Sedation and Analgesia in Interventional Radiology

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ABSTRACT

Complex medical procedures requiring the administration of sedation and analgesia are frequently performed in sites outside the operating room. In particular, interventional radiologists must understand basic principles of sedation and analgesia to direct nurses or nurse practitioners to provide adequate conscious sedation. The purpose of this article is to review basic principles of sedation, pharmacologic agents used for sedation and analgesia, practice guidelines, monitoring, and management of common hemodynamic problems encountered during sedation.

KEYWORDS: Sedation, analgesia, practice guidelines, nonanesthesiologist

Objectives: Upon completion of this article, the reader should be able to (1) identify characteristics of patients that may make complications of sedation more likely and (2) list several of the more commonly used pharmacologic agents for sedation and describe their effects.

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Complex medical procedures requiring the administration of sedation and analgesia are now frequently performed in sites outside the operating room. The physicians performing these procedures often provide sedation by directing an assistant such as a nurse or nurse practitioner. Providing safe and effective sedation and analgesia to patients with multiple medical problems can be challenging for nonanesthesiologists. Therefore, it is important for physicians who are involved in such procedures to develop an adequate knowledge base regarding the clinical and pharmacologic effects of common sedative and analgesic drugs and to understand the basic principles involved in their use.

BASIC PRINCIPLES

The terms sedation and analgesia refer to a continuum of clinical entities produced by pharmacologic agents. These states are defined not only by a patient's level of consciousness but also by the effects on airway maintenance, the adequacy of spontaneous ventilation, and cardiovascular function.¹ During *minimal sedation (anxiolysis)*, a patient responds normally to verbal commands. Airway maintenance and ventilatory and cardiovascular functions are unaffected. *Moderate sedation/analgesia (conscious sedation)* refers to a drug-induced depression of consciousness during which patients respond purposefully to verbal commands or light

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tactile stimulation. The airway, ventilatory, and cardiovascular functions are usually adequate. *Deep sedation/analgesia* depresses consciousness such that patients are not easily aroused by verbal commands but respond purposefully to painful stimulation (reflex withdrawal from a painful stimulus is not considered a purposeful response). The patency of the airway and adequacy of spontaneous ventilation may be compromised, sometimes requiring intervention such as maneuvers to relieve airway obstruction (chin lift or jaw thrust), placement of an oral or nasal airway, and positive pressure ventilatory assistance. Cardiovascular function is usually unaffected. Deep sedation becomes *general anesthesia* when the patient no longer responds to even painful stimuli. Airway intervention is usually required, spontaneous ventilation is often inadequate, and cardiovascular function may be impaired (myocardial depression, blunting of autonomic responses).

Another important distinction between sedation and general anesthesia is the maintenance of protective reflexes. The corneal reflex (the “blink” reflex) and the airway reflexes (the “gag” reflex) are typically preserved during minimal or moderate sedation but are often depressed during deep sedation and abolished during general anesthesia. The potential consequences of depressed or absent airway reflexes should be of highest priority when making decisions regarding sedation/analgesia. We have all had the experience of having had something “go down the wrong tube” while eating or drinking. Vigorous coughing ensues because of the intense innervation of the larynx and trachea preventing pulmonary aspiration and its sequelae (severe bronchospasm, airway obstruction, chemical pneumonitis, adult respiratory distress syndrome).

For this reason, it is worth reviewing practice guidelines for preprocedure fasting in which sedation/analgesia is planned. An overall preprocedure evaluation is necessary when considering the potential for pulmonary aspiration. The American Society of Anesthesiologists (ASA) guidelines for minimum fasting periods prior to sedation/analgesia apply to “healthy patients who are undergoing elective procedures.”² Therefore, conditions in which delayed gastric emptying or gastric reflux occurs (e.g., pregnancy, diabetic gastroparesis, gastroesophageal reflux disease, hiatal hernia, peritonitis, trauma) should be established during the initial history. The presence and severity of related symptoms have practical implications and should be elucidated. A patient with a history of a large hiatal hernia causing severe heartburn when supine may be managed differently from a patient with mild reflux disease well controlled by medications, although both have a history of gastroesophageal reflux disease. Nausea and vomiting imply abnormal gastric motility. Despite a patient having fasted an “adequate” period of time, the aforementioned conditions make patients more likely to have

Table 1 American Society of Anesthesiologists Recommendations for Minimum Fasting Periods Prior to Sedation/Analgesia

Ingested Material	Minimum Fasting Period (h)
Clear liquids	2
Breast milk	4
Infant formula	6
Nonhuman milk	6
Light meal	6

larger than normal volumes of gastric contents, resulting in an increased propensity to aspiration during periods of depressed airway reflexes.

The ASA Task Force on Preoperative Fasting and the Use of Pharmacologic Agents to Reduce the Risk of Pulmonary Aspiration recommends minimum fasting periods prior to sedation/analgesia² (Table 1). A liquid is “clear” when one can see through it when it is held up to light (water, fruit juices without pulp, carbonated beverages, clear tea, and black coffee). A light meal consists of dry toast and clear liquids. Fatty foods and meat may prolong gastric emptying time (bacon and eggs do not constitute a light meal even if 6 hours have passed since consumption). For meals beyond those considered light “both the amount and type of food ingested must be considered when determining an appropriate fasting period.”² Practitioners should resist the temptation to proceed with sedation for an elective case when the patient has had a very small amount of solids and not fasted adequately (the “just one cracker, doc” scenario). Mastication and the presence of food in the stomach stimulate secretion of gastric acid, increasing gastric volume and decreasing gastric pH. The severity of aspiration is related to the volume and pH of gastric contents aspirated.^{3,4}

PHARMACOLOGIC AGENTS

What are the characteristics of the ideal sedative/analgesic? It should optimize performance of the procedure, that is, minimize patient’s movement, maximize comfort for the patient, and have no side effects. Specifically, it should provide a sedative/hypnotic effect (a dose-dependent depression of consciousness), analgesia (if necessary for supplementing local anesthesia), and amnesia, ideally with minimal cardiovascular and respiratory effects. Rapid-onset and short-acting or reversible agents would allow optimal control over these effects. Unfortunately, no single drug accomplishes all of these goals. With some basic understanding of the pharmacology of some of the more commonly used sedatives, combinations of these drugs can achieve the desired effect.

Benzodiazepines provide most of the qualities of an ideal sedative/analgesic. Pharmacologic characteristics include relief of anxiety, sedation, anterograde amnesia (impairment of the storage of new information), and a minimum of cardiovascular and respiratory depression. Notably, however, they lack analgesic properties. The most commonly used parenteral benzodiazepine is midazolam (Versed). This popularity can be attributed to its rapid onset and relatively short half-life (1–4 hours) as compared with diazepam (Valium) and lorazepam (Ativan), with half-lives of 21–37 and 10–20 hours, respectively. The typical dosage range of midazolam for sedation is 0.01–0.1 mg/kg. The expected onset of action of an intravenous (IV) dose is 1 to 2 minutes. Repeated doses can be given after this interval to achieve the desired effect.

Caution should be taken when giving benzodiazepines to elderly patients, as older patients often require smaller doses, have decreased hepatic clearance, are more susceptible to respiratory depression, and are more likely to respond with paradoxical agitation. Because benzodiazepines are not analgesics, they are typically combined with opioids, such as fentanyl, which are potent respiratory depressants. Benzodiazepines and opioids administered together produce a synergistic response in both sedative qualities and respiratory depressive effects. Careful titration is necessary to prevent severe hypoventilation and apnea.

Flumazenil (Romazicon), a competitive antagonist of the benzodiazepines, is effective in reversing their effects. The dose is 0.2 mg IV every minute until reversal is observed, up to a maximum of 1.0 mg. Its relatively short half-life (1 hour) can lead to re sedation by the longer acting benzodiazepine. Redosing may be necessary.

Opioid receptors are located throughout the central nervous system and spinal cord. Endogenous peptides such as endorphins bind to these receptors. Opioids are exogenous substances that also bind to these receptors. Of the four types of opioid receptors identified (μ , κ , δ , and σ), μ (with subtypes μ -1 and μ -2) is the most clinically relevant. μ -1 receptors are responsible for supraspinal analgesia, and μ -2 activation causes respiratory depression and bradycardia. A pure μ -1 agonist, therefore, would be ideal.

Fentanyl is a synthetic opioid that binds with relative specificity to μ receptors but to both μ -1 and μ -2 receptors. It has a rapid onset and a short duration of action. It is approximately 100 times more potent than morphine. Titration of 1–2 μ g/kg at a time provides analgesia and minimizes side effects. An IV dose of fentanyl produces analgesia and respiratory depression in approximately 2 minutes. It is prudent not to redose fentanyl at intervals shorter than 2 minutes. Fentanyl does not cause histamine release as morphine does, so

that the incidence of hypotension and skin manifestations (flushing, hives, rash) is less.

Morphine, a still widely used opioid, has several pharmacologic disadvantages when considering it as part of a sedative/analgesic plan for interventional procedures. In comparison with fentanyl, its onset of action is slower. Despite a shorter half-life, morphine's clinical effects are longer than those of fentanyl. For this reason, morphine is popular as a postoperative analgesic when pain is expected for a prolonged period of time. As previously mentioned, its main side effects are related to histamine release. The incidence of nausea and untoward central nervous system effects are greater as well. Morphine does not fit the model of a rapid-onset, short-acting, low-side-effect agent as well as fentanyl.

Meperidine (Demerol) is a synthetic opioid that (despite its wide use in many areas of medicine) is a weak analgesic. It is one tenth as potent as morphine with side effects unlike those of other opioids. Delirium and seizures are caused by accumulation of normeperidine, a metabolite of Demerol. An increase in heart rate can occur because of its structural similarity to atropine.

Remifentanyl is a synthetic opioid with several advantageous properties as an analgesic for sedation. It is a pure μ agonist. Because of an ester linkage in its structure, it is rapidly metabolized by plasma esterases independent of hepatic metabolism, a unique feature among opioids. With an elimination half-life of 6–14 minutes, it can be given as an infusion, titrated to effect for the duration of a procedure, and has a predictable, rapid offset. If prolonged pain is expected after the procedure, however, a longer acting opioid is needed.

Propofol is a unique sedative-hypnotic. It is structurally different from other classes of sedative-hypnotic drugs such as barbiturates or ketamine. The overwhelming popularity of propofol as a sedative and induction agent for general anesthesia is due to its rapid onset and offset (propofol is cleared faster than hepatic blood flow would allow, implying extrahepatic metabolism, which, to date, is unknown). This action produces rapid awakening and recovery, with less of the "hangover" effects associated with other agents. These properties make an infusion technique ideal. A typical starting infusion dose is 25–50 μ g/kg/min, and 150–200 μ g/kg/min usually produces deep sedation or general anesthesia. Whereas other sedative-hypnotic agents are implicated in postoperative nausea, propofol is actually antiemetic. Although it is often called "milk of amnesia," it has no inherent amnestic effect. The drug is colorless but must be emulsified with egg phospholipids and soybean oil because it is not water soluble, resulting in the characteristic white color. The principal side effects of propofol are respiratory and cardiovascular. Propofol is a profound respiratory depressant. It is not predictable what size bolus or infusion rate of propofol, often in the setting of other respiratory depressants, will cause airway

obstruction or apnea. Even moderate sedative doses can cause airway obstruction in susceptible patients. Deep sedative doses usually result in airway obstruction and a marked decrease in ventilation. Induction (general anesthetic) doses usually cause apnea. Propofol is a potent myocardial depressant, decreasing cardiac contractility. It causes vascular dilatation, decreasing both preload and systemic vascular resistance. These effects can lead to a pronounced drop in blood pressure. Patients who are elderly, who have preexisting myocardial dysfunction, or who are hypovolemic are particularly at risk for hypotension.

Controversy exists concerning the safe use of propofol by practitioners who are not anesthesiologists. Gastroenterologists in particular have pursued the use of propofol for sedation during endoscopic procedures. Several large randomized controlled studies have been published demonstrating its safe use by gastroenterologists, often with nurses administering the drug under their supervision.^{5,6} In these studies, personnel were given training and strict guidelines for the dosing of propofol, and indeed the reported incidence of adverse events was low. When propofol is administered in lower doses, as for conscious sedation, the likelihood of cardiopulmonary events is low, but the quality of sedation cannot be expected to be as good as that which can be achieved using doses that provide deep sedation or general anesthesia. The temptation to use incrementally larger doses when sedation is inadequate can lead to a dangerous “slippery slope” to apnea. If propofol is to be used by a nonanesthesiologist physician, the level of sedation should be strictly limited to moderate sedation, for which it has been shown to be used safely. If moderate sedation is predicted to be inadequate, an anesthesiologist should be present to administer deep sedation or general anesthesia.

Neuromuscular blockers (NMBs) are neither sedative nor analgesic but are mentioned here in light of the temptation to use them as substitutes for actual sedative/analgesics for intubated patients. NMBs are drugs that bind to the acetylcholine receptor of the skeletal muscle end plate, preventing the native agonist, acetylcholine, from binding. Nerve impulses at the neuromuscular junction are then unable to stimulate the skeletal muscle to contract, and paralysis ensues. NMBs have *no effect* on consciousness, so they must be given with sedatives or amnestics, or both, to prevent awareness and recall of a period of paralysis. Unfortunately, some clinicians who have gained a small experience with these agents find them very helpful in rendering a combative patient motionless. *The fact that the patient cannot move does not mean that he or she has been given anesthesia.* NMBs also commit the patient to positive pressure ventilation, which usually requires endotracheal intubation. A physician skilled at airway management should be present in these instances.

PRACTICE GUIDELINES

“Practice guidelines for sedation and analgesia by non-anesthesiologists,” initially published by the ASA in 1995 and last amended in 2001, aid clinicians in making decisions regarding sedation.¹ The following, in part, summarizes important recommendations contained in these guidelines.

Preprocedure Preparation

Successful sedation/analgesia requires planning. A physician performing an invasive procedure would not “wing it”; he or she would have thought about the case, obtained pertinent tests, radiographic images, and so forth. Creating a sedation plan need not consume much time. It does require attention to critical factors in the history and physical examination as well as knowledge of the procedure and its potential physiologic effects on the patient.

HISTORY

A targeted history should focus on issues that are most influenced when receiving sedation/analgesia. As mentioned before, airway obstruction, respiratory depression, cardiovascular depression, and impairment of airway reflexes are the most common side effects of sedative/analgesics. The practitioner should inquire about abnormalities of the major organ systems, particularly the heart and lungs. A history of prior anesthetics may reveal adverse reactions known to the patient, such as increased or decreased sensitivity to sedatives or nausea. A list of current medications is a part of any medical history and often reveals medical problems the patient fails to acknowledge—for example, a patient who takes three antihypertensives yet denies high blood pressure when questioned about medical history. Smoking has well-documented effects on respiratory and cardiovascular function. Smokers also tend to have “irritable” airways and decreased clearance of airway secretions leading to an increased incidence of coughing, which may be deleterious during a technically difficult procedure. Patients with a history of alcohol or substance abuse are more likely to have concomitant diseases and may require larger doses of sedatives. Besides establishing adequate fasting, one should inquire about medical problems that delay gastric emptying such as gastroesophageal reflux disease, gastroparesis, or severe pain.

Airway obstruction and respiratory depression are critical side effects of sedation, and identifying the patients who are most susceptible is of paramount importance. Obesity and snoring or obstructive sleep apnea deserve special mention. Obesity tends to cause deposition of fat in the tissues of the airway leading to redundancies of mucosal surfaces. When the musculature of the airway (i.e., the muscles of the tongue and pharynx) relax during sleep, the redundant tissue and the

tongue tend to obstruct the airway. Snoring indicates partial airway obstruction. When complete airway obstruction occurs during sleep, obstructive sleep apnea exists. A patient whose airway is obstructed during normal sleep is sure to have an obstructed airway during sedation, a drug-induced depression of consciousness. Signs and symptoms of obstructive sleep apnea include loud snoring, frequent episodes of awakening at night (because of hypoxia from airway obstruction), and resultant daytime somnolence. Morbid obesity, defined as a weight of 100 pounds more than ideal body weight, is particularly associated with this phenomenon.⁷ Morbidly obese patients often exhibit pickwickian syndrome (obesity-hypoventilation syndrome), characterized not only by mechanical upper airway obstruction but also by blunted respiratory drive, suggesting a central nervous system component. These patients can be exquisitely sensitive to the effects of sedatives. In addition to pulmonary hypertension from chronic hypoxia and hypercarbia, cardiovascular complications such as dysrhythmias and myocardial infarction are more prevalent.

PHYSICAL EXAMINATION

Physical examination should always begin with a set of vital signs, including weight. Alterations in vital signs offer valuable clues to underlying problems that may become exacerbated during the procedure. It is important to remember not to interpret vital signs in a vacuum; they need to be correlated with the history and, ideally, at the bedside to evaluate the overall state of the patient. Hypertension and tachycardia, for example, may be caused by pain, anxiety, or missed doses of a usual β -blocker. The patient who is extremely anxious might simply need a benzodiazepine. A patient with severe coronary artery or valvular disease may require blood pressure and rate control to reduce the risk of cardiac ischemia from further hypertension and tachycardia during a stressful procedure.

The heart and lungs should be auscultated. Wheezing or crackles can signify pneumonia, poorly controlled chronic obstructive pulmonary disease, or decompensated congestive heart failure. Any possible improvements to a patient's medical condition should occur before initiating a procedure and may prevent an adverse outcome.

The airway should be evaluated. Factors such as the extent of mouth opening, loose or removable dentition, range of motion and thickness of the neck, and size of the tongue relative to the oropharynx (the so-called Mallampati-Samsoon classification) are key parts of the airway examination. Nonanesthesiologists cannot be expected to have expertise in such an evaluation but should be able to identify gross abnormalities that warrant consultation with an anesthesiologist, such as an immobile neck from cervical fusion surgery or one-fingerbreadth mouth opening related to temporoman-

dibular joint disease. Morbidly obese patients should be considered to have difficult airways—meaning difficult to mask ventilate and intubate using direct laryngoscopy—until proved otherwise.

Monitoring

The ASA Task Force on Sedation and Analgesia by Non-Anesthesiologists recommends that "a designated individual, other than the practitioner performing the procedure, should be present to monitor the patient throughout procedures performed with sedation/analgesia. During deep sedation, this individual should have no other responsibilities. However, during moderate sedation, this individual may assist with minor, interruptible tasks."¹ Having an individual dedicated to monitoring the patient, particularly during deeper states of sedation when respiratory depression is more likely to occur, provides appropriate vigilance without distracting the physician performing the procedure. Parameters that should be monitored are (1) level of consciousness, which serves as a guide to the depth of sedation and to the potential need for cardiopulmonary support; (2) ventilatory function, by observation or auscultation during lighter stages of sedation and, ideally, by capnography during deep sedation; (3) oxygenation using pulse oximetry; and (4) hemodynamics with noninvasive blood pressure monitoring a minimum of every 5 minutes and continuous electrocardiography.

It is worth noting the distinction between oxygenation and ventilation. Oxygenation refers to the passage of oxygen from the alveoli to the pulmonary circulation and the subsequent saturation of hemoglobin. A pulse oximeter calculates the percentage of hemoglobin sites bound with oxygen. Ventilation refers to the elimination of carbon dioxide by breathing. It can be evaluated by observing normal breathing patterns such as adequate chest expansion during inspiration. It can be *quantified* only by capnography (measurement of end-tidal CO_2) or arterial blood gas. An adequate hemoglobin oxygen saturation level does not necessarily imply normal carbon dioxide levels. Normal, healthy adults can usually maintain adequate oxygen saturation at very low respiratory rates. In fact, oxygenation can still occur during periods of apnea. The normal respiratory rate of 16–20 breaths per minute is required to maintain a carbon dioxide level of ~ 40 mm Hg. Respiratory drive is a function of the central nervous system, and the principal stimulus is carbon dioxide. Sedatives blunt the central nervous system's response to hypercarbia. During deep sedation or general anesthesia, a patient may become profoundly hypercarbic before there is sufficient stimulus to trigger breathing. Hypertension, tachycardia, dysrhythmias, and acidosis are some of the deleterious effects of hypercarbia. Therefore, it is recommended that during deep sedation, when respiratory depression is more

likely, capnography should be considered. Nasal cannulas are now available with a sampling port for end-tidal CO₂ monitoring. Although this does not give an entirely accurate CO₂ level (because a nasal cannula is open to the room as well as the patient's nares), it does provide some assessment of ventilation. A change in the capnogram along with observation of the patient allows diagnosis of airway obstruction well before oxygen desaturation is seen on the pulse oximeter.

CONSULTATION WITH AN ANESTHESIOLOGIST

Unfortunately, it is not always possible to predict how a specific patient will respond to sedative and analgesic medications. Providing sedation and analgesia competently also means that the practitioner must be able to rescue the patient whose level of sedation is deeper than initially intended.¹ This undertaking is particularly important for deep sedation as the threshold for general anesthesia may be easily crossed, with concomitant respiratory and cardiovascular instability. The challenge to the physician performing a procedure is to identify the patients in whom the rescue would exceed the scope of the physician's expertise. Patients with "significant underlying medical conditions (e.g., extremes of age, severe cardiac, pulmonary, hepatic or renal disease; pregnancy; drug or alcohol abuse)" do not tolerate respiratory depression, airway obstruction, and myocardial depression. Patients with "significant sedation-related risk factors (e.g., uncooperative patients, morbid obesity, potential difficult airway, sleep apnea)" are at particular risk for adverse events during sedation. In these instances it is recommended that an anesthesiologist be consulted.¹

A difficult airway is one in which mask ventilation and endotracheal intubation are challenging to an experienced practitioner. As previously stated, obesity, particularly morbid obesity, and obstructive sleep apnea are highly associated with a difficult airway. The neck, mouth, and jaw should be examined. Characteristics to look for include a short, thick neck, limited neck extension, an ill-defined chin, presence of a neck mass, or facial or airway trauma. A short thyromental distance, less than three fingerbreadths between the chin and the thyroid cartilage, results in a poor view of the larynx during laryngoscopy. Abnormalities of the mouth associated with a difficult airway include a small opening, missing or loose teeth, prominent overbite, large tongue, and a poorly visualized uvula. Patients with jaw abnormalities such as micrognathia or temporomandibular joint disease are also difficult to intubate or ventilate. These anatomical features should be sought out during the preprocedure evaluation. A patient with a suspected difficult airway who requires sedation warrants consultation with an anesthesiologist.

MANAGEMENT OF COMMON HEMODYNAMIC PROBLEMS DURING SEDATION

Invasive procedures elicit pain and the stress response, often resulting in hypertension and tachycardia. Deepening the sedation/analgesia within safe guidelines is a reasonable first approach. If that fails to control the blood pressure adequately, an antihypertensive may be indicated. An understanding of autoregulation is helpful to know how tightly blood pressure should be controlled. Autoregulation refers to the ability of vital organs to maintain a constant blood flow over a range of systemic arterial pressures. In normal adults, that range is a mean arterial pressure of 50–150 mm Hg. The *mean* arterial pressure, which represents the effective pressure at tissue level, is the key number, not systolic or diastolic pressure. This way of interpreting blood pressure obviates the need to pick a particular systolic or diastolic pressure to deem unacceptably high or low. Common sense dictates that mean arterial pressures on the outer reaches of the 50–150 mm Hg range should be treated to ensure a margin of safety.

For hypertension and tachycardia, a β -blocker lowers the blood pressure and the heart rate. Labetalol, a mixed α/β -blocker with predominantly β activity, is a reliable choice. A starting dose is 5–10 mg IV, which may be repeated in 10 minutes. The dose can be increased to 10–15 mg if necessary. Hydralazine is a vascular smooth muscle relaxant that results in vasodilatation and a resultant drop in blood pressure. The dosing range is 2.5–10 mg IV. It takes ~15 minutes to work, and repeated doses should not be given before this period of time.

Hypotension may be caused by the effects of sedatives related to myocardial depression or blunting of the sympathetic nervous system response. Preexisting myocardial dysfunction and dehydration can contribute to hypotension. If dehydration is suspected, a fluid bolus of 10–20 mL/kg should be given. If hydration appears adequate, a pharmacologic agent can be used to raise the blood pressure. Ephedrine is a mixed α/β -agonist, which elevates blood pressure by increasing cardiac output (increasing contractility and heart rate) and by vasoconstriction. Ephedrine should be given in 5–10 mg IV boluses initially for mild to moderate hypotension. Phenylephrine is an α -agonist, which causes vasoconstriction. It can lead to a reflex bradycardia. Phenylephrine is therefore a good choice for hypotension and tachycardia as it treats both. A typical starting dose of phenylephrine is 50–100 μ g IV.

POSTPROCEDURE ANALGESIA

Adequate postprocedure analgesia is necessary for the patient's comfort and to combat the deleterious physiologic effects of pain (i.e., the stress response). Parenteral

Table 2 Guidelines for the Most Common Potent Opioids Used for Patient-Controlled Analgesia

Drug	Bolus Dose	Lockout Interval (min)	Infusion Rate
Morphine	1.0–3.0 mg	10–20	0–1 mg/hr
Hydromorphone	0.2–0.5 mg	10–20	0–0.5 mg/hr
Fentanyl	15–25 µg*	10–20	0–50 µg/hr

*Fentanyl is dosed in micrograms.

opioids remain the mainstay of pharmacologic treatment of acute pain. Patient-controlled analgesia (PCA) is an advantageous method of administering IV opioids. In comparison with intermittent intramuscular or IV bolus, PCA offers superior overall analgesia because it is more likely to keep plasma concentrations of drug within the therapeutic window, with fewer peaks and valleys of drug effect. At the same time, patients tend to use less drug and have fewer side effects.⁸ With PCA devices the physician has control over the choice of drug, the size of a bolus (incremental dose), the lockout period (time between incremental doses), and the continuous rate if one is used.

The most common potent opioids used for PCA are morphine, hydromorphone (Dilaudid), and fentanyl. Table 2 delineates guidelines for their use.⁹ In comparison with morphine, hydromorphone is ~7.5 times as potent and fentanyl 100 times as potent. Barring prior adverse reaction, morphine is a sensible drug to start with, as it is efficacious, longer acting, and generally the most familiar to staff. As stated earlier, it is associated with a relatively high incidence of nausea and histamine-related side effects. Hydromorphone is a derivative of morphine that offers more potency for a similar side-effect profile. Fentanyl has the lowest incidence of nausea associated with it but the shortest duration of action. If fentanyl PCA is not providing adequate analgesia, the lockout period should be reduced to 5–10 minutes to account for the shorter duration of action.

Several factors should be considered when deciding whether or not to use a “background” infusion of opioid. Infusions are useful for procedures that are expected to result in a high degree of pain and for patients who chronically take opioids and have developed tolerance. Caution should be exercised when prescribing for patients who are more likely to be sensitive to the respiratory depressive effects of opioids, such as elderly patients and those with obstructive sleep apnea. If PCA without infusion is proving inadequate for pain

relief, an infusion can be started at a dose that would provide 30–50% of the 24-hour consumption. For example, a patient who consumed 60 mg of morphine in the last 24 hours should be started on an infusion of 1–1.5 mg/hr.⁹

The only IV nonsteroidal anti-inflammatory drug available is ketorolac. A 30-mg dose is equipotent to 5 mg of morphine. Because of potential renal toxicity, dosing is limited to 6-hour intervals and should be reduced to 15 mg in elderly patients.

CONCLUSION

Sedation/analgesia is a critical part of performing procedures safely and effectively outside the operating room. The physician responsible for providing sedation/analgesia needs to be aware of the effects of commonly used sedatives and able to identify characteristics of patients that make complications of sedation more likely.

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