Pediatric Sedation Management

Sean Barnes, MD, MBA,* Myron Yaster, MD,† Sapna R. Kudchadkar, MD‡

*Department of Anesthesiology & Critical Care Medicine, Johns Hopkins University School of Medicine, Charlotte R. Bloomberg Children's Center, Baltimore, MD.

†Departments of Anesthesiology & Critical Care Medicine, Pediatrics, and Neurosurgery, Johns Hopkins University School of Medicine, Charlotte R. Bloomberg Children's Center, Baltimore, MD.

‡Departments of Anesthesiology & Critical Care Medicine and Pediatrics, Johns Hopkins University School of Medicine, Charlotte R. Bloomberg Children's Center, Baltimore, MD.

Practice Gap

The differences between deep sedation and general anesthesia in the practice of pediatric procedural sedation are often underemphasized and must be a key part of clinician education to optimize patient selection and safety.

Objectives

After completing this article, the reader should be able to:

1. Define the various levels of procedural sedation.
2. Know how to prepare for adverse events associated with procedural sedation.
3. Identify special patient populations that pose challenges to performing safe procedural sedation.
4. Understand basics of pediatric intensive care unit (PICU) sedation assessment and management.
5. Know common pharmacologic agents used for sedation in the PICU and best practices for weaning of sedative medications.

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INTRODUCTION

Historically, children have been undertreated for pain and painful procedures. Many practitioners believed that children neither remembered nor experienced pain to the same degree that adults did. Fortunately, the past 25 years has seen an explosion in research and interest in pediatric pain and sedation management. Indeed, the provision of sedation and analgesia for children undergoing procedures and mechanical ventilation is now routine and the standard of care. Due to a wide spectrum of ages and developmental levels, sedation of infants and children is associated with unique challenges for even the most seasoned practitioner. Therefore, understanding the optimal level of sedation for each child's circumstance and how to safely administer a given sedation plan is the focus of this review. We discuss who provides this care, how patients should be assessed and prepared for sedation, the drugs and techniques used, and the surroundings in

which sedation and recovery from care should occur. Finally, we discuss the special consideration of critically ill children being cared for in the pediatric intensive care unit (PICU).

PROCEDURAL SEDATION

Procedural sedation for painful procedures involves the use of one or more pharmacologic agents to relieve anxiety and pain while also producing immobility to optimize conditions for the procedure. In the past, procedural sedation was referred to as "conscious sedation," with loose definitions and varying interpretations. In 2002, the terminology of the American Society of Anesthesiologists (ASA) "Practice Guidelines for Sedation and Analgesia for Non-Anesthesiologists" was adopted: (1)

- **Mild sedation (anxiolysis):** Intent is anxiolysis with maintenance of consciousness.
- **Moderate sedation:** Formerly known as conscious sedation. A controlled state of depressed consciousness during which airway reflexes and airway patency are maintained. Patient responds appropriately to age-appropriate commands ("Open your eyes.") and light touch.
- **Deep sedation:** A controlled state of depressed consciousness during which airway reflexes and airway patency may not be maintained, and the ability to independently maintain ventilatory function may be impaired. The child cannot be easily aroused but responds *purposefully* following repeated or painful stimulation.
- **General Anesthesia:** Loss of consciousness occurs. Patients likely have impaired airway reflexes, airway patency, and ventilatory function. Children are not arousable, even by painful stimulation.

Sedation is often described as a continuum, ranging from lighter to deeper and finally to general anesthesia. Dissociative sedation is a unique state of sedation achieved with ketamine that results in a deep level of depressed consciousness while generally maintaining airway reflexes and patency. Dissociative sedation is not part of this continuum, but conceptualizing sedation as a continuum illustrates how easily a patient can go from moderate sedation to deep sedation or even cross the line to general anesthesia.

PATIENT ASSESSMENT

Not every patient is a suitable candidate for sedation. Clinicians must carefully evaluate each child, starting with a focused history and physical examination, to determine whether sedation, rather than general anesthesia, is the best option. Pertinent history and physical examination should begin with an overall assessment and move to specific systems.

General

The first step is to evaluate the patient's underlying health, such as with the 5-point Physical Status Classification System of the ASA (Table 1). Procedural sedation is often performed only in patients whose status is Class I (a normal, healthy patient) or Class II (a patient with mild systemic disease), except in urgent or special situations. (2) Current medications and allergies must be verified, and clinicians should inquire about the patient's or family members' previous adverse experiences with procedural sedation or anesthesia. Prematurity or a postconceptual age of less than 60 weeks is not a strict contraindication, but this population is at higher risk for respiratory adverse events, including apnea and airway obstruction. Therefore, general anesthesia with a controlled airway should be strongly considered for these infants.

Airway and Respiratory System

The airway and respiratory tract requires special attention. Craniofacial abnormalities, such as Pfeiffer, Crouzon, Apert, and Pierre Robin syndromes, involve airway anomalies and present potential difficult scenarios that may lead to intubation challenges. The airway examination should focus on the upper airway, ascertaining the Mallampati classification (3) (Figure), facial symmetry, mouth opening, mandibular size, and neck size and flexion. Clinicians should evaluate the patient's dentition, inspecting for loose or missing teeth. Pathology affecting the respiratory tract, such as asthma, acute respiratory disease, and reactive airway disease,

TABLE 1. American Society of Anesthesiologists Physical Status Classification

Class I	A normal, healthy patient
Class II	A patient with mild systemic disease (eg, controlled reactive airway disease)
Class III	A patient with severe systemic disease (eg, a child who is actively wheezing)
Class IV	A patient with severe systemic disease that is a constant threat to life (eg, a child with status asthmaticus)
Class V	A moribund patient who is not expected to survive without the operation (eg, a patient with severe cardiomyopathy requiring heart transplantation)

Modified from: http://www.asahq.org/resources/clinical-information/asa-physical-status-classification-system

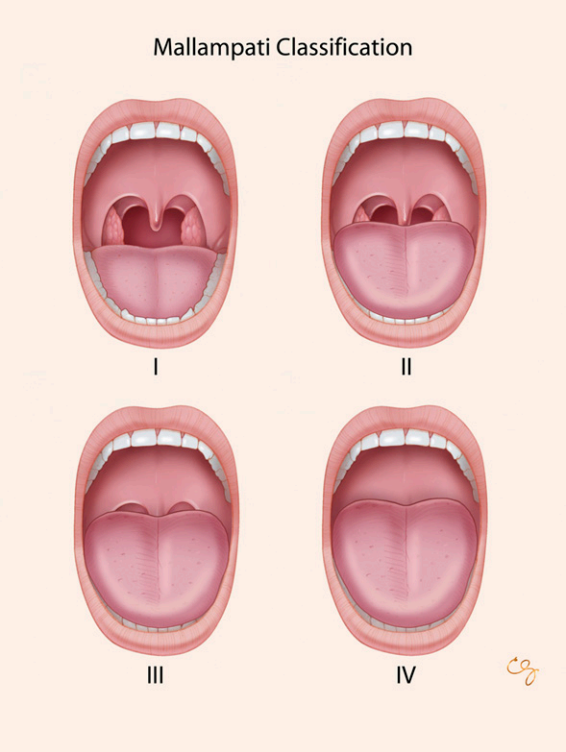

Figure. Mallampati Scoring System used to predict ease of intubation.
- Class I: Full visibility of tonsils, uvula, and soft palate
- Class II: Visibility of hard and soft palate, upper portion of tonsils and uvula
- Class III: Soft and hard palate and base of uvula are visible
- Class IV: Only hard palate is visible

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increases the risk of bronchospasm. The respiratory examination should include auscultation of the lungs to rule out any active wheezing or evidence of pneumonia, as demonstrated by crackles or rales. In addition, a reported history of recent upper respiratory tract infection increases the risk of laryngospasm and bronchospasm as well as the need for supplemental oxygen. (4) Asking if a patient has airway obstruction (snoring), mediastinal mass, or a history of noisy breathing or has been formally diagnosed with obstructive or central sleep apnea is especially important. Patients who suffer from sleep-disordered breathing are at increased risk of apnea and desaturation during sedation and in the recovery period and should be considered for general anesthesia with a protected airway. (1)

Cardiovascular System

Defining a patient's cardiovascular status and hemodynamic reserve is essential because most of the pharmacologic agents used for procedural sedation can cause vasodilatation, hypotension, and dysrhythmias. At a minimum, children require a thorough history and physical examination looking for evidence of heart failure. A child's baseline activity and ability to "keep up" with other children his or her age can serve as a subjective but important method of understanding a child's cardiovascular status. The physical examination includes careful auscultation of the heart to identify murmurs, gallop rhythms, crackles (rales), and rhonchi. This is especially important in children with known cardiovascular disease. When assessing children with known cardiovascular disease, clinicians must define the nature of the disease and underlying anatomy as well as cardiac function and degree of hemodynamic reserve. All children with known uncorrected significant congenital heart disease should undergo recent (within 6 months) echocardiography because sedative hypnotics affect breathing and oxygenation and shunt flow direction can acutely and dangerously change.

Gastrointestinal System

Aspiration of gastric contents is a concern when performing deep sedation. It is imperative to identify what and when the patient last ate or drank, which is termed the NPO (nil per os) time. The length of time a patient should be NPO before sedation depends on the type of solids or liquids ingested (Table 2). (5) Even when patients fast, certain conditions increase the risk of aspiration during sedation, including pregnancy, intraabdominal pathology (eg, bowel obstruction, peritonitis), esophageal disease or history of previous esophageal surgery, neuromuscular disease, altered mental status, trauma, and morbid obesity. Pregnant women in the second or third trimester or any patient who has suffered trauma (eg, motor vehicle collision, fall) are in the same risk stratification for aspiration as those who have just eaten. If a procedure needs to be performed emergently, which is not uncommon, these at-risk patients require rapid sequence induction and tracheal intubation to protect their airways.

TABLE 2. **Fasting Recommendations for Sedation and Anesthesia**

FOOD TYPE	MINIMUM FASTING PERIOD (HR)
Clear liquids	2
Breast milk	4
Nonhuman milk, formula	6
Solids	8

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Hepatic and Renal Systems

Many of the pharmacologic agents used for sedation are dependent on hepatic and/or renal metabolism and excretion. Accordingly, patients with hepatic and/or renal conditions are always at risk for prolonged drug effects, even when the administered drugs are titrated to effect.

PREPARATION

Preparation is a key aspect of safely providing procedural sedation. After completing the patient assessment, clinicians must obtain informed consent for sedation. This includes discussing the risks (aspiration, apnea, need for tracheal intubation), benefits (providing amnesia, analgesia, and producing immobility), and alternatives (distraction, restraining the child, general anesthesia) with the parent or guardian and with the patient (if capable). To ensure patient safety, it is imperative to have an emergency plan in place. The clinician providing sedation must ensure that qualified backup personnel and equipment are easily accessible. **SOAP IM** is an acronym used by many anesthesiologists to remember the essential components of a setup requiring management of an airway:

S = SUCTION: If a patient has excessive secretions or it becomes necessary to intubate.

O = OXYGEN: A source of oxygen that can be provided passively (nasal cannula or face mask) or actively (bag-mask).

A = AIRWAY: Although the goal of procedural sedation is to maintain spontaneous ventilation, clinicians must always be prepared to intubate, deliver oxygen, or support a patient who develops obstruction with ventilation. Airway/intubation equipment that should be available includes: a method of delivering oxygen (bag, mask, and valve resuscitation device as well as endotracheal tubes and supralaryngeal airways), airway adjuvants (appropriate-sized oral/nasal airway), and a functioning laryngoscope.

P = PHARMACY: This includes pharmacologic agents to achieve sedation and address pain management. However, most importantly, this portion of the acronym is a reminder to have emergency medications **and the personnel who know how to use them** immediately available. For rapid induction of unconsciousness, hypnotic agents such as propofol, ketamine, and/or etomidate are required. Succinylcholine, vecuronium, and/or rocuronium are commonly administered for paralysis. Emergency antidotes for hypotension or bradycardia should be readily available. These include epinephrine, atropine, and phenylephrine. Finally, reversal agents (eg, naloxone, flumazenil) must also be available.

I = INTRAVENOUS ACCESS and FLUIDS: Every patient requires adequate intravenous access for safe administration of pharmacologic agents. Moderate or deep sedation should *never* be performed without intravenous access.

M = MONITORS: The patient's vital signs and airway must be continuously monitored **by a second individual who is not performing the procedure and who is skilled in resuscitation.** It is important to obtain baseline vital signs (including pulse oximetry) before initiation of sedation. Clinicians must then continuously monitor heart rate, respiratory rate, and oxygen saturation, while intermittently monitoring blood pressure (recommended every 3 minutes). Increasingly, capnography is used and recommended, particularly if the patient cannot be seen during the procedure. Capnography measures end-tidal carbon dioxide levels, thereby not only measuring the adequacy of ventilation but also respiratory rate, which can immediately alert the clinician if apnea occurs. Vital signs should be recorded at least every 5 minutes until the patient returns to a presedation level of consciousness. Complications most often occur 5 to 10 minutes after administration of intravenous medication or immediately after a procedure is completed (when stimuli associated with the procedure are removed).

Unlike out-of-the-hospital cardiovascular arrests, the overwhelming majority of complications related to sedation are caused by respiratory depression. (6) Because all of the sedatives, hypnotics, and most of the analgesics used in sedation cause respiratory depression, monitoring the adequacy of ventilation and oxygenation is imperative.

PHARMACOLOGIC AGENTS

The goal of sedation is to provide the conditions necessary to perform a procedure whether it is painful, such as burn debridement or fracture reduction, or nonpainful, such as diagnostic imaging studies. Pharmacologic agents used in procedural sedation generally fall into 5 classes: opioids for analgesia, sedatives for anxiety reduction and sedation, dissociative agents for analgesia and sedation, inhalational gases for mild analgesia and sedation, and opioid and benzodiazepine antagonists to reverse the effects of these agents, when necessary. These agents can be administered through multiple routes, including oral, intranasal, rectal, intramuscular, intravenous, and inhalational (Tables 3 and 4). Central nervous system, cardiovascular, and respiratory depression are potentiated by combining sedative drugs and opioids and by rapid drug infusion.

Many procedures require repeat dosing to achieve and maintain the chosen sedation end point, and drugs must be titrated to effect.

The chosen pharmacologic agents for procedural sedation vary, based on the needs of the child, the procedure, the comfort and experience of the clinician providing the sedation, and the qualities of the agents. Examples of commonly used combinations of sedative and analgesic agents as well as a quick dosage reference are listed in Tables 5 and 6. Dexmedetomidine, an α-2 agonist with properties similar to clonidine, has recently emerged as an option for procedural sedation. Dexmedetomidine maintains a child's respiratory drive and can facilitate cooperation during a procedure while still providing anxiolysis.

DISCHARGE CRITERIA

After the procedure is completed, monitoring should be continued until the patient returns to the age-appropriate baseline state. The airway should be patent, with intact protective reflexes (swallow and cough, gag reflex) and cardiovascular function stable. The child should be alert or easily arousable and return to appropriate developmental baseline. It is important to ensure that the patient can

TABLE 3. **Commonly Used Opioids**

DRUG	ROUTE: EQUIANALGESIC DOSES (MG/KG/DOSE)	ONSET (MIN)	DURATION (HR)	ADVERSE EFFECTS	COMMENTS
Codeine	PO: 1.2	30–60	3–4	• Can cause severe nausea and vomiting • Histamine release	**No longer recommended in pediatrics;** 3%–5% of population overmetabolize, potentially leading to catastrophic overdose. Converted in liver to morphine (10%). Newborns and 10% of US population cannot make this conversion.
Fentanyl	IV: 0.001 Transdermal: 0.001 Transmucosal: 0.01	1–2 12 15	0.5–1 2–3	• Pruritus • Bradycardia • Chest wall rigidity with doses >5 μg/kg (but can occur at all doses); treat with naloxone or neuromuscular blockade	Rarely causes cardiovascular instability (relatively safer in hypovolemia, congenital heart disease, or head trauma). Respiratory depressant effect much longer (4 hr) than analgesic effect. Levels of unbound drug are higher in newborns. Most commonly used opioid for short, painful procedures, but transdermal route is more effective in chronic pain situations.
Hydromorphone	IV/SQ: 0.015 PO: 0.02–0.1	5–10 30–60	3–4		Less sedation, nausea, and pruritus than morphine.
Methadone	IV: 0.1 PO: 0.1	5–10 30–60	4–24 4–24		Initial dose may produce analgesia for 3–4 hr; duration of action is increased with repeated dosing.
Morphine	IV: 0.1 IM/SQ: 0.1–0.2 PO: 0.3–0.5	5–10 10–30 30–60	3–4 4–5 4–5	• Seizures in neonates • Can cause significant histamine release	The gold standard against which all other opioids are compared. Available in sustained-release form for chronic pain.
Oxycodone	PO: 0.1	30–60	3–4		Available in sustained-release form for chronic pain. Much less nauseating than codeine.

IM=intramuscular, IV=intravenous, PO=oral, SQ=subcutaneous

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TABLE 4. **Commonly Used Benzodiazepines**

DRUG CLASS	DURATION OF ACTION	DRUG	ROUTE	ONSET (MIN)	DURATION (HR)	COMMENTS
Benzodiazepines	Short	Midazolam	IV	1–3	1–2	• Has rapid and predictable onset of action, short recovery time
			IM/IN	5–10		• Causes amnesia
			PO/PR	10–30		• Results in mild depression of hypoxic ventilatory drive
	Intermediate	Diazepam	IV (painful)	1–3	0.25–1	• Poor choice for procedural sedation
			PR	7–15	2–3	• Excellent for muscle relaxation or prolonged sedation
			PO	30–60	2–3	• Painful on IV injection
						• Faster onset than midazolam
	Long	Lorazepam	IV	1–5	3–4	• Poor choice for procedural sedation
			IM	10–20	3–6	• Ideal for prolonged anxiolysis, seizure treatment
			PO	30–60	3–6	

IM=intramuscular, IN=intranasal, IV=intravenous, PO=oral, PR=rectal
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maintain hydration and does not suffer known adverse effects of sedation such as nausea or vomiting. Recovery time after sedation protocols varies but typically ranges from 60 to 120 minutes. Any decision for admission to the hospital should be made on a multidisciplinary level with the team performing the procedure and based on the child's medical history and risk for postprocedure complications. For example, a child who receives 10 minutes of sedation for incision and drainage of an abscess on the thigh may be able to go home after an appropriate period of observation, but a child who has reduction of a supracondylar fracture in the emergency department may need to be admitted for ongoing pain management and determination of surgical disposition.

SEDATION IN THE PEDIATRIC INTENSIVE CARE UNIT

Sedation is not limited to children undergoing procedures; another important area in which sedation is used is for the mechanically ventilated child in the PICU. The ideal sedation management plan for any patient who is mechanically ventilated encompasses analgesia to treat pain from the noxious stimuli of the endotracheal tube and sedation to provide adequate comfort and safety as required for the child's critical illness, while optimizing patient-ventilator synchrony and minimizing the risk of delirium and sleep disturbances. (7) For the purposes of this review, we focus on sedation of the critically ill child in the PICU. Given the unique physiology, environment, and pharmacologic management of neonates, sedation in the neonatal intensive care unit is beyond the scope of this review.

Sedation Assessment

Whenever sedation is administered, substantial patient morbidity and mortality is a possibility. Optimal sedation management requires assessing a child's level of sedation at regular intervals to guide the clinician in titration of subsequent therapy to avoid over- or undersedation. The most commonly used sedation assessment tools are the State Behavioral Scale (SBS) and the COMFORT Scale. Both the SBS and COMFORT Scale have been validated in critically ill children. (8)(9) The SBS defines the sedation-agitation continuum to guide goal-directed therapy using a patient's response to voice, gentle touch, and noxious stimuli such as suctioning. The COMFORT Scale measures 5 behavioral variables (alertness, facial tension, muscle tone, agitation, and movement) and 3 physiologic variables (heart rate, respiration, and blood pressure). These tools provide a consistent but modifiable goal for PICU clinicians to titrate sedation to the level necessary for each individual child. Sedatives can be increased or decreased by the nurses or physicians based on the goal sedation score, as shown in the recently published RESTORE trial. (10)

Sedatives and Analgesics

Most recommendations regarding sedation management in the pediatric intensive care population are based on experience and best practice rather than evidence-based medicine. Very few studies have evaluated the pharmacokinetic and pharmacodynamic properties of analgesic and sedative drugs in critically ill patients.

Sedation and analgesia in the PICU is often needed for prolonged periods of time, and optimal agents for long-term

TABLE 5. **Examples of Sedation Protocols***

PROTOCOL/DOSES	COMMENTS
Ketamine (1 mg/kg/dose IV × 1–3 doses)	Lowest rates of adverse events when ketamine used alone‡
Ketamine + midazolam + atropine ("ketazolam")	Atropine = antisialogogue
IV route: • Ketamine 1 mg/kg/dose × 1–3 doses • Midazolam 0.05 mg/kg × 1 dose • Atropine 0.02 mg/kg × 1 dose IM route: combine (use smallest volume possible) • Ketamine 1.5–2 mg/kg • Midazolam 0.15–0.2 mg/kg • Atropine 0.02 mg/kg	Midazolam = counter emergence delirium
• Midazolam + fentanyl – Midazolam 0.1 mg/kg IV × 3 doses PRN	High likelihood of respiratory depression
– Fentanyl 1 μg/kg IV × 3 doses PRN	Infuse fentanyl no more frequently than every 3 min

IM=intramuscular, IV=intravenous, PRN=as needed
**These examples reflect commonly used current protocols at the Johns Hopkins Children's Center; variations are found at other institutions.*
‡*Green, SM, Roback MG, Krauss B, et al. Predictors of emesis and recovery agitation with emergency department ketamine sedation: an individual-patient data meta-analysis of 8,282 children.* Ann Emerg Med. *2009;54(2):171-180.*
Modified from Yaster M, Cote C, Tone E, et al. Pediatric Pain Management and Sedation Handbook. *St Louis, MO: Mosby; 1997.*
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sedation differ from those used for procedural sedation. For example, propofol infusions are rarely prescribed for longer than 4 hours in critically ill children requiring sedation due to a concern for the development of propofol infusion syndrome, which is characterized by cardiac failure, rhabdomyolysis, metabolic acidosis, renal failure, and death. The most commonly used agents for long-term sedation in the PICU are benzodiazepines, opioids, and α-agonists. (7)

Opioids commonly used in pain management are μ-opioid receptor agonists. All of the μ-opioid receptor agonists have similar pharmacodynamic effects at equianalgesic doses (the equivalent dose of analgesic required to achieve the same amount of analgesia). These pharmacodynamic effects include analgesia, respiratory depression, sedation, nausea and vomiting, pruritus, constipation, miosis, tolerance, and physical dependence. Fentanyl is the most commonly used analgesic for procedures and pain control in the PICU. (7) Ironically, fentanyl has the least sedating quality of all of the opioids, but it is short-acting following single doses. Of note, fentanyl can be long-acting following infusions due to its "context-sensitive half-life" or the time needed for blood plasma concentrations of a drug to decline by one-half after discontinuing the infusion once the infusion achieves a constant plasma concentration.

Benzodiazepines are potent amnestics, hypnotics, and skeletal muscle relaxants. However, most sedatives, specifically benzodiazepines, chloral hydrate, and the barbiturates, have *no analgesic properties*. Benzodiazepines are also independent risk factors for development of delirium.

α-Agonists such as clonidine and dexmedetomidine are useful adjuvants because they cause very little respiratory depression and are not deleterious to natural sleep when compared to opioids and benzodiazepines.

Neuromuscular Blockade

In clinical scenarios in which sedation and analgesia are adequate, immobility may be necessary to facilitate recovery from the child's illness. Therefore, in rare instances, long-term neuromuscular blockade (NMB) may be used. NMB has no analgesic or sedating qualities, and the level of NMB must be constantly monitored to prevent prolonged blockade. Commonly used NMB agents in the PICU include rocuronium, vecuronium, and cisatracurium. Cisatracurium is commonly used as a continuous infusion in children requiring long-term NMB and is the preferred agent for children with renal dysfunction due to an organ-independent metabolic pathway called "Hofmann elimination." Clearance of drugs through Hofmann elimination is best described as spontaneous nonenzymatic degradation at normal pH and body temperature.

TABLE 6. **Analgesics and Sedative-Hypnotic Drugs Quick Reference**

DRUG	ROUTE	DOSE
Sedative-Hypnotic		
Diazepam	PO IV (painful)	0.25–0.3 mg/kg 0.1 mg/kg; maximum 0.6 mg/kg within 8 hours
Dexmedetomidine	IN IV	1–2 μg/kg 0.5–2 μg/kg over 10 min, followed by 0.2–1 μg/kg/hr
Diphenhydramine	PO, IV, IM	1 mg/kg; maximum 50 mg/dose
Hydroxyzine	PO IM	2 mg/kg/day divided every 6–8 hr; maximum 600 mg/24 hr 0.5–1 mg/kg/dose every 4–6 hr; maximum 600 mg/24 hr
Lorazepam	PO, IV, IM	0.05 mg/kg; maximum 2 mg/dose
Midazolam	PO PR IN IM IV sedation	0.5–0.8 mg/kg; maximum 20 mg/dose 0.5–1 mg/kg 0.2–0.3 mg/kg 0.15–0.2 mg/kg 0.1 mg/kg; maximum 10 mg/total dose
Analgesic		
Acetaminophen	PO, PR, IV	10–15 mg/kg every 4–6 hr (if >50 kg, 650–1000 mg every 4–6 hr)
Fentanyl	IV IV infusion PO oralet IN	1 μg/kg 1–5 μg/kg/hr 10–15 μg/kg; maximum 400 μg 1 μg/kg
Hydrocodone*	PO	0.135 mg/kg every 4–6 hr; maximum 2 mg/dose
Hydromorphone	IV IV infusion	0.015 mg/kg; maximum 2 mg/dose 2–4 μg/kg/hr
Ketorolac	IV, IM	0.5 mg/kg every 6 hr; maximum 30 mg/dose
Methadone	PO, IV, IM, SQ	0.1 mg/kg every 8–12 hr; maximum 10 mg/dose
Morphine	IV IV infusion	0.05–0.2 mg/kg; maximum 15 mg/dose 10–40 μg/kg/hr
Oxycodone	PO	0.1 mg/kg every 4–6 hr; maximum 5 mg/dose
Other		
Ketamine	PO IV IM	5 mg/kg 0.25–2 mg/kg 2–5 mg/kg

**Commonly with acetaminophen.*
IM=intramuscular; IN=intranasal, IV=intravenous, PO=oral, PR=rectal, SQ=subcutaneous
Data from Fishier QA. Pediatric Anesthesia Pearls. *Baltimore, MD: Johns Hopkins Department of Anesthesia and Critical Care Medicine; 2000.*
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Weaning of Sedatives/Analgesics

Tolerance and physical dependence are unavoidable consequences of prolonged use and high quantities of opioids and sedatives administered to the critically ill patient. Tolerance develops following opioid and benzodiazepine use to some degree following 3 to 5 days of usage. At this point, the risk for withdrawal symptoms is increased, and patients should be weaned at the appropriate time from their opioids and sedatives rather than abruptly discontinuing therapy. The length of exposure should correlate with the weaning strategy. (11)

Weaning sedatives and analgesics requires thoughtful planning. To simplify the weaning process, clinicians should make every effort to convert the patient from intravenous to oral therapy and from continuous infusions to intermittent bolus therapy. This substantially eases patient care and can allow for final tapering and weaning in an outpatient setting. Changing from one opioid to another may

be necessary because of ease of administration, duration of action, and ability to taper the dose. However, equianalgesic dosing is mandatory.

α-2 Adrenergic agents such as clonidine or dexmedetomidine are often used as adjuvants when weaning sedatives or analgesics. The addition of these agents has been demonstrated to prevent or mitigate drug withdrawal syndrome symptomatology regardless of the drug causing addiction or dependence. However, high doses of dexmedetomidine for long durations also have the potential for inducing a withdrawal syndrome with discontinuation, necessitating close attention to dose and duration of administration. (12) Drug withdrawal syndrome and symptomatology varies, depending on the class of drug to which the patient has developed dependence. Some symptoms may include vomiting, diarrhea, tachycardia, hypertension, diaphoresis, and restlessness.

Sleep Promotion and Delirium Screening

The PICU is a chaotic environment for the critically ill child, who has multiple risk factors for sleep disturbances. Although the administration of sedation and analgesia is an important part of the care of the mechanically ventilated child, sleep promotion is also crucial. Unfortunately, all sedatives, with the exception of dexmedetomidine, are detrimental to experiencing restorative sleep. (7) Benzodiazepines are particularly deleterious to sleep-wake homeostasis and an independent risk factor for delirium. Sedation during mechanical ventilation leads to a behavioral state often assumed to be sleep in which a child is at rest with eyes closed. However, mechanically ventilated patients receiving sedatives have no circadian rhythmicity, and rapid-eye movement and slow-wave sleep are severely decreased or absent. (13)(14) Therefore, sedatives and analgesics are often increased in dose and frequency to improve sleep. However, these drugs may contribute to a vicious cycle of sleep disruption that progressively leads to agitation.

Optimizing the sleep-wake cycle through simple nonpharmacologic interventions such as sunlight exposure during the day and noise reduction at night can decrease the amount of sedatives and analgesics to which a child is exposed. Understanding the interplay between sleep, sedation, and delirium is imperative in the comprehensive management of the critically ill child. Delirium is known to increase morbidity and mortality in critically ill patients, and validated screening tools are available to screen for this important clinical entity in children. (15)(16)

Summary

- On the basis of expert opinion/consensus, pediatric sedation management can be divided into procedural sedation and sedation in the pediatric intensive care unit.
- On the basis of some research evidence as well as consensus, procedural sedation is necessary to provide a safe and painless experience for infants or children undergoing diagnostic or therapeutic procedures. It is both effective and safe when performed by appropriately trained clinicians. (1)(2)(7)
- On the basis of some research evidence as well as consensus, clinicians should consider sedation as a continuum and must understand that the patient can go from a state of mild sedation to general anesthesia in seconds. Providing safe care is paramount and hinges on targeted assessments and thoughtful preparation. (1)(2)(7)
- On the basis of some research evidence as well as consensus, critically ill children in the pediatric intensive care unit (PICU) may need pharmacologically induced sedation to facilitate mechanical ventilation, invasive procedures, and treatment of multiorgan system dysfunction. Regardless of the methods used, the goals of sedation in the PICU are to provide anxiolysis and comfort while maintaining safety to prevent inadvertent removal of life-sustaining medical equipment.
- On the basis of some research evidence as well as consensus, unlike with procedural sedation, the long-term effects of pharmacologic agents administered in the PICU must be addressed, including potential toxicities, tolerance and physical dependence, sleep disturbances, and delirium. The process of weaning patients from these agents must be thoughtful and include a multidisciplinary approach. (8)(9)(10)(14)

Note. The content of this article is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

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PIR Quiz

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1. Individual CME quizzes are available via a handy blue CME link under the article title in the Table of Contents of any issue.
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1. You use a combination of fentanyl and midazolam to provide procedural sedation to a child undergoing reduction of a fractured radius in your emergency department. After the medications are infused intravenously, the child cannot be easily aroused but does cry out softly and withdraw his arm on the initial attempts at reduction. Of the following, which best describes the level of procedural sedation that has been achieved for this child?
    A. Conscious sedation.
    B. Deep sedation.
    C. General anesthesia.
    D. Mild sedation.
    E. Moderate sedation.
2. Which of the following statements is true regarding complications during procedural sedation?
    A. Most complications are due to frequent measurement of end-tidal carbon dioxide levels.
    B. Complications most often occur 5 to 10 minutes after administration of intravenous medications.
    C. Complications rarely occur after the procedure is completed.
    D. Most complications are due to cardiovascular effects of the medications used.
    E. Complications most often occur within the first minute of sedation.
3. A 4-year-old critically ill child is intubated and under heavy sedation in the pediatric intensive care unit. Which of the following tools is most helpful in avoiding either over- or undersedation?
    A. American Society of Anesthesiology Scale.
    B. Glasgow Coma Scale.
    C. Mallampati Score.
    D. State Behavioral Scale.
    E. Trauma Score.
4. A 6-year-old child requires prolonged sedation in the pediatric intensive care unit after multisystem trauma. The surgeon estimates that the child will require this sedation for at least 3 to 4 days. Prolonged use of which of the following medications is most likely to lead to the development of delirium in this child?
    A. Clonidine.
    B. Dexmedetomidine.
    C. Midazolam.
    D. Morphine.
    E. Propofol.
5. A patient in the emergency department is in need of procedural sedation for complex laceration repair. The child has a history of asthma and is actively wheezing. After 3 albuterol treatments and a dose of systemic corticosteroids, the wheezing is much improved but still present. According to the 5-point Physical Status Classification System of the American Society of Anesthesiologists (ASA), what is the ASA class for this patient?
    A. Class I.
    B. Class II.
    C. Class III.
    D. Class IV.
    E. Class V.

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Pediatric Sedation Management

Sean Barnes, Myron Yaster and Sapna R. Kudchadkar

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