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STATEMENT OF FINANCIAL DISCLOSURE

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Pediatric Procedural Sedation

Procedural sedation is a critical skill to facilitate the performance of necessary diagnostic and therapeutic procedures in children. The clinician must have knowledge of the preparatory steps, indications, pharmacologic agents, monitoring, and recovery phase to safely and effectively perform this necessary adjunct to many common procedures. The authors review steps, current recommendations, and options to utilize procedural sedation skillfully in children. In addition, they present guidelines for managing adverse events that may be associated with the administration of procedural sedation.

— Ann M. Dietrich, MD, FAAP, FACEP, Editor

Procedural sedation in the pediatric emergency department is a common occurrence, as it facilitates a state of mind that allows children to endure unpleasant procedures while maintaining cardiorespiratory independence.[1,2] Understanding the indications, risks, preparation, and medications associated with procedural sedation is a must for the practicing pediatric emergency medicine (EM) provider.

Definition of the Problem

Procedural sedation refers to the technique of administering sedatives or dissociative agents with or without analgesics to induce a state that allows the patient to tolerate unpleasant procedures while maintaining cardiorespiratory function.[1,2] Children often present to the emergency department (ED) with painful conditions that require unpleasant diagnostic and therapeutic procedures. In these settings, procedural sedation is employed to manage a child's pain and/or anxiety with a combination of medications to achieve the desired effect.[3] While keeping in mind the possible adverse reactions and side effects of each medication or combination of medications, the astute EM provider must be comfortable with this evolving practice.[3] Emergency physicians are challenged with the task of using sedative agents while honing and applying procedural sedation skills in a way that is both safe and efficacious for the pediatric patient in the ED.

Over the past 30 years, procedural sedation has evolved into a distinct skill set with a growing number of indications and practice settings. Given the logistical and economic disadvantages of the operating room, procedures previously confined there now commonly take place in the ED.[4] The increasing availability of short-acting sedatives, as well as accurate noninvasive hemodynamic monitoring and expanded EM practitioner skills, has enabled safe management of sedation and analgesia outside of the operating room.[4,5]

Epidemiology

Sedation increasingly is used to perform procedures on sick or injured

EXECUTIVE SUMMARY

- Children younger than 6 years of age and those with developmental delays may require deeper levels of sedation to gain control of their behavior relative to older, more cooperative children.
- Goals of effective procedural sedation are well outlined by the American Academy of Pediatrics: 1) to protect the patient's safety and welfare; 2) to minimize discomfort and pain; 3) to control anxiety, minimize psychological trauma, and maximize the potential for amnesia; 4) to control the patient's behavior and promote safe completion of the procedure; and 5) to return the patient to a state in which discharge from medical care is safe.
- Patients who are American Society of Anesthesiologists (ASA) classes I and II generally are considered appropriate candidates for minimal, moderate, or deep sedation, while children in ASA classes III and IV, those with special needs, or children with known anatomic airway abnormalities require additional consideration; these patients may require a consult from the appropriate subspecialty.
- The American College of Emergency Physicians recommends that ED practitioners not delay procedural sedation in pediatrics based on fasting time. Operative practice guidelines for elective procedures based on two systematic reviews and two practice advisories revealed no evidence to support pre-procedural fasting requirements, and therefore do not note that pre-procedural fasting of any duration is required.

children in EDs.[6,7,8] The sedation of children has its own inherent challenges that differ from the adult population. Procedural sedation in children often is required to control behavior for safe performance of a procedure. A child's ability to control his or her own behavior and cooperate with a procedure depends on age and developmental status.[9] It is estimated that children younger than 6 years of age and those with developmental delays may require deeper levels of sedation to gain control of their behavior relative to older, more cooperative children.[10] The goals of effective procedural sedation are well outlined by the American Academy of Pediatrics (AAP): 1) to protect the patient's safety and welfare; 2) to minimize discomfort and pain; 3) to control anxiety, minimize psychological trauma, and maximize the potential for amnesia; 4) to control the patient's behavior and promote safe completion of the procedure; and 5) to return the patient to a state in which discharge from medical care is safe.[9]

Typical indications for procedural sedation are reviewed in Table 1.[11,12] Analysis of the Procedural Sedation in the Community Emergency Department (ProSCED) registry reveals the most common pediatric procedures performed using sedation in 2006 included laceration repairs (25%), shoulder reductions (23%), and fracture care of the upper extremity (16%).[13]

Emergency provider practices vary in the use of procedural sedation and procedure performance. In some instances, EM providers perform the sedation and the procedure, while at other times the sedation is performed by a separate physician from the one performing the procedure.[13]

There is increasing consensus that pediatric procedural sedation can be performed safely in the ED. In one study, researchers analyzed 131,751 pediatric procedural sedation cases using the Pediatric Sedation Research Consortium and concluded that major complication rates of aspiration, death, cardiac arrest, unplanned hospital admission, level of care increase, or emergency anesthesia consultation were not statistically different among anesthesiologists, EM providers, intensivists, and pediatricians either before or after adjusting for confounding variables. Event rates per 10,000 sedations using anesthesiologists as the reference group adjusted for age, emergency status, American Society of Anesthesiologists (ASA) physical status > 2, nil per os (NPO) for solids, propofol use, and clustering by site were anesthesiologists 7.6 (4.6-12.8), EM providers 7.8 (5.5-11.2), intensivists 9.6 (7.3-12.6), pediatricians 12.4 (6.9-20.4), and others 10.2 (5.1-18.3), with no statistical difference ($P > 0.05$) between provider complication rates.[14] Specific risks associated with procedural sedation are discussed below.

Pathophysiology

There is evidence to suggest that pain pathways, including cortical and subcortical centers necessary for pain perception and neurochemical systems associated with pain transmission and modulation, are well-developed and functional as early as late gestation. In addition, physiological responses to painful stimuli have been well-documented in neonates and are reflected in hormonal, metabolic, and cardiorespiratory changes similar to but greater than those observed in adults. Psychological forms of stress suggestive of integrated emotional and behavioral responses to pain are retained in memory long enough to modify behavioral patterns in newborn infants.[15]

At birth, the nervous system displays a hypersensitivity to sensory stimuli and reduced thresholds of response to mechanical and thermal stimulation, with further sensitization occurring with sustained or repetitive inputs.[16] Structural and functional changes in the peripheral and central nervous system involving alterations in expression, distribution, and function of receptors, ion channels, and neurotransmitters of different regulatory factors dramatically affect the character of nociceptive responses at different stages of childhood development.[17]

Research findings from laboratory and clinical studies have identified possible mechanisms and help provide evidence that long-term behavioral changes can extend far beyond the post-injury recovery period and even into adulthood.[5] Due to the plasticity of both the peripheral and central sensory connections in early life, invasive procedures that are painful can

Table 1. Common Indications for Procedural Sedation[11,12]
Fracture/dislocation reduction
Wound care
Laceration repair
Lumbar puncture
Incision and drainage of an abscess
Placement of a venous catheter
Diagnostic imaging
Cardioversion
Source: Author created.

lead to prolonged structural and functional alterations in pain pathways that can last into adult life.[16]

Twenty-five years ago, published reports discussed the inadequate treatment of pain in children.[18,19] Since then, researchers have discovered much about the etiology, mechanisms, and treatment of pain. For this reason, research into the causes, mechanisms, and clinical treatment of pain have become areas of intensifying research in recent years. The goals of procedural sedation have evolved to address the long-lasting effects of inadequate treatment of pain in children.

The Sedation Continuum

Procedural sedation serves as a treatment approach in EM practice to facilitate an alteration of a patient's level of consciousness.[2] The depth of sedation varies depending on the requirements needed for the procedure and the patient. The Joint Commission has defined non-dissociative sedation on a continuum of minimal sedation, moderate sedation, deep sedation, and general anesthesia.[20] Dissociative anesthesia is considered separately because of its unique features that are incompatible with The Joint Commission's hierarchy of sedation definitions.[2,4,21]

In minimal or mild sedation, patients respond normally to verbal commands, although cognitive abilities and coordination may be impaired. Cardiovascular functions are unaffected. This is used most often in the ED to facilitate minor procedures and to achieve anxiolysis prior to moving to a greater level of sedation.[20,22,23]

Moderate sedation is a drug-induced depression of consciousness in which the patient responds purposely to commands, but no interventions are required to maintain the patient's airway. In the ED, moderate sedation is a deeper level of sedation commonly achieved with a benzodiazepine or nitrous oxide in conjunction with an opioid such as fentanyl. It is commonly used for moderately painful procedures, such as a shoulder reduction or an incision and drainage, in cooperative patients, or minor procedures, such as laceration repair or lumbar puncture, in less cooperative patients.[20,22,23]

In deep sedation, patients require painful and repeated stimuli to evoke a purposeful response. Airway and ventilator support may be needed. It is a drug-induced depression of consciousness during which patients cannot be aroused easily but respond purposefully following repeated or painful stimulation. The ability to maintain an independent airway may be impaired. In the ED, it is commonly obtained with agents such as propofol, etomidate, or a benzodiazepine in conjunction with an opiate or dissociative medication for painful procedures, such as fracture and dislocation reduction or cardioversion.[20,22,23]

General anesthesia is a drug-induced loss of consciousness in which the patient has no purposeful responses. Airway and ventilator support is required. Indications for ED general anesthesia include rapid sequence intubation in conjunction with a paralytic agent, post-intubation sedation/anesthesia, or for critical care procedures in intubated patients such as a tube thoracostomy, central line placement, cardioversion, or intracranial pressure monitoring. In practice, prolonged general anesthesia rarely is used in the ED in the absence of a physician trained in anesthesia.[20,22,23] (*See Table 2.*)

Dissociative sedation is a trance-like cataleptic state induced by the dissociative drug ketamine. It is characterized by profound analgesia, amnesia with retention of protective airway reflexes, spontaneous respiration, and cardiopulmonary stability. In the ED, ketamine commonly is administered to facilitate moderate to severely painful procedures, such as fracture and dislocation reduction, abscess incision and drainage, and procedures requiring immobilization in uncooperative patients such as a laceration repair.[2,4,21,23]

As the level of sedation exists on a continuum and it is not always possible to predict how an individual patient may or may not respond, hospitals must ensure that procedures are in place and that providers are qualified to rescue patients whose level of sedation becomes deeper than intended. Rescue may require intervention by a provider skilled in airway management and resuscitation to reverse adverse physiologic consequences of deeper than intended sedation.[23,24]

Pre-procedural Sedation Planning

Emergency care providers with privileges to perform procedural sedation must conduct a pre-procedural evaluation to identify concurrent medical conditions, ascertain risks for adverse events, and document the pre-sedation state.[7,22] A systematic and consistent approach to pediatric procedural sedation must be employed to minimize adverse reactions during and after sedation. These reactions can be mitigated by a careful pre-procedural review of the

Table 2. Anesthesia Guidelines

	Minimal Sedation/ Anxiolysis	Moderate Sedation/ Analgesia	Deep Sedation	General Anesthesia
Responsiveness	Normal response to verbal stimulation	Purposeful response to verbal commands or light touch	Purposeful response to repeated or painful tactile stimulation	Unarousable even to repeated or painful stimulation
Airway	Unaffected	No intervention required	Intervention may be required	Intervention often required
Spontaneous ventilation	Unaffected	Adequate	May be inadequate	Frequently inadequate
Cardiovascular function	Unaffected	Usually maintained	Usually maintained	May be impaired

Source: Author adapted.

patient's underlying medical conditions and consideration of how the sedation might affect these underlying conditions.[25] Patients who are ASA classes I and II generally are considered appropriate candidates for minimal, moderate, or deep sedation while children in ASA classes III and IV, those with special needs, or children with known anatomic airway abnormalities require additional consideration; these patients may require a consult from the appropriate subspecialty.[26] (*See Table 3.*)

The American College of Emergency Physicians (ACEP) states that the EM physician should choose when sedation is appropriate based on the pain and distress typical for the procedure and the patient's anxiety, cooperativeness, age, and health.[23] It is important to perform a history and physical exam, documented in the ED record, which reflects a focused evaluation of the airway, cardiovascular status, pulmonary status, allergies, and history of prior adverse reactions to sedatives. LEMON is an example of an airway assessment mnemonic that has been evaluated in adults and may aid in identification of a difficult airway in children.[27] (*See Figure 1.*) Patients with high-risk features, including congenital abnormalities that may be associated with facial abnormalities, limited neck mobility, small oral cavities or limited oral aperture, large tongues, neck masses, or laryngeal or subglottic abnormalities, may preclude ED sedation. Other high-risk acquired conditions, such as retropharyngeal or peritonsillar abscesses, bacterial tracheitis, croup or epiglottitis, anaphylaxis, foreign body or trauma, or burns to the face, may require a referral to the operating room for further management.[23]

Aspiration risk should be assessed by balancing patient risk factors, time

Table 3. Classification for Pediatric Physical Status Prior to Sedation

Class	Description	Examples
I	Healthy, normal child	
II	Child with mild systemic disease	Controlled asthma, controlled diabetes
III*	Child with severe systemic disease	Active wheezing, diabetes mellitus with complications, heart disease that limits activity
IV*	Child with severe systemic disease that is a constant threat to life	Status asthmaticus, sepsis
V*	Child who is moribund and not expected to survive without the procedure	Cerebral trauma, pulmonary embolus, septic shock

*Anesthesia consult usually required

Source: American Society of Anesthesiologists

Figure 1. Airway Evaluation with LEMON[27]

L	LOOK externally for indicators of a difficulty airway
E	EVALUATION of inter-incisor distance, hyoid mental distance, and thyroid to floor of the mouth distance.
M	MALLAMPATI score
O	signs of OBSTRUCTION
N	NECK mobility

Source: Author adapted.

Table 4. Pre-procedure Fasting Guidelines According to the American Society of Anesthesiologists[29]

Type of Food	Minimum Fasting Period
Clear liquids	2 hours
Breast milk	4 hours
Infant formula	6 hours
Nonhuman milk	6 hours
Light meal	6 hours

Source: Author adapted.

Table 5. Considerations for Airway Equipment on an Emergency Cart[26]

Oral and nasal airways
Bag-valve mask
Face masks
Supraglottic airway devices
Laryngoscope blades
Endotracheal tubes

Source: Author created.

of last oral intake, and urgency of the procedure. Lack of fasting is not a contraindication for administering procedural sedation but should be considered in choosing the timing and target level of sedation.[23,28] The ASA, AAP, and ACEP each have differing statements on pre-procedural fasting.[7] The ASA's pre-procedural fasting guidelines are found in Table 4.[29] The AAP states that ideally patients should fast per the ASA recommendations, but that when fasting cannot be assured, the benefits of performing a procedure emergently should be weighed against the risks of not fasting. It recommends the lightest form of sedation should be utilized in these situations.[9] ACEP recommends that ED practitioners not delay procedural sedation in pediatrics based on fasting time; operative practice guidelines for elective procedures based on two systematic reviews and two practice advisories reveal no evidence to support pre-procedural fasting requirements, and therefore do not note that pre-procedural fasting of any duration is required.[8,21,28,30,31]

A "time out" in which the sedation team collectively verifies the procedure to be performed, anatomical site of the procedure if applicable, patient identity, patient consent, allergies, NPO status, weight, and team member roles should be performed before the procedural sedation or when the person performing the procedure changes. This is a requirement of The Joint Commission and is part of standard universal protocol.[23]

Procedural Sedation: Equipment

To perform procedural sedation safely, the ED practitioner who uses sedation must have immediately available facilities, personnel, and equipment to manage emergency and rescue situations. Sedation in environments without these resources has been associated with "failure to rescue" from adverse events. Emergency medical services (EMS) may be required in such settings to transport the patient to a facility with a higher level of care. The practitioner is responsible for life support measures while awaiting EMS arrival.[26]

At the patient bedside, appropriate hemodynamic monitoring and airway equipment, as well as rescue drugs as indicated, are essential features of a safe and successful sedation. An emergency airway cart must be available immediately and should include age- and size-appropriate equipment to successfully resuscitate an apneic child.[26] (*See Table 5.*) Additional equipment, such as blood pressure cuffs, intravenous catheters of various sizes, a cardiac monitor, a pulse oximeter with size-appropriate probes, end tidal carbon dioxide detector, and a defibrillator with size-appropriate patches/paddles, should be at the bedside and must have a safety and function check according to local or state regulations. Continuous capnography is not mandatory, but there is increasing evidence that the addition of capnography to standard monitoring reduces hypoxia and provides advance warning for hypoxic events.[32,33] Checklists should be employed routinely to assure important drugs and pieces of equipment are available in the case of a developing emergency and also to assure that a proper procedural time out has occurred. A common acronym used to confirm proper equipment and medications are in the room is SOAPME: **S**uction with size-appropriate suction catheters; **O**xygen supply and functioning flow meters; appropriately sized **A**irway equipment (endotracheal tubes, laryngoscope blades, stylets, face mask, bag valve mask); **P**harmacy including all the basic drugs needed during an emergency, including antagonists; **M**onitors including pulse oximeter with size-appropriate oximeter probes, noninvasive blood pressure, end tidal carbon dioxide, and cardiac monitor; and **E**quipment, including special equipment for particular cases (e.g., defibrillator).[26]

Procedural Sedation: Medication Options

There are at least five classes of procedural sedation and analgesia drugs: sedative hypnotics/amnestics, analgesics, dissociative sedatives, inhalational agents, and antagonists.

Table 6. Common Medications Used in Pediatric Procedural Sedation

	Onset (min)	Duration (min)	Comments
Sedative Hypnotics/Amnestics			
Diazepam	IV: 4-5	IV: 60-120	Reduce dose when using in combination with opioids
Etomidate	IV: < 1	IV: 5-10	Adverse effects include respiratory depression, myoclonus, nausea, and vomiting
Midazolam	IV: 2-3 IM: 10-20 Oral: 15-30 Intranasal: 10-15 Rectal: 10-30	IV: 45-60 IM: 60-120 Oral: 60-90 Intranasal: 60 Rectal: 60-90	Reduce dose when using in combination with opioids May produce paradoxical excitement.
Propofol	IV: < 1	IV: 5-10	Frequent hypotension and respiratory depression Avoid with egg or soy allergies Avoid in patients with porphyria
Dissociative			
Ketamine	IV: 1 IM: 3-5	IV: dissociation 15, recovery 60 IM: dissociation 15-30, recovery 90-150	Unpleasant dreams or hallucinations rare in children Can be given with atropine or glycopyrrolate to counter hypersalivation
Inhalational			
Nitrous oxide	< 5	< 5 after discontinuation	Requires specialized apparatus and gas scavenger capability
Reversal Drugs			
Naloxone	IV: 2	IV: 20-40 IM: 60-90	If shorter acting than reversed drug, serial doses may be required
Flumazenil	IV: 1-2	IV: 30-60	If shorter acting than reversed drug, serial doses may be required

Source: Author created.

Table 6 discusses onset and duration of the various medications.[4] Dose of each medication depends on the patient's age/weight and route of administration. The selection of pharmacologic agents, dose, and combination of agents should be tailored to each patient by the EM physician. Table 7 lists procedural goals and potential medications that may be beneficial. Different depths of sedation, time of onset, and duration of sedation can be achieved by selection of specific agents and routes of administration.

In general, the sedative hypnotics are the most widely used, with several ultra-short-acting agents, such as propofol and etomidate, gaining popularity. Given that sedative hypnotics lack specific analgesic properties, they frequently are supplemented with opioids. Other common techniques of anesthesia include dissociative sedation (ketamine) and inhalational sedation (nitrous oxide).[4]

One combination of medications gaining in popularity is "ketofol." It is thought that propofol-associated hypotension and respiratory depression can be reduced with increases in circulatory norepinephrine that are induced by ketamine. In addition, ketamine-associated nausea and emergence reactions may be reduced by the antiemetic and anxiolytic properties of propofol.[8]

Intravenous administration is the most reliable, titratable form of administration of procedural sedation medications. Oral, transmucosal, and intramuscular routes of administration can be convenient and useful in children when intravenous access is difficult; however, variable duration

Table 7. Procedural Sedation Goals and Medications

Goal of Procedure					
	Motion control	Anxiolysis	Sedation	Analgesia	Amnesia
Agent	Sedative, dissociative agents	Sedative, dissociative agents	Sedative, dissociative agents	Opioids, dissociative agents	Opioids, dissociative agents, or sedatives
Type of Procedure					
Not painful (i.e., diagnostic imaging)		Minimally painful (i.e., minor trauma, instrumentation, vascular access)		Painful (i.e., minor trauma, instrumentation, vascular access [central])	
• Pentobarbital • Midazolam • Propofol		• Nitrous oxide • Topical local anesthesia • Midazolam		• Ketamine • Fentanyl + midazolam • Propofol	

Source: Author adapted.

Table 8. Risks of Procedural Sedation[34]

Common Events That Are Not Dangerous	Common Events That May Need Treatment	Uncommon Events That May Be Serious
Agitation	Hypoxia	Laryngospasm
Nausea	Apnea	Intubation
Vomiting	Hypotension	Aspiration

Source: Author adapted.

of action and time of onset can be observed depending on efficacy of absorption and pharmacokinetics of the agent given.

Several older medication options that have fallen out of favor include choral hydrate and barbiturates, including methohexital, pentobarbital, and thiopental. Several shorter-acting opioids, such as alfentanyl and sufentanil, are becoming available. The alpha-2 agonist dexmedetomidine has been used for procedural sedation in both pediatric and adult patients. It is considered generally effective for sedation for noninvasive and short procedures, but because of its slow onset, delayed recovery, and minimal analgesia and amnesia, it has not been adopted widely. There is growing interest in combining dexmedetomidine with ketamine for procedural sedation, but it is mostly based on anecdotal experience.[22]

Risks of Pediatric Procedural Sedation

Commonly associated risks with pediatric procedural sedation include vomiting, agitation, hypoxia, and apnea. (*See Table 8.*) Additionally, several severe but rare respiratory events, including laryngospasm, intubation, and aspiration, can occur. Quantitative risk estimates of adverse events can be used to facilitate shared decision-making, risk communication, informed consent, and resource allocation in children undergoing procedural sedation in the ED.[34] One study that reviewed a large database collected by the Pediatric Sedation Research Consortium of 26 institutions and 30,037 sedations showed cardiopulmonary resuscitation was required only once, O_2 saturations < 90% for more than 30 seconds occurred in 157 per 10,000 sedations, stridor and laryngospasms occurred in 4.3 per 100,000 sedations, and unexpected apnea, excessive secretions, and vomiting had frequencies of 24, 41.6, and 47.2, respectively, per 100,000 sedations. The researchers concluded that serious adverse events were rare and that the safety of practice likely depends on the system's ability to manage less serious events.[35]

A review that evaluated 14 systematic reviews, including 210 primary studies, found consistent safety and efficacy for nitrous oxide and ketamine, with very rare significant adverse events for propofol.[12]

ACEP concludes that sedation and analgesia are safe and effective in providing patient comfort and ease of procedural performance. Future studies are needed to evaluate challenges encountered in high-risk subgroups and effects of various clinical environments across different EDs.[8] Table 9 lists recommended management steps

Table 9. Management of Risks with Sedation[26]

Suggested Management of Airway Obstructions

- Reposition the airway
- Perform a jaw thrust
- Insert oral airway
- Call for help
- Insert nasal trumpet
- Insert supraglottic device (LMA or other)
- Tracheal intubation
- Surgical airway

Suggested Management of Apnea

- Bag/mask ventilation
- Reposition the airway
- Perform a jaw thrust
- Insert oral airway
- Call for help
- Insert nasal trumpet
- Insert supraglottic device (LMA or other)
- Tracheal intubation
- Surgical airway

Suggested Management of Laryngospasm

- Positive pressure ventilation
- Deepen sedation (e.g., propofol)
- Call for help
- Give muscle relaxant (succinylcholine + atropine unless contraindicated)
- Tracheal intubation
- Surgical airway

Source: Author adapted.

for airway obstruction, apnea, and laryngospasm.[26]

Additional Aspects

Procedural sedation is a common ED practice. The pediatric emergency physician must claim responsibility for the skill set that distinguishes the pediatric emergency doctor from an ambulatory or urgent care pediatrician, including: 1) airway management including intubation, managing non-intubated airway, recognizing hypoxia, and respiratory depression; 2) understanding of drug pharmacology including pharmacokinetics, pharmacodynamics, and adverse event profiles; 3) vascular access, including intraosseous and central access; and 4) techniques of cardiopulmonary resuscitation.[36] Expertise in critical care skills, advanced airway management, cardiovascular and ventilator resuscitation techniques, and basic drug pharmacology are core competencies in EM residency training as well as pediatric EM fellowships.[8,37-39] The unique procedural sedation and analgesia qualifications of EM physicians are recognized by the Centers for Medicare and Medicaid Services: "… emergency medicine-trained physicians have very specific skill sets to manage airways and ventilation that is necessary to provide patient rescue. Therefore, these practitioners are uniquely qualified to provide all levels of analgesia/sedation and anesthesia (moderate to deep to general)."[8,24]

Distraction Techniques

Distraction techniques also may be helpful when treating pediatric patients who must undergo sedation. These techniques can be used when a patient first presents to triage, through the initial assessment phase, and during pharmacologic intervention. EM providers can use different modalities to engage the patient's sensory pathways of sight, hearing, and touch to achieve a more successful outcome.

Techniques that may be helpful include breathing control, goal-directed tasks, and the use of both visual and auditory distractions. The providers should use age-appropriate techniques that mimic the coping styles of each patient. In young children, distraction techniques include favorite blankets/toys, bubbles, books, audiotapes, and videos. Distraction techniques that are successful with older children and teenagers include books, movies, virtual reality glasses, handheld video games, and guided visual imagery.

To minimize anxiety, EM providers should involve pediatric patients in selecting distraction stimuli early in the evaluation process. In addition, guided visual imagery may be beneficial for children since they generally are more accepting of fantasy. Since ketamine has dissociative effects, it is particularly successful as an adjunct with guided imagery.

Disposition

After the procedure is completed, monitoring should be continued until the patient returns to an age-appropriate baseline state and meets local criteria for safe discharge. Specifically, the child should be alert, have stable vital signs, be able to tolerate PO without post-anesthesia vomiting, and should be able to talk and sit without assistance as appropriate for age. Time to recovery of baseline state varies by drugs used and depth of sedation, but most patients can be discharged in one to two hours.[11] Serious adverse events are rare after discharge. One study analyzed 1,341 consecutive sedations and found that 92% of adverse events occur during the procedure, with serious adverse events occurring a median of two minutes after the final medication dose and rarely occurring after 25 minutes from the final medication administration; those that occurred that late were preceded by a separate similar adverse

Table 10. Proposed Discharge Criteria Following Procedural Sedation[22]
Protective reflexes are intact
No signs of respiratory distress
Vital signs within 15% of pre-procedural value
Able to sit upright
No active bleeding
Not actively vomiting
Able to ambulate with assistance without hypotension
Nausea, if any, is mild
Patient is accompanied by a responsible adult
A minimum of 30 minutes has elapsed since the end of the procedure
Discharge instructions given
Source: Author created.

effect during the expected peak drug effect.[40] General discharge criteria are included in Table 10.[22]

Summary

The ED is a unique environment where a variety of emergent and urgent conditions are managed, with many of these conditions resulting in significant pain and anxiety to pediatric patients. Many of the procedures performed by emergency physicians are time sensitive. The pediatric emergency physician must be facile in the use of procedural sedation and analgesia.[1] Inadequacy of pain control due to fear of oversedation and concern of altering physical findings can be addressed proactively as well-trained and equipped pediatric emergency medicine providers facilitate safe interventional procedural sedation.[1,41]

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CME/CE Questions

1. Which of the following is a common indication for procedural sedation in pediatric patients?
   a. Laceration repair
   b. Fracture reduction
   c. Diagnostic imaging
   d. All of the above
2. A drug-induced depression of consciousness in which the patient responds purposefully to commands but no interventions are required to maintain the child's airway is defined as which of the following?
   a. Minimal sedation
   b. Moderate sedation
   c. Deep sedation
   d. Dissociative anesthesia
3. Successful pediatric procedural sedation depends on which of the following?
   a. Immediate access to a pediatric anesthesiologist
   b. Careful patient assessment and procedural planning
   c. A second provider performing the procedure
   d. Only the provider administering the medications
4. A 2-year-old male patient presents to the emergency department following a fall from a swing set with obvious right forearm deformity. He arrives eating ice cream, as his parents stopped en route at a gas station to calm him. According to ACEP, an appropriate amount of time to wait prior to sedation is:
   a. 2 hours
   b. 4 hours
   c. 12 hours
   d. None; procedural sedation should not be delayed based on fasting time
5. Which of the following equipment is ***not*** mandatory during procedural sedation?
   a. Cardiac monitor
   b. Continuous capnography
   c. Pulse oximeter
   d. Blood pressure cuff
6. What is SOAPME?
   a. A type of enema
   b. A reminder for healthcare worker hand hygiene
   c. An acronym that can be used to assure important medications and equipment are at bedside during procedural sedation
   d. A hand-off tool for facilitating communication between the ED provider and the inpatient services
7. During procedural sedation, what is midazolam considered to be?
   a. a sedative hypnotic
   b. an analgesic
   c. a dissociative drug
   d. a reversal agent
8. When is a pediatric patient ready for discharge following procedural sedation?
   a. As soon as the IV is removed following the procedure
   b. Immediately after vomiting
   c. When he or she is able to ambulate without assistance
   d. If he or she can sit upright with mild nausea
9. Which of the following regarding pathophysiology of pain in children is true?
   a. Physiologic responses to painful stimuli in neonates reflected in hormonal, metabolic, and cardiorespiratory changes are of similar magnitude in children and adults.
   b. Psychological forms of stress are retained in memory long enough to modify behavioral patterns.
   c. The inadequate treatment of pain in children has not been well documented.
   d. The nervous system at birth displays a hypersensitivity to sensory stimuli with increased thresholds of response to mechanical and thermal stimulation regardless of length or repetition of inputs.
10. The core skill set expected of the pediatric ED physician includes:
    a. airway management, including intubation, management of a non-intubated airway, and recognition of hypoxia and respiratory depression
    b. understanding of pharmacokinetics, pharmacodynamics, and adverse event profiles of medications used
    c. vascular access, including intraosseous and central access
    d. All of the above

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Upon completion of this educational activity, participants should be able to:

- recognize specific conditions in pediatric patients presenting to the emergency department;
- describe the epidemiology, etiology, pathophysiology, historical and examination findings associated with conditions in pediatric patients presenting to the emergency department;
- formulate a differential diagnosis and perform necessary diagnostic tests;
- apply up-to-date therapeutic techniques to address conditions discussed in the publication;
- discuss any discharge or follow-up instructions with patients.

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PEDIATRIC EMERGENCY MEDICINE REPORTS

Practical, Evidence-Based Reviews in Pediatric Emergency Care

Pediatric Procedural Sedation

Common Medications Used in Pediatric Procedural Sedation

	Onset (min)	Duration (min)	Comments
Sedative Hypnotics/Amnestics			
Diazepam	IV: 4-5	IV: 60-120	Reduce dose when using in combination with opioids
Etomidate	IV: < 1	IV: 5-10	Adverse effects include respiratory depression, myoclonus, nausea, and vomiting
Midazolam	IV: 2-3 IM: 10-20 Oral: 15-30 Intranasal: 10-15 Rectal: 10-30	IV: 45-60 IM: 60-120 Oral: 60-90 Intranasal: 60 Rectal: 60-90	Reduce dose when using in combination with opioids May produce paradoxical excitement.
Propofol	IV: < 1	IV: 5-10	Frequent hypotension and respiratory depression Avoid with egg or soy allergies Avoid in patients with porphyria
Dissociative			
Ketamine	IV: 1 IM: 3-5	IV: dissociation 15, recovery 60 IM: dissociation 15-30, recovery 90-150	Unpleasant dreams or hallucinations rare in children Can be given with atropine or glycopyrrolate to counter hypersalivation
Inhalational			
Nitrous oxide	< 5	< 5 after discontinuation	Requires specialized apparatus and gas scavenger capability
Reversal Drugs			
Naloxone	IV: 2	IV: 20-40 IM: 60-90	If shorter acting than reversed drug, serial doses may be required
Flumazenil	IV: 1-2	IV: 30-60	If shorter acting than reversed drug, serial doses may be required

Source: Author created.

Common Indications for Procedural Sedation[11,12]

- Fracture/dislocation reduction
- Wound care
- Laceration repair
- Lumbar puncture
- Incision and drainage of an abscess
- Placement of a venous catheter
- Diagnostic imaging
- Cardioversion

Source: Author created.

Pre-procedure Fasting Guidelines According to the American Society of Anesthesiologists[29]

Type of Food	Minimum Fasting Period
Clear liquids	2 hours
Breast milk	4 hours
Infant formula	6 hours
Nonhuman milk	6 hours
Light meal	6 hours

Source: Author adapted.

Airway Evaluation with LEMON[27]

L	LOOK externally for indicators of a difficulty airway
E	EVALUATION of inter-incisor distance, hyoid mental distance, and thyroid to floor of the mouth distance.
M	MALLAMPATI score
O	signs of OBSTRUCTION
N	NECK mobility

Source: Author adapted.

Risks of Procedural Sedation[34]

Common Events That Are Not Dangerous	Common Events That May Need Treatment	Uncommon Events That May Be Serious
Agitation	Hypoxia	Laryngospasm
Nausea	Apnea	Intubation
Vomiting	Hypotension	Aspiration

Source: Author adapted.

Procedural Sedation Goals and Medications

Goal of Procedure					
	Motion control	Anxiolysis	Sedation	Analgesia	Amnesia
Agent	Sedative, dissociative agents	Sedative, dissociative agents	Sedative, dissociative agents	Opioids, dissociative agents	Opioids, dissociative agents, or sedatives

Type of Procedure		
Not painful (i.e., diagnostic imaging)	Minimally painful (i.e., minor trauma, instrumentation, vascular access)	Painful (i.e., minor trauma, instrumentation, vascular access [central])
• Pentobarbital • Midazolam • Propofol	• Nitrous oxide • Topical local anesthesia • Midazolam	• Ketamine • Fentanyl + midazolam • Propofol

Source: Author adapted.

Management of Risks with Sedation[26]

Suggested Management of Airway Obstructions

- Reposition the airway
- Perform a jaw thrust
- Insert oral airway
- Call for help
- Insert nasal trumpet
- Insert supraglottic device (LMA or other)
- Tracheal intubation
- Surgical airway

Suggested Management of Apnea

- Bag/mask ventilation
- Reposition the airway
- Perform a jaw thrust
- Insert oral airway
- Call for help
- Insert nasal trumpet
- Insert supraglottic device (LMA or other)
- Tracheal intubation
- Surgical airway

Suggested Management of Laryngospasm

- Positive pressure ventilation
- Deepen sedation (e.g., propofol)
- Call for help
- Give muscle relaxant (succinylcholine + atropine unless contraindicated)
- Tracheal intubation
- Surgical airway

Source: Author adapted.

Proposed Discharge Criteria Following Procedural Sedation[22]

- Protective reflexes are intact
- No signs of respiratory distress
- Vital signs within 15% of pre-procedural value
- Able to sit upright
- No active bleeding
- Not actively vomiting
- Able to ambulate with assistance without hypotension
- Nausea, if any, is mild
- Patient is accompanied by a responsible adult
- A minimum of 30 minutes has elapsed since the end of the procedure
- Discharge instructions given

Source: Author created.

Considerations for Airway Equipment on an Emergency Cart[26]

- Oral and nasal airways
- Bag-valve mask
- Face masks
- Supraglottic airway devices
- Laryngoscope blades
- Endotracheal tubes

Source: Author created.

Supplement to *Pediatric Emergency Medicine Reports*, February 2017: "Pediatric Procedural Sedation." Authors: Derick D. Jones, MD, MBA, Resident Physician, Department of Emergency Medicine, Mayo Clinic, Rochester, MN; and Heather A. Heaton, MD, Assistant Professor of Emergency Medicine, Mayo Clinic College of Medicine, Department of Emergency Medicine, Mayo Clinic, Rochester, MN.