chapter 14

The Postanesthesia Patient

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objectives

Based on the content in this chapter, the reader should be able to:

- Compare and contrast anesthetic options used for surgery.
- Differentiate between anesthetic agents appropriate for the conscious patient and those appropriate for the unconscious patient.
- Summarize five potential problems encountered during the immediate postanesthetic period.
- Describe nursing interventions for the patient recovering from anesthesia.

The time immediately after surgery, when the patient is taken to the postanesthesia care unit (PACU) or the intensive care unit (ICU), is the most crucial period in the patient's recovery from anesthesia. Most patients are taken to the PACU for close observation and care by a qualified PACU nurse. Others are taken directly to the ICU, where nurses must be competent in postanesthesia nursing care. Alterations in the patient's physiological condition that occur in the immediate postoperative period are the focus of this chapter.

The critical care nurse must have a basic understanding of anesthetic options available for use during the intraoperative phase. To help with this understanding, common clinical terminology related to the use of anesthesia is listed in Box 14-1.

COLLABORATION BETWEEN THE ANESTHESIA PROVIDER AND NURSE

The anesthesia provider examines the patient before surgery. From this examination, the anesthesia provider decides which options and techniques to use. Decisions are based on the patient's condition, age, surgical and anesthetic history, and ongoing disease processes; the operation to be performed; and the position required for the surgical procedure. The anesthesia provider's options range from maintaining a conscious state with the use of minimal, regional, or intravenous (IV) agents to inducing an unconscious state with the use of IV or inhalation agents. These options are illustrated in Figures 14-1 and 14-2.

What happens in the operating room may affect the patient's immediate postoperative care and the overall recovery. To convey what has occurred in the operating suite, the anesthesia provider gives a detailed report to the nurse who is assuming postoperative care of the patient. Information given in the report is listed in Box 14-2.

While receiving the report from the anesthesia provider, the nurse must simultaneously assess the patient's condition and individualize the nursing plan of care. Initial assessment parameters reported by the anesthesia provider are the patient's vital signs (blood pressure, pulse, respiration, and temperature), pulse oximetry, and level of consciousness. Cardiac monitoring, hemodynamic parameters, and urine output monitoring also may be indicated. Vital signs are monitored every 15 minutes or more often if the patient's condition warrants. Box 14-3 provides the collaborative care guidelines for the postanesthesia patient. The American Society of PeriAnesthesia Nurses, as endorsed by the American Society of Anesthesiologists and the American

box 14-1
Clinical Terminology

Sedation: An induced state of quiet, calm, or sleep by means of a medication. The degree of sedation ranges from anxiolysis to anesthesia.
Minimal sedation: A state in which the patient responds normally to verbal stimuli. Impairment to cognition and coordination may exist.
Moderate sedation: A drug-induced depression of consciousness during which the patient responds purposefully to verbal commands either alone or in conjunction with tactile stimulation. There is some alteration of mood, drowsiness, and sometimes analgesia. The patient's protective reflexes remain intact.
Deep sedation: A drug-induced depression of consciousness during which the patient cannot be easily aroused but responds purposefully after repeated or painful stimulation. Spontaneous ventilation and the ability to maintain a patent airway may be impaired. The patient may require assistance in maintaining a patent airway.
General anesthesia: A drug-induced loss of consciousness during which a patient cannot be aroused, even by painful stimulation. The ability to independently maintain ventilatory function is often impaired. The patient may require assistance in maintaining a patent airway, and positive-pressure ventilation may be required. Cardiovascular function may be impaired.
Monitored anesthesia care (MAC): Describes a specific anesthesia service in which an anesthesia provider has been requested to participate in the care of a patient undergoing a therapeutic or diagnostic procedure. It does not describe a continuum of depth of sedation.
Regional anesthesia: This state of anesthesia produces analgesia in a specific body part. Regional anesthesia is achieved by placing local anesthetics close to appropriate nerves to achieve a conduction block.
Spinal anesthesia: In this type of anesthesia, local anesthetic is injected into the lumbar intrathecal space. The anesthetic blocks conduction in spinal nerve roots and dorsal ganglia. Analgesia occurs below the level of injection.
Epidural anesthesia: A local anesthetic is injected via a catheter into the epidural space. The effects are similar to spinal analgesia.
Peripheral nerve block: A local anesthetic is injected at a specific site to achieve a defined area of anesthesia.

Association of Nurse Anesthetists, recommends all assessment data be collected and documented on the patient's postoperative record.[1]

MODERATE SEDATION

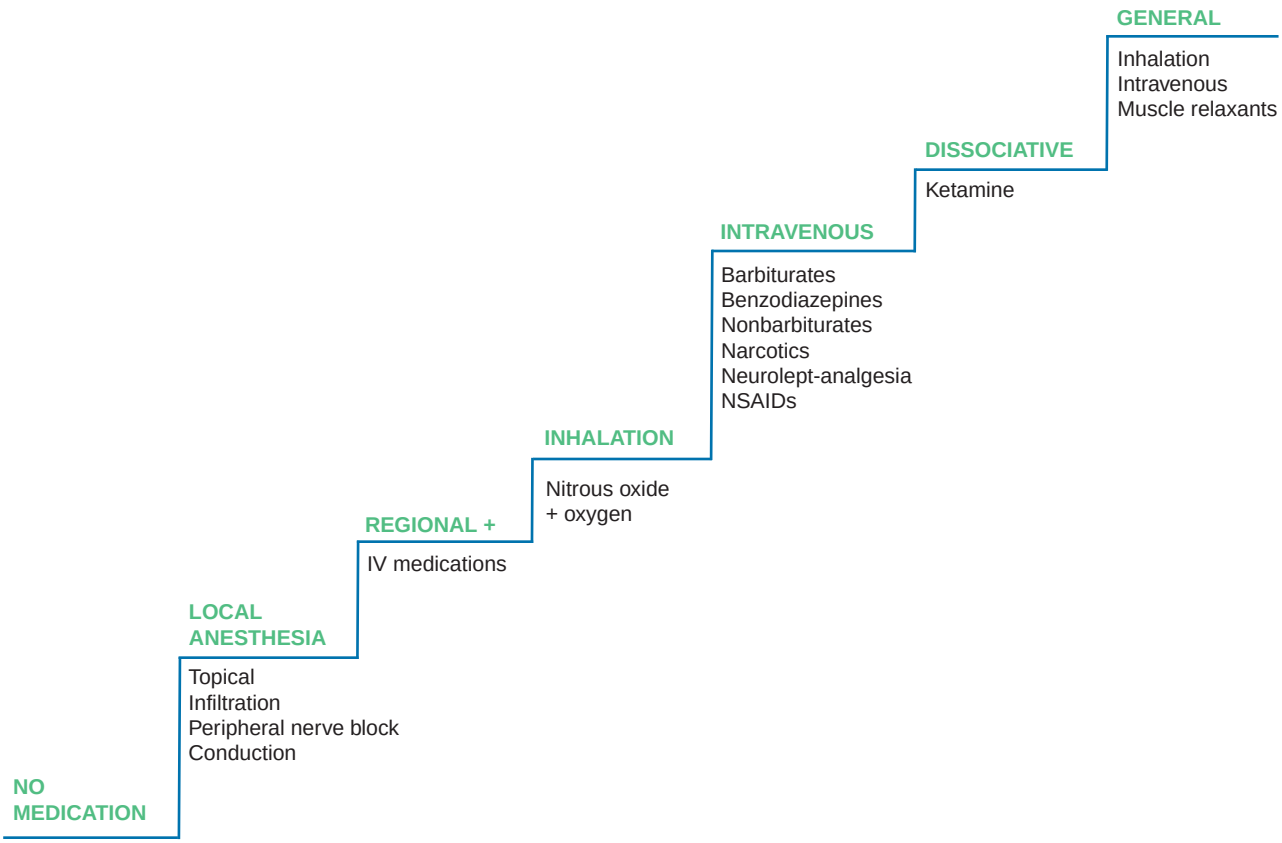
Moderate sedation is an anesthetic technique that provides a drug-induced depression of consciousness during which the patient responds purposefully to verbal commands, either alone or associated with light tactile stimulation. No interventions are required to maintain airway patency or spontaneous ventilation. In addition, cardiovascular function is maintained. A patient under moderate sedation adheres to three major criteria: He or she will be able independently to maintain a patent airway, retain protective airway reflexes, and respond to verbal and physical stimulation. If these three conditions are not met, then the patient is not receiving moderate sedation, and perhaps this is not the correct anesthetic choice for the patient or the procedure. The advantage of moderate sedation is that it allows the patient to respond to the verbal directives of the practitioner and to physical stimulation. Moderate sedation is used for certain ambulatory surgical, therapeutic, and diagnostic procedures. The regimen usually consists of an opiate, an amnestic, a sedative, and a local anesthetic.[2]

Initial objectives for moderate sedation were developed by Scammon and colleagues in 1985.[2] The main goal of moderate sedation is to decrease patient anxiety associated with the proposed procedure. The least amount of medication to achieve sedation and comfort is the goal. In addition, moderate sedation alters the patient's mood and enhances cooperation, maintains stable vital signs, elevates the pain threshold, provides amnesia, and allows for rapid recovery.[2]

Standards for administration of moderate sedation are regulated by multiple entities. Individual State Boards of Nursing, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), and individual hospital and unit policies are available. Standards for planning and providing moderate sedation are available to practitioners and should be followed.[3]

A group of 14 nursing societies developed standards for the role of the registered nurse in managing patients receiving IV moderate sedation. These standards are published in Standards of Perianesthesia Nursing Practice[1] and include management and monitoring before, during, and after the procedure. Among the standards are the following skills required of the registered nurse who is managing the care of patients receiving IV moderate sedation:

- Demonstrate the required knowledge of anatomy, physiology, pharmacology, cardiac dysrhythmia recognition, and complications related to IV moderate sedation and medications.
- Assess total patient care requirements during moderate sedation and recovery. Physiological measurements should include, but are not limited to, respiratory rate, oxygen saturation, blood pressure, cardiac rate and rhythm, and patient's level of consciousness.
- Understand the principles of oxygen delivery, respiratory physiology, transport, and uptake, and demonstrate the ability to use oxygen delivery devices.
- Anticipate and recognize potential complications of IV moderate sedation in relation to the type of medication being administered.
- Possess the requisite knowledge and skills to assess, diagnose, and intervene in the event of complications or undesired outcomes and to institute nursing interventions in compliance with orders (including standard orders) or institutional protocols or guidelines.
- Demonstrate skills in airway management resuscitation.



Conscious State	Sedation State	Unconscious State
Protective reflexes are intact May see alteration of mood, relief of anxiety, and some analgesia	Protective reflexes are minimally depressed May see patient sleeping but easily aroused	Protective reflexes are diminished or absent Respiration is automatic and involuntary; may see loss of airway reflexes

NSAIDs, nonsteroidal anti-inflammatory drugs; IV, intravenous.

figure 14-1 Anesthetic options for surgery.

- Demonstrate knowledge of the legal ramifications of administering IV moderate sedation or monitoring patients receiving IV moderate sedation, including the registered nurse's responsibility and liability in the event of an untoward reaction or life-threatening complication.

Monitored anesthesia care (MAC) describes a specific anesthesia service in which the anesthesia provider has been requested to participate in the care of a patient undergoing a therapeutic or diagnostic procedure. The main difference between moderate sedation and MAC is that the anesthesia provider deviates from the major goal of having the patient maintain his or her own airway and follow commands. To facilitate the surgical/diagnostic procedure and experience, the patient may be rendered unconscious or apneic for a period of time. IV agents are used in conjunction with local anesthetics that are injected by the surgeon. Postoperative or postprocedural care of the patient who has received moderate sedation or MAC is similar, although the patient who has received MAC may require more intervention in the postanesthesia phase.

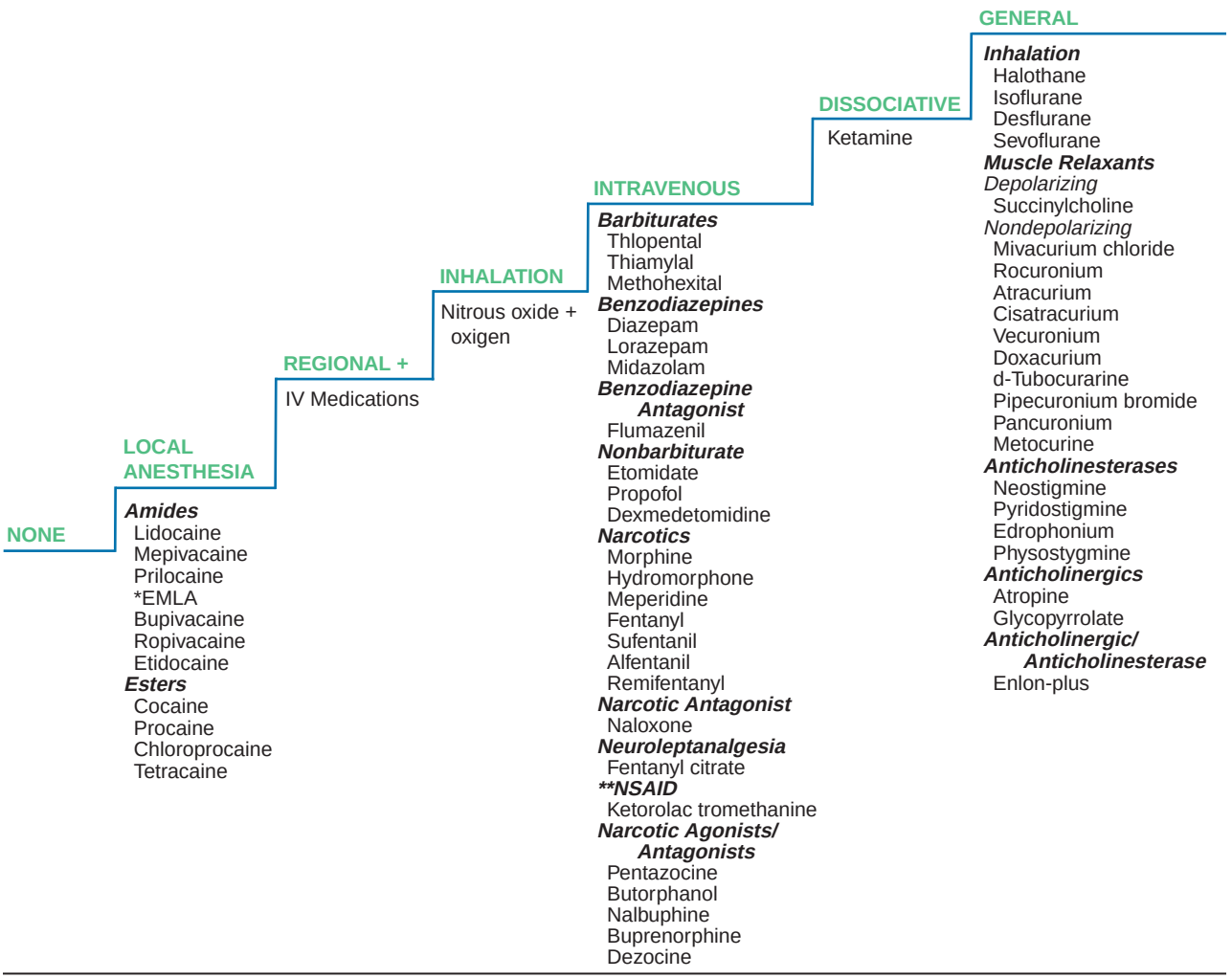
Table 14-1 provides a comparison of moderate sedation and MAC.

POTENTIAL PROBLEMS IN THE POSTANESTHESIA PATIENT

There are common potential problems in the postanesthesia patient for which the nurse must assess. They are discussed in the following sections.

Hypoxemia

Hypoxemia is a common occurrence in the immediate postoperative period. Severe hypoxemia is characterized by a partial pressure of arterial oxygen (PaO_2) of less than 50 mm Hg and is life-threatening. Hypoventilation leads to hypoxia, which is difficult to diagnose because of its multiple presentations. Clinical manifestations of hypoxia may include hypotension or hypertension, tachycardia or bradycardia, cardiac dysrhythmias, dyspnea, tachypnea,



* EMLA, Eutectic mixture local anesthetics
** NSAID, Nonsteroidal anti-inflammatory drugs

figure 14-2 Medication choices for anesthetic options.

box 14-2
Anesthesia Provider-to-Nurse Report: Information to Convey

Name of patient
Surgical procedure
Anesthetic options (agents and reversal agents used)
Estimated blood loss/fluid loss
Fluid/blood replacement
Vital signs—significant problems
Complications encountered (anesthetic or surgical)
Preoperative condition (e.g., diabetes, hypertension, allergies)
Considerations for immediate postoperative period (pain management, reversals, ventilator settings)
Language barrier

Ideally, the anesthesia provider should not leave the patient until the nurse is satisfied with the patient's airway and immediate condition.

hypoventilation, disorientation, agitation, decreased partial pressure of arterial carbon dioxide ($PaCO_2$), and cyanosis.

When investigating the etiology of hypoxemia related to anesthetic agents, the nurse considers the effects of a spinal or epidural block that has traveled too high, narcotic use, deep sedation, use of inhalation agents, and the use of neuromuscular blocking agents, particularly if they have not been adequately reversed. Diffusion hypoxia may occur when nitrous oxide is used, but because administering 100% oxygen for 3 to 4 minutes after the nitrous oxide is discontinued may prevent this complication, diffusion hypoxemia usually is not seen in the PACU patient.

All patients who receive a general anesthetic or sedation should receive supplemental oxygen in the immediate postoperative period. The oxygen may be weaned subsequently using pulse oximetry. Because pulse oximetry offers a noninvasive method of continuously monitoring oxygen saturation, increasing numbers of patients are receiving supplemental oxygen for 24 hours after surgery.

In addition to being aware of hypoxia, the nurse uses a "stir-up" regimen for patients in the postoperative period.

table 14-1 Comparison of Moderate Sedation and Monitored Anesthesia Care

	Moderate Sedation	Monitored Anesthesia Care (MAC)
Responsiveness	Purposeful response to repeated or painful verbal or tactile stimulation	Purposeful response after stimulation
Airway	No intervention required	Intervention may be required
Spontaneous ventilation	Adequate	May be inadequate
Cardiovascular function	Usually maintained	Usually maintained

This regimen involves encouraging the patient to deep breathe, cough, and move in bed, as allowed by the procedure or intervention. An integral part of recovery from anesthesia, this routine should be included every time vital signs are checked. It also allows the nurse to identify subtle changes in the patient's condition and to make appropriate interventions.

Reversal agents may be required while the patient is still under the effects of muscle relaxants, benzodiazepines, and opioids. Close monitoring is always indicated when reversal agents are administered. The effects of muscle relaxants, benzodiazepines, and opioids may last longer than the reversal medication, resulting in hypoventilation and hypoxia at some point after the reversal medication is administered. It is important for the nurse to be knowledgeable about the onset and duration of action of reversal agents, and the drugs they are being used to reverse. This knowledge allows for appropriate intervention in the event of a change in the patient's condition.[4]

Hypoventilation

Hypoventilation leading to hypercarbia may result from the following:

- Inadequate respiratory drive secondary to the effects of residual anesthesia (i.e., opioids, sedatives, and inhalation agents)
- Inadequate functioning of the respiratory muscles (the lungs may be unable to move an adequate tidal volume because of pain or inadequate reversal of neuromuscular blockade)

box 14-3 collaborative care guide *for the Postanesthesia Patient*

OUTCOMES	INTERVENTIONS
Oxygenation/Ventilation	
Depth and rate of respiration after extubation will be normal.	■ Monitor respiratory rate and breathing pattern every 15 min and PRN.
Arterial blood gases are within preoperative normal values.	■ Assess weaning parameters before extubation. ■ Monitor end-tidal CO_2 and pulse oximetry of mechanically ventilated patients.
Airway will be maintained with intact protective reflexes.	■ Encourage patient to cough and deep breathe. ■ Elevate head of bed if not contraindicated. ■ Use jaw thrust, head tilt, or oral oropharyngeal or nasopharyngeal airway to maintain airway. ■ Stimulate patient every few minutes (e.g., call name, touch).
There will be no evidence of aspiration.	■ Administer antiemetic as indicated. ■ Position patient on side; suction and maintain airway if patient is vomiting.
Circulation/Perfusion	
Heart rate and blood pressure will return to preoperative values within 1–2 h after anesthesia.	■ Monitor vital signs every 15 min and PRN. ■ Assess pulse quality and regularity. ■ Monitor for dysrhythmias. ■ Monitor for hypotension related to bleeding. ■ Monitor for hypotension related to warming and vasodilation. ■ Administer IV solution and blood products as ordered.

(continued)

box 14-3 collaborative care guide *for the Postanesthesia Patient (Continued)*

OUTCOMES	INTERVENTIONS
Body temperature will be within normal limits.	■ Anticipate hypothermia; have warming devices readily available. ■ Measure temperature on admission and PRN until normal. ■ Warm patient at 1° to 2°C/h.
There will be no evidence of malignant hyperthermia.	■ Monitor for malignant hyperthermia, and immediately notify anesthesia provider of temperature increase of 0.5°C. ■ Administer dantrolene, and initiate cooling measures. ■ Assist with malignant hyperthermia protocol.
Fluids/Electrolytes	
Patient will have stable blood pressure and heart rate.	■ Maintain patient IV. ■ Monitor intake and output. ■ Assess skin, mucous membranes for signs of hypovolemia.
Urine output will be 0.5–2 mL/kg/h. There will be no evidence of hypervolemia or hypovolemia.	■ Measure specific gravity if indicated. ■ Assess for signs of hypervolemia (e.g., pulmonary crackles, neck vein distension). ■ Measure serum electrolytes if indicated.
Mobility/Safety	
Patient will arouse easily and respond appropriately to commands.	■ Assess level of consciousness every 15 min and PRN. ■ Monitor motor and sensory function to assess reversal of neuromuscular blockade.
Patient will move all extremities purposefully and with normal strength.	■ Assess level of regional block, epidural, or spinal anesthesia.
Skin Integrity	
Skin will remain intact.	■ Assess skin immediately postoperatively for pressure areas and burns.
Nutrition	
Nutritional intake will be reestablished without nausea or vomiting.	■ Resume enteral feeding with return of bowel sounds. ■ Begin oral fluids with return of protective airway reflexes.
Comfort/Pain Control	
Pain will be less than 4 on pain scale or visual analog.	■ Assess location, type, and severity of pain. ■ Administer opioids as indicated. ■ Monitor response to analgesics. ■ Institute nonpharmacological pain relief strategies and comfort measures. ■ Evaluate patient-controlled analgesia IV or epidural as postoperative pain management option.
Psychosocial	
Personal support systems will be used to reduce anxiety.	■ Encourage significant other visits in early postoperative phase. ■ Validate patient's significant other's understanding of surgery and illness. ■ Initiate referrals to social services, clergy, and so forth.
Teaching/Discharge Planning	
Discharge from postanesthesia care phase will occur within 1–2 h.	■ Orient patient frequently. ■ Explain procedures and pain management treatment plan.
Exercises to prevent postoperative pulmonary complications will be demonstrated.	■ Teach coughing, deep breathing, incentive spirometer use. ■ Teach early mobilization. ■ Teach pain control strategies.
Patient or significant other will state understanding of surgical procedure and outcome of surgery.	■ Provide information regarding the procedure, and discuss probable outcomes.

- Intrinsic lung disease, which often requires postoperative ventilatory support of the patient (e.g., chronic obstructive pulmonary disease)
- Laryngospasm and obstruction of the airway, which must be identified and treated promptly (Box 14-4)

The nurse institutes the stir-up regimen in the immediate postoperative phase to stimulate the patient, especially if opioids and sedatives were used during surgery. Also, the nurse considers the length of time since reversal agents were administered to antagonize neuromuscular blockade. The patient may not be fully reversed and exhibit signs of residual neuromuscular blockade. Inadequate respiratory effort, inability to maintain a head lift for 5 seconds, inappropriate use of chest and abdominal wall muscles, air hunger, anxiety, and tachycardia are signs that may indicate residual paralysis.[4] Neuromuscular blocking agents are summarized in Box 14-5. Information about various muscle relaxants, their onset and duration, and other comparisons are given in Table 14-2.

Hypothermia may prolong neuromuscular blockade associated with nondepolarizing muscle relaxants; therefore, the patient's temperature must be monitored. Other conditions that increase the effects of neuromuscular blocking agents are listed in Box 14-6.

box 14-4
Managing Laryngospasm and Airway Obstruction

Laryngospasm

Laryngospasm is a spasm of the laryngeal musculature. The spasm is often caused by blood, mucus, or other oral secretions that irritate the vocal cords. Careful suctioning of the oropharynx before extubation helps to prevent spasm. In most cases, laryngospasm will break with the application of positive pressure with 100% fraction of inspired oxygen (FIO_2) via a bag-valve mask with a tight seal. If this does not break the spasm, a dose of depolarizing muscle relaxant (succinylcholine) may be given.

Upper Airway Obstruction

Upper airway obstruction must be identified and treated promptly and effectively. Airway obstruction may range from minimal to complete. Signs of obstruction include:

- Paradoxical breathing
- Stridor
- Lack of, or change in, breath sounds
- Alteration in vital signs
- Change in level of consciousness

Treatment to relieve obstruction must be provided in a systematic fashion.

1. Tilt head/lift chin.
2. Thrust jaw.
3. Call for assistance.
4. Insert an oropharyngeal or nasopharyngeal airway. (Bear in mind that an oropharyngeal airway may not be tolerated by the partially obtunded patient.)
5. Apply positive-pressure ventilation.
6. Administer succinylcholine.

box 14-5
Neuromuscular Blocking Agents

Muscle Relaxants

- Neuromuscular blockers pharmacologically paralyze patients and provide no sedation or analgesia.
- Neuromuscular blocking agents are used to facilitate endotracheal intubation, relax muscles for surgical procedures, terminate laryngospasm, eliminate chest wall rigidity, and provide for ease of mechanical ventilation if indicated.
- There are two groups of muscle relaxants, depolarizing and nondepolarizing, that work at the myoneural junction, affecting the chemical transmitter acetylcholine.

Depolarizing Agent (succinylcholine)

- This drug combines with acetylcholine receptors at the myoneural junction and mimics the action of acetylcholine.
- Onset of action is 1–2 minutes and duration of action is 4–6 minutes.
- The enzyme pseudocholinesterase removes succinylcholine from plasma, so in conditions involving a decrease in pseudocholinesterase, the length of action of succinylcholine increases, keeping patients paralyzed for longer periods.
- Increased pseudocholinesterase enzyme may be seen in pregnancy, liver disease, malnutrition states, severe anemia, cancer, and with other pharmacological agents, such as quinidine, phospholine eye drops, and propranolol.

Nondepolarizing Agents

- Nondepolarizing agents (atacurium, cisatracurium, mivacurium chloride, pipecuronium bromide, vecuronium, *d*-tubocurarine, pancuronium, doxacurium, rocuronium) compete with acetylcholine at the myoneural junction for muscle membrane receptors.
- Onset of action is within 2–3 minutes.
- Duration of action ranges from 20 minutes to 2 hours, depending on the medication and dosage.
- May be reversed pharmacologically with anticholinesterase drugs (neostigmine, pyridostigmine, edrophonium). Duration of action of anticholinesterase is brief, so there is a chance the patient may have continued muscle weakness or respiratory depression. Anticholinesterases may induce muscarinic side effects, including bradycardia, lacrimation, defecation, and increased salivary and bronchial secretions. These side effects are counteracted with the routine administration of anticholinergic drugs (atropine, glycopyrrolate) in conjunction with the anticholinesterase.

Hypotension

Probably the most common cardiovascular complication seen in the postoperative period is hypotension. It is most often caused by a decreased circulating blood volume. Hypotension is defined as a 25% to 30% decrease in systolic blood pressure from the resting baseline value.

table 14-2 ■ Muscle Relaxant Comparisons

Drug	Onset	Duration	Dose	Metabolism Elimination	Histamine	Side Effects	Advantages
Depolarizing							
Succinylcholine	1–2 min	4–6 min	1.5–2 mg/kg	Plasmacholinesterase Renal, biliary	Possible	↓ Pulse Fasciculations Cardiac dysrhythmia Hyperkalemia ↑ ICP ↑ IOP	Short acting
Nondepolarizing							
Mivacurium chloride (Mivacron)	2–2.5 min	10–15 min	0.1–0.25 mg/kg	Plasmacholinesterase Renal, biliary	Yes	Flushing Hypotension Dysrhythmia Rash, muscle spasm Bronchospasm	Short acting Minimal CV side effects
Atracurium (Tracrium)	Within 2 min	30–45 min	0.4–0.5 mg/kg	Hoffman elimination Ester hydrolysis	Mild		Intermediate acting No CV effect Easily reversed Block not prolonged
Vecuronium (Norcuron)	Within 3 min	30–45 min	0.06–0.1 mg/kg	Hepatic, renal to none	Very mild		Intermediate acting Little or no CV effect Easily reversed
Rocuronium (Zemuron)	1–1.5 min	20–40 min	0.45–1.2 mg/kg	Renal, biliary	Low	↑ PVR	Intermediate acting Minimal CV effects
Cisatracurium (Nimbex)	2–3 min	40–60 min	0.15–0.2 mg/kg	Hoffman elimination Renal and hepatic	None		Intermediate acting Hemodynamic stability
d-Tubocurarine (Curare)	Within 3 min	45–60 min	Up to 0.6 mg/kg	Renal, hepatic	Yes	Hypotension Histamine-like reaction	Long acting
Pancuronium (Pavulon)	Within 4 min	1–1 1/2h	0.04–0.1 mg/kg	Renal, hepatic, biliary	Isolated cases	Avoid with: Myasthenia gravis Renal disease Hypersensitivity to bromide Coronary artery disease	Long acting
Doxacurium (Nuromax)	4–6 min	100–160 min	0.05–0.08 mg/kg	Renal	None	Potentiated by inhalation agents, particularly halothane Prolonged recovery in elderly	Long acting
Pipecuronium (Arduan)	3–5 min	60–120 min	0.14 mg/kg	Renal, biliary	None	Hypoglycemia Hyperkalemia CNS depressant Respiratory depressant	Long acting No CV effects

ICP, intracranial pressure; IOP, intraocular pressure; CV, cardiovascular; PVR, peripheral vascular resistance; CNS, central nervous system.

box 14-6
Conditions and Medications That Increase the Effects of Nondepolarizing Muscle Relaxants

Local anesthetics
General anesthetics
Antibiotics: aminoglycosides, polypeptides, polymyxin
Antiarrhythmics: quinidine, procainamide
Furosemide
Acid–base status: respiratory acidosis, metabolic alkalosis
Electrolyte imbalance: hypokalemia, hypocalcemia, dehydration, magnesium administration
Hypothermia

Intervention is indicated if the pressure decreases by more than 30% of the baseline value.[5] Risk factors for postanesthesia hypotension are listed in Box 14-7.

Anesthetic agents may affect the blood pressure in various ways. Regional anesthetics, such as bupivacaine and tetracaine, may decrease blood pressure by sympathetic blockade and vasodilation. IV agents, including opioids, cause vasodilation and histamine release, resulting in lowered blood pressure. Tranquilizers, especially droperidol and chlorpromazine hydrochloride, produce sympathetic blockade and subsequent decreased blood pressure. Barbiturates cause myocardial depression, as do inhalation agents such as isoflurane, enflurane, halothane, sevoflurane, and desflurane. Muscle relaxants may cause hypotension by ganglionic blockade and histamine release.

Because decreased venous return is seen with hypovolemia and myocardial depression, the nurse considers the adequacy of volume replacement, blood loss, third spacing, and excessive diuresis. The nurse evaluates the patient for orthostatic hypotension by taking vital signs with the patient supine and after raising the head of the bed 60 degrees (if not contraindicated by the surgical procedure or patient status). Cardiac dysrhythmias may cause hypotension, especially when cardiac output is decreased, as it is with supraventricular tachycardia and marked bradycardias. Other causes of early postoperative hypotension include sepsis, pulmonary embolism, transfusion reaction, and pain.

Deliberate, controlled hypotensive techniques are often used during specific procedures, such as neurosurgical procedures of the head and neck, shoulder arthroscopy, and some oncologic operations. The advantages of this technique are that it minimizes blood loss and the need for transfusion, and decreases oozing and possible hematoma formation.

Treatment of hypotension is directed to the underlying cause. A complete report from the anesthesia provider, including the techniques used during surgery and any untoward events that occurred, helps the nurse identify the underlying cause.

Various interventions may be used to treat hypotension. A priority is to ensure adequate oxygenation and ventilation of the patient while the blood pressure is being addressed. Anesthetic drugs may require reversal, including muscle relaxant reversal with anticholinesterase and anticholinergic agents, narcotic reversal with naloxone, and benzodiazepine reversal with flumazenil. Vasopressor drugs can be administered to increase blood pressure. IV fluids, including blood products, plasma expanders, and crystalloids, may be administered. Dressings, drains, and surgical sites should be inspected frequently for signs of hemorrhage.

box 14-7 ***Risk Factors for Hypotension Postanesthesia***

Anesthetic Agents
- Regional agents
- Opioids
- Tranquilizers
- Barbiturates
- Muscle relaxants
- Inhalation agents

Decreased Venous Return
- Hypovolemia (inadequate replacement, continued blood loss)
- Hypothermia
- Myocardial depression
- Third spacing
- Sepsis
- Transfusion reaction
- Tight abdominal dressing
- Increased intrathoracic pressure

Cardiac
- Dysrhythmias (supraventricular tachycardia)
- Myocardial infarction
- Congestive heart failure

Pulmonary
- Hypoxia
- Acidosis
- Pulmonary embolism
- Pneumothorax

Vasovagal Reactions
- Bradycardia
- Pain
- Bladder/abdominal distension

Technical Problems
- Blood pressure cuff size and position
- Transducer balance and calibration
- Stethoscope position

An important consideration when assessing and treating the patient with hypotension is the possibility of technical rather than physiological problems. Is the blood pressure cuff the correct size and is it positioned correctly? Is the stethoscope positioned correctly? Is the patient's position a factor? If an arterial line is present, is the patient peripherally constricted, or does peripheral vascular disease exist? Is the transducer balanced and correctly calibrated? Troubleshooting should occur simultaneously with assessment.

Hypertension

Hypertension is classified according to its degree of severity. It ranges from mild with a diastolic pressure between 90 and 104 mm Hg, to severe with a diastolic pressure

between 105 and 120 mm Hg, to malignant with a diastolic pressure greater than 120 mm Hg.

The two most common causes of postoperative hypertension are a history of hypertension, and pain. Hypertension may be associated with peripheral vasoconstriction and shivering. Inhalation and IV anesthetic agents may produce hypoxia and hypercarbia with a resultant increase in catecholamine release and blood pressure elevation. Ketamine, a dissociative drug used in anesthesia, stimulates the sympathetic nervous system and may cause tachycardia and hypertension. Also, if given too rapidly, naloxone may precipitate hypertension, which in turn may precipitate pulmonary edema or cerebral hemorrhage. Other causes of hypertension include hyperthermia, anxiety, urinary bladder distention, fluid overload, pain, a too-narrow blood pressure cuff, and withholding of antihypertensive therapy before surgery.

Transient hypertension may occur during induction, intubation, or positioning, when the surgical incision is made, or during postanesthesia. Transient hypertension can be avoided by a vigilant anesthesia practitioner.

The hypertensive patient requires reassurance, close observation, and aggressive postoperative treatment. The treatment is first directed to the cause of the hypertension, if known. Unless instructed otherwise, patients should take their antihypertensive medication up to the time of the surgical procedure. Antihypertensive medications may be ordered if indicated by the severity of hypertension. Short-acting peripheral vasodilators, such as hydralazine and nifedipine, may be used. Labetalol, a beta-adrenergic blocker, may also be prescribed. Continuous vasodilator drips of sodium nitroprusside or nitroglycerin are used to bring the blood pressure within safe limits and maintain it. When hypertension accompanies emergence delirium, opioids or physostigmine, an anticholinesterase, may be required. If the patient is hypertensive due to anxiety and verbal reassurance is ineffective, tranquilizers, such as diazepam, midazolam, and lorazepam, may be indicated. Urinary catheterization and aggressive treatment with diuretics such as furosemide may be used if the hypertension is a result of fluid overload during surgery.

Cardiac Dysrhythmias

The dysrhythmias covered in this chapter are those induced by anesthetic agents and complications frequently seen in the immediate postoperative period (Table 14-3). Refer to Chapter 17 for detailed information on identifying specific cardiac dysrhythmias. There are many causes of cardiac dysrhythmias in the immediate postoperative period. Some of the most common are residual anesthetic agents, anticholinesterase drugs, hypoxemia, hypoventilation, hypovolemia, fluid overload, hyperthermia, hypothermia, and pain (Box 14-8).

Hypothermia

Hypothermia is present when the body temperature is less than 35°C (95°F). Heat loss during surgery occurs secondary to reduced basal metabolism when patients given muscle relaxants fail to shiver. Also, vasodilation caused by inhalation anesthetic agents, related to sympathetic blockade with inhibition of motor and sensory nerve fibers, and resulting when regional techniques are used, is a factor in hypothermia. Other intraoperative causes include heat loss through radiation, exposure, convection, and conduction because of prolonged exposure of body surface; lying under saturated drapes (especially in long procedures); use of antiseptic prepping solutions; and use of cold irrigation or IV solutions. Older, debilitated patients and newborns are more intolerant of temperature changes and thus more prone to hypothermia. Hats and other warming devices, such as fluid warmers and warming blankets, may prevent hypothermia.

Hypothermia, with its associated vasoconstriction and initial increase in blood pressure, requires special attention in the postoperative phase. Care must be taken in rewarming because too rapid rewarming of the patient may result in an acute drop in blood pressure and other significant problems.

Hyperthermia

Hyperthermia is a body temperature greater than 39°C (102.2°F). Elevated temperature may occur in the anesthetized patient secondary to thermal insulation from the surgical drapes and the administration of inhalation anesthetics. Anticholinergic drugs may also induce a pharmacological loss of thermoregulatory capacity. Most patients with an elevated temperature either arrive in the surgical suite with a fever or have a pyrogenic response from septicemia. Other possible causes of postoperative hyperthermia are allergic reactions to blood or drugs, central nervous system disorders, and infection.

Malignant Hyperthermia

One of the most catastrophic events that can occur in the immediate postoperative period is malignant hyperthermia. Although most cases of malignant hyperthermia occur in the operating room during the administration of a general anesthetic, the immediate 12-hour period after general anesthesia is also a critical time. Malignant hyperthermia is a hypermetabolic syndrome that may be triggered in susceptible individuals by commonly used anesthetic agents, including succinylcholine and the halogenated inhalation agents. Other anesthetic agents are safe to use, including nitrous oxide, local anesthetics, opioids, propofol, sodium thiopental, and the nondepolarizing muscle relaxants.

The exact mechanism of malignant hyperthermia is not well understood. Research points to a derangement in muscle contraction. The known triggering agents cause a release of calcium from muscle storage sites, leading to an elevated concentration of calcium. This high calcium level increases metabolism and causes muscle to contract and become rigid (masseter muscle rigidity). This process results in hyperthermia, acid–base imbalance, and muscle cell breakdown.

Malignant hyperthermia is a rare, inherited autosomal dominant disorder of skeletal muscle and is more prevalent in those with muscular abnormalities. Malignant hyperthermia has been linked to several other muscle disorders, including some forms of muscular dystrophy, but whether this is true malignant hyperthermia is not clear. Most experts on malignant hyperthermia do not believe that caffeine or stress will precipitate malignant hyperthermia. The

table 14-3 ■ Cardiac Dysrhythmias Associated With Anesthetic Options

Anesthetic Option	Dysrhythmia
Local anesthesia with epinephrine	Tachycardia
Spinal and epidural	Bradycardia second-degree vagal response; PACs, PVCs, supraventricular tachycardia, atrial fibrillation second-degree sympathetic stimulation; wandering pacemaker and heart block second-degree increased vagal tone
Barbiturates	
Pentothal	Bradycardia, AV dissociation, occasional PVC
Nonbarbiturate etomidate	Sinus tachycardia
Opioids	
Morphine sulfate	Transient brachycardia
Meperidine hydrochloride	Transient tachycardia
Fentanyl	Bradycardia
Opioid antagonist	PVCs, ventricular tachycardia, occasional ventricular fibrillation
Neuroleptanalgesia (droperidol component)	Tachycardia
Dissociative agent	Myocardial depression, ventricular ectopy, tachycardia
Inhalation agents	
Halothane	AV dissociation, ventricular dysrhythmias if hypercarbia occurs
Halothane plus aminophylline, cocaine, lidocaine	Bradycardia
Halothane plus pancuronium	PACs and PVCs
Isoflurane	Tachycardia
Enflurane	AV dissociation
Muscle relaxants	
Succinylcholine	Sinus bradycardia, junctional rhythms, PVCs Patients with burns, trauma, paraplegia or quadriplegia prone to ST segment depression, peaked T waves, widening QRS complex leading to ventricular tachycardia, ventricular fibrillation, or asystole
Pipecuronium bromide	Atrial fibrillation, ventricular extrasystole
Pancuronium	Tachycardia and nodal rhythms
d-Tubocurarine	Tachycardia
Anticholinesterases	Bradycardia, slowed AV conduction, PVC
Anticholinergics	Tachycardia

PAC, premature atrial contraction; PVC, premature ventricular contraction; AV, atrioventricular.

exact incidence of malignant hyperthermia is not known. The rate of occurrence has been estimated at between 1 in 5000 and as rare as 1 in 65,000. The states with the highest incidence are Michigan, West Virginia, and Wisconsin.[6]

Clinical manifestations include an increase in temperature of 0.5°C or more every 15 minutes from the time of induction of anesthesia to as high as 46°C, muscle rigidity, hypercarbia, unexplained tachycardia, sweating, and unstable blood pressure. Masseter muscle rigidity after the administration of succinylcholine is the earliest warning sign of malignant hyperthermia. Temperature elevation is quite dramatic but is not the first sign of malignant hyperthermia. If the patient's temperature increases rapidly and the anesthetic is not discontinued and treatment rapidly instituted, death may occur.

Malignant hyperthermia is treated vigorously with dantrolene sodium (Dantrium), 100% oxygen administration, correction of acid–base imbalances, and removal of triggering agents. Cooling measures, such as icing down the patient and cold fluids, are used. Dantrolene sodium 2.5 mg/kg IV is given and may be repeated up to 10 mg/kg as necessary to control signs and symptoms. Dantrolene sodium is reconstituted with preservative-free sterile water. The administration of dantrolene is labor intensive, thus requiring assistance. Most institutions that administer anesthesia have a malignant hyperthermia kit in the operating suite. Box 14-9 lists the common contents of a malignant hyperthermia kit.

After the acute phase of the malignant hyperthermia crisis, care includes observation in a critical care unit for at least 24 hours and administration of dantrolene sodium 1 mg/kg every 6 hours for 24 to 48 hours. Oral dantrolene may then be used with monitoring of arterial blood gases, creatinine kinase, potassium, calcium, urine, serum myoglobin, and clotting studies every 6 hours. Patients should be referred to the Malignant Hyperthermia Association of the United States (MHAUS) for support and continued education about this disorder.[7]

box 14-8 ***Risk Factors That Precipitate Dysrhythmias***

- Hypoxemia (sinus bradycardia, sinus tachycardia, PVCs, supraventricular tachycardia)
- Hypoventilation/Hypercarbia (sinus tachycardia, PVCs, sinus bradycardia)
- Hypovolemia (sinus tachycardia)
- Fluid overload (PVCs, supraventricular tachycardia, PACs, atrial fibrillation/flutter)
- Hyperthermia (sinus tachycardia, PVCs)
- Hypothermia (sinus bradycardia, atrial fibrillation, atrioventricular nodal blocks)
- Pain (sinus tachycardia, PVCs)

PVCs, premature ventricular contractions; PACs, premature atrial contractions.

Nausea and Vomiting

Nausea and vomiting occur frequently in the immediate postoperative period and may result from any of the anesthetic options. Nausea is a subjective, unpleasant experience usually leading to vomiting. Although not usually life-threatening, postoperative nausea and vomiting (PONV) leaves the patient with a lasting unpleasant memory and may have an impact on future surgical and anesthetic decisions. PONV is a major complication associated with the need for admission after outpatient surgery. Frequent causes include use of preoperative and intraoperative opioids; increased gastric secretions; certain anesthetic techniques, particularly spinal anesthesia; and surgical procedures involving manipulation of eye muscles, abdominal muscles, and genitourinary muscles. Laparoscopic techniques and procedures involving the breast are also associated with an increase in postoperative nausea and vomiting.

Vomiting is controlled by the vomiting center located in the medulla. Once stimulated, efferent impulses are sent by the 5th, 7th, 9th, 10th, and 12th cranial nerves, spinal nerves, and phrenic nerves to the diaphragm, esophagus, and stomach. The vomiting center receives input directly from the gastrointestinal tract, the chemoreceptor trigger zone, the labyrinthine apparatus (motion sickness), and various cortical and visual stimuli.

The critical care nurse must be cognizant of the potential for regurgitation and aspiration in all patients who have been anesthetized. Vomiting is an active process, whereas regurgitation is passive. Adequate positioning of the unconscious patient is essential. The ideal position is on the side with the head and neck extended. If the surgical procedure precludes turning the patient on the side or the patient is unable to comply, then the patient must not be left unattended until consciousness is regained.

Antiemetics frequently are ordered in the immediate postoperative period. The critical care nurse should recognize that many antiemetics potentiate the effects of other medications, particularly opioids. Therefore, decreased doses of opioids for pain relief may be indicated.

Often, nausea and vomiting can be relieved by identifying the causative factor (e.g., gastric distension, hypotension, administration of opioids) and making the appropriate intervention.

box 14-9
Contents of Malignant Hyperthermia Kit

- Methylprednisolone
- Furosemide
- Sodium bicarbonate
- Dextrose (50%)
- Sterile water
- Insulin
- Mannitol
- Refrigerated intravenous fluids
- Dantrolene sodium
- New oxygen tubing and delivery devices
- Foley catheter tray
- Nasogastric tubes
- Blood specimen tubes
- Arterial blood gas kits

Postoperative Pain

Patients normally expect to feel pain when their surgical procedure is over. The incidence of pain and its severity depend on the individual. All pain assessment in the immediate postoperative period must be individualized. A number of factors affect the severity of pain, including the site of the operation, the psychological state of the patient, and the anesthetic technique used.

If the anesthetic option chosen was use of inhalation agents without the use of opioids or local anesthetics, then the patient may have more pain than one who received some form of analgesia during surgery. Patients who have been given analgesic medication during the procedure and who then receive naloxone at the end may also experience severe pain because naloxone reverses the analgesic effects of any prior medication. Because these patients may renarcotize, the nurse must wait 15 to 45 minutes after the administration of naloxone before medicating the patient with an analgesic. Box 14-10 outlines some factors that may influence the patient's response to pain.

INTRAVENOUS MEDICATIONS

IV titration of opioids in the immediate postoperative period offers the quickest and most effective method of pain relief. Because the patient's basal metabolic rate is decreased during surgery, the uptake of intramuscular medication is difficult to predict.

INTRAMUSCULAR MEDICATIONS

One intramuscular medication, ketorolac tromethamine (Toradol), administered during surgery, has proved effective in the management of postoperative pain. Ketorolac tromethamine is a nonsteroidal anti-inflammatory drug (NSAID) that exhibits analgesic, anti-inflammatory, and antipyretic activity. Peak analgesia occurs in 45 to 60 minutes after intramuscular or IV injection, and the analgesic effect lasts 6 to 8 hours. The medication should not be used for more than 5 days, and no more than a 30-mg dose should be used. The medication is contraindicated in

box 14-10
Factors Influencing Pain

Surgical procedure: Site and nature of the operation
Anxiety level: Fear of surgery, disfigurement, death, loss of control
Patient expectations: Effectiveness of preoperative teaching, adequately prepared for outcome
Pain tolerance: Prior use of medications, including analgesics, individual differences
Anesthesia technique: Analgesics used during the intraoperative period, use of naloxone

patients with active peptic ulcers, recent gastrointestinal bleeds, or renal insufficiency.[4]

PATIENT-CONTROLLED ANALGESIA AND EPIDURAL MEDICATIONS

Trends in pain control management include use of patient-controlled analgesia (PCA) devices and epidural analgesia. The use of PCA pumps has increased significantly during recent years, and it is believed that patients report less pain when they maintain autonomy by controlling the administration of opioids for their pain relief.

Epidural analgesia has proved successful in treating acute pain after surgery. Patients who receive epidural opioids are less sedated and therefore ambulate sooner and have improved respiratory function. Epidural medications may be administered as a bolus injection or by a continuous infusion. When administering continuous infusions, an infusion pump should be used. Safeguards to be taken include using preservative-free medications in the epidural infusion; using infusion sets that have no injection ports; and labeling the infusing pump, infusion bag, and infusion tubing with the word *epidural*. The reason for such safeguards is that accidental infusion of vasodilators, chemotherapy medications, antibiotics, and medications with any type of preservative could permanently destroy nerve tissue and paralyze or even kill the patient.

Frequently used preservative-free epidural medications include morphine, hydromorphone, meperidine, and fentanyl. The duration of sensory analgesia varies with the opioid administered. The more lipid-soluble agents penetrate the dura mater more rapidly, resulting in a more rapid diffusion away from the spinal cord and subarachnoid space and hence a shorter duration of action. The most frequently used opioids for epidural administration for which average duration times have been identified are morphine, with a duration that varies from 2 to 24 hours; hydromorphone, with an average duration of 10 to 14 hours; meperidine, with an average duration of 6 to 8 hours; and fentanyl, with an average duration of 4 to 6 hours.

Dilute local anesthetic solutions are used either in conjunction with the previously mentioned opioids or used alone. Local anesthetics used alone and in conjunction with narcotics are lidocaine, mepivacaine, prilocaine, bupivacaine, and etidocaine. The most common local anesthesia used for epidural infusions is bupivacaine. The combination of local anesthetics and opioids has been used to obtain a rapid onset and prolonged duration of analgesia. The local agents work more rapidly, and the opioids have a more prolonged action. Side effects may occur with the use of opioids and anesthetic solutions in the epidural space. Nurses have the primary responsibility for recognizing and preventing side effects when caring for patients receiving epidural analgesia, as listed in Box 14-11. Adequate pain relief during the postoperative period allows the patient to cough, deep breathe, and ambulate sooner, thus preventing complications.

OTHER MEDICATION METHODS

Other techniques investigated as alternatives in pain management include intrathecal and interpleural methods, transdermal patches, and transmucosal–nasal aerosol delivery systems. Intrathecal analgesia is injected, usually as a one-time dose, directly into the cerebrospinal fluid of the subarachnoid space.[7] Interpleural techniques involve administration of local anesthetics into the interpleural space. A series of injections are given or a catheter is placed during the perioperative period, but occasionally after surgery. Continuous infusions and bolus injections may be given.

Transdermal patches of fentanyl are being studied, as are transmucosal–nasal aerosol delivery systems.[1–3] Transdermal fentanyl is an excellent alternative to sustained-release morphine preparations, especially when oral medication is not possible or is contraindicated. Patches are constructed as a drug reservoir separated from the skin by a microporous rate-limiting membrane and adhesive polymer. The major disadvantages, to the transdermal patches are the

box 14-11
Side Effects From Epidural Analgesia

Specific protocols for epidural management are essential for each individual hospital.

Urinary retention
- Catheterize as needed.

Postural hypotension
- Give fluid (volume) replacement.
- Administer ephedrine 5 mg IV as ordered.

Pruritus (itching of face, head, and neck)
- Treat with Benadryl 25 mg PO, IM, IV.
- Treat with naloxone 0.1 mg IV.
- Treat with propofol 10 mg IV.

Nausea and vomiting
- Administer metoclopramide 10 mg IV.
- Administer scopolamine patch.
- Administer ondansetron (Zofram) 4 mg IV.
- Administer dolasetron 12.5 mg IV.

Respiratory depression (risk increases with age)
- Assess for first signs which may include change in level of consciousness.
- Assess for occurrence up to 24 hours after opioid injection with naloxone 0.1 mg up to a maximum of 0.4 mg IV.
- Observe continuously because naloxone's duration is 30 minutes.
- Have naloxone and ephedrine readily available at the bedside of patients who have received epidural opioids or anesthetics.

slow onset and the inability to change dosages rapidly in response to changing opioid requirements. Oral transmucosal fentanyl citrate has been evaluated and approved for pediatric premedication and sedation. The onset of sedation is within 5 to 10 minutes, and full recovery is within 60 minutes after administration of the "fentanyl oralet." Plasma levels rise as the patient sucks on the lozenge on a stick. These oralets should be used only in the hospital setting where 1:1 observation of respiratory function may be measured. Side effects of oral transmucosal fentanyl citrate include nausea and vomiting and facial pruritus.

clinical applicability challenges

Self-Challenges: Critical Thinking

1. *Compare and contrast the actions of the depolarizing muscle relaxants with the nondepolarizing muscle relaxants and identify medications that may be used to reverse these agents pharmacologically.*
2. *Develop a plan of care for the patient who has a known family history of malignant hyperthermia.*
3. *Relate any dysrhythmias demonstrated by the anesthetized patient to his or her clinical condition.*
4. *Discuss the admission of a postoperative patient to your unit and detail priorities of care on arrival.*
5. *Compare and contrast postoperative pain modalities for the patient who has received general anesthesia with parenteral opioids versus general anesthesia and has an epidural catheter in place.*
6. *Develop a plan of care for the patient who presents to the postanesthesia care unit (PACU) with postoperative shivering.*

Study Questions

1. *Which of the following medications should be available for a patient with suspected malignant hyperthermia?*
   a. *Dantrolene sodium*
   b. *Calcium chloride*
   c. *Succinylcholine*
   d. *Dextrose 70%*
2. *Which of the following agents is associated with the lowest incidence of postoperative nausea and vomiting?*
   a. *Thiopental*
   b. *Etomidate*
   c. *Ketamine*
   d. *Propofol*
3. *Which of the following is a major cause of postoperative hypoxemia?*
   a. *A high inspired oxygen concentration*
   b. *Hyperventilation*
   c. *Hypothermia*
   d. *Atelectasis*
4. *Which of the following should be the first monitor attached to the patient on arrival in the postanesthesia care area (PACU)?*
   a. *Pulse oximeter*
   b. *Cardiac monitor*
   c. *Noninvasive blood pressure*
   d. *Temperature monitoring device*
5. *Your postoperative patient is ready for extubation in the PACU. What objective criteria do you use?*
   a. *A negative inspiratory force greater than -20 cm H_2O*
   b. *A vital capacity greater than 5 mL/kg*
   c. *Patient is awake*
   d. *Heart rate greater than 110 beats per minute*
6. *Which of the following oxygen administration devices would you expect to use to provide supplemental oxygen to a patient in the PACU after repair of a fractured tibia?*
   a. *Simple face mask*
   b. *Bag-valve mask*
   c. *Venturi mask*
   d. *Nasal cannula*

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