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REVIEW ARTICLE

Perioperative Care of Elderly Surgical Outpatients

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Abstract The ambulatory setting offers potential advantages for elderly patients undergoing elective surgery due to the advancement in both surgical and anesthetic techniques resulting in quicker recovery times, fewer complications, higher patient satisfaction, and reduced costs of care. This review article aims to provide a practical guide to anesthetic management of elderly outpatients. Important considerations in the preoperative evaluation of elderly outpatients with co-existing diseases, as well as the advantages and disadvantages of different anesthetic techniques on a procedural-specific basis, and recommendations regarding the management of common postoperative complications (e.g., pain, postoperative nausea and vomiting [PONV], delirium and cognitive dysfunction, and gastrointestinal dysfunction) are discussed. The role of anesthesiologists as perioperative physicians is important for optimizing surgical outcomes for elderly patients undergoing ambulatory surgery. The implementation of high-quality, evidence-based perioperative care programs for the elderly on an ambulatory basis has assumed increased importance. Optimal management of perioperative pain using opioid-sparing multimodal analgesic techniques and preventing PONV using prophylactic antiemetics are key elements for achieving enhanced recovery after surgery.

Key Points

Performing a thorough preoperative assessment, careful hemodynamic and respiratory monitoring during the perioperative period, use of short-acting anesthetic drugs which are adjusted based on patient age and co-existing medical conditions, achieving complete neuromuscular recovery at the end of the procedure, and preventative analgesia are important factors in insuring an optimal recovery for elderly outpatients.

Strategies to minimize the use of opioids in the perioperative period will minimize adverse side effects (e.g., ventilator depression, constipation, urinary retention) and postoperative opioid dependency. Use of effective non-opioid analgesic techniques is an important factor in expanding the use of ambulatory surgery for the elderly surgical population.

A combination of prophylactic antiemetic drugs should be administered to elderly outpatients with moderate-to-high risk of developing postoperative nausea and vomiting in order to facilitate the recovery process.

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1 Introduction

Population aging is a global public health challenge [1–3]. The proportion of the world population aged ≥60 years will increase from 11.0% in 2010 to 21.8% in 2050 while the portion aged ≥80 years (i.e., 'oldest-old' or geriatric) will increase from 1.5 to 4.3% (http://esa.un.org/unpd/wpp/unpp/p2k0data.asp). It has been estimated that elderly people require surgery four times more often than the rest of the population, and that this number will increase by 25% by 2020 [4]. Given the economic and social pressure to reduce healthcare expenditures, it is imperative that strategies are developed to meet these growing demands and to ensure higher quality care for elderly surgical patients [5, 6].

Given the recent advances in anesthesia, surgery, and monitoring technology, the ambulatory setting offers many potential advantages for elderly patients undergoing elective surgery [3, 7]. The most common procedures for elderly outpatients can be performed with minimally invasive surgery techniques and are safely manageable in ambulatory settings. However, age is independently associated with a greater rate of unanticipated hospital admission within 30 days of ambulatory surgery [8]. Efficient ambulatory surgery centers rely on anesthesia regimens that facilitate early recovery, provide high-quality analgesia, and have low levels of postoperative nausea and vomiting (PONV) and low rates of unplanned hospital admission [9]. This review article aims to provide a practical guide to anesthetic management of elderly outpatients.

2 Preoperative Assessment

The preoperative assessment should identify potential risk factors of the proposed operative procedure (e.g., diabetes mellitus, cardiovascular disease, pulmonary disorders, hepatic disease, or renal impairment) [10–12]. Comprehensive history and physical examination and appropriate laboratory testing are the initial steps to preoperative evaluation. A study by Chung et al. involving 1000 outpatients reported that there was no difference in the incidence of adverse perioperative events between those receiving no preoperative laboratory testing and those undergoing 'routine' lab testing [13]. These data suggest that for the majority of older patients with well-controlled (stable) coexisting diseases, routine (screening) lab tests are not necessary. Preoperative diagnostic tests should be performed selectively, and limited to higher risk patients with known comorbidities, and the type of procedure to be performed [14–16].

2.1 Diabetes Mellitus Assessment

In the perioperative period, uncontrolled diabetes mellitus can result in electrolyte imbalances, dehydration, and wound infections [17, 18]. An optimal interventional strategy for uncontrolled diabetes mellitus utilizing intravenous (IV) insulin for type I diabetics, and oral hypoglycemic drugs and/or parenteral insulin for type II diabetics are necessary. There are no present guidelines on perioperative glycemic control. A reasonable approach would be to maintain blood glucose at <200 mg/dL intraoperatively and <150 mg/dL postoperatively, but avoid levels <80 mg/dL [18]. Minor ambulatory surgery is not associated with a clinically relevant increase in glucose. The small increase in blood glucose level after surgery is clinically insignificant and may be attributed to the use of dexamethasone for PONV prophylaxis [19].

2.2 Cardiac Risk Assessment

Cardiovascular diseases are common among elderly outpatients, including hypertension, chronic heart failure, arrhythmias, and ischemic heart disease. Elderly patients are more vulnerable to perioperative cardiac adverse events [20]. Therefore, it is critical to evaluate elderly patients with higher risk of cardiac complications according to the American College of Cardiology and American Heart Association (ACC/AHA) algorithm for noncardiac surgery [21]. Preoperative risk assessment should focus on three elements: the surgical risk for cardiac events after the planned procedure, patient functional capacity, and risk indices [22]. Evaluation of cardiac reserve is more important than the resting value of ejection fraction. Functional capacity should be >4 metabolic equivalents (METs), which corresponds to the ability to climb two flights of stairs. There is a clear consensus to continue most chronic medications up to and including the day of surgery (particularly β-blockers and statins) [14, 23]. However, less compelling evidence exists on continuing calcium-channel blockers, angiotensin-converting enzyme inhibitors, and angiotensin-receptor-blocking drugs [23, 24]. A controversial issue in elderly outpatients is perioperative continuation of antithrombotic drugs and/or platelet inhibitors [25], particularly when regional anesthesia is planned. A comprehensive guideline by the European Society of Anesthesiologists on Regional Anesthesia suggests that elderly patients should continue antiplatelet drug therapy if they are undergoing ambulatory procedures [26, 27].

2.3 Respiratory Risk Assessment

Advanced age is an important predictor of postoperative pulmonary complications, including aspiration, pulmonary

edema, atelectasis, and pneumonia [17]. Patient-related risk factors include age >60 years, ASA ≥II, chronic obstructive pulmonary disease (COPD), functional dependence, and congestive heart failure, while procedure-related risk factors include prolonged surgery (>3 h), head and neck surgery, thoracic surgery, neurosurgery, abdominal surgery, vascular surgery, emergency surgery, and general anesthesia [17]. In a review, Smetana and Conde further identified pulmonary hypertension and obstructive sleep apnea (OSA) as emerging pulmonary risk factors [28]. Regarding laboratory testing to reduce risk, serum albumin level <35 g/L is a strong predictor of increased postoperative pulmonary complication risk. The guideline of the American College of Physicians recommends that clinicians should employ strategies to reduce postoperative pulmonary complications in elderly patients who are at high risk after clinical risk stratification. Preoperative spirometry and chest radiography may be useful in patients with past history of COPD or asthma, along with risk reduction strategies (e.g., incentive spirometry and deep breathing exercises) [29]. In COPD patients, preoperative tiopropium may reduce postoperative pulmonary complication rates, and preoperative systemic corticosteroids may also be useful in the elderly with chronic pulmonary diseases [17]. Smoking cessation has been shown to decrease risk of perioperative complications, and should be strongly encouraged at least 4 weeks before surgery [30, 31]. Patients with OSA had an increased risk of perioperative events requiring additional anesthetic management [15]. A decision regarding the suitability of elderly obese patients with OSA for ambulatory surgery depends on the invasiveness of the procedure, the choice of anesthesia, the severity of the airway obstruction, the presence of comorbidities, the need for postoperative opioid analgesics, and the level of home care [3].

2.4 Renal Function Assessment

Preventing perioperative acute renal failure is another important consideration in elderly patients, particularly those with preexisting renal insufficiency, diabetes, and long-standing hypertension. Serum creatinine concentration is an insensitive indicator of renal function in the elderly as it is influenced by nonrenal factors such as age, sex, total muscle mass, race, and diet [32]. Strategies used to optimize an elderly patient's renal function include optimal hydration, careful blood pressure control, electrolyte imbalance correction, drug dosage adjustment, avoidance of nephrotoxic drugs, monitoring blood glucose, and estimating creatinine clearance [17]. Patients with preexisting renal failure and at risk for postoperative renal impairment should have their urine output monitored carefully throughout the perioperative phase and adequate hydration should be provided to prevent any deterioration [33].

2.5 Functional Status Assessment

Improving functional status may be as important as optimizing their medical treatment, as many elderly patients are frail (up to 30%). Functional level assessment should be practiced throughout the perioperative period using a validated scale that includes an assessment of weakness, weight loss, exhaustion, low physical activity, and slowed walking speed [34]. Identification of risk factors for these geriatric syndromes may promote restoration of compensatory ability and prevent the onset of functional dependence [35]. Functional exercise capacity can be increased through structured training programs, and has been shown to improve outcomes in elderly surgical patients [36, 37].

2.6 Nutritional Risk Assessment

Poor nutritional status is associated with perioperative complications that increase the risk for pneumonia, extended intubation, prolonged wound healing and infection, sepsis, and 30-day mortality [38]. Protein energy malnutrition is the most common nutritional inadequacy found in the geriatric population. Several nutritional status indicators (e.g., serum albumin concentration, mid-arm muscle circumference, usual weight percentage, presence of decubitus ulcers, dysphagia) have proven to be valuable predictors of mortality in geriatric patients [39].

3 Effects of Aging on Anesthetic Drugs

Age-related pharmacokinetic changes in drug distribution, metabolism, and elimination have a significant impact on drug dosing in elderly patients [3, 40] (Table 1). Aging results in an overall loss of neurons in both cerebral cortex and spinal cord, which enhances the sensitivity of the elderly to centrally active anesthetic drugs (e.g., opioid analgesics, volatile agents, benzodiazepines, and sedative hypnotics [IV anesthetics] [41–43]) and the local anesthetics used in neuraxial and peripheral nerve blocks (PNBs). An age-related increase in adipose tissue leads to an expansion of the 'lipid (deep) reservoir' (i.e., total volume of distribution) for centrally active anesthetic drugs, contributing to prolonged elimination half-life values and an increased duration of action of these drugs in the elderly. However, the reduction in total body water decreases the central volume of distribution for water-soluble drugs, resulting in higher average and peak plasma

Table 1 Age-related physiologic changes and clinical implications for anesthesia

	Physiologic alterations	Clinical implications
Cardiovascular	Decreased sympathetic response	Labile blood pressure
	Reduced vascular elasticity	Susceptibility to hypotension
	Decrease in preload	Susceptibility to volume overload
	Baroreceptor response impaired	Exaggerated decline in cardiac function with inadequate cardiac filling
	Cardiac diastolic dysfunction	Profound cardiovascular-depressing effects of anesthetics
	Cardiac interstitial fibrosis	
Pulmonary	Increased pulmonary arterial pressures	Increased A—a gradient
	Decreased response to hypoxia and hypercarbia	Higher risk of hypercarbia, atelectasis and hypoxemia
		Susceptibility to residual anesthetic effects
	Decreased elasticity in lung parenchyma and chest wall	Increased work of breathing
		Increased dead space ventilation
	Increased closing capacity of the smaller airways	Impaired pharyngeal function: reduced cough reflexes, increased risk of aspiration
	Decreased cough reflex and esophageal motility	Increased ventilation/perfusion (V/Q) mismatch, reduction in baseline PaO_2
	Weakening of respiratory muscles (loss of muscle mass)	
Nervous system	Reduction in brain mass, number of neurons, neurotransmitters and receptors	Increased risk of postoperative delirium and cognitive dysfunction
		Decreased autonomic responsiveness (diminished central response to hypercapnia/hypoxemia, autoregulation, decreased parasympathetic function)
	Reduced number of pain-transmitting peripheral nerve fibers	Slower and decreased pain perception and ability to report pain
		Higher sensitivity to most anesthetics
Endocrine system	Impaired glucose tolerance	Increased intraoperative hyperglycemia
Hepatic/renal system	Altered drug metabolism	Decreased drug clearance
	Decreased hepatic blood flow	Diminished albumin levels result in increased free-fraction concentration of highly protein-bound drug
	Decreased renal mass	
	Reduction in hepatocyte mass and function, modified architecture	Susceptible to acute kidney injury
		Use medications with renal toxicity risk cautiously (e.g., NSAIDs)
Thermoregulation	Decreased muscle mass	Increased risk of hypothermia
	Decreased vascular reactivity	

NSAIDs nonsteroidal anti-inflammatory drugs

drug concentrations and an enhanced peak effect [44]. Older patients with poor nutrition can have a 20% or more decrease in albumin levels. Because many anesthetic drugs are highly bound to albumin (e.g., propofol, diazepam), even modest decreases in albumin levels can increase free-drug concentrations, contributing to increased sensitivity to these drugs in the elderly. Liver mass decreases by 20–40% during the typical human lifespan, with a concomitant decline in hepatic blood flow [45, 46]. The kidneys lose approximately 10% of parenchymal thickness per decade of life [47], accompanied by a 10% decline in renal blood flow per decade, contributing to a 30–50% decrease in creatinine clearance between the ages of 20 and 90 years [44]. Impaired hepatic and renal functions in elderly patients affects the metabolism and excretion of many different anesthetic, analgesic, and muscle relaxant drugs [48].

4 Anesthesia Management

Elderly patients may have a higher risk of complications for general anesthesia compared with local anesthesia [49]. However, in a case-control study, age per se was not an independent risk factor of serious morbidity or mortality under general anesthesia in the ambulatory setting [50]. The use of general anesthesia can be dictated by patient preference, surgeon preference, type of surgery, or by the patient's preexisting comorbidities. With neuraxial anesthesia, age-related cardiovascular alterations, sympathetic block, and consequent decrease in peripheral vascular resistance may produce hypotension and bradycardia, with potentially dangerous consequences in the case of reduced cardiovascular reserve. The choice of the anesthetic technique appears to play a minor role in recovery from anesthesia or in the occurrence of minor postoperative

complications or home discharge, except for the use of total intravenous anesthesia to reduce the risk for PONV [51].

4.1 General Anesthesia

Reduced levels of neurotransmitters, neuronal density, and innervation of skeletal muscles are predictable consequences of aging and cause a reduction in the anesthetic requirement [22]. Reducing the dosage and careful titration of anesthetic drugs is essential for elderly outpatients (Table 2). Both reduced cardiac index (which causes increased induction time) and reduced baroreflex response (which causes reduced compensatory tachycardia) may allow overdosing of IV anesthetics. Discrepancies between end-expiratory and plasma concentration, which are due to reduced alveolar exchanges, increase the risk for overdosing inhaled anesthetics. Elderly patients have up to a 2-fold increase in sensitivity to the ventilatory-depressant effects of opioid analgesics compared with younger patients, and thus require lower doses [52]. Benzodiazepines also exert a more potent and prolonged sedative, amnestic, and respiratory-depressant effect in older patients [53]. The α-2 agonist dexmedetomidine can be used as an alternative to opioid analgesics for maintenance of spontaneous ventilation in the fragile elderly patient [54]. However, residual sedation and hypotension after discontinuation of a dexmedetomidine infusion can be problematic in the ambulatory setting [55]. Psychomimetic ketamine-related reactions appear less common in elderly patients, particularly in combination with benzodiazepine or propofol [56]. Despite a continuing controversy regarding its potential to increase PONV and risk of postoperative myocardial infarction, use of nitrous oxide as an adjuvant to the volatile and IV anesthetics can be beneficial for elderly outpatients because of its rapid elimination and anesthetic- and analgesic-sparing effects [57]. The dose of neuromuscular blocking drugs should be modestly reduced in the elderly because of reduced rates of elimination.

In the ambulatory setting, anesthetics should ideally be fast-acting with quick offset time and minimal postoperative side effects. The old adage to "start low and go slow" applies when administering anesthetic medications to elderly patients in the ambulatory setting. Elderly outpatients should have minimal, if any, sedative premedication in the ambulatory setting to avoid prolonging emergence from anesthesia. Short-acting benzodiazepines (a dose of 0.5–1 mg of midazolam IV) and propofol (20 mg) are preferred for premedication if necessary to reduce anxiety and facilitate patient positioning [58]. An empathic patient-centered intervention can reduce preoperative anxiety and increase surgical recovery, wound healing, and patient satisfaction [59]. Since elderly patients have a less-compliant vasculature system and a higher incidence of chronic hypertension, they are more prone to develop hypotension after induction of anesthesia. General anesthesia induction with titrated IV doses of propofol will minimize acute cardiorespiratory depression. A small dose of a potent opioid (e.g., fentanyl 0.5 μg/kg IV) may be useful prior to the procedures to minimize acute autonomic responses and movements in response to painful stimuli. Less soluble volatile anesthetics such as desflurane or sevoflurane allow for ideal anesthetic depth and can facilitate a quicker

Table 2 Recommended anesthetic drug dosage adjustments for elderly ambulatory surgery patients

	Usual quoted doses	Suggested adjustments
Intravenous agents		
Propofol	Bolus 1.5–2.5 mg/kg	20% reduction in bolus dose
	Infusion 4–12 mg/kg/h	30% reduction in infusion
Etomidate	0.3–0.4 mg/kg	0.2 mg/kg
Midazolam	0.2–0.3 mg/kg	0.05–0.15 mg/kg (premedication)
		20% reduction (aged >55 y)
		75% reduction (aged >90 y)
Inhalational agents		
Isoflurane	1.2%	Minimum alveolar concentration is reduced by 6% per decade of increasing age
Sevoflurane	1.8%	
Desflurane	6.6%	
Opioids		
Fentanyl	1–2 μg/kg for short-term analgesia	50% reduction in dose
Morphine	0.1–0.2 mg/kg	50% reduction in dose
Remifentanil	Bolus 0.5–1 μg/kg	50% reduction in bolus dose
	Infusion 0.2–0.5 μg/min	33% reduction in infusion

postoperative recovery process. Total intravenous anesthesia with propofol alone or in conjunction with short-acting opioids (e.g., remifentanil) is gaining popularity. The ester-based muscle relaxants (e.g., cisatracurium) have a more predictable duration of effect in the ambulatory setting than do the steroidal-based muscle relaxants (rocuronium). However, use of steroidal muscle relaxants allows for the use of the new cyclodextrin reversal drug sugammadex when the standard anticholinesterase reversal drugs fail to adequately reverse the residual neuromuscular blockade [48, 60]. Supraglottic airway devices are associated with minimal hemodynamic changes during general anesthesia [61]. A laryngeal mask airway should be considered for qualifying patients as an alternative to tracheal intubation. If tracheal intubation is necessary, neuromuscular blocking agents should be either short or intermediate-acting. Use of the Bispectral Index (BIS) monitor can facilitates early recovery after general anesthesia [62]. A preliminary study suggested that avoiding prolonged periods of 'deep' hypnosis (i.e., low BIS values) may be associated with decreased morbidity and mortality in the elderly population [63].

Target-controlled infusion (TCI) is an anesthetic technique which is designed to improve the perioperative titration of IV drugs for anesthesia and sedation [64]. TCI systems implement pharmacokinetic principles for administration of anesthetic drugs with the expectation that such administration would produce more predictable and stable blood concentrations of the drug in the patient during surgery (or diagnostic) procedures [65]. On the basis of the pharmacokinetic description of an anesthetic drug, TCI can calculate an approximate time course of drug concentration during and after turning off the infusion, thereby providing guidance on IV drug administration during and/or after the procedure. The effect of age in decreasing the anesthetic requirement for propofol should be taken into account when the propofol concentration is targeted using a TCI system [52, 66]. Target concentrations of propofol for anesthesia and/or sedation should be reduced in elderly patients. This is important to avoid perioperative hemodynamic instability. However, the decrease in the overall dose requirement of propofol is relatively modest in most patients [67]. A systematic review revealed that there is no clinically significant difference in terms of quality of anesthesia or adverse events between TCI and a less costly, manually controlled infusion of propofol [68].

4.2 Neuraxial Anesthesia

Spinal anesthetics can result in a complete, dense, and widespread sensory block, allowing for optimal surgical conditions. Epidural anesthesia may provide more precise control of the duration of neuraxial blockade in the ambulatory setting. The term unilateral spinal anesthesia is a one-sided block with minimal sensory and motor block on the non-operative side [69]. The cardiovascular stability following unilateral spinal anesthesia is one of the most important benefits for elderly outpatients with heart disease. Enk et al. concluded the importance of "low-dose, low-volume and low-flow" in the induction of unilateral spinal anesthesia [70]. Maintaining the lateral decubitus position for 10 min produced a unilateral motor block in 87–100% of the patients when a low dose of hyperbaric bupivacaine (3–4 mg) was used [69]. Using a unilateral technique, hyperbaric ropivacaine 7.5 mg and levobupivacaine 5 mg provided adequate spinal anesthesia for knee arthroscopy, with home-readiness after 197 min [71].

Clinicians need to carefully consider both the type and dose of local anesthetics used to prevent unwanted prolonged anesthetic effects that may delay discharge. The prolonged recovery associated with the traditional doses of spinal anesthetics is problematic when used for short-stay surgery procedures (e.g., hernia repair, prostate biopsy, and knee arthroscopy) [72]. When lidocaine is administered, the 50-mg dose should not be exceeded [73]. For single-lower-extremity procedures, hyperbaric bupivacaine 5 mg produces a reliable unilateral block with a reasonable time to home-readiness and a low incidence of side effects [74]. Compared with traditional dosage, utilization of mini-dose intrathecal lidocaine (10–30 mg), bupivacaine (3.5–7 mg), or ropivacaine (5–10 mg) with a potent opioid (e.g., fentanyl 10–25 μg) [22, 69], has been shown to provide optimal surgical conditions while still facilitating faster recovery of motor and sensory function. Unfortunately, even with this technique, the time to discharge home is unpredictable and remains longer than with general anesthetic techniques.

Short-acting local anesthetics (e.g., articaine, chloroprocaine, and prilocaine) are potentially beneficial for day-case surgery in the elderly population due to the shorter duration of the motor block, more predictable discharge times, and less frequent residual transient neurologic symptoms (TNS) [75–77]. In a preliminary study, Casati et al. reported that 2-chloroprocaine (50 mg) provided excellent anesthesia with a faster recovery than lidocaine (50 mg) after knee arthroscopy [75]. Short-acting intrathecal drugs should only be used for procedures lasting <1 h (e.g. knee arthroscopy). Use of shorter acting neuraxial local anesthetic agents may provide superior recovery profiles in the ambulatory setting [78]. Studies involving ultrashort-acting local anesthetics or use of small doses of conventional local anesthetics combined with adjuvants like clonidine can achieve recovery times after ambulatory surgery that are similar to those found with general anesthesia [77, 79]. However, spinal and epidural anesthetic techniques can result in perioperative

hypotension, postoperative urinary retention, nausea and vomiting, dizziness, and delayed ambulation time, particularly in elderly male outpatients [80]. When IV sedation is used to supplement neuraxial anesthetic techniques, the risks of respiratory depression and hemodynamic instability may be higher than with general anesthesia [81].

4.3 Local Anesthetics

Local anesthetics are commonly administered by different routes and at differing sites to manage acute surgical pain (Table 3). Advances in PNB techniques, such as ultrasound guidance, multistimulation, and ambulatory continuous perineural catheters, have contributed to a renewed interest in their use [82, 83]. PNBs significantly reduce opioid requirements postoperatively, facilitate the recovery process, and enable earlier ambulation and discharge home (i.e., 'fast-track' recovery) after orthopedic ambulatory surgical procedures in the elderly [3, 84, 85]. A study by Saporito et al. revealed that the use of continuous regional analgesia with PNBs has an overall positive impact on overall healthcare costs by decreasing the incidence of unplanned ambulatory visits and unscheduled readmissions, without compromising on the quality of analgesia, patient satisfaction, or safety [86]. Another study also found that PNBs reduce total perioperative costs and reduce length of stay after ambulatory foot surgery [5]. Although additional preparation time may be required prior to the start of surgery when 'major' PNBs are performed, improvements in methods of neural localization (e.g., ultrasound techniques) have made this method more reliable [87]. PNBs may also be used as adjuncts to general anesthesia. They improve perioperative analgesia, thereby reducing unanticipated admission as a result of pain or side effects of opioid analgesics [88].

Table 3 Selective regional nerve blocks are highly recommended as primary techniques or adjuncts to general anesthesia for elderly ambulatory surgery patients

Regional nerve blocks	Indications
Interscalene/supraclavicular/infraclavicular	Shoulder surgery
	Hand, forearm, and wrist surgery
Paravertebral	Breast surgery
	Inguinal and umbilical hernia
Lumbar plexus	Knee arthroscopy, patella, and quadriceps tendon repair
	Superficial procedures of anterior thigh
Transversus abdominis plane (TAP)	Urology, gynecology
	General surgery
Femoral/obturator/lateral femoral cutaneous/sciatic	Knee surgery
	Lower limb surgery
Saphenous nerve block at the adductor canal	Knee surgery
	Lower limb, foot, medial ankle surgery
	Saphenous vein stripping
Ilioinguinal/hypogastric	Herniorrhaphy
Paracervical	Dilation/curettage, cone biopsy

Peripheral regional anesthesia (e.g., femoral and sciatic nerve blocks) provides adequate pain control for total knee arthroplasty. However, these techniques require careful titration of the local anesthetic to avoid impairment of motor function and delays in the rehabilitation process [89]. As a result of ongoing concerns regarding exacerbations in motor weakness and impairment of rehabilitation, distal nerve block techniques [e.g., adductor canal block (ACB) and tibial nerve block in the popliteal fossa] have gained increasing popularity [90]. For this reason, use of the ACB may facilitate the recovery process compared with use of a femoral nerve block for total knee arthroplasty in the elderly population.

Periarticular infiltration and local infiltration analgesia (LIA) provide satisfactory pain relief, and allow virtually immediate mobilization and earlier discharge from hospital following knee and hip surgery [91, 92]. If used as the primary anesthetic, patients can bypass the post-anesthesia care unit (PACU) and thereby reduce recovery costs [93, 94]. However, some studies have questioned the analgesic efficacy of local infiltration after more painful surgical procedures [95]. The location, volume, and timing of local anesthetic administration, as well as the accuracy and consistency of the pumps, are key factors in determining efficacy of pain relief following local infiltration [84].

The use of continuous local anesthetic infusion techniques (e.g., perineural blocks, wound infiltration) have become increasingly popular due to their ability to control moderate-to-severe pain after major ambulatory surgery procedures [96–98]. A study revealed that perineural analgesia (interscalene or popliteal catheters) improved pain control, reduced opioid-related side effects, and significantly increased patients' ability to perform activities of daily living at home [98]. In contrast with epidural analgesia, continuous PNB techniques provide pain relief superior to systemic opioid analgesia with a lower incidence of side effects and reduced risk of long-term opioid dependency [99]. These beneficial effects of PNBs can now be extended to the postdischarge period in the patients' home with the availability of perineural catheters and disposable pumps. However, the clear benefits of these approaches for managing pain after surgery must be balanced against the cost of the equipment and the resources need to safely manage these systems outside the hospital environment.

Liposomal bupivacaine is a novel formulation of bupivacaine. This formulation aims to sustain safe therapeutic

levels of bupivacaine for up to 72 h after administration [100]. Local infiltration with liposomal bupivacaine reduced postoperative pain and decreased opioid consumption and opioid-related adverse events after superficial surgery procedures (e.g., hernia repairs and hemorrhoidectomy) [101]. A recent study found that liposomal bupivacaine via subcostal transversus abdominis plane infiltration provided superior analgesia up to 72 h after injection when compared with non-liposomal bupivacaine [102]. Therefore, liposomal bupivacaine is an effective, safe, and long-acting local anesthetic that can be used for both local infiltrations at the surgical site and for prolonged perineural blocks. SABER-Bupivacaine is another extended-release formulation which reduced acute postoperative pain and the need for supplemental opioids after inguinal hernia surgery [74, 103].

Despite the well documented advantages of local anesthetic techniques, the use of perineural catheters in the ambulatory setting is limited by concerns over staffing, equipment needs, and potential for complications. Local anesthetics can be used alone or in association with other adjunctive drugs to decrease latency, and to increase their analgesic effect (e.g., clonidine) [104]. Several investigative groups have documented prolongations of PNBs with the addition of dexamethasone (~8 mg) to mepivacaine (332 vs 228 min), ropivacaine (22.2 vs 11.8 h), and bupivacaine (22.4 vs 14.8 h) [105, 106]. A study by Abdallah et al. revealed that the effectiveness of IV dexamethasone in prolonging the duration of analgesia was similar to perineural dexamethasone when administered as part of a single-injection supraclavicular block with a long-acting local anesthetic [107]. PNBs with local anesthetics minimize the endocrine-metabolic responses to surgical trauma and facilitate the recovery process [108].

5 Monitored Anesthesia Care

For minor procedures in elderly patients, monitored anesthesia care (MAC) is an excellent alternative to general and regional anesthesia. Guidelines for MAC in elderly patients have been published by Ekstein et al. [109]. Standard monitoring practices for MAC include pulse oximetry, blood pressure, ECG, heart rate, sedation, and respiratory rate or capnography. Clinical signs of adequate spontaneous ventilation (e.g., maintenance of a patent airway and respiratory rate >10 breaths per minute, hemoglobin oxygen saturation values >90%) must be continuously monitored because of the risk of ventilatory depression in the elderly. Often, patients undergoing procedures with MAC are able to bypass the PACU, resulting in reduced costs, early discharge home, and excellent patient acceptance.

Anesthetic drugs (e.g., midazolam, etomidate, propofol, dexmedetomidine) are frequently used for sedation, either by intermittent bolus or by continuous IV infusion. Propofol produces a rapid and controllable reduction of consciousness with a predictably rapid recovery and is the 'drug of choice' for MAC sedation in elderly outpatients [110]. Small doses of midazolam provide anxiolysis and anterograde amnesia but may delay discharge. Midazolam combined with an opioid analgesic for brief diagnostic procedures can produce prolonged sedation in elderly patients [111]. When used in combination with propofol, dexmedetomidine can increase the risk for cardiovascular depression. Since the leading cause of serious patient injury associated with MAC is over-sedation and subsequent respiratory depression, the careful evaluation of the level of sedation is critically important [112]. Overall, MAC has shorter recovery time than general anesthesia or regional anesthesia and is more cost-beneficial for superficial ambulatory operations.

6 Postoperative Side Effects and Complications

6.1 Postoperative Pain Management

Despite expansion of the armamentarium of analgesic drugs and techniques used for pain management, many elderly outpatients continue to experience unacceptable levels of pain after surgery [3, 113–115]. Unrelieved postoperative pain may result in clinical and psychological changes that increase morbidity and mortality and hamper the rehabilitation process, and decrease patient satisfaction with their surgical experience [116]. Extensive use of opioids is associated with a variety of perioperative side effects, including cardio-respiratory depression, drowsiness and sedation, hallucinations, PONV, pruritus, urinary retention, ileus, and constipation, which can contribute to a delayed hospital discharge and resumption of normal activities of daily living [3, 113–115]. More importantly, in a retrospective study involving over 390,000 outpatients aged >66 years who had undergone minor ambulatory surgery procedures (e.g., cataract surgery, varicose vein stripping, hernia repair), Alam et al. [117] reported that opioid-naive patients receiving an opioid analgesic medication within 7 days after undergoing a minor surgical procedure were 44% more likely to continue using opioids 1 year after the operation. The adaptation of multimodal (or balanced) analgesic techniques as the standard approach for the prevention of pain in the ambulatory setting is one of the keys to improving the recovery process following increasingly complex day-case surgery procedures in

elderly patients while reducing the long-term risk of chronic opioid dependency [116, 118, 119].

The expanding number of elderly surgical outpatients requires a perioperative analgesic regimen that is highly effective, has minimal side effects, is intrinsically safe, and can be safely managed away from the hospital or surgical center [120, 121]. A multimodal analgesic regimen should be adjusted to meet the needs of elderly patients by taking into consideration their pre-existing medical conditions, types of surgery, and previous experiences with analgesic drugs for treating postoperative pain [122]. The non-opioid analgesic therapies will likely assume an increasingly important role in facilitating the recovery process and improving the satisfaction for elderly ambulatory surgery patients. Combining long-acting local anesthesia and more potent non-opioid analgesics [e.g., parenteral nonsteroidal anti-inflammatory drugs (NSAIDs)] has become the standard analgesic approach for the management of elderly patients undergoing ambulatory surgery (Table 4) [123].

The use of multiple chronic medications is common among elderly patients undergoing ambulatory surgery procedures [124]. Drug selection and dosage must be adjusted to make pain management as safe as possible in elderly outpatients. Opioid analgesics should be used primarily as 'rescue' analgesic medication for the short-term treatment of moderate-to-severe acute pain which failed to respond to a 'preventative' analgesic regimen involving the use of one or more non-opioid analgesic drugs. Acetaminophen is a commonly used non-opioid analgesic with a well established safety and tolerability profile in the elderly, and dosage adjustments were not recommended despite a reduced clearance rate [125]. The efficacy of NSAIDs in preventing postoperative pain and reducing the requirement for opioids is also well documented [126–128]. However, the potential occurrence of adverse effects (e.g., gastrointestinal bleeding and thrombotic events) is a consideration in elderly patients. For procedures at low risk for hemorrhage, traditional nonselective NSAIDs are a more cost-effective alternative. Because the side effects of these agents are dose and time dependent, NSAIDs and acetaminophen should only be used in the early postdischarge period (2–5 days). Cyclooxygenase-2 (COX-2) inhibitors are useful adjuncts to opioids, but long-term use may increase the risk of cardiovascular events. A single dose of glucocorticoid steroid can reduce pain following ambulatory surgery without increasing postoperative bleeding risk in elderly outpatients. Among nontraditional drugs, ketamine has been used to reduce early postoperative pain [114]. Gabapentanoids can reduce pain, but pregabalin causes sedation and dizziness. Dexmedetomidine infusion 0.2–0.8 mg/kg/min decreased perioperative propofol, remifentanil and fentanyl use, postoperative antiemetic requirements, and reduced the PACU stay, but did not facilitate late recovery [129]. White and colleagues have also reported beneficial effects on postoperative pain management when an infusion of esmolol is used to control autonomic responses during ambulatory surgery [130].

6.2 Postoperative Nausea and Vomiting

PONV and post-discharge nausea and vomiting (PDNV) are common and distressing complications following surgery and anesthesia, and may result in dehydration, electrolyte imbalance, wound dehiscence, pulmonary aspiration, and delayed hospital discharge [131–133]. A wide variety of antiemetic drugs and non-pharmacologic techniques (e.g., acupressure, acupuncture, and transcutaneous electrical stimulation) are available for the treatment and prevention of PONV. 5-HT_3 receptor antagonists are recommended as the first-line regimen for PONV prophylaxis. Dexamethasone, a corticosteroid, has been shown to be effective administered at a dose of 4–12 mg IV [134, 135]. NK-1 receptor antagonists with a long elimination half-life were effective for the prophylaxis and treatment of PONV [136]. The NK-1 receptor antagonist aprepitant appears to be more effective in decreasing the incidence of PONV as compared with ondansetron [137]; however, it is very costly. Droperidol remains the most cost-effective antiemetic therapy despite concerning extrapyramidal side effects and the potential for prolonging the electrocardiographic QT interval when large doses (>1.25 mg) of the drug are administered [138]. Metoclopramide is probably the most commonly used antiemetic for treatment of PONV, in particular when the 5-HT_3 compounds and/or droperidol prophylaxis has failed. Prophylactic doses and timing for the administration of antiemetics are summarized in Table 5. Apfel et al. reported that droperidol, dexamethasone, and ondansetron possess similar antiemetic efficacy when administered for antiemetic prophylaxis [139].

A combination antiemetic therapy using drugs that act at different neuroreceptor sites has been recommended for the 'at-risk' patients [133, 140]. Previous clinical studies have demonstrated that the use of a combination of prophylactic antiemetic drugs can reduce the incidence of PONV and PDNV while improving patient satisfaction with their quality of recovery and facilitating the recovery process compared with the use of a single antiemetic drug modality [131]. A meta-analysis suggested that combining dexamethasone with a 5-HT_3 receptor antagonist provided greater antiemetic efficacy, and this combination therapy was recommended as the 'optimal' choice for prophylaxis against PONV [141]. The combination of dexamethasone with either granisetron, or haloperidol was also more effective than single-drug therapy [142]. The impact of

Table 4 Recommendations in relation to magnitude of postoperative pain expected following ambulatory surgery procedures

Mild intensity pain	Moderate intensity pain	Severe intensity pain
		Epidural local analgesia, continuous peripheral (perineural) nerve blocks, wound infiltration, periarticular infiltration, and local infiltration analgesia
		Use small doses of potent opioids (e.g., fentanyl 25–50 μg or sufentanil 5–10 μg IV) or opioid injection (IV PCA) during and/or immediately after surgery
		Acetaminophen and NSAIDs (unless contraindicated)
	Consider the use of single-shot peripheral (perineural) nerve blocks, wound infiltration, periarticular infiltration, and local infiltration analgesia	
Oral acetaminophen and NSAIDs (unless contraindicated)		
Opioid-sparing drugs (e.g., α2-adrenergic agonists, ketamine, β-blockers, and calcium channel blockers)		
Non-pharmacologic techniques (e.g., high-intensity cold laser therapy)		

PCA patient control analgesia, *NSAIDs* nonsteroidal anti-inflammatory drugs

Table 5 Prophylactic doses and timing for the administration of antiemetic drugs in the ambulatory setting

Drug group	Drugs	Dose	Timing	Adverse effect
Serotonin (5-HT_3 receptors) antagonists	Ondansetron	4–8 mg IV	End of surgery	Headaches, constipation, raised liver enzymes
	Granisetron	1 mg IV		
	Tropisetron	2 mg IV		
Corticosteroids	Dexamethasone	4–10 mg IV	After induction of anesthesia	Increased blood glucose level, hypo/hypertension, diabetes mellitus
Butyrophenone	Droperidol	0.625–1.25 mg IV	After induction of anesthesia	Psychomimetic, extrapyramidal disturbance, sedation, dizziness, Parkinson's disease, increased QT interval
Neurokinin antagonists (NK-1 receptors)	Aprepitant	40 mg orally	1–2 h prior to induction	Headaches, constipation, fatigue
Anticholinergics	Scopolamine	Transdermal patch	Evening prior to surgery or in preoperative period	Dizziness, dry mouth, visual disturbances
Dopamine antagonists	Metoclopramid	10–25 mg IV	15–30 min prior to end of surgery	Sedation, hypotension (fast injection)

PDNV requires that the prophylactic treatment of this complication would ideally extend well beyond the time of discharge from the hospital [143, 144]. New research is centered on different antiemetics, administered at various time points, to evaluate the effects on reducing PDNV. A study demonstrated patients who received the combination of ondansetron 4 mg IV and ondansetron oral disintegrating tablet 8 mg immediately before discharge had less severe nausea and fewer vomiting episodes compared with ondansetron 4 mg IV alone (3 vs 23%) [145].

Patient, anesthetic, and surgical factors all contribute to the incidence of emetic symptoms in the postoperative period (Table 6) [146]. In addition to using a combination of antiemetics with different mechanisms of action, the multifactorial etiology of PONV might be better addressed by the adoption of a multimodal approach to reduce the baseline risk for PONV. Several effective strategies are recommended to reduce the baseline risk for PONV, such as (1) local and regional anesthesia (e.g., local infiltration and/or peripheral nerve blocks); (2) propofol induction and maintenance; (3) minimization of perioperative opioids; (4) minimized use of volatile anesthetics; (5) avoidance of nitrous oxide and reversal drugs; and (6) insuring adequate intraoperative hydration [147, 148].

Pharmacological management of PONV and PDNV should be tailored to the patients' risk level using scoring systems developed by Apfel et al. [139, 140, 149]. These investigators identified four primary predictors for developing PONV: female sex, nonsmoking status, history of PONV or motion sickness, and use of postoperative opioids [150]; and for PDNV: female gender, history of PONV after previous operation, age <50 years, opioid administration and nausea prior to discharge home [139]. PONV prophylaxis is rarely warranted in low-risk patients (<1 factor). However, moderate-risk patients benefit from a single or often multiple antiemetic interventions.

Table 6 Patient-, anesthesia-, and surgery-related risk factors for developing postoperative nausea and vomiting (PONV) and postdischarge nausea and vomiting (PDNV)

Category	Risk factors
Patient related	Female gender
	History of PONV
	Motion sickness
	Nonsmoking status
	Age <50 years
Anesthesia related	Prolonged duration of anesthesia
	Intraoperative and postoperative opioid analgesics
	Volatile agents
	Nitrous oxide (>50%)
	Increased doses of neostigmine (>3 mg)
	Inadequate hydration and postoperative hypotension
	Prolonged PACU stay
Surgery related	Prolonged surgery procedures
	Type of surgery (e.g., neurosurgery, intra-abdominal surgery, cholecystectomy, laparoscopic surgery, gynecological surgery)

PACU post-anesthesia care unit

'Multimodal' therapy (e.g., triple antiemetic prophylaxis) should be routinely used for all high-risk patients (Table 7) [147]. Optimal management of perioperative pain using opioid-sparing multimodal analgesic techniques and preventing PONV and PDNV using prophylactic antiemetics are both key elements for facilitating both early and late recovery after ambulatory surgery [151].

6.3 Postoperative Delirium and Cognitive Dysfunction

Elderly patients undergoing surgical intervention often have postoperative delirium (POD) and cognitive dysfunction (POCD). POCD is associated with prolonged hospitalization, delayed recovery, and an increased risk of disability and mortality. Age has been increasingly reported as a significant and independent risk factor for POCD [152]. In a large-scale study involving patients aged >60 years, Canet et al. found a lower incidence of POCD 1 week after minor surgery in an ambulatory (vs inpatient) setting. However, no significant difference for the incidence of POCD was found at the later assessment [153]. POD is an acute temporary change in orientation and cognition, whereas POCD is a more subtle and persistent impairment in intellectual/cognitive performance. POD occurs in 5–15% of elderly patients undergoing noncardiac surgery and POCD occurs in 10–13% at 3 months, and can have significant socioeconomic and medical implications [154].

Healthcare professionals caring for surgical patients should perform an assessment of delirium risk factors, including age >65 years, chronic cognitive decline or dementia, poor vision or hearing, severe illness (e.g., ICU admission), and presence of infection [155]. Healthcare providers should evaluate elderly outpatients who develop POD and POCD for possible precipitating conditions (e.g., uncontrolled pain, hypoxia, pneumonia, infections, electrolyte abnormalities, urinary retention, fecal impaction, hypoglycemia). Although elderly patients may have a higher incidence of transient (early) cognitive dysfunction after general anesthesia in comparison with local/regional techniques, there appears to be no causative relationship between general anesthesia and long-term POCD [156]. Several nonpharmacologic and pharmacologic interventions (e.g., reorientation, environmental modifications, antipsychotic agents) are commonly used when delirium occurs and are associated with varying levels of success [157].

7 Enhanced Recovery After Surgery (ERAS)

ERAS programs are multimodal care pathways that aim to decrease intraoperative blood loss, decrease postoperative complications, and reduce recovery times. Studies have suggested that adoption of ERAS decreases postoperative complications by 50%, reduces length of stay by 30%, and decreases readmission rates, thereby lowering overall health costs [158]. Enhanced recovery pathways vary amongst institutions but include key elements such as hemodynamic optimization, early ambulation, and standardized multimodal pain and emesis control regimens. Fast-tracking can be facilitated with the use of short- and ultrashort-acting anesthetic drugs, together with their optimal titration using new monitoring technologies (e.g., BIS monitoring) [159–161]. Fasting from solid food for only 6 h and perioperative liquid-carbohydrate loading up to 2 h prior to surgery appeared to be safe and reduced recovery times. Appropriate use of IV fluids to prevent adverse effects associated with decreased physiologic reserve is important when caring for elderly surgical patients [162]. In general, the administration of IV fluids should take into account the combined effects of aging, anesthetics, and analgesics on physiologic responses [163]. Deep vein thrombosis prophylaxis, antibiotic prophylaxis, and thermoregulation were also found to help reduce postsurgical complications. Chewing gum, prokinetic agents, oral laxatives, and an early resumption to normal diet leads to a faster return to normal bowel function.

Table 7 Recommendations in relation to various risk factors of postoperative nausea and vomiting (PONV) following surgical procedures

Mild risk (none or 1 risk factor)	Moderate risk (2 risk factors)	High risk (≥3 risk factors)
No prophylaxis required or monotherapy with a cost-effective antiemetic drug if there is a risk of medical sequelae from PONV	Consider antiemetic prophylaxis with a combination of antiemetic therapies If general anesthesia is required, reduce baseline risk factors by minimizing the use of volatile anesthetics, opioid analgesics, nitrous oxide, and high-doses of reversal drugs Utilize local anesthetic infiltration and regional anesthesia with peripheral nerve blocks Non-pharmacologic alternatives (e.g., acupressure or electrical acupoint stimulation) may be used as an alternative or adjuvant therapy	Initiate combination therapy with 2 or 3 prophylactic agents acting at different receptor sites The baseline risks should be reduced by employing multimodal opioid-sparing analgesic techniques whenever possible—minimize the perioperative use of opioid analgesics. In addition, minimize the use of volatile anesthetics, nitrous oxide, and high doses of reversal drugs (e.g., neostigmine, flumazenil, naloxone) Utilize local anesthetic infiltration and regional anesthesia with peripheral nerve blocks
Treatment options:		
If prophylaxis fails or was not received, use antiemetic from different class than prophylactic agent		
Re-administer only if >6 h after post-anesthesia care unit; do not re-administer dexamethasone or scopolamine		

8 Keys to Future Expansion of Ambulatory Surgery for the Elderly Population

Technological advancements in surgery, improvements in anesthesia monitoring, and pain control will lead to the future expansion of ambulatory surgery for the elderly [164]. New anesthetic drugs (e.g., non-opioid analgesics, sugammadex, depo-bupivacaine) have the potential to reduce morbidity and facilitate a faster recovery for elderly patients [165]. The use of mobile health systems and home telemedicine can lead to improved follow-up care and avoidance of unnecessary emergency room visits [166]. The ASA is encouraging anesthesiologists to include the 'surgical home' care program as part of perioperative care [167]. However, these technological advances must be made available at a reasonable cost to the patient and the healthcare system.

The surgical approach (e.g., open vs minimal access) may influence outcomes, complications, and recovery rates. Minimally invasive surgery requires smaller incisions, reduces analgesic requirements, and decreases blood loss [168]. As such, laparoscopy may decrease postoperative complications, pain, and discharge time compared with open surgery [169]. There are clearly economic, societal, and patient benefits in treating elderly surgical patients on an ambulatory basis. However, the economic benefits related to avoiding hospitalization after surgery must be balanced against the additional costs associated with unplanned hospital admissions to treat postoperative complications, as well as the increased need for postoperative medical and social support in extended care facilities and the home environment. Age per se and preexisting medical conditions should not preclude an elderly patient from undergoing ambulatory surgery [170]. However, poor baseline functional status in elderly patients will increase their risk of an adverse outcome after ambulatory surgery. There is general agreement that elderly patients scheduled for surgery in an ambulatory unit should be reasonably fit and any underlying medical conditions should be under stable control.

9 Conclusion

As ambulatory surgery continues to expand in our aging society, implementing evidence-based perioperative care programs for the elderly will assume increased importance. A synergistic and proactive approach is required by the entire healthcare team to facilitate resumption of normal activities after ambulatory surgery in the elderly population. Increasing use of PNBs for anesthesia and perioperative analgesia has the potential to transform anesthesia services for the elderly in the ambulatory setting [171]. Increased use of opioid-sparing multimodal approaches to pain management and adequate treatment of anesthesia and surgery-related side effects is essential to ensure higher levels of patient satisfaction and a faster recovery after ambulatory surgery [172]. Given the recent advances in surgical techniques (e.g., minimally invasive surgery), anesthetic pharmacology, regional anesthesia, and postoperative pain management, the ambulatory setting can offer many potential advantages for the elderly surgical patient.

Compliance with Ethical Standards

Conflict of interest XZC, PFW, and HM declare that there is no conflict of interest.

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