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Authors:

Derya Caglar, MD, Assistant Professor, University of Washington School of Medicine Attending Physician, Division of Emergency Medicine, Seattle Children's Hospital, Seattle, WA.

Richard Kwun, MD, Attending Physician, Department of Emergency Medicine, Swedish Medical Center, Issaquah, WA.

Peer Reviewer:

Christopher J. Haines, DO, FAAP, FACEP, Assistant Professor of Pediatrics and Emergency Medicine, Drexel University College of Medicine, Director, Department of Emergency Medicine, Medical Director, Critical Care Transport Team, St. Christopher's Hospital for Children, Philadelphia, PA.

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Pediatric Procedural Sedation and Analgesia in the Emergency Department

Procedural sedation and analgesia (PSA) has been provided to children in the emergency department for decades. When patients are evaluated properly, and adequate equipment, personnel, and medications are utilized, effective and safe PSA is delivered by the emergency physician, whether in a university or community setting, over a wide range of ages, and with a broad selection of medications.[1,2] This article will review goals and levels of sedation, pre- and post-procedure evaluation, necessary equipment and personnel, as well as medication choices.

—The Editor

Introduction

PSA is a standard practice of emergency physicians (EP), recognized by the American College of Emergency Physicians (ACEP) as integral to the practice of emergency medicine.[3] It is defined as the use of pharmacologic agents to provide anxiolysis, analgesia, sedation, and motor control during procedures or diagnostic tests.[4] Traditionally performed by anesthesiologists, the need for PSA outside of the operating room (OR) setting has led to its use by many non-anesthesiologist practitioners, both in the inpatient and outpatient setting. In one report, the number of procedures performed in one year outside the OR at a children's hospital approached those in the OR, and these figures excluded the emergency department.[5] At another institution, of 63,000 patients undergoing PSA, 41% were sedated by non-anesthesiologists.[6]

According to the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), "the standards for sedation and analgesia care apply when patients in any setting receive, for any purpose and by any route, moderate or deep sedation."[7] Guidelines for the practice of PSA by non-anesthesiologists were developed by the American Society of Anesthesiologists (ASA) in 2002.[8] Guidelines for PSA in the pediatric population soon followed and were developed by the American Academy of Pediatrics (AAP) and American Academy of Pediatric Dentistry in 2006.[9]

Sedation of the pediatric patient is very different from sedation of the adult. PSA is often administered to control behavior to facilitate the safe completion of a procedure. A child's ability to control his or her behavior for a procedure depends both on cognitive age and developmental age. Often children younger than 6 years of age and those with developmental delay require deeper levels of sedation to gain control of their behavior. Children are also particularly vulnerable to medication effects on respiratory drive, airway patency, and hemodynamic stability. A thorough understanding of the unique anatomy and physiology of children is required to perform effective and safe PSA.

Executive Summary

- The ideal sedation minimizes the patient's emotional and physical discomfort and maximizes amnesia to any painful elements.
- Any history of snoring, sleep apnea, or hypoventilation may indicate an increased risk of obstruction or airway compromise with sedation.
- At least two trained providers should be present for each sedation, with one person dedicated to the continuous monitoring of the patient while the other performs the procedure.
- Patients monitored with capnography, in addition to standard care, experience significantly fewer episodes of hypoxia than those monitored with standard care alone.
- The use of chloral hydrate has fallen out of favor with the development of newer medications with safer profiles.

Goals of Procedural Sedation and Analgesia

The emergency clinician must determine the appropriate level of sedation and/or analgesia required for a particular procedure. Multiple modalities, including medications, verbal reassurance and coaching, distraction techniques, and child life, can all work together to provide the optimal experience. The ideal sedation (*see Table 1*) minimizes the patient's emotional and physical discomfort and maximizes amnesia to any painful elements. It allows the physician to adequately control the patient's behavior, providing for a safe and effective procedure with minimal potential for harm. Upon completion of an ideal sedation, the patient returns to his or her pre-sedation baseline in a timely manner with minimal post-sedation side effects.

Levels of Sedation

When considering sedation of a patient, the provider must determine the level of sedation required for a particular procedure. Analgesia is the relief of pain without intentionally producing a sedated state. Altered mental status may, however, be a secondary effect of analgesic medications. The levels of sedation described are consistent with those defined by the ASA (*see Table 2*).[8]

Minimal sedation, or anxiolysis, allows the patient to respond normally to verbal commands. While cognitive function and coordination may be impaired, ventilatory and cardiovascular functions remain intact. Most patients will generally not require more than observation and intermittent evaluation of their level of sedation.

Moderate sedation (formerly called conscious sedation) allows the patient to respond purposefully to verbal commands or light touch. Patients maintain their airway, are able to ventilate without intervention, and cardiovascular function is maintained.

With deep sedation, the patient responds purposefully to noxious stimulation. These patients may require assistance to maintain their airway and adequate ventilation. Cardiovascular function is usually maintained.

Under general anesthesia, the patient cannot be aroused and often requires assistance to maintain his or her airway and positive pressure ventilation for adequate oxygenation. Cardiovascular function may be impaired.

Pre-sedation Evaluation

A pre-sedation evaluation should be completed for all patients to determine the appropriate sedation plan. Chronic medical conditions, hospitalizations, medications, and allergies should be noted. Any history of snoring, sleep apnea, or hypoventilation may indicate an increased risk of obstruction or airway compromise with sedation. Previous experience with anesthesia or sedation and associated complications should be reviewed. A family history of significant problems with anesthesia may indicate potential for increased risk with sedation. The time and type of last oral intake should be documented.

The physical examination should focus on areas for potential decompensation during sedation. Vital signs, including baseline heart rate, respiratory rate, pulse oximetry, and blood pressure should be documented. Any oral or airway abnormalities (for example, facial dysmorphism, micrognathia, macroglossia, dental anomalies or hardware, tracheal deviation) that could interfere with resuscitation and intubation should be noted. Wheezing or crackles may indicate decreased pulmonary reserve. An accurate weight should be documented for appropriate medication dosing.

Laboratory studies are determined by the patient's medical status, drug therapy, or the nature of the proposed procedure. There is no need for routine studies in the otherwise healthy patient.

Prior to sedation, every patient should be assigned an ASA physical status classification (*see Table 3*). Patients with ASA classes I and II generally are acceptable candidates for mild, moderate, and deep sedation outside of the operating room. Those patients with ASA III and above, airway abnormalities, or any additional special needs may benefit from anesthesiology consultation and intervention.

The ideal duration of fasting prior to procedural sedation is under debate. Consensus-based ASA guidelines advise a minimum fasting time of two hours for clear liquids; four hours for breast milk; and six hours for formula, non-human milk, and solids. These rules

Table 1. Goals of Sedation

- Maintain patient safety
- Obtain cooperation of the patient
- Minimize emotional and physical discomfort in patient and parent(s)
- Decrease anxiety and psychological stress in patient and parent(s)
- Maximize amnesia to a painful procedure
- Control behavior to allow for a safe and effective procedure
- Recover to a pre-sedation baseline in a timely manner

Table 2. Levels of Sedation

Level of sedation	Minimal sedation	Moderate sedation	Deep sedation	General anesthesia
Responsiveness	Normal response to verbal stimulation	Purposeful response to verbal or tactile stimulation	Purposeful response after repeated or painful stimulation	Unarousable, even with painful stimulus
Airway	Unaffected	No intervention required	Intervention may be required	Intervention often needed
Spontaneous ventilation	Unaffected	Adequate	May be inadequate	Frequently inadequate
Cardiovascular function	Unaffected	Usually maintained	Usually maintained	May be impaired

Adapted from: American Society of Anesthesiologists. Task force on sedation and analgesia by non-anesthesiologists. Practice guidelines for sedation and analgesia by non-anesthesiologists. *Anesthesiology* 2002;96:1005.

were adopted with the intent to minimize the risk of gastric aspiration. Fasting guidelines were based on OR patients and, more typically, deep sedation and general anesthesia. Aspiration is associated with deeper levels of sedation, as well as ASA physical status III or IV, and for these reasons, traditional fasting guidelines may not be applicable to the ED population. The ASA guidelines acknowledge that there is "insufficient published evidence to address the safety of a preoperative fasting period and do not offer specific guidance for fasting times in emergency procedures."[10]

Fasting times present a significant challenge to pediatric patients who are rarely fasted before presentation and often require urgent or emergent procedures. A systematic review of randomized trials of preoperative fasting regimens for children at normal risk for aspiration during anesthesia showed no benefit to fasting from fluids for more than six hours (as compared with two hours) with regard to intraoperative gastric volume and pH.[11] In addition, several studies have shown no difference in the incidence of adverse events between those who met fasting guidelines and those who did not.[11,12,13] Recent food intake is not a contraindication for PSA, but must be considered carefully by the EP.[7]

The risks and benefits, as well as the urgency, of the procedure must be balanced with the anticipated depth of sedation and available fasting time.

Equipment and Monitoring

Age-appropriate equipment for airway management and resuscitation should be immediately available at the location of sedation (*see Table 4*). This includes oxygen, suction, a bag-valve mask device with age- and size-appropriate masks, and intubation equipment. AAP guidelines use the acronym SOAP-ME (*see Table 5*) in the planning and preparation for a procedure. Patients requiring deep sedation should have intravenous (IV) access for administration of multiple doses of sedatives and resuscitation medications, as needed. If access is not initially obtained, trained personnel and equipment should be immediately available to establish vascular access should the need arise. With lighter sedation given orally, nasally, rectally, or intramuscularly, vascular access is not required but should be available in the event of an adverse reaction.

Designated personnel capable of managing complications of sedation, including hemodynamic instability, respiratory depression, apnea, and airway compromise, should monitor and continuously visualize the patient. Both AAP and ACEP guidelines call for practitioners to have "the skills to rescue the patient from a deeper level than intended" with any sedation.[7,14] At least two trained providers should be present for each sedation, with one person dedicated to the continuous monitoring of the patient while the other performs the procedure. The provider responsible for airway management must recognize early signs of respiratory depression, apnea, obstruction, or bronchospasm and act appropriately to address and reverse problems.

Continuous pulse oximetry and cardiac monitors should have audible and visual signals. Vital signs should be recorded at specific intervals, including at the start of the procedure, after administration of any

Table 3. ASA Physical Status Classification

Class	Description	Examples	Suitability for Sedation
I	A normally healthy patient	Unremarkable medical history	Excellent
II	A patient with mild systemic disease (no functional limitation)	Mild asthma, controlled seizure disorder, anemia, controlled diabetes mellitus	Generally good
III	A patient with severe systemic disease (definite functional limitation)	Moderate-to-severe asthma, poorly controlled diabetes mellitus, moderate obesity	Intermediate to poor; consider benefits relative to risks
IV	A patient with severe systemic disease that is a constant threat to life	Severe bronchopulmonary dysplasia, sepsis, advanced degrees of pulmonary, cardiac, hepatic, renal, or endocrine insufficiency	Poor; benefits rarely outweigh risks
V	A moribund patient who is not expected to survive without the operation	Septic shock, severe trauma	Extremely poor

medications, when the procedure is completed, during the recovery period, and when recovery is completed. If deep sedation is used or patients have significant underlying illness, vital signs should be measured at least every five minutes.

End-tidal capnography is a noninvasive way to monitor a patient's ventilatory status. Respiratory gases are sampled either from a chamber attached in-line to an endotracheal tube or at the nares via nasal cannula. Output is analyzed and given a numeric value and waveform. Increases in end-tidal carbon dioxide ($ETCO_2$) with respiratory depression are detected before hypoxemia is, particularly in those who are receiving supplemental oxygen. Respiratory depression caused by over-sedation will manifest as an abnormally high or low (when respirations are not reliably detected) $ETCO_2$ level well before pulse oximetry detects a declining oxyhemoglobin saturation.[15] Several randomized trials have shown that patients monitored with capnography, in addition to standard care, experience significantly fewer episodes of hypoxia than those monitored with standard care alone.[15,16,17] JCAHO and the AAP recommend capnography as an essential component of monitoring children during deep sedation.[14,18]

Bispectral (BIS) index monitoring is another noninvasive method of evaluating a patient's level of sedation. The BIS monitor uses highly processed electroencephalogram (EEG) signals that are obtained from a probe placed on the patient's forehead. EEG waveforms change with a patient's level of alertness. These electroencephalographic waveforms are high frequency and low amplitude when a patient is awake, and low frequency and high amplitude when a patient is deeply sedated. Based on a study of healthy adult volunteers, a numeric scoring system was developed, known as the BIS index, that ranges from 0–100.[19] A BIS index of 0 denotes coma, 0-40 denotes a deep hypnotic state; 40–60 is general anesthesia; 60–70 is deep sedation; 70–90 is light to moderate sedation, and 100 is awake.[20] The ASA critically reviewed BIS data and found that "a specific numerical value may not correlate with a specific depth of anesthesia."[21] Several studies have found inconsistent BIS scores and levels of sedation in pediatric patients.[22,23] A relatively newer modality, BIS monitoring may prove to be a useful adjunct in evaluating the status of the sedated patient but, at present, data do not support its regular use in PSA.

Role of Child Life

Child programs in pediatric settings, including the ED, have become widely accepted and advocated by the AAP.[24] With expertise in child behavior and development, child-life specialists promote effective coping during potentially stressful situations through play, distraction, psychological preparation, education, and support.[25] Preparation is patient-focused and includes sensory aspects of the procedures (what the child will see, feel, hear, smell, and touch) and what the child can do during the procedure (count, read, watch television, etc). Teaching dolls are frequently used to help children understand where on the body the procedure will be performed. These techniques are known to decrease anxiety and discomfort during painful procedures.

Fear and anxiety are decreased in both the patient and parents when children are empowered by being given specific roles and tasks.

Pharmacologic Agents

There are five general categories

Table 4. Procedural Sedation Resources

Equipment

Suction: Appropriate-sized suction catheters and suction apparatus
Airway:
- Oxygen
- Bag valve mask
- Oropharyngeal and nasopharyngeal airways
- Laryngoscope with appropriately sized blades
- Endotracheal tubes, stylets
- Laryngeal mask airway
- Cricothyroidotomy kit

Monitors:
- ECG monitor
- Pulse oximeter
- End tidal CO_2 monitor
- Defibrillator with pads

Pharmacy:
- Normal saline
- ACLS drugs
- RSI agents
- Reversal agents
- Antiemetic agents

Table 5. Planning and Preparation for PSA, SOAP-ME Mnemonic

S (suction)	Size-appropriate suction catheters and a functioning suction apparatus (placed on right side of patient's head)
O (oxygen)	Adequate oxygen supply and functioning flow meters/other devices to allow its delivery
A (airway)	Size-appropriate airway equipment (nasopharyngeal and oropharyngeal airways, laryngoscope blades [checked and functioning], endotracheal tubes, stylets, face mask, bag-valve mask or equivalent device [functioning])
P (pharmacy)	Emergency medications including antagonists
M (monitors and medications)	Functioning pulse oximeter with size-appropriate oximeter probes and other monitors as appropriate for the procedure (e.g., noninvasive blood pressure, end-tidal carbon dioxide, electrocardiogram, stethoscope).
E (equipment)	Special equipment as needed based on the patient and the procedure

of agents used in PSA: sedative-hypnotic, analgesic, dissociative, inhalational, and antagonistic (*see Table 6*). Sedative-hypnotics are the most widely used, and include benzodiazepines, barbiturates, and unique agents such as propofol, etomidate, and chloral hydrate. When used in combination rather than individually, lower dosages of these agents can achieve similar results. Opioids and benzodiazepines, for example, when used together, exhibit synergy not only in desired effects but also side effects such as respiratory depression.

Sedative-hypnotics. Medications in this class do not have analgesic properties. Analgesics should be used in conjunction with sedative-hypnotics for painful procedures.

Chloral hydrate has decreased efficacy in children older than 48 months.[26] It is a nonreversible agent and does not provide analgesia. It may cause paradoxical excitement and may predispose patients to airway obstruction.[27] Because of its depressive effects on myocardial contractility, chloral hydrate use is contraindicated in patients with severe cardiac dysfunction and those on vasopressor support. Rectal use has been described, but absorption is erratic.[28] Once commonly used, it has fallen out of favor with the development of newer medications with safer profiles.

Etomidate has been used safely in children as young as 2 years old. It should be avoided when adrenal insufficiency is a concern, as in sepsis. Side effects include myoclonus, nausea, and vomiting.[29] For the reduction of displaced extremity fractures, etomidate appears to provide superior PSA when compared to midazolam.[30]

Benzodiazepines, such as diazepam and midazolam, can cause respiratory depression as well as hypotension. Paradoxical excitement has also been described. Midazolam has the added effect, oftentimes desirable, of antegrade amnesia. As an adjunct to ketamine, midazolam decreases the incidence of emesis, but not of emergence reactions, and is not recommended for routine prophylaxis.

Barbiturates such as methohexital, pentobarbital, and thiopental can cause hypotension and respiratory depression. Methohexital, whether administered intravenously, intramuscularly, or rectally, and pentobarbital

Table 6. Pharmacologic Agents Used in Procedural Sedation for Children

Sedative-hypnotic	Dose and route	Onset (min)	Duration (min)	Contraindications
Etomidate	IV: 0.1-0.3 mg/kg, repeat if inadequate	< 1	5-15	Adrenal insufficiency
Midazolam	IV (0.5-5 years): 0.05-0.1 mg/kg, titrate to max 0.6 mg/kg	2-3	45-60	Hypotension
	IV (6-12 years): 0.025-0.05 mg/kg, titrate to max 0.4 mg/kg			
	IM: 0.1-0.15 mg/kg	10-20	60-120	
	Oral: 0.5 mg/kg	15-30	60-90	
	Intranasal: 0.2-0.5 mg/kg	10-15	60	
	Rectal: 0.25-0.5 mg/kg	10-30	60-90	
Methohexital	IV: 0.5-1 mg/kg			Porphyria
	Rectal: 25 mg/kg	10-15	60	
Pentobarbital	IV: 1-6 mg/kg, titrate 1-2 mg/kg doses every 3-5 min	3-5	15-45	Porphyria
	IM: 2-6 mg/kg, max 100 mg	10-15	60-120	
	Oral or rectal (< 4 years): 3-6 mg/kg, max 100 mg	15-60	60-240	
	Oral or rectal (> 4 years): 1.5-3 mg/kg, max 100 mg			
Thiopental	Rectal: 25 mg/kg	10-15	60-120	Porphyria
Propofol	IV: 1 mg/kg, titrate 0.5 mg/kg doses	< 1	5-15	Egg, soy, or sulfite allergy
Analgesic				
Fentanyl	IV: 1 ug/kg up to 50 ug/dose, repeat every 3-5 min	3-5	30-60	
	Intranasal: 1.5-2 ug/kg	5-15	120-240	
Morphine	IV: 0.05-0.15 mg/kg up to 3 mg/dose, repeat every 3-5 min	5-10	120-180	
Dissociative				
Ketamine	IV: 1-1.5 mg/kg, repeat every 10 min	1	15-60	Age < 3 months, schizophrenia
	IM: 4-5 mg/kg, repeat 2-4 mg/kg after 10 min	3-5	15-150	
Inhalational				
Nitrous oxide	Preset mixture with minimum 30% oxygen	2-3	< 5	Pregnant medical provider, bleomycin use, reductase deficiency
Antagonistic				
Naloxone	IV or IM: 0.1-0.4 mg, max 2 mg/dose, repeat every 3 min, max 10-20 mg	IV: 2	IV: 20-40	
Flumazenil	IV: 0.02 mg/kg/dose, repeat every 1 min up to 1 mg	1-2	30-60	Long-term benzodiazepine use Use carefully in children with a seizure disorder

Min = minutes; max = maximum; IV = intravenous; IM = intramuscular

Adapted from: Krauss B, Green SM. Procedural sedation and analgesia in children. *Lancet* 2006;367:772.

can provide effective and safe sedation for painless procedures such as imaging studies.[31] Paradoxical excitation can occur in the pediatric patient, such as with chloral hydrate and benzodiazepines. This class is contraindicated in patients with porphyria, as it can exacerbate disease. Of note, this class of drugs is not reversible.

The exact mechanism of action of propofol is unclear, but its site of action is believed to be at the gamma-aminobutyric acid receptor. It has side effects of hypotension and pain at the site of infusion. To prevent infusion pain, EPs may consider premedicating patients with IV lidocaine before propofol infusion, with a rubber tourniquet applied. This prevents pain in 60% of patients

treated.[32] Propofol use in the ED has been well-documented and proven to be effective and safe.[33,34]

Analgesics. At higher doses, opioids such as fentanyl and morphine can cause sedation in addition to analgesia. Side effects include respiratory depression, hypotension, nausea, and pruritus. When opioids are combined with propofol, effective and safe PSA can be provided.[26] Depending on the procedure, topical and subcutaneous administration of medications such as lidocaine and bupivacaine should be used as adjuncts.

Dissociative Agents. Ketamine provides both analgesia and sedation. It is relatively contraindicated in the head-injured patient, as it can raise intracranial or intraocular pressure. A seizure disorder is not a contraindication, and ketamine has even demonstrated anticonvulsant properties.[35] Involuntary movements may occur, and ketamine should be avoided for imaging studies such as computerized tomography (CT) and magnetic resonance imaging (MRI). An emergence reaction occurs in a significant minority of patients; other side effects include hypersalivation, bronchorrhea, laryngospasm, and nausea. Ketamine should be used with caution in patients with porphyria, thyroid disorder, or thyroid medications, as enhanced sympathomimetic responses have been reported anecdotally. Its use may also exacerbate known or suspected schizophrenia.[36] Traditionally administered as adjuncts to limit excessive mucosal secretions, anticholinergic agents such as glycopyrrolate and atropine have not been found to be effective in the ED setting.[35,37,38]

For laceration repairs, intravenous ketamine in combination with midazolam, as well as intramuscular ketamine used alone, were superior to intranasal midazolam in terms of sedation onset and efficacy.[31] Typical indications for ketamine use are short, painful procedures and examinations likely to produce excessive emotional disturbance (e.g., pediatric sexual assault examinations).[36]

Inhalational Agents. Nitrous oxide is combined with 30-70% oxygen and inhaled by a demand-valve mask, requiring a cooperative patient to generate sufficient negative inspiratory pressure.[4] Continuous flow delivery has been described but this requires two physicians, one to deliver the agent and one to perform the procedure, which may be impractical in many ED settings.[39] Systemic opiates, regional or local anesthesia are also recommended, as there is only mild analgesia if nitrous oxide is used alone. There is an association with spontaneous abortions in medical providers that administer nitrous oxide for more than three hours per week in the absence of scavenging equipment.[40] Other rare contraindications include use of bleomycin[41] and a history of 5,10-methylenetetrahydrofolate reductase deficiency.[42] Nausea and vomiting occur in 0.5% of patients, and more often with longer administrations, increased nitrous oxide concentrations, and fluctuations in nitrous oxide levels.[43] Higher concentrations, from 50-70%, of nitrous oxide appear to be safe and effective in children as young as 1 year old.[44]

Antagonistic. Naloxone is a short-acting opioid antagonist and can be administered intravenously, intranasally, and intramuscularly. It has a long safety record of use in children. Higher doses should be used when treating respiratory depression and not central nervous system depression alone.[45]

Flumazenil is the only benzodiazepine antagonist available, and is short-acting. It should not be used in patients with a history of long-term benzodiazepine use, as it may precipitate withdrawal symptoms and seizures. It should also be avoided when drugs known to lower seizure threshold have been ingested, such as cyclosporine, isoniazid, lithium, propoxyphene, theophylline, and tricyclic antidepressants.

Other. Ketofol is a preformed mixture, combining in equal parts ketamine at 10 mg/mL and propofol at 10 mg/mL. The combined agent is administered in 1-3 mL doses, with the median dose being 0.75 mg/kg. It has shown promise in PSA, as subdissociative amounts of ketamine and less-than-typical amounts of propofol are used with success, although further research is needed.[46] When compared to ketamine alone, ketofol demonstrates less vomiting, greater provider satisfaction scores, but only slightly faster recovery times.[47] When compared to propofol alone, ketofol demonstrates greater provider satisfaction, but does not show significant improvement in the incidence of respiratory depression, decreased propofol administration, and sedation quality.[48]

Table 7. Recommended Discharge Criteria

1. Cardiovascular function and airway patency have returned to baseline.
2. The patient is easily arousable, and protective reflexes are intact.
3. The patient can talk (if age appropriate).
4. The patient can sit up unaided (if age appropriate).
5. For a very young or handicapped child incapable of the usually expected responses, the pre-sedation level of responsiveness or a level as close as possible to the normal level for that child should be achieved.
6. The patient is adequately hydrated.

Adapted from Cote CJ, Wilson S. Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures: An update. *Pediatrics* 2006;118(6):2602.

Table 8. Nonpharmacologic Interventions to Reduce Pain and Distress with Procedures

Technique	Description
Distraction	Infant: pacifier, bubbles, toys Toddler: bubbles, songs, pop-up books, party blower, kaleidoscope, toys School-age: videos, video games, search for objects in pictures, stories, joking, counting, nonprocedural conversation Adolescent: music by headphones, video games, nonprocedural conversation, focusing on objects
Deep breathing	Have the child breathe rhythmically with slow deep breaths.
Blowing	Have the child blow out imaginary candles or take a deep breath and "blow away the pain." Party blowers have been used successfully.
Suggestion	Help the child put on a "magic glove" that does not allow pain, or apply "magic invisible cream" or turn off a "pain switch."
Superhero imagery	Have the child imagine that he or she is a superhero and the procedure is a special mission.
Guided imagery	Help the child imagine a favorite place or activity, concentrating on all the associated sensations.
Thought-stopping and positive self statements	Teach the child to think or say "Stop!" when feeling pain and then to think and say, "I can handle this," or similar positive self statements.
Rewards	Let the child know that rewards such as stickers, decorative bandages, small trophies, certificates, or prizes are available. Make behavior such as cooperation a goal, but give all children the reward.
Spot pressure or counterirritation	Rub the surrounding skin or provide spot pressure to the surrounding skin.
Sweet solution or pacifier or breast-feeding	Useful for infant for minor procedures. Give 2 mL of 30% sucrose or 30% glucose immediately before or during the procedure. Allow sucking on pacifier or breast-feeding during the procedure.
Cognitive behavior therapy	Preparation with dolls or other materials, role playing, role modeling, practicing desirable behavior, desensitization (slow introduction to subparts of procedure), hypnosis, guided imagery, progressive muscle relaxation, memory alteration
Reprinted with permission from: Young KD. Pediatric procedural pain. *Ann Emerg Med* 2005;45:166.	

Dexmedetomidine is a sedative-hypnotic with an increasing array of applications, including PSA. It can be administered intravenously or intranasally, has a short half-life of six minutes, and appears to be efficacious and safe in children. Side effects include hypotension and bradycardia.[49] There may be mild analgesia and anxiolysis associated with its use. Also, dexmedetomidine may cause less respiratory depression than benzodiazepines, barbiturates, and opiates.[50]

Remifentanil has been traditionally used in combination with other agents such as propofol, and in an elective setting. It has been used successfully as a sole agent in PSA in one small series, but further research, especially in the pediatric population and emergency setting, is required.[51]

Post-procedure Assessment and Discharge

Children receiving any form of sedation should be observed in an appropriately staffed and equipped recovery area after the conclusion of the procedure. One database study showed that the highest risk of serious adverse events occurred within 25 minutes of receiving the last dose of intravenous medication.[52] Before discharge, the patient should no longer be at risk for airway compromise or cardiopulmonary depression and should return to his or her baseline level of consciousness. Cardiac monitors and pulse oximetry should continue to monitor the patient during observation. Recommended discharge criteria are provided by the AAP (*see Table 7*); based on these, it should be noted that a return to pre-sedation ambulatory status is not required.[9]

The patient should be discharged to a responsible adult who will accompany the child and be able to monitor and react to any post-procedural complications. Discharge

instructions should be reviewed prior to discharge, with an emphasis on the signs of respiratory distress.

Special Considerations

While there is a lack of data regarding adverse outcomes in PSA, it appears that they occur more often in non-hospital-based, non-emergency department settings. This may be a reflection of the specialty of the practitioner and/or ability to recognize and treat adverse events, such as desaturation, apnea, and laryngospasm.[53] The ASA only differentiates between anesthesiologists and non-anesthesiologists, despite considerable variability of training and experience within non-anesthesiologists to rescue patients from unintended levels of sedation, as well as to perform cardiopulmonary resuscitation when needed.

About 8.6% of patients experience intraprocedural agitation, defined by struggling, crying, or requiring restraint. While agitation is not uncommon with PSA, it can occur when standard regimens and doses are used. Though rare, intraprocedural agitation appears to be associated with an increased risk of adverse outcomes, such as cardiovascular compromise, allergic reaction, use of reversal agents, and need for resuscitation.[54]

Other methods of analgesia that the EP may consider, without affecting a patient's level of sedation, include topical anesthetics, local anesthetic injection, regional anesthesia in the form of nerve blocks, and oral sucrose for neonates. Nonpharmacologic interventions are listed in Table 8.[55]

Conclusion

Pediatric patients must be carefully evaluated before PSA, as their anatomy and physiology, in addition to their acute condition, will dictate appropriate medications. Proper equipment and monitoring should be standard with each sedation and administering personnel should be well-versed in resuscitation skills. Child life specialists play an important role and are underutilized in most departments. Studies suggest that ASA guidelines are not wholly applicable to the ED setting. Ideal medications for PSA have a rapid onset and short duration of action, have few side effects, and maintain hemodynamic stability. Several medications are commonly used and no single agent is ideal for every situation. PSA provided by emergency physicians has been well-documented to be safe and effective.

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Physician CME Questions

11. The goals of sedation include:
    A. minimizing emotional and physical pain and discomfort
    B. decreasing anxiety and psychological stress
    C. controlling behavior to allow for a safe and effective procedure
    D. recovering to a pre-sedation baseline in a timely manner
    E. all of the above

12. Deep sedation is achieved when the patient:
    A. responds normally to verbal commands
    B. cannot be easily aroused but responds purposefully to noxious stimulation
    C. requires assistance to maintain airway and positive pressure ventilation
    D. becomes amnestic to the procedure
    E. has relief of pain

13. An example of an ASA Class II patient includes:
    A. patient with abscess with no past medical history
    B. diabetic toddler in diabetic ketoacidosis

Pediatric Emergency Medicine Reports

CME Objectives

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.

C. patient status-post heart transplant in severe heart failure
D. asthmatic patient well-controlled on medications with femur fracture
E. obtunded patient with severe head trauma

14. Patients should be considered for anesthesiology consultation when:
A. mild or moderate sedation is planned
B. patients are free of airway abnormalities
C. a brief procedure is anticipated
D. patients have an ASA class of III or higher

15. End-tidal capnography is effective in detecting:
A. hypoxia
B. hypoventilation
C. cardiac arrhythmias
D. allergic reactions
E. hypotension

16. Essential components of the pre-sedation assessment include:
A. chest radiograph
B. electrocardiogram
C. detailed history and focused physical examination
D. vascular access
E. fasting status of 12 hours or more

17. In the sedative-hypnotic class of medications:
A. etomidate has both analgesic and sedative properties
B. ketamine has both analgesic and sedative properties
C. reversible agents include chloral hydrate, methohexital, and propofol
D. hypotension is not a recognized side effect of propofol use

18. Nitrous oxide in the emergency department:
A. can be used when the patient is agitated and uncooperative
B. should only be used in children greater than 8 years old
C. is frequently associated with nausea as a side effect at lower concentrations
D. only has mild analgesic properties, and combination with an analgesic is recommended.

19. When considering ketamine use:
A. anticholinergic agents as adjuncts, to limit excessive mucosal secretions, are not necessary in the ED setting
B. midazolam should be used as an adjunct to prevent emergence reactions
C. it is an ideal agent for PSA when movement must be minimized during imaging
D. its use is contraindicated in patients with seizure disorder

20. Discharge criteria after PSA include:
A. adequate hydration status
B. return to pre-sedation level of responsiveness
C. ability to talk and sit un-aided, if age appropriate
D. stable cardiovascular function and airway patency
E. all of the above

CME Instructions

HERE ARE THE STEPS YOU NEED TO TAKE TO EARN CREDIT FOR THIS ACTIVITY:

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2. Log on to **www.cmecity.com** to take a post-test; tests can be taken after each issue or collectively at the end of the semester. *First-time users will have to register on the site using the 8-digit subscriber number printed on their mailing label, invoice, or renewal notice.*

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Pediatric Emergency Medicine Reports

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Pediatric Procedural Sedation and Analgesia

Goals of Sedation

- Maintain patient safety
- Obtain cooperation of the patient
- Minimize emotional and physical discomfort in patient and parent(s)
- Decrease anxiety and psychological stress in patient and parent(s)
- Maximize amnesia to a painful procedure
- Control behavior to allow for a safe and effective procedure
- Recover to a pre-sedation baseline in a timely manner

Levels of Sedation

Level of sedation	Minimal sedation	Moderate sedation	Deep sedation	General anesthesia
Responsiveness	Normal response to verbal stimulation	Purposeful response to verbal or tactile stimulation	Purposeful response after repeated or painful stimulation	Unarousable, even with painful stimulus
Airway	Unaffected	No intervention required	Intervention may be required	Intervention often needed
Spontaneous ventilation	Unaffected	Adequate	May be inadequate	Frequently inadequate
Cardiovascular function	Unaffected	Usually maintained	Usually maintained	May be impaired

Adapted from: American Society of Anesthesiologists. Task force on sedation and analgesia by non-anesthesiologists. Practice guidelines for sedation and analgesia by non-anesthesiologists. *Anesthesiology* 2002;96:1005.

ASA Physical Status Classification

Class	Description	Examples	Suitability for Sedation
I	A normally healthy patient	Unremarkable medical history	Excellent
II	A patient with mild systemic disease (no functional limitation)	Mild asthma, controlled seizure disorder, anemia, controlled diabetes mellitus	Generally good
III	A patient with severe systemic disease (definite functional limitation)	Moderate-to-severe asthma, poorly controlled diabetes mellitus, moderate obesity	Intermediate to poor; consider benefits relative to risks
IV	A patient with severe systemic disease that is a constant threat to life	Severe bronchopulmonary dysplasia, sepsis, advanced degrees of pulmonary, cardiac, hepatic, renal, or endocrine insufficiency	Poor; benefits rarely outweigh risks
V	A moribund patient who is not expected to survive without the operation	Septic shock, severe trauma	Extremely poor

Procedural Sedation Resources

Equipment

Suction: Appropriate-sized suction catheters and suction apparatus

Airway:
- Oxygen
- Bag valve mask
- Oropharyngeal and nasopharyngeal airways
- Laryngoscope with appropriately sized blades
- Endotracheal tubes, stylets
- Laryngeal mask airway
- Cricothyroidotomy kit

Monitors:
- ECG monitor
- Pulse oximeter
- End tidal CO_2 monitor
- Defibrillator with pads

Pharmacy:
- Normal saline
- ACLS drugs
- RSI agents
- Reversal agents
- Antiemetic agents

Pharmacologic Agents Used in Procedural Sedation for Children

Sedative-hypnotic	Dose and route	Onset (min)	Duration (min)	Contraindications
Etomidate	IV: 0.1-0.3 mg/kg, repeat if inadequate	< 1	5-15	Adrenal insufficiency
Midazolam	IV (0.5-5 years): 0.05-0.1 mg/kg, titrate to max 0.6 mg/kg	2-3	45-60	Hypotension
	IV (6-12 years): 0.025-0.05 mg/kg, titrate to max 0.4 mg/kg			
	IM: 0.1-0.15 mg/kg	10-20	60-120	
	Oral: 0.5 mg/kg	15-30	60-90	
	Intranasal: 0.2-0.5 mg/kg	10-15	60	
	Rectal: 0.25-0.5 mg/kg	10-30	60-90	
Methohexital	IV: 0.5-1 mg/kg			Porphyria
	Rectal: 25 mg/kg	10-15	60	
Pentobarbital	IV: 1-6 mg/kg, titrate 1-2 mg/kg doses every 3-5 min	3-5	15-45	Porphyria
	IM: 2-6 mg/kg, max 100 mg	10-15	60-120	
	Oral or rectal (< 4 years): 3-6 mg/kg, max 100 mg	15-60	60-240	
	Oral or rectal (> 4 years): 1.5-3 mg/kg, max 100 mg			
Thiopental	Rectal: 25 mg/kg	10-15	60-120	Porphyria
Propofol	IV: 1 mg/kg, titrate 0.5 mg/kg doses	< 1	5-15	Egg, soy, or sulfite allergy
Analgesic				
Fentanyl	IV: 1 ug/kg up to 50 ug/dose, repeat every 3-5 min	3-5	30-60	
	Intranasal: 1.5-2 ug/kg	5-15	120-240	
Morphine	IV: 0.05-0.15 mg/kg up to 3 mg/dose, repeat every 3-5 min	5-10	120-180	
Dissociative				
Ketamine	IV: 1-1.5 mg/kg, repeat every 10 min	1	15-60	Age < 3 months, schizophrenia
	IM: 4-5 mg/kg, repeat 2-4 mg/kg after 10 min	3-5	15-150	
Inhalational				
Nitrous oxide	Preset mixture with minimum 30% oxygen	2-3	< 5	Pregnant medical provider, bleomycin use, reductase deficiency
Antagonistic				
Naloxone	IV or IM: 0.1-0.4 mg, max 2 mg/dose, repeat every 3 min, max 10-20 mg	IV: 2	IV: 20-40	
Flumazenil	IV: 0.02 mg/kg/dose, repeat every 1 min up to 1 mg	1-2	30-60	Long-term benzodiazepine use Use carefully in children with a seizure disorder

Min = minutes; max = maximum; IV = intravenous; IM = intramuscular

Adapted from: Krauss B, Green SM. Procedural sedation and analgesia in children. *Lancet* 2006;367:772.

Planning and Preparation for PSA, SOAP-ME Mnemonic

S (suction)	Size-appropriate suction catheters and a functioning suction apparatus (placed on right side of patient's head)
O (oxygen)	Adequate oxygen supply and functioning flow meters/other devices to allow its delivery
A (airway)	Size-appropriate airway equipment (nasopharyngeal and oropharyngeal airways, laryngoscope blades [checked and functioning], endotracheal tubes, stylets, face mask, bag-valve mask or equivalent device [functioning])
P (pharmacy)	Emergency medications including antagonists
M (monitors and medications)	Functioning pulse oximeter with size-appropriate oximeter probes and other monitors as appropriate for the procedure (e.g., noninvasive blood pressure, end-tidal carbon dioxide, electrocardiogram, stethoscope).
E (equipment)	Special equipment as needed based on the patient and the procedure

Supplement to *Pediatric Emergency Medicine Reports*, August 2011: "Pediatric Procedural Sedation and Analgesia in the Emergency Department." *Authors:* **Derya Caglar, MD,** Assistant Professor, University of Washington School of Medicine, Attending Physician, Division of Emergency Medicine, Seattle Children's Hospital, Seattle, WA; and **Richard Kwun, MD**, Attending Physician, Department of Emergency Medicine, Swedish Medical Center, Issaquah, WA.