Chapter

14 CHOICE OF ANESTHETIC TECHNIQUE

Elizabeth L. Whitlock and Manuel C. Pardo, Jr.

The decision-making process regarding anesthetic technique begins with the preoperative evaluation (see Chapter 13). The three most important factors include type of surgical procedure, the patient's coexisting diseases, and patient preferences. The ultimate responsibility for anesthetic choice lies with the anesthesia provider. Often, there is no single best choice. The anesthesia provider must have the ability to implement a range of anesthetic plans and be prepared to address unexpected events that may necessitate a sudden change in plan.

TYPES OF ANESTHESIA

Choices for anesthesia include (1) general anesthesia, (2) regional anesthesia, and (3) monitored anesthesia care (MAC).

Although there is some debate about the clinical definition of general anesthesia, the components include immobility, amnesia, analgesia, and lack of patient harm.[1] The American Society of Anesthesiologists (ASA) defines general anesthesia as "a drug-induced loss of consciousness during which patients are not arousable, even by painful stimulation."[2] Modern approaches to general anesthesia involve administration of a combination of medications, such as hypnotic drugs (see Chapters 7 and 8), neuromuscular blocking drugs (see Chapter 11), and analgesic drugs (see Chapter 9).

Regional anesthesia includes neuraxial (spinal, epidural, caudal) anesthesia (see Chapter 17) as well as peripheral nerve blocks (see Chapter 18). With a cooperative patient, regional anesthesia may ensure the appropriate immobility and analgesia required for surgery, without exposing the patient to the risks of general anesthesia.

The editors and publisher would like to thank Dr. Ronald D. Miller for contributing to this chapter in the previous edition of this work. It has served as the foundation for the current chapter.

Table 14.1 Continuum of Depth of Sedation

Function	Minimal Sedation (Anxiolysis)	Moderate Sedation (Conscious Sedation)	Deep Sedation	General Anesthesia
Response (stimulation type)	Normal (verbal stimulus)	Purposeful (verbal or tactile stimulus)	Purposeful (repeated or painful stimulus)	None (even with painful stimulus)
Ability to maintain airway and spontaneous ventilation	Not affected	Airway maintained without intervention; ventilation adequate	Airway intervention may be required; ventilation may be inadequate	Airway intervention often required; ventilation frequently inadequate
Cardiovascular function	Not affected	Usually maintained	Usually maintained	May be impaired

From Continuum of Depth of Sedation: Definition of General Anesthesia and Levels of Sedation/Analgesia (approved by the ASA House of Delegates on October 13, 1999, and last amended on October 15, 2014).

The phrase *monitored anesthesia care* was created by the ASA in the 1980s to replace the term *standby anesthesia* and to facilitate professional fee billing. The original description of MAC referred to the anesthesiologist providing anesthesia services to a patient receiving local anesthesia or no anesthesia at all.[3] The ASA currently defines MAC as "a specific anesthesia service in which an anesthesiologist has been requested to participate in the care of a patient undergoing a diagnostic or therapeutic procedure." The ASA has also described a continuum of depth of sedation that includes progressive levels of sedation (Table 14.1). These definitions are used by regulatory bodies such as The Joint Commission to create standards for administration of sedation by nonanesthesiologist personnel. The term MAC is not part of the description of the sedation continuum, as the level of consciousness may change during a procedure and even progress to an "unplanned" general anesthetic. The preoperative evaluation, monitoring, and other anesthesia care standards apply equally to the patient receiving MAC.

CHOOSING AN APPROPRIATE ANESTHETIC TECHNIQUE

Factors identified in the preoperative evaluation can indicate that general anesthesia may be the most appropriate anesthetic choice (Box 14.1). If general anesthesia is chosen, the anesthesia provider must then determine a plan for airway management, induction of anesthesia, maintenance of anesthesia, and immediate postoperative care. If general anesthesia is not chosen, other anesthetic options include regional anesthesia or MAC.

Certain patient or procedure characteristics may preclude safe regional anesthesia (Box 14.2). Depending on the level of sedation required, a regional technique may allow surgical anesthesia with complete preservation of upper airway reflexes, even in the patient at risk for aspiration of gastric contents. Regional anesthesia cannot provide surgical analgesia for all procedures. The most important factor is the planned location of the surgical incision (Fig. 14.1).

If the analgesic requirements for the planned procedure can be met with local or topical anesthesia, or if the

Box 14.1 Clinical Settings Appropriate for General Anesthesia

A requirement for systemic neuromuscular blockade
A requirement for establishment of a secure airway
- Due to surgical procedures that may compromise native airway integrity, oxygenation, or ventilation
- Due to level of consciousness required to provide immobility, analgesia, or anxiolysis

Patient or procedural characteristics that are not appropriate for monitored anesthesia care
- Uncooperative patient or patient refusal
- Surgical pain not amenable to local or topical anesthesia

Patient or procedural characteristics that are not suitable for regional anesthetic
Preferences of the patient, anesthesia provider, and/or surgeon

Box 14.2 Situations in Which Regional Anesthesia May Not Be Appropriate

Preferences and experience of the patient, anesthesia provider, and surgeon
The need for an immediate postoperative neurologic examination in the anatomic area impacted by the regional anesthetic
Coagulopathy
Preexisting neurologic disease (e.g., multiple sclerosis, neurofibromatosis)
Infected or abnormal skin at the planned cutaneous puncture site

Specific Considerations for Neuraxial Anesthesia

Hypovolemia increases the risk for significant hypotension
Coagulopathy (including anticoagulant and antiplatelet medication therapy) increases risk of epidural hematoma
Increased intracranial pressure may result in cerebral herniation with intentional or inadvertent dural puncture

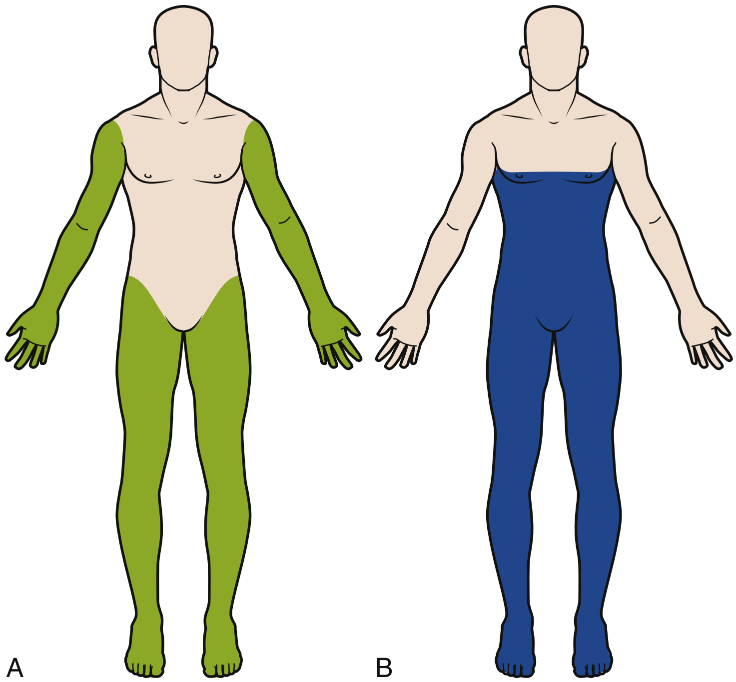

Fig. 14.1 Anatomic regions potentially amenable to peripheral nerve or neuraxial block. (A) Peripheral nerve block: green areas indicate where complete surgical analgesia can typically be provided. (B) Neuraxial block: blue areas indicate where complete surgical analgesia can typically be provided.

planned procedure is not associated with pain (e.g., diagnostic radiology procedure such as magnetic resonance imaging), MAC may be the most appropriate choice. However, the anesthesia provider must be prepared to convert to general anesthesia if it becomes apparent that appropriate analgesia and immobility cannot be achieved by other means. The anesthetic risks associated with MAC are not necessarily different from general or regional anesthesia. An ASA Closed Claims study of patient injury documented a comparable incidence of injury severity with MAC compared to general anesthesia.[4] In patients receiving MAC, respiratory depression from sedative drugs (e.g., propofol, benzodiazepines, opioids) is an important mechanism of injury.

Anesthetic techniques can be combined to meet patient or surgical goals. For example, a patient with subarachnoid hemorrhage who requires diagnostic cerebral angiography may initially receive MAC. If the imaging reveals a cerebral aneurysm requiring endovascular coiling, the anesthesia provider may be asked to convert to general anesthesia to provide patient immobility and control of ventilation during the procedure.

Neuraxial and peripheral nerve blockade may be combined with general anesthesia to provide long-lasting postoperative analgesia following a surgical procedure that may not be amenable to regional anesthesia alone (also see Chapter 40). A 2013 systematic review documented that, in a broad range of surgical procedures, use of local infiltration or peripheral nerve block in addition to general anesthesia improved postoperative pain scores and decreased opiate consumption.[5] This result may be directly due to analgesia provided by the technique or by “preventive analgesia,” which is defined as analgesia lasting longer than 5.5 half-lives of an analgesic drug. Even use of a peripheral nerve block in addition to a single-shot spinal block improves postoperative analgesia for many surgeries of the lower extremity.[5]

The addition of a regional technique to general anesthesia may reduce intraoperative blood loss and, in some situations, the rate of perioperative transfusion.[6] Addition of neuraxial or peripheral nerve blockade to general anesthesia also reduces rates of postoperative chronic pain.[7] A meta-analysis of systematic reviews did not find a mortality rate benefit for the addition of neuraxial anesthesia to general anesthesia.[8] The same meta-analysis suggested that neuraxial anesthesia was associated with lower 30-day mortality rates compared to general anesthesia alone in patients with an intermediate risk of cardiac complications. However, most of the studies reviewed were performed in the 1970s to 1990s, and management of cardiovascular disease has evolved significantly in subsequent decades.[8]

There is increasing emphasis on improving patient outcomes not just in the immediate term (e.g., intraoperatively) but facilitating in-hospital recovery, mitigating risks for development of postoperative chronic pain, and improving long-term survival.

Fig. 14.2 provides a summary of the decision-making process in choosing an appropriate anesthetic for an individual patient.

PRACTICAL ASPECTS OF ANESTHESIA CHOICE

General Anesthesia

The choice of general anesthesia includes planning for induction of anesthesia, airway management, maintenance of anesthesia, and postoperative care. Induction of anesthesia can be accomplished via the inhaled or intravenous route of anesthetic administration. Both choices may benefit from verbal or pharmacologic (e.g., benzodiazepine) anxiolysis. Preoxygenation—also called *denitrogenation*—is the deliberate replacement of nitrogen in the patient's functional residual capacity (FRC) with oxygen. Eight vital capacity breaths of 100% oxygen over 60 seconds, or tidal volume breathing of 100% oxygen for 3 minutes, replaces roughly 80% of the FRC with oxygen. This provides a crucial margin of safety during periods of apnea or upper airway obstruction that can occur with induction of general anesthesia. Thus, adequate preoxygenation can delay or eliminate the onset of hypoxemia during the time period between the intravenous induction of anesthesia and the start of controlled ventilation.

An inhaled induction of anesthesia is often chosen for pediatric patients in whom preinduction placement of an intravenous catheter is impractical (also see Chapter 34). Also, it may be indicated in the patient who is anticipated to have a difficult airway to manage, because spontaneous respiratory efforts are preserved with an inhaled induction of anesthesia. However, inhaled anesthetics ablate protective airway reflexes and pharyngeal muscular tone, so this method will not be suitable for all patients in whom difficulties with airway management are anticipated. Sevoflurane is the most commonly used anesthetic for inhaled induction of anesthesia because of its low pungency, high potency (permitting delivery of high-inspired oxygen concentration), and rapidity of onset. To further hasten onset, a technique called *priming* can be used. This involves filling the breathing circuit with 8% sevoflurane by emptying the reservoir bag, opening the adjustable pressure-limiting valve, and using a high fresh gas flow (e.g., 8 L/min) for 1 minute before applying the face mask to the patient. This approach to inhaled induction of anesthesia can produce loss of consciousness within 1 minute.

Intravenous induction of anesthesia is the most common technique in the adult patient. Pharmacologic options include propofol, thiopental, etomidate, ketamine, and a benzodiazepine-opioid combination (also see Chapters 8 and 9). After the patient loses consciousness, ventilation via a mask is initiated. The anesthesia provider may then choose to administer an inhaled anesthetic to increase the

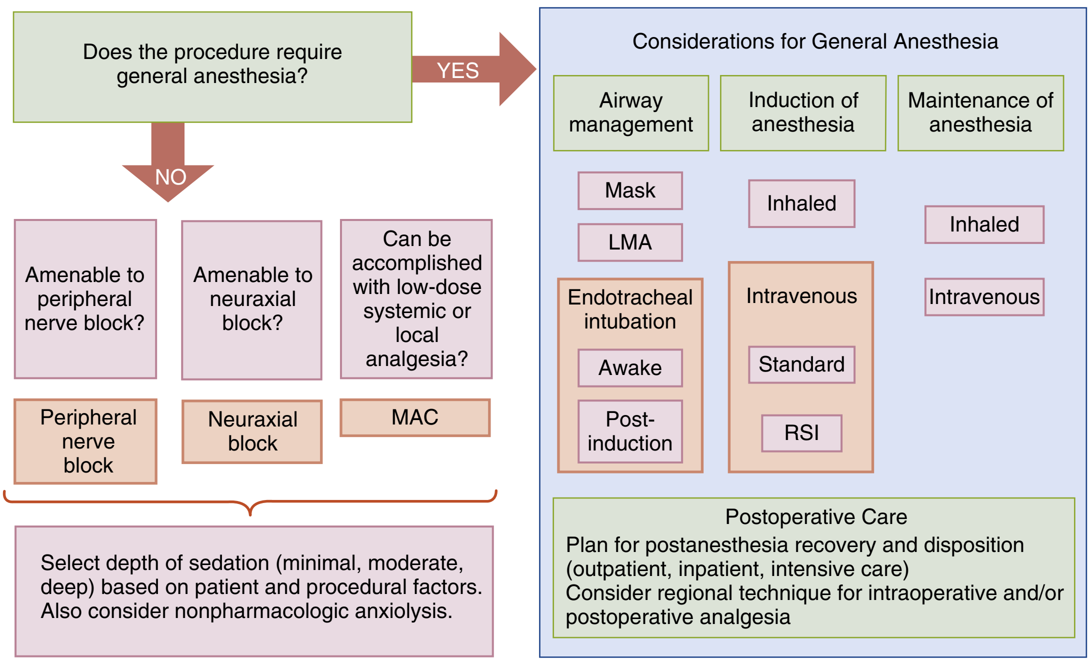

Fig. 14.2 Decision-making process for anesthetic choice. An approach to determining anesthetic plan based on surgical procedure, patient's coexisting diseases, and patient preferences. *GA,* General anesthesia; *LMA,* laryngeal mask airway; *MAC,* monitored anesthesia care; *RSI,* rapid sequence induction.

depth of anesthesia prior to airway instrumentation. If tracheal intubation is planned, a neuromuscular blocking drug is usually given to facilitate direct laryngoscopy (also see Chapter 11).

Sometimes an intravenous rapid sequence induction (RSI) is indicated. RSI is performed in patients at increased risk for aspiration of gastric contents (e.g., clinically significant gastroesophageal reflux disease, delayed gastric emptying, unknown fasting state, or a known full stomach). The goal of RSI is to minimize the time between onset of unconsciousness and tracheal intubation and reduce the risk of regurgitation by applying cricoid pressure. The sequence of events involves (1) preoxygenation; (2) intravenous administration of a hypnotic (e.g., propofol); (3) immediate administration a of a rapid-onset neuromuscular blocking drug (e.g., succinylcholine 1.0–1.5 mg/kg or rocuronium 1.0–1.2 mg/kg); (4) application of cricoid pressure (using force of 30 newtons, approximately 7 pounds); (5) avoidance of ventilation via a mask or (6) tracheal intubation; and (7) release of cricoid pressure after confirmation of correct endotracheal tube placement. Though ventilation via a mask is generally avoided with RSI, the use of positive pressure less than 20 cm H_2O (called *modified* RSI) should minimize the risk of gastric insufflation and may be needed if the patient develops hypoxemia prior to tracheal intubation. Although RSI with cricoid pressure has been used for several decades and is a standard of care approach, a recent meta-analysis did not demonstrate a measurable impact of cricoid pressure on clinical outcomes during RSI.[9]

Airway management techniques (e.g., direct laryngoscopy, supraglottic airway placement) are implemented after the intravenous or inhaled induction of anesthesia. However, if the anesthesia provider anticipates difficulty with ventilation via a mask or tracheal intubation then tracheal intubation should be initiated prior to induction of anesthesia (i.e., awake intubation) (also see Chapter 16).

After induction of anesthesia and appropriate airway management, anesthesia is maintained typically by administration of a combination of anesthetic drugs, each titrated to achieve the desired anesthetic goal while minimizing side effects. For example, although high concentrations of inhaled anesthetics can produce skeletal muscle relaxation, the risks of cardiac depression and vasodilation increase. Neuromuscular blocking drugs can facilitate surgical exposure once adequate hypnosis and analgesia are achieved. Thus, the anesthesia provider selects medications that target specific anesthetic requirements while minimizing the cumulative risk of undesired effects. Individual patients and particular surgical procedures may present special considerations that influence the choice of anesthesia maintenance strategy.

Potent inhaled anesthetics (also see Chapter 7) represent the mainstay of drugs used to maintain anesthesia in most clinical situations. They are easily titratable, reduce the autonomic response to noxious stimulation, and at clinically relevant doses can often provide sufficient muscle relaxation to facilitate surgical exposure. Another inhaled anesthetic, nitrous oxide, can provide both hypnosis and analgesia at clincially relevant doses but cannot be used as a sole drug for general anesthesia because it lacks the potency of the volatile inhaled anesthetics (also see Chapter 47) as a processed electroencephalogram (EEG) monitor.[10] However, inhaled anesthetics increase the risk for postoperative nausea and vomiting. Emergence from hypnosis provided by volatile anesthetics can be associated with airway hyperreactivity and coughing, although those side effects can be mitigated by coadministration of other drugs. Another inhaled anesthetic, nitrous oxide, can provide both hypnosis and analgesia at clinically relevant doses but cannot be used as a sole agent for general anesthesia because it but lacks the potency of the newer inhaled anesthetics. The minimum alveolar concentration required to prevent movement to surgical stimulation is greater than the concentration that can be delivered at atmospheric pressure, so it cannot be used alone to provide reliable hypnosis. Substitution of nitrous oxide for a portion of the inhaled anesthetic dose can reduce the cardiovascular effects observed with potent inhaled anesthetics while maintaining the same anesthetic depth. Nitrous oxide also provides analgesia and is rapidly titratable because of its low blood-gas partition coefficient. The concern that use of nitrous oxide may increase rates of perioperative cardiac complications after noncardiac surgery could not be documented in a large 2015 trial.[11]

Intravenous hypnotic drugs can also be used for maintenance of anesthesia (also see Chapter 8). Propofol reduces the incidence of postoperative nausea and vomiting and may have more favorable emergence characteristics with less coughing and laryngospasm risk compared to inhaled anesthetics alone. However, depth of hypnosis cannot be reliably measured in the absence of EEG or auditory evoked potential monitoring. For certain surgical procedures, intravenous maintenance of anesthesia is most appropriate. For example, laryngeal surgery with intraoperative jet ventilation is accomplished without an endotracheal tube, making delivery of inhaled anesthetics difficult. Patients undergoing scoliosis surgery often require somatosensory and motor evoked potential monitoring. The inhaled anesthetics produce a decrease in amplitude and increase in latency of both somatosensory and motor evoked potential signals. Therefore, a combination of propofol, ketamine, and opioid infusions is commonly administered for maintenance of anesthesia in these patients.[12]

The postoperative disposition of the patient also influences anesthetic choice for maintenance and emergence from anesthesia. For example, if the patient will

III

receive postoperative mechanical ventilation in the intensive care unit, the use of short-acting anesthetic drugs is less important, and prolonged neuromuscular blockade is not likely to be a significant clinical issue. Patients undergoing outpatient surgery require special attention to the prevention of postoperative and postdischarge nausea and vomiting (also see Chapter 37). This may involve selection of a less emetogenic anesthetic maintenance drug (e.g., propofol) as well as administration of multiple antiemetic drugs (also see Chapter 39).

Regional Anesthesia

Superficial and deep operations on the extremities—particularly the distal extremities—may be amenable to peripheral nerve block (see Chapter 18). Because surgical anesthesia may be achieved without sedation, this technique is particularly attractive in patients for whom systemic disease (e.g., severe pulmonary disease, cardiovascular disease, or renal failure) may present a significant challenge during general anesthesia. Unlike neuraxial anesthesia, the localized sympathectomy resulting from peripheral nerve block rarely results in systemic hypotension. However, peripheral nerve blockade as the primary anesthetic technique requires patient cooperation and may be inappropriate in patients with dementia, acute intoxication, or other conditions associated with altered mental status. Peripheral nerve blockade may be difficult to accomplish or may result in an inadequate, "patchy" block. If surgical anesthesia is not achieved with a peripheral nerve block, the anesthesia provider is faced with the options of supplementing the block with local anesthesia, administering intravenous analgesics and hypnotics, postponing surgery and reattempting the block at a later time, or converting to general anesthesia.

Neuraxial anesthesia can provide excellent operating conditions in the lower extremities and lower abdomen. Higher levels of neuraxial blockade (e.g., midthoracic to high thoracic) with surgical anesthesia concentrations of local anesthetic (e.g., epidural 2% lidocaine) result in more profound sympathectomy and increased risk of hypotension, which may require infusion of vasoactive medications to maintain hemodynamic stability. However, analgesic concentrations of local anesthetic (e.g., epidural 0.1% ropivacaine) are commonly given via thoracic epidural catheter to provide postoperative analgesia after open thoracic surgery. The smaller concentration of local anesthetic required for analgesia (as opposed to surgical anesthesia) results in decreased incidence of hypotension.

Postoperative disposition of the patient also influences medication choice or type of regional anesthesia. Patients undergoing ambulatory surgery who receive spinal anesthesia may have prolonged recovery time if they receive long-acting local anesthetics, because they must be able to ambulate prior to discharge. Ambulatory surgical patients undergoing procedures associated with significant postoperative pain may benefit from a long-lasting peripheral nerve block or nerve catheter placement.[13]

Monitored Anesthesia Care

Pharmacologic sedation using opioids or hypnotic medications is often provided as a component of MAC (also see Chapters 8 and 9). Nonpharmacologic approaches such as video or audio distraction or verbal reassurance can also complement a MAC technique. The ASA depth of sedation continuum can be used to choose the level of sedation that is most appropriate for the patient undergoing MAC. Local or topical anesthesia administered by the surgeon is commonly used during MAC to provide adequate analgesia for the procedure. The anesthesia provider must track the total dose of local anesthetic and be alert for signs of local anesthetic toxicity (also see Chapter 10). The injection of local anesthetic near sensitive areas (e.g., face, eyes) may initially require a deeper level of sedation until the injection is complete. The most dangerous anesthetic risk during MAC is respiratory depression from excessive sedation. The manifestations of respiratory depression include upper airway obstruction, hypoventilation, and hypoxemia. During MAC, end-tidal capnography can be accomplished with a nasal cannula that has a dedicated sampling line attached. However, capnography monitoring is less reliable in this setting, and the absence of increased end-tidal CO_2 does not guarantee the adequacy of ventilation. The medications typically used for sedation during MAC (benzodiazepines, opioids, propofol) produce dose-dependent respiratory depression. Ketamine and dexmedetomidine are less likely to cause hypoventilation but have other potential side effects and may have synergistic sedative effects with other hypnotic medications (also see Chapter 8).

The anesthesia provider may choose to administer sedation to improve patient comfort during a procedure performed under regional anesthesia, although the term MAC would not be used if the primary anesthetic was a regional technique. Depth of hypnosis has recently come under scrutiny as a possible contributor to postoperative outcomes. A randomized clinical trial of light versus deep sedation in elderly hip fracture surgical patients receiving spinal anesthesia showed a short-term reduction in postoperative delirium and a reduction in 1-year mortality rate in the sickest patients for the light-sedation group (i.e., deep sedation was associated with increased risk of complications).[14]

ENVIRONMENTAL IMPACT

Anesthetic choice has important implications for environmental impact and cost of care. The potent inhaled anesthetics and nitrous oxide are ozone-depleting, and nitrous oxide is an important greenhouse gas. In 2006, the anesthetic use of nitrous oxide was responsible for 3% of total nitrous oxide emissions in the United States. Nitrous oxide is estimated to be the single largest ozone-depleting potential (ODP)-weighted emission for the rest of the 21st century. Of halogenated anesthetics, desflurane is the worst offender, with a global warming potential almost 4000 times that of carbon dioxide.[15,16] The environmental impact of inhaled anesthetics can be minimized by use of total intravenous anesthesia, low-flow anesthesia, or closed-circuit anesthesia.

QUESTIONS OF THE DAY

1. What are the most important factors in determining whether general anesthesia is an appropriate choice for a patient undergoing a surgical procedure?
2. What are the potential benefits of the addition of a regional anesthesia technique to general anesthesia?
3. What are the advantages and disadvantages of volatile anesthetics versus intravenous anesthetics for maintenance of anesthesia?
4. What is the most dangerous anesthetic risk for a patient undergoing monitored anesthesia care? What steps can be taken to diagnose and prevent anesthetic complications during monitored anesthesia care?

REFERENCES

1. Urban BW, Bleckwenn M. Concepts and correlations relevant to general anaesthesia. *Br J Anaesth*. 2002;89(1):3–16.
2. American Society of Anesthesiologists. Continuum of Depth of Sedation: Definition of General Anesthesia and Levels of Sedation/Analgesia. Amended October 15, 2014. http://www.asahq.org/~/media/Sites/ASAHQ/Files/Public/Resources/standards-guidelines/continuum-of-depth-of-sedation-definition-of-general-anesthesia-and-levels-of-sedation-analgesia.pdf. Accessed May 3, 2016.
3. Cohen NA, McMichael JP. What's New in … Definitions of monitored anesthesia care. *American Society of Anesthesiologists Newsletter*. 2004;68(6):22–26.
4. Bhananker SM, Posner KL, Cheney FW, et al. Injury and liability associated with monitored anesthesia care: a closed claims analysis. *Anesthesiology*. 2006;104(2):228–234.
5. Barreveld A, Witte J, Chahal H, et al. Preventive analgesia by local anesthetics: the reduction of postoperative pain by peripheral nerve blocks and intravenous drugs. *Anesth Analg*. 2013;116:1141–1161.
6. Guay J. The effect of neuraxial blocks on surgical blood loss and blood transfusion requirements: a meta-analysis. *J Clin Anesth*. 2006;18:124–128.
7. Andreae MH, Andreae DA. Regional anaesthesia to prevent chronic pain after surgery: a Cochrane systematic review and meta-analysis. *Br J Anaesth*. 2013;111:711–720.
8. Guay J, Choi PT, Suresh S, et al. Neuraxial anesthesia for the prevention of postoperative mortality and major morbidity: an overview of Cochrane Systematic Reviews. *Anesth Analg*. 2014;119:716–725.
9. Algie CM, Mahar RK, Tan HB, et al. Effectiveness and risks of cricoid pressure during rapid sequence induction for endotracheal intubation. *Cochrane Database Syst Rev*. 2015;(11):CD011656.
10. Mashour GA, Shanks A, Tremper KK, et al. Prevention of intraoperative awareness with explicit recall in an unselected surgical population: a randomized comparative effectiveness trial. *Anesthesiology*. 2012;117(4):717–725.
11. Leslie K, Myles PS, Kasza J, et al. Nitrous oxide and serious long-term morbidity and mortality in the Evaluation of Nitrous Oxide in the Gas Mixture for Anaesthesia (ENIGMA)-II Trial. *Anesthesiology*. 2015;123(6):1267–1280.
12. Glover CD, Carling NP. Neuromonitoring for scoliosis surgery. *Anesthesiol Clin*. 2014;32(1):101–114.
13. Ilfeld BM. Continuous peripheral nerve blocks: a review of the published evidence. *Anesth Analg*. 2011;113(4):904–925.
14. Brown CHt, Azman AS, Gottschalk A, et al. Sedation depth during spinal anesthesia and survival in elderly patients undergoing hip fracture repair. *Anesth Analg*. 2014;118:977–980.
15. Ryan SM, Nielsen CJ. Global warming potential of inhaled anesthetics: application to clinical use. *Anesth Analg*. 2010;111:92–98.
16. Ishizawa Y. Special article: general anesthetic gases and the global environment. *Anesth Analg*. 2011;112:213–217.

III