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Special Anesthetic Consideration for the Fragility Fracture Patient

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Synopsis

This article presents an overview of perioperative management of the fragility fracture patient including, pre-operative risk stratification and optimization, anesthesia risks and anesthesia options as well as post-operative pain management. It is the intent of this manuscript to communicate the issues of preoperative evaluation which are of concern for the anesthesiologist because of their direct effect on intraoperative care. A team interdisciplinary approach and good communication between specialties involved in care of the elderly surgical patients is important for optimal patient outcomes and to avoid perioperative complications. Cooperation between anesthesiology and medicine is indispensable in reaching a reasonable consensus regarding preoperative evaluation, and should occur on a case-by-case basis.

Keywords

Fragility fractures; Regional anesthesia; Epidural anesthesia; Orthopedic fractures; General anesthesia; Elderly

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Introduction

Fragility fractures are defined by the World Health Organization as fractures caused by injury that would be insufficient to fracture a normal bone.¹ Clinically they have been described as a low energy fracture that occurs from minimal trauma such as a fall from a standing height or less.²⁻⁴ With the aging of the population, fragility fractures are becoming more common. See chapter on epidemiology for more detailed information. We will focus on special anesthesia management for fragility fractures of the extremities and hip. Vertebral fractures are common but are to be discussed with special anesthesia considerations related to spine surgery, which are beyond the scope of this manuscript.

Initial Workup Considerations

Several principles should be kept in mind when assessing anesthetic risk in an elderly patient with a fragility fracture. A major priority is to evaluate for associated injuries to assure no injury takes precedence over the fracture repair.

Dementia, depression, hearing difficulties, and stroke all may interfere with the ability to make independent decisions and obtain informed consent in frail elderly patients. If one's ability to make decisions becomes severely impaired then a surrogate must give consent. Advance directives, when available, can be helpful. Neurologic, pulmonary and cardiac morbidities are the most common types of postoperative complications in the elderly and the anesthesiologist should pay attention to these specific organ systems.

Risk stratification

Preoperative pulmonary risk stratification—In general what the anesthesiologist wants to know about the patient's preoperative pulmonary status is their risk for respiratory failure, pulmonary complications like pneumonia or aspiration, and difficulty in ventilator weaning or need for ICU care. Certain physiological parameters help predict the likelihood of postoperative pulmonary complications. (Figure 1)

Risk of hypoxia may be evidenced by room air saturation less than 90% or may be associated with low preoperative hemoglobin although the exact level of hemoglobin where this risk increases is controversial. Risk of post-operative CO₂ retention maybe predicted by pulmonary function test, if available. Parameters such as pre-operative FEV₁ less than 50% of predicted or forced vital capacity of less than 1.7 liters are associated with a higher likelihood of CO₂ retention.⁶

Preoperative cardiac risk stratification—The information of importance to the anesthesiologist when the patient had a fall concerns whether the fall is secondary to cardiac etiology. If the patient has a pacemaker does it work? Are they in heart failure? Are they having an acute coronary syndrome? Excellent guidelines are available. We refer the reader to figure one in the American College of Cardiology/American Heart Association Task Force 2007 guidelines on perioperative cardiovascular evaluation and care for non-cardiac surgery specifically.⁷ Please refer to the chapter entitled "Preoperative Optimization and Risk Assessment" for further details on preoperative cardiac evaluation.

Preoperative central nervous system evaluation—The anesthesiologist wishes to know that there are no active neurologic problems which may have contributed to the fall, and which may, in turn, impact the patient's ability to tolerate surgery. The presence of delirium preoperatively warrants investigation to rule out serious conditions like hypoxia, hypoglycemia, electrolyte imbalances or sepsis.⁶ Neuroimaging may be necessary if history or signs point to a cerebrovascular accident (CVA). A recent CVA is associated with impaired autoregulation of the cerebral vasculature and hemodynamic stress associated with general anesthesia could make the infarction worse.⁶

Besides the fracture itself, when evaluating the elderly it is important to keep in mind that associated acute illness may have an atypical presentation. There may be significant differences in the presentation of disease in demented versus non-demented patients as studies suggest that the nonspecific presentation of disease in older people is primarily linked to the presence of dementia rather than a characteristic feature of the aging process.

Elderly trauma patients should be assessed for any cervical spine fracture or injury. This would change how intubation is managed or perhaps the decision may be made to avoid airway instrumentation by choosing a regional technique. However, even if a regional technique is performed there is always the chance that we need to convert to general anesthesia and secure the patient airway secondary to inadequate anesthesia, prolonged procedure or large fluid shifts requiring a large volume replacement.

Substance abuse, particularly alcohol, is often an underappreciated factor associated with falls. Alcohol disorders are estimated to be present in 5–14% of older patients in the emergency department. It relates to anesthesia because the patient having delirium tremens or agitation in the recovery room can be problematic to manage.

Overall risk stratification—Preoperative assessment is done with an eye to avoiding complications. The most important risk factors for perioperative complications in the elderly are summarized in Figure 2.

The American Society of Anesthesiologists has a classification system that is often used to indicate the overall physical health pre-operatively. (Figure 3) This classification is often used to help predict patient risk for undergoing surgery and anesthesia.

The association between age and surgical risk is associated with increased incidence of comorbidities in the setting of decreased physiologic reserve. This has profound effects on the usual compensatory mechanisms. Emergency surgery is an independent predictor of adverse postoperative outcomes in older surgical patients undergoing noncardiac surgery. The consultant geriatrician would help us exclude patients from immediate surgery if they have conditions that could develop into life threatening events with surgical stress for example, severe blood loss and hypovolemic state, severe electrolyte derangements, oxygen supply and demand imbalances that could lead to end organ damage. Volume status should be optimized because the cardiovascular effects of anesthetics are exaggerated in a hypovolemic patient (see section on effects of general anesthetics below).

Surgical mortality in the elderly varies widely according to procedure. The current guidelines for cardiovascular evaluation of patients undergoing noncardiac surgery⁷ provide a useful means of categorizing procedures into those of low, intermediate, and high risk. In general, most procedures for fragility fractures are intermediate risk.

Effects of general anesthetics by system

We will review the most common agents used for general anesthesia and their effects on major organ systems. Tables 1–3

Cardiovascular effects—The anesthesiologist's goal is to maintain hemodynamic stability throughout the perioperative period, ensuring adequate perfusion pressures and avoiding end-organ ischemia. Co-morbidities that increase their risk for cardiovascular problems include an increase in wall thickness and stiffness of the major arteries, increase in systemic vascular resistance, decrease in myocardial compliance, and age-related decrease in activity of baroreceptors⁸. Chronic hypertension shifts the blood pressure autoregulation curve of several end organs, making it necessary to maintain the patient blood pressure within 25–30% of their normal baseline values to help prevent end-organ ischemia. The presence of peripheral vascular disease (PVD) or prior CVAs can decrease the patient's tolerance to hypotensive episodes.

The majority of intravenous anesthetics tend to cause a decrease in blood pressure by a variety of mechanisms, and the effect is exaggerated by common cardiovascular medications including angiotensin receptor blocker's (ARB's), angiotensin converting enzyme inhibitor (ACEI), and diuretics. The cardiovascular effects of individual agents are discussed in the next section: (Table 1)

Propofol causes hypotension when used as an induction drug by creating arterial and venous vasodilation. It is also a direct myocardial depressant and abolishes the baroreceptor reflex, limiting the patient's ability to respond to hypotension. These effects are more pronounced with advanced age, hypovolemia, and rapid infusion. Elderly patients exhibit increased sensitivity to the hypnotic effects of propofol, requiring smaller doses than their younger counterparts⁹. Therefore, it is important to titrate the dose to the desired effect in the elderly population.

Etomidate lacks any direct cardiodepressant effect¹⁰ and maintains cardiovascular stability. It is an excellent induction agent for patients with known coronary artery disease (CAD), prior CVA, pulmonary hypertension, in which cardiovascular instability may be catastrophic. Undesirable effects include adrenocortical suppression, and higher incidence or postoperative nausea and vomiting.

Ketamine is considered a direct myocardial depressant. Its net effect is an increase in blood pressure, heart rate, and cardiac output through a centrally mediated increase in sympathetic stimulation, making it a suitable agent in hypovolemic patients to avoid an exaggerated hypotensive response. The tachycardia and increase in cardiac output can be undesirable in patients with known CAD. These net effects are also blunted by the administration of beta-blockers, or in critically-ill patients who are unable to further stress their sympathetic

system. Ketamine can have psychomimetic effects, which tend to be ameliorated by prior and concomitant benzodiazepine administration.

Opioids have a stable cardiovascular profile, unlikely to cause hypotension or myocardial depression. Morphine can stimulate histamine release, which can cause a decrease in blood pressure if administered as a rapid bolus or in high doses. Sensitivity to the analgesic effects of opioids also increases with age¹¹.

Inhalational anesthetics share similar cardiovascular effects. Commonly used agents, with the exception of nitrous oxide, cause a dose-dependent decrease in mean arterial pressure (MAP). Cardiac index is not affected. Volatile agents have been shown to protect against myocardial ischemia^{12–13}.

Respiratory effects—The relationship between Functional Residual Capacity (FRC) and Closing Capacity (CC) plays an important role in the pulmonary mechanics of the elderly patient. FRC is defined as the lung volume at the end of normal exhalation, and is reduced in the supine position due to decreased chest compliance from the pressure of abdominal contents on the diaphragm. CC refers to the volume at which small airways lacking cartilaginous support start to collapse in dependent areas of the lung, causing an intrapulmonary shunt and promoting hypoxia. CC steadily rises with age, but is not affected by posture. When CC exceeds FRC, alveoli in dependent areas of the lung collapse during normal tidal ventilation, increasing the risk of atelectasis and hypoxia. By age 66, CC equals or exceeds FRC in the upright position increasing the risk of atelectasis and hypoxia.¹⁴ General anesthesia compounds this effect by further collapsing aerated lung via a cephalad displacement of the diaphragm. Therefore age with its increase in CC and general anesthesia which further decreases the number of aerated alveoli increases the risk of atelectasis, shunt and hypoxia. This effect is eliminated when regional techniques are used as the main anesthetic.

Anesthesia affects the respiratory function and ventilation through a variety of mechanisms that relate to both position (as discussed above) and the intrinsic effects of anesthetics. Anesthesia also causes hypoventilation, increase in dead space, and increase in pulmonary shunting. Intravenous anesthetics inhibit input in multiple neurons of the respiratory system, while volatile agents decrease excitatory neurotransmission. Clinically, it translates into a decrease in ventilatory responses to hypoxia and hypercarbia¹⁵. Alveolar dead space is increased mostly during general anesthesia due to atelectasis and airway collapse in dependent areas of the lung. This effect can be reduced by application of positive end-expiratory pressure (PEEP). Inhalational agents also inhibit hypoxic pulmonary vasoconstriction at high doses, increasing the ventilation/perfusion (V/Q) mismatch.

The respiratory effects of individual agents is discussed in the next section: (Table 2)

Propofol is a potent respiratory depressant that causes apnea at induction doses. It also reduces upper airway reflexes, making it suitable in reactive airway disease.

Etomidate has less depressant effects on respiration than propofol. For this reason, it is an acceptable agent for sedation when maintenance of spontaneous ventilation and avoiding hypoxia and hypercarbia is paramount.

Ketamine does not severely depress respiratory function. It also has bronchodilating properties, which may be beneficial in patients with reactive airways or treating bronchospasm.

Benzodiazepines are not strong respiratory depressants, although transient apnea can occur following rapid administration. This effect is exacerbated in the elderly patients and in concomitant administration of opioids¹¹.

Opioids decrease ventilatory responses to CO₂, which can persist for several hours. Large doses can result in apnea. Clinically, opioids result in a breathing pattern characterized by a decrease in respiratory rate with a compensatory increase in tidal volume¹⁶.

Inhalational anesthetics result in an increased respiratory rate and decreased tidal volume, which leads to increased dead space ventilation. They also depress the respiratory response to hypoxia and hypercarbia, as well as hypoxic pulmonary vasoconstriction. They have bronchodilating properties.

Cerebral effects—Most intravenous anesthetics decrease both cerebral blood flow (CBF) and cerebral metabolic rate (CMRO₂), with the exception of ketamine.

The cerebral effects of individual agents is discussed in the next section: (Table 3)

Propofol decreases CBF and CMRO₂ resulting in a decrease in intracranial pressure (ICP). However the systemic hypotension associated with its administration can compromise cerebral perfusion pressure (CPP). Propofol may be neuroprotective against focal ischemia (not global ischemia). Excitatory responses such as muscle twitching can be observed after administration of propofol. Most studies support an anticonvulsant effect of propofol¹⁷.

Etomidate shares a similar profile with propofol.. However it can activate seizure foci and can also cause myoclonus during administration.

In contrast to most intravenous anesthetics, **Ketamine** is a cerebral vasodilator causing an increase in CBF, CMRO₂, and ICP, therefore not recommended in patients with intracranial hypertension.

Opioids are considered cerebral vasoconstrictors. However, the respiratory depression associated with them can lead to significant hypercarbia, which will in turn cause an increase in CBF and ICP. When administered in high doses, opioids can cause severe skeletal muscle rigidity (stiff-chest syndrome), which may interfere with adequate mechanical ventilation. The dose for volatile anesthetics is decreased in the presence of opioids¹⁸.

Benzodiazepines also cause a reduction of CBF and CMRO₂, but to a lesser extent. Similarly to the case with opioids, caution must be taken when administering them to patients with decreased intracranial compliance due to the transient respiratory depression caused after their administration. Benzodiazepines are also strong anticonvulsants.

Inhalational anesthetics do not abolish cerebral vascular responses to CO₂, but do impair cerebral autoregulation of blood flow. Nitrous oxide causes cerebral vasodilation and increases CMRO₂, whereas the potent inhalational agents decrease CMRO₂. Increases in cerebral blood flow and intracranial pressure occur at concentrations greater than average dosing.¹⁹

Effects of regional anesthetics

Regional anesthesia is an anesthetic technique that renders a portion of the patient's body insensate to pain allowing for the surgical procedure to take place while maintaining normal cognitive function. Regional anesthesia is accomplished by depositing local anesthetics perineurally. Local anesthetics provide anesthesia and analgesia by blocking voltage gated sodium channels leading to an interruption of the transmission of pain sensation along the nerve. The degree of nerve blockage depends on local anesthetic drug choice as well as drug concentration and volume. These local anesthetics vary from short acting anesthesia (thirty minutes) to long acting anesthesia (eight hours) and have variable analgesia from thirty minutes to twelve to twenty-four hours, depending how quickly the patient clears the drug. Additives may be beneficial to increase the duration of block by decreasing systemic absorption of the drug as well as providing an indicator of intravascular injection with placement of the block. In the absence of continuous peri-neural catheters prolongation of the local anesthetic may be achieved with additives.

Examples of regional anesthesia include spinals, epidurals and peripheral nerve blocks. Each will be discussed in detail below.

There are many advantages regional anesthesia.

The use of regional anesthesia instead of general anesthesia with volatile agents has been shown to reduce post-operative nausea and vomiting and lead to a reduced need for postoperative analgesics.^{20–23} It has also been associated with decreased blood loss during surgery.²⁴

Peripheral nerve blocks provide the additional benefit of only affecting the extremity that they are performed on and are not associated with major hemodynamic shifts that can be seen with general anesthesia.

As with any anesthetic there are risks associated with regional anesthesia, however serious complications are exceedingly rare.²⁵

The advantages of regional anesthesia in preventing cognitive dysfunction have been reviewed many times. This is a controversial topic and a recent meta-analysis was unable to show that the use of intraoperative neuraxial anesthesia reduces the incidence of post-operative cognitive dysfunction when compared with general anesthesia.²⁶

Neuraxial: Spinal and Epidural—Neuraxial anesthesia is divided into spinal anesthesia, epidural anesthesia or a combination of the two.

Spinal anesthesia onset begins shortly after the injection of drug in the intrathecal space regardless of the local anesthetic used. However the time of onset of spinal anesthesia varies depending on the drug used with shorter acting local anesthetics taking ten to fifteen minutes and longer acting local anesthetics taking greater than twenty minutes.

Epidural anesthesia requires the same block height as the spinal anesthesia but requires more time for onset and there can be greater variability with the spread. There is greater spread in older patients which is thought to be related to a less compliant epidural compartment.²⁷

Differential nerve block is the phenomenon describing nerve fibers with varying sensitivity to local anesthetic blockade. The order of nerves blocked are sympathetic nerve fibers followed by pain, touch, proprioception and motor. This phenomenon happens in both peripheral nerves blocks, spinals and epidurals. It is more of a temporal phenomenon in the peripheral nerve blocks and a spatial phenomenon in neuraxial blocks. Chamberlain et al described a sympathetic block extending two to six dermatomes higher than pin-prick sensation.²⁸ The significance of this is there may be cardiovascular side effects during spinal and epidural anesthesia. The blockade of the sympathetic fibers is the principal mechanism for hypotension and bradycardia in neuraxial anesthesia. Hypotension is the result of both arterial and venodilation. Venodilation generally leads to a fall in pre-load which can be compensated with intravenous fluid bolus and vasopressors.

The renin-angiotensin system helps offset the hypotensive event from neuraxial anesthesia therefore special consideration should be made when administering neuraxial anesthesia to patients taking angiotensin converting enzyme inhibitors or angiotensin II receptor blockers. The effect of neuraxial anesthesia on respiratory physiology is minimal. Lung volumes, resting minute ventilation, deadspace and arterial blood gas tensions show little or no change with neuraxial anesthesia. However high blocks can affect active exhalation.²⁹

Complications of neuraxial anesthesia

Post-dural puncture headache (PDPH) is a common complication of spinal anesthesia with variable reported incidence depending on needle size. The headache is classically described as virtually non-existent in the supine position and severe fronto-occipital headache with associated symptoms that disappears when supine again. The incidence of PDPH decreases with age.³⁰ Inadvertent spinal anesthesia above the dermatome level of C4 leads to profound hypotension, bradycardia, and respiratory arrest. If cardiovascular and respiratory functions are adequately supported then the spinal anesthetic resolves without sequelae.

Epidural and spinal hematoma are rare but devastating complications. The incidence is reported as less than 1 in 150, 000.²⁹ The leading risk factor for neuraxial hematoma is anticoagulation use. For guidelines concerning administration in patients that are anticoagulated, we refer the reader to the American Society for Regional Anesthesia and Pain Medicine consensus statement on neuraxial anesthesia and anticoagulation.³¹

Spinal and epidural anesthesia has been shown to decrease the intraoperative blood loss³² and decrease the mortality in surgical patients by one third.³³ The mechanism of the decreased blood loss is likely secondary to arterial and venous hypotension below the level of the neuraxial blockade. Authors from a 2000 review article were not certain about the mechanism for the decreased mortality.³³

Like peripheral nerve blocks epidural anesthesia can extend into the post-operative period to provide analgesia with superior analgesia to parenteral opioids.³⁴

Peripheral nerve blocks—This section of the manuscript is dedicated to specific techniques. We will provide an overview of the indications and brief description of the blocks. (Table 5)

Complications that apply to all peripheral nerve blocks are hemorrhagic, infectious, and neurologic. We will focus on specific complications based on region of the body where the block took place. The overall risk of a serious adverse event after peripheral nerve block has been reported as 0.04%.³⁵

Upper extremity—There are many techniques describing blocks of the brachial plexus. We will review them in the category of above the clavicle and below the clavicle. See Figure 4

Above the clavicle: Interscalene and supraclavicular nerve blocks are techniques named for their approach to the brachial plexus. The interscalene nerve block blocks the brachial plexus between the anterior and medial scalene muscles at the trunk level. This block reliably covers the upper and middle trunks and often misses ulnar distribution.²⁵

Side effects and complications—These may be a result of spread of the local anesthetic to surround structures or by accidental placement of needle to incorrect location or damage from placement.

The overall incidence of short and long term complications is 0.4%.³⁶ Complications or side effects with upper extremity blocks arise from effects of local anesthetic on surrounding structures or as the result from inappropriate needling. Table 4 These complications are likely dependent on the skill of the person performing the regional technique. Serious infections associated with single shot or continuous blocks are extremely rare.²⁵

Supraclavicular approach targets the brachial plexus at the trunk or division level depending on insertion site. This approach has similar risks as the interscalene with the incidence of phrenic nerve paresis ranging from 50% to 100%,²⁵ likely depending on insertion site and volume of drug given. The incidence of pneumothorax is approximately 6% based on all published literature but likely much more rare in experts trained in regional anesthesia using ultrasound guidance.²⁵

One major benefit of regional anesthesia is it may provide the initial surgical anesthesia and continue to provide post-operative analgesia. Peripheral nerve blocks are not associated with major respiratory changes except for a pulmonary function decrease with blocks above the

clavicle transiently affecting the phrenic nerve and in turn leading to a transient hemidiaphragm paresis.

Brachial plexus blocks below the clavicle—Infraclavicular, axillary and distal terminal branch blocks. See Figure 4

The infraclavicular approach targets the brachial plexus at the cord level in the lateral aspect of the chest. It has a small risk of pneumothorax 0.6%²⁵ and no chance of phrenic nerve blockade allowing the patient to maintain normal respiratory function. The anesthesia associated with this block is mid humerus and distal.

Axillary nerve block targets the brachial plexus at the terminal branches. The risks associated with this block are bleeding, infection, damage to underlying tissue and intravascular injection of drug.

Lower extremity—The lumbar plexus gives rise to the femoral nerve, which turns into the saphenous nerve and provides innervation of the skin over the medial leg and ankle.

The remainder of the leg receives innervations from branches from the sciatic nerve. The sciatic nerve can be anesthetized anywhere along its course from proximally to distally but is often blocked proximally under the gluteus maximus muscle or distally prior to the split into common peroneal and tibial nerves in the popliteal fossa. If a thigh tourniquet is going to be used this will require a neuraxial or a proximal sciatic and femoral nerve block to provide anesthesia for the tourniquet discomfort in addition to the surgical site. Risks of the femoral and sciatic nerve blocks are bleeding, intravascular injection, infection, damage to the nerve.

Choice of anesthetic by fracture

The anesthetic options are based on location of fracture as well as the patient comorbidities and preferences.

The choice of anesthetic is less of a concern in ASA I–II patients. ASA III and IV patients with significant cardiovascular or respiratory comorbidities may benefit from avoidance of general anesthesia and the hemodynamic derangements associated with it.

Extremity fracture—Extremity fractures are amenable to regional anesthesia for the intraoperative anesthetic and a peripheral nerve catheter for post-operative pain control. Upper extremity anesthesia can be accomplished with a single brachial plexus injection or placement of a peripheral nerve catheter. Table 5

Regional anesthesia choice for lower extremity fractures depends on the location of the fracture, patient co-morbidities, duration of surgery, location of the tourniquet and patient preference. Branches of the sacral plexus as well as branches of the lumbar plexus need to be anesthetized for the primary anesthesia. This can be accomplished with a neuraxial technique, or peripheral nerve techniques. Table 5

Hip fracture—Our anesthetic of choice is neuraxial anesthesia assuming no contraindications. Table 5 In our center, 42% of procedures are done under spinal often due to relative and absolute contraindications for regional anesthesia and anesthesiologist preference. These patients are in pain and often deteriorate the longer it takes to fix the fracture. Early fracture repair helps with cognitive function and earlier mobilization.

Researchers from Cornell University reviewed data from 400 US hospitals to determine whether neuraxial anesthesia or general anesthesia had better outcomes following primary hip or knee replacements.⁴¹ They reviewed 382,236 cases from 2006 to 2010 comparing neuraxial to general anesthesia. They found that the neuraxial group had an 80% lower 30 day mortality rate and 30%–50% lower risk of major complications including stroke, renal failure, pneumonia or need for mechanical ventilation.

Strategies for Post operative pain management—Undertreatment of postoperative pain can lead to adverse physiological and psychological consequences that can lead to increased morbidity and mortality and prolong patient recovery time.⁴² Suboptimal pain management leads to inadequate ambulation and increased complications including greater lengths of hospital stay and costs associated with those.⁴³

Multimodal analgesia: The pain management objective is to maximize patient recovery and function and minimize the associated side effects. A multi-modal approach can best accomplish this.⁴⁴ First line agents are non-opioid agents like acetaminophen, and targeted local anesthetics. Acetaminophen is likely the agent of choice for mild to moderate pain in the elderly patient with normal hepatic function owing to its effective analgesic properties and minimal side effects. Peripheral nerve blocks either single shot or catheter techniques offer the unique ability to provide superior pain control to opioid alone and the ability to do so over an extended period of time.

Peripheral nerve catheters, a technique gaining popularity in the United States, can be placed pre or post-operatively and provide extended pain relief while the infusion is running. Patients may be discharged home with peripheral nerve catheters in place and remove them at home or return to the hospital for removal. This practice is hospital specific.

Conclusions

Older adults presenting with fragility fractures often require special preoperative management. Medical optimization prior to surgery is often a team approach. Anesthetic consideration for intraoperative management are based on patient comorbidities and preferences. Regional anesthesia may be preferable to general due to reduced negative cardiovascular, pulmonary, and possible cognitive effects.

References

1. Guidelines for preclinical evaluation and clinical trials in osteoporosis. World Health Organization; Geneva: 1998.
2. Brown JP, Josse RG. 2002 clinical practice guidelines for the diagnosis and management of osteoporosis in Canada. Scientific Advisory Council of the Osteoporosis Society of Canada CMAJ. 2002; 167(10 Suppl):S1–34.

3. Vanasse A, Dagenais P, Niyonsenga T, et al. Bone mineral density measurement and osteoporosis treatment after a fragility fracture in older adults: regional variation and determinants of use in Quebec. *BMC Musculoskelet Disord*. 2005; 6:33. [PubMed: 15969760]
4. American Academy of Orthopaedic Surgeons. [Accessed September 14, 2013] Position Statement. 2009. Available at: <http://www.aaos.org/about/papers/position/1159.asp>
5. Holroyd C, Cooper C, et al. Epidemiology of osteoporosis. *Best Pract Res Clin Endocrinol Metab*. 2008; 22(5):671–85. [PubMed: 19028351]
6. Wong GT, Sun NC. Providing perioperative care for patients with hip fractures. *Osteoporos Int*. 2010; 21:S547–S553. [PubMed: 21057994]
7. Fleisher LA, Beckman JA, Brown KA, et al. American College of Cardiology/American Heart Association Task Force on Practice Guidelines Writing Committee to Revise the 2002 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery); American Society of Echocardiography; American Society of Nuclear Cardiology; Heart Rhythm Society; Society of Cardiovascular Anesthesiologists; Society for Cardiovascular Angiography and Interventions; Society for Vascular Medicine and Biology; Society for Vascular Surgery. ACC/AHA 2007 guidelines on perioperative cardiovascular evaluation and care for noncardiac surgery: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 2002 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery): developed in collaboration with the American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Rhythm Society, Society of Cardiovascular Anesthesiologists, Society for Cardiovascular Angiography and Interventions, Society for Vascular Medicine and Biology, and Society for Vascular Surgery. *Circulation*. 2007; 116(17):e418–99. Epub 2007 Sep 27 Erratum in: *Circulation* 2008, 117 (5), e154. [PubMed: 17901357] *Circulation*. 2008 Aug 26; 118(9):e143–4.
8. Leung, JM. Elderly patients. In: Stoelting, RK.; Miller, RD., editors. *Basics of Anesthesia*. 5. Philadelphia: Churchill Livingstone; 2007. p. 518–519.
9. Dundee JW, Robinson FP, McCollum JS, Patterson CC. Sensitivity to propofol in the elderly. *Anaesthesia*. 1986; 41:482–485. [PubMed: 3487990]
10. Eilers, H. Intravenous anesthetics. In: Stoelting, RK.; Miller, RD., editors. *Basics of Anesthesia*. 5. Philadelphia: Churchill Livingstone; 2007. p. 109
11. Geriatric anesthesia 95–98
12. DeHert SG, Cromheeke S, ten Broecke PW, et al. Effects of propofol, desflurane, and sevoflurane on recovery of myocardial function after coronary surgery in the elderly high-risk patients. *Anesthesiology*. 2003; 99:314–323. [PubMed: 12883404]
13. DeHert SG, Van Der Linden PJ, Cromheeke S, et al. Cardioprotective properties of sevoflurane in patients undergoing coronary surgery and cardiopulmonary bypass are related to the modalities of its administration. *Anesthesiology*. 2004; 101:299–310. [PubMed: 15277911]
14. Morgan, ME.; Mikhail, MS.; Murray, MJ. *Clinical Anesthesiology*. 4. McGraw-Hill; 2006. Respiratory Physiology: the effects of anesthesia; p. 546
15. Feiner, J. Clinical cardiac and pulmonary physiology. In: Stoelting, RK.; Miller, RD., editors. *Basics of Anesthesia*. 5. Philadelphia: Churchill Livingstone; 2007. p. 62
16. Stoelting, R. Opioids. In: Stoelting, RK.; Miller, RD., editors. *Basics of Anesthesia*. 5. Philadelphia: Churchill Livingstone; 2007. p. 116
17. Stoelting, RK.; Hillier, SC. Pharmacology and Physiology in Anesthetic Practice. 4. Philadelphia: Lippincott Williams & Wilkins; 2006. Nonbarbiturate intravenous anesthetic drugs; p. 155–178.
18. Lang E, Kapila A, Schlugman D, et al. Reduction of isoflurane minimal alveolar concentration by remifentanyl. *Anesthesiology*. 1996; 85:721–728. [PubMed: 8873541]
19. McKay, RE.; Sonner, J.; McCay, WR. Inhaled anesthetics. In: Stoelting, RK.; Miller, RD., editors. *Basics of Anesthesia*. 5. Philadelphia: Churchill Livingstone; 2007. p. 93–94.
20. Pavlin DJ, Rapp SE, Polissar NL, Malmgren JA, Koerschgen M, Keyes H. Factors affecting discharge time in adult outpatients. *Anesth Analg*. 1998; 87(4):816–26. [PubMed: 9768776]
21. Hadzic A, Kerimoglu B, Loreio D, et al. Paravertebral blocks provide superior same-day recovery over general anesthesia for patients undergoing inguinal hernia repair. *Anesth Analg*. 2006; 102(4):1076–81. [PubMed: 16551902]

22. Williams BA, Kentor ML, Vogt MT, et al. Femoral-sciatic nerve blocks for complex outpatient knee surgery are associated with less postoperative pain before same-day discharge: a review of 1,200 consecutive cases from the period 1996–1999. *Anesthesiology*. 2003; 98(5):1206–13. [PubMed: 12717143]
23. Williams BA, Kentor ML, Vogt MT, et al. Economics of nerve block pain management after anterior cruciate ligament reconstruction: potential hospital cost savings via associated postanesthesia care unit bypass and same-day discharge. *Anesthesiology*. 2004; 100(3):697–706. [PubMed: 15108988]
24. Richman JM, Rowlingson AJ, Maine DN, Courpas GE, Weller JF, Wu CL. Does neuraxial anesthesia reduce intraoperative blood loss? A meta-analysis. *J Clin Anesth*. 2006; 18(6):427–35. [PubMed: 16980159]
25. Neal JM, Gerancher JC, Hebl JR, et al. Upper extremity regional anesthesia: essentials of our current understanding, 2008. *Reg Anesth Pain Med*. 2009; 34(2):134–70. [PubMed: 19282714]
26. Wu CL, Hsu W, Richman JM, et al. Postoperative cognitive function as an outcome of regional anesthesia and analgesia. *Reg Anesth Pain Med*. 2004; 29(3):257–68. [PubMed: 15138912]
27. Burn JM, Guyer PB, Langdon L. The spread of solutions injected into the epidural space. *Br J anaesth*. 1973; 45:338. [PubMed: 4267504]
28. Chamberlain D, Chamberlain B. Changes in skin temperature of the trunk and their relationship to sympathetic block during spinal anesthesia. *Anesthesiology*. 1986; 65:139. [PubMed: 3740502]
29. Bernards, CM. Epidural and spinal anesthesia. In: Barash, PG.; Cullen, BF.; Stoelting, RK., editors. *Clinical anesthesia*. 6. Lippincott Williams & Wilkins; Philadelphia, PA: 2009. p. 946
30. Lybecker H, Møller JT, May O, et al. Incidence and prediction of postdural puncture headache. A prospective study of 1021 spinal anesthetics. *Anesth Analg*. 1990; 70(4):389–94. [PubMed: 2316881]
31. Horlocker TT, Wedel DJ, Rowlingson JC, et al. Regional anesthesia in the patient receiving antithrombotic or thrombolytic therapy: American Society of Regional Anesthesia and Pain Medicine Evidence-Based Guidelines (Third Edition). *Reg Anesth Pain Med*. 2010; 35(1):64–101. [PubMed: 20052816]
32. Richman JM, Rowlingson AJ, Maine DN, et al. Does neuraxial anesthesia reduce intraoperative blood loss? A meta-analysis. *J Clin Anesth*. 2006; 18:427–35. [PubMed: 16980159]
33. Rodgers A, Walker N, Schug S, et al. Reduction of postoperative mortality and morbidity with epidural or spinal anaesthesia: results from overview of randomised trials. *BMJ*. 2000; 321:1493. [PubMed: 11118174]
34. Block BM, Liu SS, Rowlingson AJ, et al. Efficacy of postoperative epidural analgesia: A meta-analysis. *J Am Med Assoc*. 2003; 290:2455.
35. Auroy Y, Benhamou D, Bargues L, et al. Major complications of regional anesthesia in France. The SOS regional anesthesia hotline service. *Anesthesiology*. 2002; 97:1274–1280. [PubMed: 12411815]
36. Borgeat A, Ekatodramis G, Kalberer F, et al. Acute and nonacute complications associated with interscalene block and shoulder surgery. A prospective study. *Anesth Analg*. 2001; 95:875–880.
37. Urmev W, McDonald M. 100% incidence of hemidiaphragmatic paresis associated with interscalene brachial plexus anesthesia as diagnosed by ultrasonography. *Anesth Analg*. 1991; 72:498–503.
38. Borgeat, A.; Blumenthal, S. Unintended destinations of local anesthetics. In: Neal, JM.; Rathmell, JP., editors. *Complications in Regional Anesthesia and Pain Medicine*. Philadelphia: Saunders Elsevier; 2007. p. 157-163.
39. Seltzer JL. Hoarseness and Horner's syndrome after interscalene brachial plexus block. *Anesth Analg*. 1977; 56:585–586. [PubMed: 560150]
40. Capdevila X, Pirat P, Bringuier S, et al. Continuous peripheral nerve blocks in hospital wards after orthopedic surgery. *Anesthesiology*. 2005; 103:1035–1045. [PubMed: 16249678]
41. Memtsoudis SG, Sun X, Chiu YL, et al. Perioperative comparative effectiveness of anesthetic technique in orthopedic patients. *Anesthesiology*. 2013; 118(5):1046–58. [PubMed: 23612126]

42. Wu CL, Cohen SR, Richman JM, et al. Efficacy of postoperative patient-controlled and continuous infusion epidural analgesia versus intravenous patient-controlled analgesia with opioids: a meta-analysis. *Anesthesiology*. 2005; 103:1079–1088. [PubMed: 16249683]
43. Karani R, Meier DE. Systemic pharmacologic postoperative pain management in the geriatric orthopaedic patient. *Clin Orthop Relat Res*. 2004:26–34. [PubMed: 15292784]
44. Hanna, MN.; Ouanes, JP.; Tomas, VG. *Practical Management of Pain*. 5. Philadelphia, PA: Elsevier; 2014. Postoperative pain and other acute pain syndromes; p. 271

Key Points

- Pre-operative workup considerations include evaluation of associated injuries as well as co-morbidities commonly found in the elderly population.
- Anesthesia options include general and regional anesthesia.
- Regional anesthesia offers the advantage of effectively anesthetizing the surgical site while avoiding some of the cardiovascular, respiratory, and cerebral physiologic alterations associated with general anesthesia.
- Regional anesthesia offers the benefit of intraoperative anesthesia with the ability to provide analgesia into the post-operative period.

Predictor of pulmonary complications

Room air O₂ saturation < 90%
Low hemoglobin
FEV₁ less than 50% predicted
FVC < 1.7 Liters

Figure 1.

Physiologic parameters that help predict post-operative pulmonary complications. O₂ = oxygen; FEV₁ = Forced Expiratory Volume at 1 second; FVC = Forced Vital Capacity

Factors which increase the risk of complications in the elderly

Emergency surgery
High ASA classification
Certain surgeries
 Major vascular (non-carotid)
 Thoracic (especially lung resection)
 Open colon resection or open cholecystectomy
Comorbidities

Figure 2.

Factors which increase the risk of complications in the elderly

ASA Physical Status Classification

ASA Physical Status 1 - A normal healthy patient

ASA Physical Status 2 - A patient with mild systemic disease

ASA Physical Status 3 - A patient with severe systemic disease

ASA Physical Status 4 - A patient with severe systemic disease that is a constant threat to life

ASA Physical Status 5 - A moribund patient who is not expected to survive without the operation

ASA Physical Status 6 - A declared brain-dead patient whose organs are being removed for donor purposes

Figure 3.

American Society of Anesthesiologists physical status classification. ASA = American Society of Anesthesiologists

Figure 4.

Table 1CV Physiology: Effects of Anesthesia⁹⁻¹³

	Propofol	Etomidate	Ketamine	Opioids	Inhalational
BP	↓	↓ (mild)	↑ *	—	↓ Decrease SVR
Preload	↑	—	—	—	—
Afterload	↑	↓	↑	—	↓
Myocardial Contractility	↑	—	↓ Direct effect *	—	—
Baroreceptor Reflex	Inhibits	—	—	—	↓

↑ Increase; ↓ Decrease; — Unchanged

* Net effect through centrally mediated sympathetic stimulation.

Table 2

Respiratory: Effects of Anesthesia⁹⁻¹⁶

	Propofol	Etomidate	Ketamine	Opioids	Benzodiazepines	Inhalational
Ventilation	⇕	↑	—	⇕	↑	↑
Upper airway reflexes	⇕	—	—	↑	—	↑
Response to Hypercarbia	↑	—	—	↑	↑	↑
Other		Depression of ventilation increased in combination with inhalational/opioids	Bronchodilator	Pattern ↑ RR ↑ V _T		Pattern ↑ RR ↑ V _T Bronchodilators

↑ Increase; ↓ Decrease; — Unchanged; RR = Respiratory Rate; V_T = Tidal Volume

Table 3

Cerebral Physiology: Effects of anesthesia⁹⁻¹⁹

	Propofol	Etomidate	Ketamine	Opioids	Benzodiazepines	Inhalational
Cerebral blood flow	⇕	⇕	↑	↓ Direct effect *	↓ *	↑ Impair autoregulation at > 1 MAC
CMRO ₂	↑	↑	↑	—	↑	↑
CPP	⇕	↑	↑	—	↑	↑ (> 1 MAC)
ICP	↑	↑	↑	↓ *	↑	
Seizure foci	-/may cause	Activates/May cause	Inhibits	—	Inhibit	—

* Hypercarbia associated with respiratory depression can cause an increase in CBF and ICP
↑ Increase; ↓ Decrease; — Unchanged

Table 4

Complications or side effects with upper extremity blocks from effects of local anesthetic on surround structures or inappropriate needling²⁵

Local anesthetic spread^{38–41}

Transient blockade of the phrenic nerve with subsequent hemidiaphragmatic paresis with an incidence of 100%³⁸ leading to reduction in spirometric measurements by 25–32%.

Blockade of the cervical sympathetic chain with an incidence of 20–90%³⁹ leading to Horner's syndrome.

Hoarseness secondary to recurrent laryngeal nerve blockade.^{40–41}

Inappropriate needling²⁵

Intravascular injection 0–11%

Subarachnoid or epidural injection

Pneumothorax 6%

Infection

Table 5

Regional Anesthesia by Fragility Fracture Type

Fracture	Technique	Anesthesia Agent	Considerations and Comments
Upper Extremity Humerus Radius/Ulnar	Single shot or catheter brachial plexus block above or below clavicle depending on fracture location and patient co-morbidities	Choice of agent based on anesthetic goal, i.e. goal of intraop ± postop anesthesia and analgesia versus intraop anesthesia alone versus postop analgesia alone	May leave a peri-neural catheter for post-operative pain control Blocks the brachial plexus above the clavicle are associated with: <ul style="list-style-type: none"> a. Ipsilateral phrenic nerve block 50%–100% of the time. b. Horner's syndrome c. Hoarseness d. Potential for pneumothorax (1–6%)
Hip/Femur	Spinal CSE Epidural	Choice of anesthesia based on estimated duration of surgery and need for post-operative analgesia	Contraindicated in patient receiving antithrombotic or thrombolytic therapy See ASRA guidelines ^{Horlocker 2010} Hip fractures pain generally controlled with acetaminophen post repair. Cautious management of epidural for post-op pain with concomitant anticoagulation. See ASRA guidelines ^{Horlocker 2010}
Lower Extremity Foot/Ankle	Spinal CSE Epidural Single shot or catheter femoral or sciatic nerve blocks	Choice of anesthesia based on estimated duration of surgery and need for post-operative analgesia	Neuraxial contraindication same as above for Hip/Femur. Peripheral nerve blocks are acceptable in patients on antithrombotic or thrombolytic therapy. Must consider risk benefit of regional and visualization of the vessels with ultrasound and compressibility of the vasculature of the purposed site.

Intraop, intraoperative; Postop, postoperative; CSE, Combined Spinal Epidural anesthesia.