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

Etomidate, a carboxylated imidazole ring, has the disadvantage of producing some disinhibitory effects leading to development of myoclonus, which has been observed in 30% to 60% of patients. Yet its minimal cardiovascular effects make it preferred in patients in whom a decrease in blood pressure may not be tolerated. It is an excellent anesthetic for an emergency situation. The volume of distribution for etomidate is reduced with aging and a 50% reduction in dose is recommended in patients80 years of age or older.

The anxiolytic and sedative properties of midazolam make it an excellent premedication for anesthesia, and the short duration, and absence of significant active metabolites or cardiovascular effects increases the utility in the elderly population. Although pharmacokinetic changes can prolong elimination, especially in obese elderly patients, the increase in sensitivity observed in geriatric patients appears to be due mainly to a pharmacodynamics change within the benzodiazepine GABA receptor unit ***(Jacobs, Reves, et al., 1995)***.

In general the dose of midazolam should be reduced by 50% and repeat doses administered in increments of 0.5 mg or less. Older patients are susceptible to midazolam-induced apnea, and when administered during spinal anesthesia there may be an increased risk of respiratory depression. Unwanted effects of midazolam can be reversed with flumazenil. Long-acting benzodiazepines have been associated with delirium in the elderly due to prolonged clearance and active metabolites. For these reasons, diazepam and lorazepam are not recommended in elderly patients.

**Inhaled Anesthetics:**

The minimum alveolar concentration (MAC) of inhaled anesthetics decreases predictably by 6% every decade after age 20 years. Thus, the MAC at age 90 years is reduced by 30% compared to a 40-year-old. This change most likely reflects a combination of age-related cerebral atrophy and alterations in neurotransmitter balance ***(Nickalls, Mapleson, 2003)***.

**Muscle Relaxants:**

Aging does not increase sensitivity to muscle relaxants at the neuromuscular junction. Of course, age-related diseases (e.g., kidney dysfunction) may increase sensitivity. Furthermore, decreases in hepatic metabolism and renal clearance may lead to delayed elimination of non-depolarizing agents. This is most prominent for pancuronium, for which 85% is eliminated through renal clearance, and the drug probably should be avoided in elderly patients. Vecuronium and rocuronium are less dependent on renal excretion and their effects are less likely to be significantly prolonged.

Cisatracurium and atracurium are dependent on Hoffman elimination that is not impacted by aging or renal or hepatic function. To ensure complete recovery from neuro muscular blockade, monitoring of neuromuscular blockade should be done to assure that successive doses are appropriate and complete reversal from neostigmine or sugammadex has occurred prior to extubation of the trachea. In the older patient, even a small degree of weakness can result in a clinically significant respiratory incident during transport to and while in the post anesthesia care unit (PACU).

**OPIOIDS:**

Pharmacodynamic changes in elderly patients account for the increase in the sensitivity of the brain to opioids, and pharmacokinetic changes impacting elimination and distribution of opioids are less significant. Opioid doses should be reduced by 50% in older patients. Inter individual variability of opioid response is common among older patients and it is important to titrate these drugs to desired effect. Fentanyl is a popular short-acting lipid-soluble opioid with a large volume of distribution. The dose should be reduced by 50%, largely due to pharmacodynamics changes. Remifentanil is an ultrashort-acting mu receptor agonist that is metabolized by plasma esterases. The bolus dose and the infusion rates should be reduced in the elderly and titrated to effect. Morphine is one of the most popular postoperative analgesics administered. In elderly patients there is a reduction in the volume of distribution and a potential accumulation of active metabolites morphine3-glucuronide and morphine 6-glucuronide that are eliminated via the kidneys ***(Cepeda, Farrar, et al., 2003)***.

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

**Neuraxial Anesthesia:**

Spinal and epidural anesthesia compared to general anesthesia do not alter the 30-day mortality rate in elderly patients. However, these techniques may be particularly useful for a wide range of orthopedic procedures suchas hip fracture repair, lower extremity joint replacement, transurethral resection of the prostate, and gynecologic and lower extremity vascular procedures. Age-related changes including calcification of the interspinous ligaments and ligamentumflavum and narrowing of the intervertebral foramina, combined with a reduction inflexibility and difficulty positioning, may make the placement of the needle for a spinal or epidural block more challenging. Age-related changes can also lead to exaggerated spread of the local anesthetic within the epidural space and a higher than expected anesthetic level.

Similarly for spinal anesthesia, the cephalad spread maybe wider than expected and the dose of local anesthetic should be reduced in older patients. Hypotension is the most likely hemodynamic consequence of neuraxial anesthesia.

Hypotension is due to vasodilation from the sympathetic blockade, causing a decrease in systemic vascular resistance and central venous pressure and are distribution of blood volume to the extremities from central splanchnic and mesenteric vascular beds. Hypotension is of particular concern in very elderly patients with limited cardiac reserve, and may be exaggerated inpatients with baseline hypertension. Pretreatment with crystalloid does not consistently offset the hypotension following a spinal block. Treatment of hypotension with vasopressors, such as ephedrine and phenylephrine, is frequently required ***(Simon, Veering, et al., 2002)***.

**Postoperative Care:**

***Pain:***

The treatment of intraoperative and postoperative pain inthe elderly patient is an important part of the anestheticplan.44–46 Age-related reduction in nerve conductivity and receptors may lead older patients to experience less pain following surgery ***(Gibson&Farrell, 2004)***, but untreated pain can have significant adverse consequences. Postoperative pain has been associated with increased length of stay, increased morbidity, pulmonary complications, and delirium.

The longer a patient stays in the hospital, the more the risks of complications increase. Generational and cultural issues may lead older patients to complain less about pain, and elderly patients frequently have lower expectations for successful treatment. For cognitively intact elders patient-controlled analgesia (PCA) is the preferred method for administering postoperative intravenous narcotics ***(Gagliese, Jackson, et al., 2000)***. Treatment of pain in patients with significant dementia is challenging both to assess and treat. If possible, pain should be assessed using a specially designed pain scale such as the PAINAD. For demented and nonverbal elders, pain medication should be offered on a regularly scheduled interval as opposed to an as-needed basis.

Opioid use can be reduced by concomitant administration of acetaminophen ***(Remy, Marret, et al., 2005)***. Non-steroidal anti-inflammatory drugs (NSAIDs) in older patients cause renal failure and gastrointestinal hemorrhage, and medications such asibuprofen and ketorolac should be administered cautiously. When administered, the dose of ketorolac should be reduced to 15 mg IV every 6 hours, with a 60 mg 24-hourdose maximum.

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

The role of nerve blocks for postoperative pain control in elderly patients is increasingly important. Adequate, but safe, postoperative analgesia is very important in the elderly. The total dose of local anesthetic should be reduced as the metabolism and clearance of local anesthetics is delayed in advanced age. Postoperative epidural analgesia with local anesthetics or opioids probably improves postoperative pulmonary outcomes including (1) improved postoperative pain control, (2)decline in atelectasis, (3) improved tracheal extubation variables, and (4) shorter intensive care unit stays ***(Rigg, Jamrozik, et al., 2002)***.

**Postoperative Neurologic Events:**

The most common postoperative neurologic events in the elderly are postoperative delirium and postoperative cognitive dysfunction (POCD)***(Moller, Cluitmans, et al., 1998)***. Delirium refers to anacute state of confusion that generally occurs within1 to 3 days following surgery. It can persist for weeks or months after surgery. Delirium is not unique to surgery patients; it also commonly develops in hospitalized elderly patients, especially those admitted to the intensive care unit. Delirium is a significant source of morbidity and occurs in 15% to 60% of elderly patients who have a hip fracture ***(Inouye, 2006)***. POCD can increase length of hospital stay, require discharge to rehabilitation facilities as opposed to home, and is associated with an increased mortality rate.

There are multiple causes of delirium in the postoperative patient. The more common ones include acute metabolic derangements such ashypo- or hypernatremia, hypoxemia, anemia, uremia, sepsis, uncontrolled pain, disorientation, depression, residual effects of anticholinergic medications, and alcohol with drawal. Treatment of delirium should start with a search for an underlying reversible condition such as hypoxemia or pain; unfortunately often there is no single factor that is easily reversed. Agitated patients may benefit from intravenously administered small doses of haloperidol.

POCD is a distinct cognitive disorder found in patients after anesthesia ***(Moller, Cluitmans, et al., 1998)***. It is diagnosed through neuropsychological testing and results in subtle changes in mental ability; unlike patients with delirium, POCD patients arenot acutely confused or agitated. In some studies 10%of older patients developed POCD 3 months after major noncardiac surgery. In most cases it resolved by 6 to12months, although its occurrence has been associated with an increased mortality rate. The role of anesthetics in the development of POCD is a current focus of significant research.

Perioperative stroke is an uncommon event following general surgery; it occurs more frequently after head and neck, vascular, and cardiac surgery. Risk factors for a postoperative stroke include advanced age and predisposing co-morbidities such as hypertension and reduced ejection fraction of less than 40%. The most frequent incidence of stroke occurs after cardiac and aortic surgery.

Most perioperative strokes are embolic and ischemic. A perioperative stroke is associated with prolonged hospitalization, increased disability, and death following surgery.

**Reduction of Perioperative Risk:**

Elderly patients have high mortality and morbidity rates after surgery, especially after major and emergent surgery. Reduction of risk should be aimed at avoiding complications and limiting risk. The patient should be in optimal condition preoperatively. Unfortunately it is not always possible to delay surgery, especially in emergent situations. Administration of perioperative b-adrenergic blockers may reduce postoperative cardiac events through a reduction in sympathetic tone, improved oxygen myocardial supply/demand, and reduction in ventricular arrhythmias as well as decreasing shear stress surrounding atherosclerotic plaque. Perioperative b-adrenergic blockade should be continued for the entire perioperative period; abrupt discontinuation can increase the incidence of adverse events. Patients with AHA Class 1 or2a indications should receive $β$-adrenergic blockers; more data are still needed to establish the most effectiveuse of perioperative $β$-blockade for elderly patients ***(Fleisher, Beckman, et al., 2007)***.55

As mentioned previously, appropriate pain control is also important, and epidural analgesia may have a significant role in preventing pulmonary complications.

Other measures that may be used to limit pulmonary complications include using positive end-expiratory pressure (5 to 10 cm H2O) to maintain FRC above closing capacity. Maintaining a higher inspired oxygencon centration (>30%) during surgery may reduce surgical infections and lead to a reduced incidence of nausea and vomiting (Table 5) ***(Lawrence, Cornell, et al., 2006)***.

**Table 5**: **Guidelines for Treating Geriatric Patients**.

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