Successful patient outcomes from an operative procedure require vigilance, diligence, and teamwork among the various providers involved with the surgical procedure. An understanding of the responsibilities and appreciation for the complexities of each healthcare provider’s role in the operative process is essential to a harmonious relationship among the perioperative team to improve the working environment and provide safe patient care. The information provided in this article is based on commonly observed practices in the anesthesia community with the caveat that the choices can vary considerably and are influenced by patient presentation and surgical requirements.

**Provision of anesthesia services**

Several regulatory agencies at state and federal levels, along with reimbursement requirements, control who can provide anesthesia services. Providers are generally limited to physicians, certified registered nurse anesthetists (CRNAs), and anesthesia assistants (AAs) in a limited number of states. The practice patterns commonly seen are: anesthesiologists or CRNAs independently providing direct anesthesia care, CRNAs and anesthesiologists working together in the anesthesia care team model, or physicians medically directing AAs. CRNAs receive direct reimbursement from the Centers for Medicare and Medicaid Services, but AAs must always work with anesthesiologists in the medical direction model. Although the provider administering anesthesia can vary by practice setting and geographic location, the process and goals are comparable.

**Types of anesthesia**

When anesthesia services are necessary, there are several options to provide the patient with pain relief, reduce anxiety, and meet the requirements of the surgical procedure. There are three basic types of anesthesia: general, regional, and monitored anesthesia care (MAC); sometimes, a combination
of techniques is appropriate. General anesthesia is selected when the patient and surgical needs require complete immobility and unconsciousness. Regional anesthesia includes spinal and epidural anesthetics (neuraxial blocks) and peripheral nerve blocks of various types. These techniques are often appropriate for surgeries involving the extremities or the lower abdomen and perineal area. Although a regional technique can provide complete pain relief to the operative area, patients are often more comfortable when sedation is also administered.

Patients can be distracted and fearful of the ambient noises in an OR combined with the conversations between the surgical and anesthesia teams. In addition, despite surgical site anesthesia, the patient may find the pressure of the drapes on areas not anesthetized to be uncomfortable. Sensations from surgical manipulation can extend outside the anesthetized area, and although they may not be painful, they can add to the discomfort.

In select cases, surgery can be performed with various levels of sedation combined with a local anesthetic injected at the operative site by the surgeon. The term MAC is an anesthesia service description and includes all levels of sedation from minimal to deep.2 MAC requires the anesthesia provider to be capable of converting to general anesthesia (if necessary) in addition to being skilled at advanced airway management if deep sedation causes airway compromise. The depth of sedation that can be provided by nonanesthesia providers, usually RNs, is controlled by regulations, such as state nurse practice acts and institutional guidelines, and is usually limited to minimal or moderate sedation where airway compromise isn’t expected.

Regional anesthesia can be useful in many cases for postoperative pain control, sometimes initiated before the surgery and combined with a general anesthetic to provide the conditions required to perform the procedure.

**Preoperative management**

The anesthesia provider performs a thorough preoperative evaluation, which is essential to identify comorbidities and assess the patient’s current health status to determine the most appropriate type of anesthesia. In this preoperative period, the entire perioperative team should discuss the assessment of safety risks and the use of checklists, which are recommended by the World Health Organization, The Joint Commission, and the FDA Safe Use Initiative.3-5 Risk assessment, such as the prevention of intraoperative fire, rely on the combined vigilance of the OR staff, surgeon, anesthesia providers, and effective/open communication with an understanding of each provider’s responsibility, which can help prevent disastrous patient outcomes. Presurgical checklists emphasize verification of the correct patient, correct procedure, and, if relevant, correct side. These tools have demonstrated effectiveness, but their routine implementation in clinical practice isn’t uniform.6

**General anesthesia**

The goals of general anesthesia are to provide amnesia, analgesia, and immobility. Analgesia includes a blockade of the sympathetic response to noxious stimuli, specifically surgical stimulation. If needed, neuromuscular blocking drugs (NMBDs), also known as muscle relaxants, may be administered to facilitate surgical access to the operative region. The process of general anesthesia begins with a phase known as induction, which is accomplished by two methods. Injection of an I.V. drug is the common approach in the adult population and is a rapid process in which unconsciousness is achieved roughly 1 minute after administration of the induction medication. All of the agents used for inductions produce an expected apnea, and airway management skill is essential. In the pediatric population, where gaining I.V. access preoperatively isn’t well-tolerated, a volatile anesthetic agent by mask is the preferred approach for induction. Compared to I.V. induction, an inhalation induction requires more time to take effect, and the patient may demonstrate progression through the various stages of anesthesia not seen with an I.V. induction.7

Most important is that some patients experience excitement when progressing from drowsiness to unconsciousness. This is a critical phase with the potential for several adverse events, such as thrashing or movement, vomiting, laryngospasm (closure of the vocal cords obstructing air flow), and dysrhythmias. Although a quiet environment is preferred for all inductions, minimizing noise with this technique is especially important because auditory senses are heightened, and exaggerated responses may occur. All OR personnel should be vigilant for sudden movements that could cause the patient to fall from the OR table, especially in the pediatric environment where safety belting is limited in smaller
patients. Since airway compromise can occur rapidly, it’s essential to have additional OR personnel available.

When general anesthesia is selected, there are several options for the type of induction and medication choices. The anesthesia provider must determine whether endotracheal intubation is required or if an alternative airway device, such as a laryngeal mask airway (LMA), can be used (see LMA and endotracheal intubation). These are reserved for cases meeting specific requirements, including patients who have been N.P.O. and without known risk of aspiration because the LMA is seated proximal to the glottis and doesn’t seal the airway from secretions.

Since the introduction of the LMA into clinical practice in 1988, there’s been considerable controversy regarding the selection criteria for use of this device in different clinical situations, often with opposite viewpoints represented in the literature and reflected in clinical practice. An LMA is usually chosen for cases in which the torso is supine, since the LMA doesn’t secure the airway, and some anesthesia providers view lateral or prone position as a risk for dislodgement. Use of the lateral position does seem to be increasing, however. Other limiting factors include the length of the case, with less than a few hours preferred, overall hemodynamic stability of the patient, and surgery not within the abdominal or thoracic cavity, which requires airway control and muscle paralysis.

An advantage to using an LMA is that it eliminates the risks associated with intubation of the trachea, such as trauma and dental damage. Although anesthesia can be provided in select circumstances via mask, this method has been largely replaced by LMAs, which free the provider’s hands for other tasks.

The sequence of actions during a standard induction with intubation usually starts with the administration of preoperative sedation, sometimes in the holding area, and additionally after the patient is secured on the OR table and monitors are applied. Midazolam, a water-soluble benzodiazepine, is commonly used for sedation because it reduces anxiety and causes amnesia with minimal cardiovascular effects. Patients receive oxygen via facemask prior to receiving an I.V. induction agent. After determining that the patient is unconscious, an NMBD is administered. It’s important to note, that when an endotracheal tube (ETT) is required for airway management, it’s placed after the patient is determined to be unconscious from the induction drug and has received an NMBD. There are two types of NMBDs, and they’re classified according to their mechanism of action. Laryngoscopy is a noxious stimuli, and the airway’s innervation is complex with strong protective reflexes. The resulting hypertension and tachycardia (if undesirable) can be attenuated by several methods, including the addition of opioid analgesics, local anesthesia to the trachea, or specific cardiovascular drugs, although none are ideal.
The patient is ventilated by mask until paralysis is complete, usually within 1 to 3 minutes, depending on the NMBD and dose used. Intubation can be performed by direct visualization of the vocal cords using a laryngoscope with either a curved (Macintosh) blade or a straight (Miller) blade, depending on provider preference. Video laryngoscopy for intubation is gaining in popularity with both portable and fixed mount devices available. The oral ETT can be prepared with a stylet to maintain an anatomic curve to facilitate intubation or inserted without a stylet depending on provider choice and patient presentation. The ETT is secured after verification of tube placement by continuous capnography (end-tidal CO₂ [ETCO₂] monitoring), clinical signs, and auscultation of breath sounds. A volatile inhalation agent or a combination of I.V. medications may be used to maintain anesthesia. Additionally, nitrous oxide (N₂O) can be included for maintenance; however, the use of this agent has stirred controversy for several reasons, including increased risk of postoperative nausea and vomiting (PONV), potential cellular toxicity, effect on embryonic development, and absorption into air-filled cavities. The introduction of more potent and safe volatile agents provides a viable alternative.

In a patient determined to be at risk for aspiration during induction (for example, obese patients, those with a history of gastric reflux, or patients who haven’t been NPO), the induction technique known as rapid sequence induction (RSI) is often utilized. Although availability of suction equipment is required for all inductions, a second suction is recommended as backup should regurgitation occur, equipment fail, or the suction become clogged by particulate matter.

The noticeable difference between an RSI and a standard induction is that cricoid pressure is initiated on induction and continues until the ETT placement is verified. The cricoid cartilage is the only tracheal structure that forms a complete ring, which can compress the esophagus located posterior and mechanically block fluid from migrating into the oropharynx and airway, causing aspiration pneumonia (see Structures of the larynx). In addition, the I.V. induction agent is followed immediately by the NMBD, and there’s no manual ventilation, as this process may force air through the esophagus and into the stomach, increasing the risk of regurgitation.

NMBD choices are limited to agents in doses that will produce intubating conditions in 1 minute, such as succinylcholine or rocuronium. This apneic period isn’t always well-tolerated despite adequate preoxygenation, and if desaturation occurs, the technique can be modified to include gentle ventilation with cricoid pressure to maintain oxygenation at safe levels.

When an LMA is used for general anesthesia, the induction is simplified. After sedation and preoxygenation, a single narcotic is administered. No NMBD is needed for LMA placement, and after the patient is unconscious, the LMA is inserted. The patient usually receives a volatile inhalation agent titrated to maintain anesthetic depth appropriate.
for the surgery; however, a propofol infusion can also be used.

**I.V. induction agents**

Historically, the drug most associated with I.V. induction was thiopental sodium, an ultrashort-acting thiobarbiturate. In recent years, thiopental sodium use began to rapidly decline in favor of newer agents, and in January 2011, the sole manufacturer permanently ceased production of the drug in the United States.\(^{12}\)

Currently, propofol is the I.V. induction agent routinely used. The drug is known for several desirable attributes, such as a rapid return to a clear mental state for recovery, and providing a pleasant overall anesthetic experience. It doesn’t simply reduce the incidence of PONV; it has antiemetic properties.\(^{11}\)

In addition to producing unconsciousness with the common induction, propofol can be used for maintenance of anesthesia and sedation, and is usually administered by continuous infusion. Propofol can cause burning on injection, and anesthesia providers can minimize the discomfort by using a large forearm or antecubital vein for drug administration, mixing lidocaine with the drug or pretreating the patient with a small bolus of lidocaine to anesthetize the vein.

Despite its many advantages, propofol can decrease BP primarily as the result of significant vasodilation and concurrent myocardial depression. Those most susceptible to the hypotensive effects of propofol include older adults, hypovolemic patients, and those with impaired compensatory mechanisms; therefore, an alternative induction agent is usually chosen.\(^{11}\)

Etomidate is the I.V. induction agent most often used for patients with myocardial contractility impairment where propofol would likely cause an undesirable and dangerous drop in BP. The induction dose of etomidate has a similar onset profile as propofol, with unconsciousness produced in about 1 minute, but has minimal cardiovascular effects. Although it may seem reasonable to use etomidate routinely for healthy patients, the many adverse reactions associated with etomidate preclude this choice for most anesthesia providers. These adverse reactions include a dose-dependent adrenocortical suppression, myoclonus, pain on injection, and an increase in PONV.\(^{11}\)

Unlike propofol, which can be administered throughout the case, etomidate is usually used only as an induction agent.

There are two other I.V. agents that can be used in selected circumstances when propofol or etomidate are not appropriate choices for induction. Ketamine is most often reserved for patients without ischemic cardiovascular disease who are hypovolemic and hypotensive. It’s usually used for the trauma patient with substantial blood loss and in need of emergent surgical intervention. Ketamine is unique in that it doesn’t induce unconsciousness by depressing central nervous system activity but is a phencyclidine derivative, causing dissociative anesthesia, which interrupts normal synaptic pathways, disrupting perception and reaction to stimuli. Ketamine causes sympathetic stimulation, which increases endogenous catecholamines, helping to maintain BP in the compromised patient. In addition, ketamine can provide bronchodilations and is the only induction agent with analgesic properties.\(^{11}\) Ketamine can also be administered I.M. in select circumstances where I.V. access is problematic. Hallucinations and perceptive distortions can limit the routine use of this agent.

Methohexitol is an ultrashort acting oxybarbiturate, and although similar in many ways to thiopental sodium, it doesn’t reduce the seizure threshold like other barbiturates. This has led to the specific use of methohexitol for induction of anesthesia for electroconvulsive therapy where the therapeutic effect of the treatment may be related to the associated seizure.\(^{13}\)

Although methohexitol can be used for routine induction of anesthesia or sedation, it’s largely been replaced by propofol.

**Inhaled anesthetics**

The current inhalation agents and techniques in clinical practice have evolved from the early days of the discovery of the pain relieving properties of substances, such as ether, chloroform, and N\(_2\)O. N\(_2\)O is a gas that is delivered by a specific flowmeter on the anesthesia gas machine (AGM). The concentration of oxygen delivered to a patient should always exceed room air (21%), and for safety reasons, levels of 25% to 30% oxygen are usually the minimum provided. Therefore, N\(_2\)O concentrations rarely exceed 70%, and most anesthesia providers often do not exceed 50%. N\(_2\)O isn’t a potent agent and can only be used to supplement other agents during general anesthesia.


\[ \text{O}_2 \text{O} \] diffuses quickly into air-filled spaces, causing dramatic increases in pressure or volume depending on the ability of the surrounding structures to distend and the concentration of the agent.

N\textsubscript{2}O is also associated with PONV, especially in at-risk populations, which include those with a history of PONV or motion sickness, women, nonsmokers, and younger patients.\textsuperscript{14}

The other inhalation agents are classified as volatile and chemically halogenated, often with fluorine, and delivered through the AGM circuit by agent-specific vaporizers. Several agents, such as halothane and enflurane, are no longer used, leaving the following three agents in current anesthesia practice: isoflurane, sevoflurane, and desflurane. Although there are subtle differences, the selection is based largely on provider preference. Inhalation anesthetics are widely used for induction in the pediatric population and maintenance of anesthesia in adults either alone or in combination with I.V. agents to meet the required goals of general anesthesia.

**Neuromuscular blocking drugs**

Paralysis is routinely used to provide optimal conditions for intubation in general anesthesia, but maintaining skeletal muscle paralysis throughout the case largely depends on surgical requirements. There are two categories of NMBDs determined by their mechanism of action: depolarizing and nondepolarizing NMBDs (see *How NMBDs work*). The depolarizing agent, succinylcholine, works by depolarizing the neuromuscular junction (NMJ), and, in essence, behaves as a long-acting acetylcholine, the neurotransmitter responsible for activation of muscle fibers. Succinylcholine causes an unsynchronized contraction of skeletal muscles visible as twitching, referred to as fasciculations. This is the only drug in the depolarizing NMBD category and has many adverse reactions. The most serious of these include dysrhythmias, massive fatal hyperkalemia in muscle wasting diseases, and prolonged paralysis in patients who demonstrate genetic defects in the enzyme needed to metabolize the drug (pseudocholinesterase deficiency).\textsuperscript{11} Despite the many adverse reactions of the drug, it’s the only NMBD that has both rapid onset and rapid recovery, so it’s still used in current anesthesia practice. Since this drug causes total body paralysis lasting a minimum of 5 minutes and there’s no reversal agent, airway management is critical.

The nondepolarizing category of NMBDs compete with acetylcholine at receptors necessary for normal muscle contraction at the NMJ. There’ve been several drugs in this category that aren’t used as
often anymore because of adverse reactions or production has been discontinued. The nondepolarizing NMBDs currently used include the following: rocuronium, vecuronium, cisatracurium, and, to a lesser extent, pancuronium. These drugs can be used for skeletal muscle relaxation during intubation, administered after intubation with succinylcholine when muscle relaxation is necessary, or given in a very small dose prior to succinylcholine to mitigate the undesirable fasciculations. It’s important to note that NMBDs have no anesthetic properties and aren’t the primary mechanism to provide immobility. Sufficient anesthetic depth is essential to prevent awareness during general anesthesia. Peripheral nerve stimulators measure adequacy of muscle paralysis and determine when additional medication is necessary.

Nondepolarizing NMBDs can be reversed with anticholinesterase drugs, usually neostigmine. These drugs block acetylcholinesterase, the enzyme responsible for metabolizing acetylcholine, and allow acetylcholine to build up, increasing competition for the NMJ receptor and allowing normal muscle function to return. These medications must be administered with an anticholinergic, often glycopyrrolate, to block the undesirable effects (bradycardia, bronchoconstriction, and excessive salivation) caused by increased levels of acetylcholine at other sites in the body—especially the cardiac muscarinic receptors—which can result in profound bradycardia.

**Pain medications**

Opioids are by far the primary drugs used for pain control under anesthesia. Fentanyl is a synthetic opioid that demonstrates cardiac stability even in high doses and is widely used in current practice. Other synthetic or naturally occurring opioids can be used depending on provider preference, including sufentanil, hydromorphone, or morphine. Remifentanil is the most recent opioid introduced to anesthesia. Commonly administered in an infusion, it has a different pathway of metabolism, which provides intense analgesia with a very quick recovery; however, it may require an additional medication to provide pain control into the postoperative period.11

Other pain medications include ketorolac, a nonsteroidal anti-inflammatory medication that can be included when the potential risk for bleeding doesn’t compromise the surgical recovery and the patient has no conditions that increase the risk of bleeding, such as peptic ulcer disease. Ketorolac shouldn’t be used in patients that have severely impaired kidney function. The most recent addition to the pain medication choices is I.V. acetaminophen, FDA approved in November 2010.15

**Maintenance and emergence**

After induction, the maintenance phase can include many options, both inhalation and I.V. drugs to continue to meet the goals for general anesthesia. Dexmedetomidine, a selective alpha2-agonist found to have sedation properties, is gaining popularity as a supplement to general anesthesia and procedural sedation. PONV is controlled or prevented by the use of a variety of antiemetics and adjunctive medications. Antibiotics are administered as per the Surgical Care Improvement Project protocols and surgeon preference.

After surgery, emergence from anesthesia is accomplished by discontinuing inhaled anesthetics and infusions as well as a reversal of muscle relaxation as indicated unless postoperative management requires controlled ventilation. The anesthesia provider will assess for readiness for extubation or removal of an LMA based on specific criteria.

**Regional anesthesia**

Regional anesthesia for surgical interventions is a complex subject with considerable variations in the types and techniques used. For a spinal anesthesia, the patient is positioned lateral (or sitting), and the anesthesia provider inserts a needle through the spinal structures and punctures the dura, confirmed by the presence of cerebrospinal fluid (CSF). A small dose of local anesthetic is injected, which provides a dense motor, sensory, and autonomic block, and is often used for surgeries below the umbilicus. Epidural anesthesia differs in that the dura is not punctured. Instead, medication (local anesthetic with or without an opioid) is injected into the epidural space, which is the potential space between the ligamentum flavum and the dura (see Injection sites for spinal and epidural anesthesia). A catheter may also be inserted into the epidural space to allow for continuous infusion of a local anesthetic agent. Pain relief can be obtained without significant impairment of motor function depending on the medication and dose; therefore, epidurals are widely used in obstetrics for labor. Postdural puncture headache is an adverse reaction of spinal anesthesia and is related to...
the loss of CSF when the dura is entered. Since the introducer needle used for an epidural is a larger diameter than a spinal needle, inadvertent dural puncture (during epidural anesthesia) increases the likelihood of a significant postdural puncture headache. The definitive treatment of the headache is an epidural blood patch, injecting the patient’s blood into the epidural space, and relief of symptoms can be immediate. A much larger volume of local anesthetic is required for epidural anesthesia compared to a spinal. A test dose (small amount of local anesthetic with epinephrine) is used to assess for inadvertent dural puncture or intravascular injection (noted by a rise in heart rate). A large volume of local anesthetic injected intravascularly can cause toxicity symptoms, such as seizure. A subarachnoid injection could result in a total spinal and serious hemodynamic instability. Multiple types of peripheral nerve blocks—axillary, interscalene, I.V., regional, or ankle—can be administered to facilitate surgical intervention or provide postoperative pain relief. The use of ultrasound technology to guide regional nerve blocks is increasing in popularity. The use of ultrasound-guided regional anesthesia provides identification of landmark anatomic, vascular, and neural structures not appreciated by conventional techniques, such as palpation, loss of resistance, or the use of a nerve stimulator. In addition, the needle tip can be constantly visualized and the spread of local anesthetic appreciated. This has shown to improve the success rate of regional anesthesia administration.16

Other considerations
Hemodynamic stability must be maintained, and careful assessment of blood loss and fluid management is essential. Invasive operative procedures often cause significant compartmental fluid shifts combined with blood loss, requiring considerable volumes of crystalloid solutions, colloids, and blood replacement.

Monitoring devices used during anesthesia follow standards established by the professional organizations for both physicians and CRNAs and include the following: cardiac rhythm monitoring, BP at least every 5 minutes, and pulse oximetry monitoring for all cases. If an airway management device is inserted, such as an LMA or ETT, ETCO₂ monitoring is also required. Many other monitors are used depending on the anesthetic technique and condition of the patient. The bispectral index monitor is a more recent technology that was introduced to anesthesia practice after FDA approval in 1997. Although consciousness monitoring has been advocated for prevention of awareness and assessment of anesthetic depth, there’s ongoing controversy regarding the reliability and clinical utility of these devices leading to variable acceptance in clinical practice.17

Positioning an anesthetized patient for surgery can be challenging and requires cooperation of the entire perioperative team to prevent injuries to both patient and provider. Position changes should be coordinated by the anesthesia provider to maintain hemodynamic stability, airway control, and to prevent neck injuries in the flaccid patient.

Moving forward
Anesthesia providers offer a wide range of perioperative services and utilize complex management modalities requiring substantial knowledge, critical thinking, and clinical expertise. Considering the anes-
Anesthesia provider’s scope of practice and the diversity of techniques and agents, this article was intended simply as an overview. Appreciation for the roles and responsibilities of all team members involved in the surgical procedure can improve cooperation, create a cohesive and supportive work environment, and promote positive patient outcomes and satisfaction. OR

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