metabolic acidosis, seizures, coma, and death	108
Peripheral vascular bypass/ endarterectomy	The incidence of peripheral artery disease is ~1 of 5 in patients aged >65 years Elderly are especially sensitive to effects of lengthy surgery, fluid shifts, temperature shifts, and blood loss	Limit exposure of body surface area to prevent hypothermia. Maintain euthermia using a combination of a forced warm air heating blanket, warmed intravenous fluids, and accurate temperature monitoring Caution with arterial cross-clamp application/ release in elderly who may be sensitive to metabolic derangements and acute changes in blood pressure	109
Orthopedic and podiatric surgery	Among the most common types of procedures in the elderly Elderly are sensitive to hypoactive effects of anesthetics, especially opioids Presence of blood thinners and difficult anatomy (narrowed/ossified intervertebral spaces) makes regional anesthesia challenging	Regional anesthesia techniques such as spinal, epidural, and peripheral nerve block reduce postoperative neurologic, cardiac, pulmonary, and endocrine complications Peripheral nerve blocks not only reduce postoperative pain but total opioid use, postoperative nausea and vomiting, and time in the recovery room. Nerve blocks are also associated with increased patient satisfaction	56,110

CEA = carotid endarterectomy; NASCET = North American Symptomatic Carotid Endarterectomy Trial; CVA = cerebrovascular accident; CV = cardiovascular; CO = cardiac output; TAP = transversus abdominus plane; HTN = hypertension.

in significant bladder stretch; however, patients may or may not have symptoms of discomfort and abdominal distension.[106] In the SCIP database, age was a statistically significant risk factor for developing POUR.[104] Hip and colon surgery were higher risk surgeries in the SCIP database; other studies report POUR after pelvic surgery, including hysterectomy,[107] anorectal surgery, and hernia repair, both open[108] and laparoscopic.[109] Across the varied types of surgeries, patients who develop POUR are at higher risk for catheterization, urinary tract infections, and longer hospital stays.

Dose of opioid has been linked to urinary retention in some studies[109,110]; however, there is no clear dose-related risk with IV opioid use. Epidural opioids interact with spinal cord receptors to decrease the detrusor muscle strength on contraction. Administration of intrathecal opioids decreases the parasympathetic firing of sacral input to the bladder, acting to weaken spontaneous bladder contraction.[111] Specifically, intrathecal morphine reportedly increases POUR in elderly men undergoing hip surgery. However, recent data using sonographic evidence to diagnose POUR do not indicate more frequent occurrence in patients using epidural/spinal opioid analgesia than those using systemic opioids.[105] Epidural local anesthetics are also associated with urinary retention.[112] Daurat et al[113] showed that a single measurement of largest transverse bladder diameter helped to confirm/exclude urinary retention postoperatively.

CONCLUSIONS

When caring for the aged patient, the anesthesiologist must account for changes in various organ systems that affect perioperative care, including the cardiovascular, pulmonary, renal, hepatic, and central nervous systems. The pharmacokinetic principles are frequently different and often unpredictable due to anatomic changes and decreased renal and hepatic function. Elderly patients tend to exhibit a more profound hypoactivity after anesthesia. This effect could be related to their increased risk of co-morbid conditions, their increased list of prescribed medications, age-related changes in central nervous system function, or hypoactive delirium. Before surgery, it is essential to identify those patients at risk for delirium and other commonly encountered postanesthesia scenarios; failure to manage these conditions can lead to an escalation of care and prolonged hospitalization (Table 1).

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CONFLICTS OF INTEREST

The authors report no relevant conflicts of interest.

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