Pediatric Pain Management in the Emergency Department

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Emergency care for children and adolescent patients accounts for about one third of the nation’s emergency department (ED) visits each year [1]. Many of these pediatric visits are related to painful injuries from trauma and accidents. Children also frequently present to emergency departments having painful medical and surgical conditions that are not related to trauma. Therefore, emergency physicians and the entire emergency care team should be proficient in the assessment and safe management of pain in children. Yet effective, compassionate pediatric pain management can be challenging, because there are many special considerations when providing pediatric analgesia. Choosing the most appropriate method in a given patient and situation entails assessment of the child’s acute medical condition, emotional and cognitive capabilities, and an understanding of his or her baseline chronic anatomic and physiologic state related to chronic medical conditions and age. Because the provision of effective pain relief in children also often requires a team effort to provide anxiolysis or sedation, emergency physicians need to understand their resources and ensure that the ED staff is adequately trained, and that the ED is appropriately equipped for the team effort of close monitoring during sedation with analgesia.

Over the past 25 years, pediatric emergency medicine research and literature have progressively augmented our knowledge of safe and effective pediatric pain management strategies. Yet there is still much more we need to do to understand the painful experiences of children and to develop
optimal safe ways of addressing those needs within the system and context of a busy pediatric ED. In this article, the authors review the history of ED pediatric pain management and sedation, discuss special considerations in pediatric pain assessment and management, review various pharmacologic and nonpharmacologic methods of alleviating pain and anxiety, and present ideas to improve the culture of the pediatric ED, so that it can achieve the goal of becoming pain-free.

**History of pediatric pain management and procedural sedation**

Fortunately, pediatric analgesia and sedation practices have advanced dramatically in the past 25 years. In response to the need to prevent complications and deaths from unsafe sedation practices, the American Academy of Pediatrics (AAP) published The Sedation Guidelines in 1985 [2]. At that time, undertreatment of pain and anxiety was very common, and many children were simply immobilized for procedures. Those patients who were administered some medications commonly received choral hydrate or an intramuscular injection of a combination of meperidine, promethazine, and chlorpromazine (demerol, phenergan and thorazine, or the “DPT lytic cocktail”). In 1990, Selbst and Clark [3] showed that children who presented to an emergency department were much less likely than adults to receive pain medications for the painful conditions of sickle cell crisis, lower extremity fractures, or second- to third-degree burns.

The results of a survey on emergency sedation practices published in 1990 [4] for pediatric laceration repair showed that over 10% of emergency departments never provided pediatric sedation, that meperidine was the most commonly used drug in emergency departments for pediatric sedation and analgesia, and that only a small minority of institutions had formal discharge criteria after sedation. The safety profile and efficacy of the DPT lytic cocktail was described by Terndrup et al in 1991 [5]. In that study, there were no serious complications, but 29% of the patients were insufficiently sedated, and patients remained affected by the drugs for extended time periods, long after the procedure was over. Now the use of that drug combination is no longer recommended, because we have safer and more effective drug alternatives for pediatric analgesia and sedation [6].

It became apparent that the 1985 AAP guidelines were not being widely used to assure safe practices, so in 1992 the AAP published “The Guidelines for Monitoring and Management of Pediatric Patients During and After Sedation of Diagnostic and Therapeutic Procedures” [7]. This document was written by the AAP Committee on Drugs and established guidelines for which patients should be sedated and when they should be sedated, medical personnel and training, availability of equipment and medication, documentation, monitoring, and safe discharge practices.

The American Academy of Emergency Physicians Pediatric Committee published its own statement on pediatric sedation and analgesia in 1994 [8]...
and stated that “sedation and analgesia are essential components of the ED management of pediatric patients.” The statement provided a practice guideline, including documentation and patient selection and discharge criteria as well as a summary of medication choices.

By 2000, there had been numerous advances and widespread increase in the use of agents to improve pediatric painful conditions, such as the use of topical agents such as Lidocaine, Epinephrine, Tetracaine (LET) and Eutectic Mixture of Local Anesthetics (EMLA), improvement in the techniques of the use of local agents, and greater use of a variety of analgesics, sedatives, and anxiolytics. Many emergency departments are now actively expanding the use of nonpharmacologic adjuncts such as distractions (toys, music, games), child life therapists, imagery, and increased parental involvement in order to improve the experience of children during their emergency department care.

The pain-free pediatric ED is a laudable goal, which many departments now strive to attain through comprehensive efforts that start from the moment a child presents to triage with a painful condition. Standard curricula that many hospitals require for pediatric and emergency medicine credentialing emphasize pediatric sedation and pain management. The 2002 Pediatric Advanced Life Support (PALS) Provider Course contains an educational module on pediatric sedation[9]. The 2004 edition of the Advanced Pediatric Life Support (APLS) text [10] likewise includes a chapter on pediatric analgesia and sedation.

Thus it is clear that there have been dramatic improvements in and increased acceptance of the use of analgesia and sedation in emergency medical care of children over the past 2 decades. Future directions include more widespread use of technical advances such as capnography during sedation [11,12], increased awareness of systems issues that could lead to risk with analgesia and sedation, expanded use of some drugs, and increased education and regulations for the entire emergency health care team when providing pediatric analgesia and sedation.

How children differ from adults with respect to pain management

There are numerous reasons why the management of pediatric pain in the ED can differ dramatically from pain management in adults. One of the most striking differences is related to the cognitive abilities and developmental status of the child. Respiratory mechanics and airway anatomy are also different in infants and children in comparison with adults. Likewise, children metabolize some medications differently than adults. Due to their small body size, drug toxicities with agents such as local anesthetics may be a greater risk.

To safely and effectively manage pediatric pain, emergency physicians need a practical understanding of these differences.

The hospital environment and medical personnel can be terribly frightening to some children, which has the potential to increase their perception of pain. Parents may also be anxious about their child’s condition,
which can augment the fear in a child. Yet if children are separated from their parents, the child will likely become even more frightened. Because of their cognitive immaturity, children can have difficulty understanding the need for and nature of particular treatments. This can increase their lack of cooperation and make any treatments or procedures more difficult. These barriers can be greatest in children who have developmental delays or in very young children. Emergency physicians and the entire ED staff should take these issues into consideration when working with children, and attempt to maximize nonpharmacologic interventions in order to reduce anxiety and gain the cooperation of the child. When nonpharmacologic interventions are inadequate to overcome the patient’s apprehension, sedation is often needed to proceed with a necessary procedure or to obtain imaging studies.

Respiratory physiology and airway anatomy in small children have many differences in comparison with adolescents and adults. These differences should be considered when planning parenteral analgesia and sedation. Small children have a relatively high oxygen consumption and low alveolar volume with respect to weight. Therefore, they will desaturate more rapidly with periods of apnea in comparison with adults [13]. Upper respiratory tract infections are very common in toddlers, which can increase the risk of sedation by increasing the frequency of mild desaturations during the sedation or in the recovery period [14]. The tongue is relatively larger in the oropharynx, and it can easily fall back into the airway during moderate or deep sedation. The large occiput means that extra attention is needed to position the head during sedation and ensure optimal airway position. Appropriately sized airway equipment should be immediately available during any sedation.

The absorption and metabolism of some drugs changes as neonates mature to infants and toddlers. Choosing the correct dose of drugs, including analgesics and sedatives, will not always be as straightforward as dosing on a milligram per kilogram basis. As the body grows, there are changes in body composition. This alters the physiologic spaces into which a drug may be distributed. Hepatic enzyme systems, protein binding of drugs related to plasma concentration of proteins, renal filtration and excretion of drugs and their metabolites, metabolic rate, and respiratory physiology all mature and change as infant develops. Therefore, clinicians should have easy access to references when choosing the doses of medications such as analgesics and sedatives [15].

**Pain assessment in children**

There are many published guidelines for the assessment and management for pediatric pain [16–20]; however, guidelines and continuing medical education do not necessarily alter health care provider behavior [21,22]. It is important to realize that appropriate pediatric pain assessment must begin with educating our providers and supervisors about not only the measurement of pediatric pain, but also the specific factors involved in the evaluation of pain.
To be adequate, assessment of pediatric pain should be individualized, comprehensive, measured, continuous, monitored, and documented [23–25]. Pain is an inherently subjective multifactorial experience, and should be assessed as such. Pain is unique to each individual, and is influenced by several factors, including age [26], race [27], gender [28,29], culture [17,30], emotions, cognitive ability [20,31], expectations, and prior experience [17,20,32]. Despite this, current evidence has shown lack of assessment and treatment of pain by health care providers in many settings [23,31,33,34]. Even when pain is assessed, it is often underestimated by health care providers [35–37]. Although the focus on assessment has resulted in possibly better documentation of patients’ pain, it has not resulted in better treatment of pain [20,38,39].

Patient self-reporting is considered the “most reliable indicator of the existence and intensity of pain” [39,40]. The lack of objective measurement in self-reporting of pain can be frustrating, and makes direct quantitative assessment difficult. Children as young as 2 can give providers some information about their degree of pain, and should be believed [20]; however, parents and providers often do not believe a child’s self-report of pain and believe that children may exaggerate their suffering to obtain secondary gain [41]. It has been documented that care providers often diminish pediatric suffering and alleviate their own assessment frustration by accusing children of protesting too much [42].

So, how does one remain unbiased and measure self-reporting of pain? As other authors in this issue describe, pain is complex and multidimensional, and cannot be easily quantified by one-dimensional parameters such as blood pressure or pulse rate. Pain involves psychological, behavioral, physiological, and emotional components [33,39,42]. The interactions of these components explain why there is variation in patients’ response to pain and perception of pain. Also, the degree of injury or tissue damage alone is an inefficient method for determining a patient’s appropriate pain intensity [43]. Finally, many pediatric patients are unable to self-report pain level [39,42], making it necessary to rely on behavioral and physiological observations and knowledge of the specific pathophysiologic processes involved.

The ideal tool for pain measurement and assessment should include the acknowledgment, intensity, and continued measurement of the pain in regards to therapy and time. This multidimensional tool should also account for all the factors that influence pain perception and intensity. Also, the tool should remain unbiased with regards to culture, age, cognitive state, ethnicity, gender, and previous pain experiences. Because of the complexity required for the ideal multidimensional measurement tool, one-dimensional pain scales have been developed for use in the acute pain setting in children above the age of 3. These scales rely on the ability of the child to self-report and his or her appropriate cognitive ability. Some one-dimensional scales that have been validated and used in the school aged pediatric population to measure and assess pain include: (1) the modified Visual Analog Scale (VAS) [44,45], (2) the Oucher Scale [46,47], (3) the Colored Analog Scale.
The Faces Pain Scale [49,50], the Body Outline Tool [51,52], and the Poker Chip Tool [39]. These are described in Box 1.

There are also several multidimensional tools available for pediatric pain assessment that incorporate behavioral patterns and physiologic signs for children who are nonverbal or who have decreased cognitive ability [39]. These are listed in Box 2.

Use of these scales to assess pediatric pain has been shown to be inferior to self-report [51]; however, younger children and neonates who lack verbal communication skills and children who have limited cognitive ability necessitate the use of these pain assessment tools that rely solely on physiologic and behavioral indicators. These scales have not been well studied in the ED, but have been used and validated in other settings such as the intensive care unit and the operating room [39,52,55,60].

Because of the paucity of validated pain assessment research in the ED setting, no specific scale or measurement tool can be endorsed. Until such research is available, the use of one-dimensional tools in the acute pain

<table>
<thead>
<tr>
<th>Box 1. One-dimensional pain scales</th>
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<tbody>
<tr>
<td><strong>Visual analog scale (VAS)—no pain to worst pain</strong></td>
</tr>
<tr>
<td>A 100 mm line on which patients place a mark to estimate their pain and the distance from the origin (no pain) is measured.</td>
</tr>
<tr>
<td><strong>Oucher Scale</strong></td>
</tr>
<tr>
<td>A vertical numerical scale from 10 to 100 for children who can count to 100, with a corresponding vertical photographic scale of expressions of no hurt to worse hurt. Pictures are available in different races.</td>
</tr>
<tr>
<td><strong>Colored Analog Scale (CAS)</strong></td>
</tr>
<tr>
<td>Colors are assigned (markers or crayons) for ”most or worst hurt,” ”a little less hurt,” and ”no hurt.” A numeric value can also be placed on each color.</td>
</tr>
<tr>
<td><strong>Faces Pain Scale</strong></td>
</tr>
<tr>
<td>Six cartoon faces ranging from very happy (smiling face) to very sad (sad face).</td>
</tr>
<tr>
<td><strong>Body Outline Tool</strong></td>
</tr>
<tr>
<td>The child marks an X or colors the painful area on a non gender-specific line drawing of a child’s body. Different colors can be used to quantify the pain.</td>
</tr>
<tr>
<td><strong>Poker Chip Tool</strong></td>
</tr>
<tr>
<td>Four poker chips are used; one chip represents a little hurt and four chips is the most hurt the child could experience.</td>
</tr>
</tbody>
</table>
setting is recommended for appropriate children. The Oucher Scale [46,47] for assessment in children above 3 years of age is recommended for the prehospital setting [61]. For the noncommunicative child and children who have decreased cognitive ability, scales that incorporate behavioral and physiologic markers must be used to guide therapy [30,31,39]. The American Pain Society, in conjunction with the American Academy of Pediatrics, states that “Observation of behavior should be used to complement self-report and can be an acceptable alternative when valid self-report is not available” [31]. Until further research is done to validate assessment tools that rely on physiologic and behavioral markers, it is best to use a multidisciplinary team to decide which assessment tool is most appropriate in a setting [39]. Finally, pain management does not end with proper assessment. Focus on provider education should be on the adequate

Box 2. Multidimensional pain scales that incorporate behavioral patterns and physiologic signs, showing appropriate age range of patients

*Postoperative pain*
- Postoperative Pain Score (POPS); 0–3 years [53]
- Liverpool Infant Distress Scale (LIDS); neonates [54]
- Neonatal Facial Coding System (NFCS); neonates <4 months [55]
- FLACC (face, legs, activity, cry, consolability);
  - 2 months–7 years [56]
- Toddler-Preschooler Postoperative Pain Scale (TPPS);
  - 1–5 years [56]
- COMFORT; 0–3 years [56]
- Children’s Hospital of Eastern Ontario Pain Scale (CHEOPS);
  - 1–7 years [57]

*Procedural pain*
- Crying, Requires oxygen to maintain saturation greater than 95%,
  - Increased vital signs, Expression, Sleepless (CRIES);
  - neonates [58]
- Pain Assessment Tool (PAT); neonates [39]
- Neonatal Infant Distress Scale (NIDS); neonates [52]
- Modified Behavioral Pain Scale (MBPS); 4–6 months [59]
- Neonatal Assessment of Pain Inventory (NAPI); 0–3 years [60]

*Decreased cognitive ability*
- Noncommunicating Child’s Pain Checklist—Postoperative Version (NCCPC-PV) [56]

*Modified from Ref [39].*
treatment and relief from unnecessary suffering for the patient, not just on the initial assessment and documentation of pain.

Nonpharmacologic interventions

Appropriate therapy for pediatric patients in pain should not be limited to analgesia or anesthesia. Although appropriate use of analgesia is important, there are many nonpharmacologic interventions recommended to improve pain management [62–64]. Nonpharmacologic therapy can be assigned to three broad categories: (1) cognitive, (2) behavioral, and (3) physical. Nonpharmacological therapeutic interventions include

Cognitive
- Music, guided imagery, distraction, positive reinforcement, decentralization, hypnosis

Behavioral
- Relaxation techniques, biofeedback exercises, breathing control

Physical
- Heat and cold application, massage or touch, position and comfort, temperature regulation, transcutaneous electrical nerve stimulation, acupuncture, chiropractic, immobilization

Several cognitive, behavioral, and physical interventions have been shown to be effective [39,62,63]. To understand the possible mechanism of action for these nonpharmacologic therapies, a basic understanding of the gate control hypothesis is necessary. The gate control hypothesis has been one proposed mechanism for the effectiveness of these nonpharmacologic interventions [64]. This hypothesis postulates the presence of blocking or gating mechanisms along the pain pathway, prohibiting pain from reaching the brain through stimulation of inhibitory neurons. These neurons can be stimulated and close the “pain gates” through stimulation of nonpainful receptors or excitatory messages from the brain itself [65]. A more thorough discussion of the pathophysiology of pain and this hypothesis can be found in the articles on pathophysiology by Fink and on chronic pain by Hansen elsewhere in this issue.

Cognitive

Music [66], guided imagery [64], distraction [67], and hypnosis [68–71] are examples of cognitive therapies that have been shown to be effective in reducing patient’s pain. The use of cognitive interventions may help distract the patient and improve control over pain, and may even contribute to endorphin release [65]. In the United Kingdom, the Royal College of Pediatrics and Child Health [72] recommends a dedicated play therapist in accident and emergency (A & E) departments who
treat more than 18,000 pediatric patients per year. Patient cooperation and provider education are necessary for cognitive interventions to be successful.

**Behavioral**

Behavioral techniques have also been used with success in pain management. Some of the interventions include: relaxation techniques, biofeedback exercises, and breathing control [73–76]. These techniques also aid in distracting the patient and shifting the focus from pain; however, these interventions also require education for the provider and patient to be effective.

**Physical**

Most providers probably provide physical interventions as part of their routine management to pediatric patients in pain; however, there are several techniques that are probably neglected or are not fully used. Some of the physical strategies that have been proven to be useful include heat and cold application [77,78], massage or touch [77], position and comfort (splinting) [79], temperature regulation, acupuncture [80,81], and transcutaneous electrical nerve stimulation [82].

**Pharmacologic methods of treating pain in pediatric patients**

There are numerous factors that impact the appropriate choice of an analgesic when a child presents too the ED with a painful condition. The severity of pain or nature of the underlying illness or injury will dictate whether an intravenous catheter is indicated. Intravenous access may then change the approach to pain management. Clinicians need to understand that analgesics and sedatives can have some overlapping properties, because some analgesics also partially sedate. Reducing anxiety will help a child’s perception of the situation and help him cope with the pain; however, pure sedatives do not have analgesic properties, and analgesics are much less effective as a sedative than a pure sedative is. Therefore, when choosing drugs to treat pain, it is important to choose the agent or combination of agents that will achieve your desired goals [59].

Specific techniques and therapies to address common painful conditions in the ED and reduce the pain of specific common ED procedures are discussed in a subsequent section. Local and topical anesthetics will be discussed there.

Tables 1 and 2 show commonly used systemic analgesics for pediatric patients in the emergency department. Meperidine doses are not listed because its use is not recommended, due to its unfavorable effect of lowering of the seizure threshold from the accumulation of its metabolite, normeperidine.
If the patient experiences mild respiratory depression due to narcotics, mild verbal stimulation can be tried to encourage deeper breathing. Naloxone should be immediately available in the emergency department for respiratory depression related to narcotic use that cannot be resolved with verbal stimulation. If the respiratory situation is not too urgent, very small doses of naloxone can be titrated to effect while trying to avoid extreme pain or withdrawal symptoms. The dose of naloxone will be determined by the urgency of the situation and degree of respiratory depression. If the situation is not too urgent, 2 microgram/kg doses can be given incrementally over several minutes while following respiratory effort. If the situation is more urgent, a 10–20 microgram/kg dose may be needed while providing assisted ventilation [85].

One special consideration is for neonates receiving opiates. Narcotic clearance is slower in neonates, and it increases over the first 2 to 6 months of life to mature clearance rates. It is recommended that neonates who receive narcotics be placed on continuous pulse oximetry monitoring and be observed in an area where rapid airway intervention can be provided, due to the risk of apnea [85].

Table 1
Mild to moderate pain—NSAIDS and weak analgesics

<table>
<thead>
<tr>
<th>Drug</th>
<th>Route</th>
<th>Mg/Kg and interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetaminophen</td>
<td>PO</td>
<td>10–15 mg/kg every 4 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maximum total dose: 75 mg/kg/day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adult dose: 4 grams/day</td>
</tr>
<tr>
<td>Ibuprofen</td>
<td>PR</td>
<td>10–15 mg/kg every 4–6 hours (25–40 mg/kg first dose)</td>
</tr>
<tr>
<td>Ketorolac (approved for</td>
<td>PO</td>
<td>4–10 mg/kg every 6 hours</td>
</tr>
<tr>
<td>children 2–16 years)</td>
<td>IV</td>
<td>0.5 mg/kg to a maximum of 15 mg as a single dose</td>
</tr>
<tr>
<td></td>
<td>IM</td>
<td>1 mg/kg to a maximum of 30 mg as a single dose</td>
</tr>
</tbody>
</table>

Abbreviations: IM, intramuscular; IV, intravenous; PO, by mouth; PR, per rectum.
Data from Refs [83,84].

Table 2
Moderate to severe pain—initial doses opioid analgesics

<table>
<thead>
<tr>
<th>Drug</th>
<th>Route</th>
<th>Dose for child &lt; 50 kg</th>
<th>Dose for child &gt; 50 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Codeine</td>
<td>PO</td>
<td>0.5–1.0 mg/kg every 3–4 hr</td>
<td>30–60 mg every 3–4 hr</td>
</tr>
<tr>
<td>Oxycodone</td>
<td>PO</td>
<td>0.1–0.2 mg/kg every 3–4 hr</td>
<td>5–10 mg every 3–4 hr</td>
</tr>
<tr>
<td>Hydrocodone (combined</td>
<td>PO</td>
<td>0.05–0.2 mg/kg every 4–6 hr</td>
<td>5–10 mg every 4–6 hr</td>
</tr>
<tr>
<td>with acetaminophen)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morphine</td>
<td>IV/sq</td>
<td>0.1 mg/kg every 2–4 hr</td>
<td>5–8 mg every 2–4 hr</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>IV/sq</td>
<td>0.5–1.0 microgram/kg every 1–2 hr</td>
<td>25–50 microgram every 1–2 hr</td>
</tr>
<tr>
<td>Hydromorphone (dilaudid)</td>
<td>IV/sq</td>
<td>0.02 mg/kg every 2–4 hr</td>
<td>1 mg every 2–4 hr</td>
</tr>
</tbody>
</table>

Data from Refs [10,85,86].
Pediatric procedural sedation

Children who arrive in the ED having a painful condition are often anxious and agitated about the pain they are experiencing. The environment of the ED may also be quite frightening to a child. When procedures are performed that increase discomfort, children’s anxiety can escalate even further. To adequately manage their condition in a humane fashion, nonpharmacologic interventions should be tried to calm patients. Frequently, however, this is not adequate to allow the child to relax and cooperate with therapy. Emergency physicians need the knowledge and clinical skills to safely and effectively provide sedation that can be combined with analgesia for the pediatric patient who has a painful condition or who will undergo a painful procedure in the ED. A comprehensive review of the details of the pharmacology of all sedative options is beyond the scope of this article, but important features of sedatives which are particularly useful in children in the emergency department are summarized.

Pediatric sedation is similar to adult sedation in many aspects. As in adult patients, the pediatric patient should have a history and physical examination before sedation. The American Society of Anesthesiologists (ASA) physical status classification system should be used to give the patient an ASA class. Typically, only those pediatric patients in Class I (normally healthy person) or Class II (mild systemic disease) receive monitored sedation by emergency physicians in the ED. Timing of the last oral intake is an important piece of history, because it will affect the plans for sedation. Clinicians should weigh the issue of the urgency of the patient’s physical condition with the information about the timing of last oral intake when planning the timing of the monitored sedation [87]. Each ED should have a protocol for documentation of sedation, and all the necessary airway equipment and reversal agents should be at the bedside before administration of the sedative. The physician should anticipate the desired goal of the depth of sedation, whether it be minimal (anxiolysis), moderate, or deep sedation [10]. In addition to continuous pulse oximetry, continuous capnography is a newer technology that is adding a greater dimension of safety for sedation [11]. These issues apply to all patients, children or adults.

Procedural sedation for pediatrics is a group of skills and body of knowledge for which hospitals require specific credentialing. To ensure that their medical staff members are adequately trained before credentialing, some hospitals will require certain courses and documentation of prior experience. The anesthesia group at Dartmouth Hitchcock Medical Center in Lebanon, New Hampshire has taken a lead nationally with its educational efforts on safe procedural sedation in children. The Dartmouth Hitchcock Medical Center Pediatric Sedation Course material can be downloaded from the internet [88]. This course is one example of a method to improve the understanding of sedation amongst all the team involved in emergency pediatric sedation.
There are numerous appropriate choices of sedatives that can be combined with analgesics to provide procedural sedation for children. The drug or combination of drugs chosen for a particular patient will depend on many factors, including the acute medical or surgical condition of the child, chronic medical conditions, timing of last oral intake, experience of the emergency team with particular drugs, the desired depth of sedation, and the anticipated length of time the child will require sedation. Listed below are some of the important features of commonly used sedatives in the emergency care of children.

**Ketamine**

Ketamine produces a state of trancelike dissociation and the effects of sedation, analgesia, and amnesia. One reason why it is very popular for pediatric sedation in the ED is its safety profile and the preservation of airway reflexes. It is most commonly administered by the intravenous (IV) or intramuscular route, but may also be given orally or rectally. When given IV, care should be taken that it be administered over 1 to 2 minutes to avoid laryngospasm, which is a rare complication. Ketamine may increase oral secretions, so the concomitant administration of atropine or glycopyrrolate will reduce that effect. Emergence reactions are common in adults, but uncommon in children, and can be treated with benzodiazepines if they occur. Contraindications to the use of ketamine include head injury or concern of increased intracranial pressure, increased intraocular pressure, and psychosis. Initial intravenous dose is 0.05 to 1.0 mg/kg with titration to effect. Generally, 2 mg/kg will be the maximum needed for initial sedation, but further doses may be administered if the procedure is lengthy. The usual intramuscular dose is 4 to 5 mg/kg [89,90].

**Benzodiazepines**

Midazolam is the benzodiazepine that is used most commonly for procedural sedation, because it is short acting. It causes sedation and amnesia and anxiolysis, although some children have paradoxical disinhibition and increased agitation with low doses. It can be given orally at 0.3 to 0.7 mg/kg, or by the IV or intramuscular route at 0.05 to 0.2 mg/kg. The intranasal route is irritating to the nasal mucosa and is less preferred. The benzodiazepines have no analgesic properties and are frequently combined with opiates for painful procedures. Diazepam and lorazepam are other benzodiazepines, but due to their longer action, they are less popular for procedural sedation in the emergency department. Flumazenil is the reversal agent for benzodiazepines, and its dose is 0.01 mg/kg to a maximum of 0.2 mg/kg. It should be immediately available for monitored sedation performed with benzodiazepines to reverse respiratory depression which cannot be improved with stimulation [10,90].
**Barbiturates**

Barbiturates are another class of pure sedatives with no analgesic properties. They work on the gamma-aminobutyric acid (GABA) receptors in the brain. They can produce respiratory depression and hypotension, and are contraindicated in people with porphyria. Pentobarbital and methohexital are the two commonly used barbiturates for pediatric procedural sedation. Pentobarbital is a short-acting agent that may be administered by the IV, intramuscular, or rectal route. Administering this drug by the intravenous route allows smooth titration when giving an initial dose of 2.5 mg/kg followed by subsequent doses of 1.25 mg/kg. Methohexital is a very rapid-acting barbiturate that is frequently administered rectally in a dose of 18 to 25 mg/kg, but can also be given intravenously as a 0.5 to 1 mg/kg dose [10,90].

**Propofol**

Propofol is a disubstituted phenol. It rapidly reaches high concentrations in the brain for quick sedation, and it also has a rapid recovery time. These pharmacokinetic features are desirable for short procedures in the ED. Experts in sedation recommend capnography in addition to continuous pulse oximetry while administering propofol, because of this drug’s potential to cause significant respiratory depression. Hypotension is another potential side effect. It has anticonvulsant and amnestic properties, but it is not an analgesic, so many physicians give a dose of fentanyl before administration of propofol for painful procedures. Propofol is commonly dosed as a 1 mg/kg bolus followed by incremental 0.05 mg/kg doses. When a longer procedure is planned, a propofol drip or intermittent small supplemental doses will be needed because of the rapid recovery [91–93].

**Etomidate**

Although not currently approved for children younger than 12, this drug is gaining in popularity for pediatric sedation because physicians have gained comfort in its use for rapid sequence induction before intubation. The dose of etomidate will depend on the intended purpose. When used for sedation, the etomidate dose is 0.1–0.2 mg/kg IV. When used as an induction agent prior to intubation, the dose is 0.2–0.6 mg/kg IV. It is a pure sedative with no analgesic properties. Etomidate can cause myoclonic jerks, which may limit its use if the patient needs to be fairly motionless for imaging studies [8,10].

**Nitrous oxide**

Nitrous oxide is an odorless, tasteless gas that is used in combination with oxygen as an inhalational sedative-hypnotic. It is administered to
Reducing pain with common painful emergency department procedures

Many children are frightened with the prospect of getting a “shot” when they see medical personnel; however, the pain of needle sticks for blood draws and intravenous line placement, intramuscular injections, spinal taps, and laceration repair can all be reduced with the application of the following techniques.

Techniques for blood draws and intravenous lines

EMLA (AstraZeneca, Wilmington, Delaware) is a combination of lidocaine and prilocaine, which comes in both a cream and a disc formulation. The cream must be used with an occlusive dressing, but the disc has the advantage of being more convenient, and the occlusive dressing is not needed. EMLA results in anesthesia down to 3 to 4 mm, but one disadvantage is that it takes 60 minutes to achieve maximal effect. EMLA can cause vasoconstriction, which can make vein cannulation more difficult. It is available by prescription only. A newer topical anesthetic is ElaMax (Ferndale Laboratories, Ferndale, Michigan), which is 4% lidocaine. It works more rapidly, achieving its maximal effect in 30 minutes. Because ElaMax can be purchased over the counter without a prescription, parents of children who have chronic illnesses can purchase it and apply this medication even before arrival to the emergency department if they anticipate the need for blood work or an intravenous line [96,97].

Lidocaine iontophoresis, Numby Stuff (Iomed, Salt Lake City, Utah), is an alternative to topical anesthetics for line placements. The iontophoresis device drives a solution of 2% lidocaine with epinephrine into the intact skin under the influence of an electric current. Within 10 to 20 minutes, it can anesthetize to a greater depth (8–9 mm) than EMLA or ElaMax, but the device may cause discomfort during the time of the electric current [98].

Another method to reduce the discomfort of line placement is through the use of a small injection with a 30 gauge needle of warmed lidocaine buffered with sodium bicarbonate. Using a simple otoscope light to transilluminate the palm has also been shown to increase the success of intravenous placement, which will reduce the number of sticks a child experiences [99].

cooperative children by a demand-flow mask. It is contraindicated in pregnancy and pregnant personnel should not assist in its administration. One advantage is that an intravenous line is not needed to provide sedation. Most EDs do not have the delivery device and scavenger apparatus, which limits its popularity as a sedative [8,94,95].
Intramuscular injections

There are several methods that can be used to reduce the pain with intramuscular injections. Ethyl Chloride, Fluori-Methane, and Fluro-Ethyl (Gebauer, Cleveland, Ohio) are vapocoolant sprays that cause a temporary freezing of the skin surface and can be applied by either a spray or with a cotton ball that has been sprayed with the liquid. This anesthesia effect begins almost immediately and lasts less than 1 minute. These vapocoolant sprays should only be applied to intact skin. Ethyl Chloride is flammable, which may limit its availability in the ED [96,100].

A new device called the ShotBlocker (Bionix Medical Technologies, Toledo, Ohio) is able to reduce the pain of intramuscular injections. The ShotBlocker is a flexible plastic device, which has multiple small raised bumps on the surface that touches the skin surrounding the planned location of the injection. The mechanism of pain reduction is felt to be through stimulation of nearby skin afferent nerve fibers, which reduces the sensation of the needle. Unpublished results show reduction of severity of pain with intramuscular injections in children and adults (Brett Smith, Bionix Medical Technologies, personal communication, December 2003).

One commonly administered medication in the pediatric emergency department is ceftriaxone. This antibiotic may be mixed with 1% lidocaine without epinephrine as an acceptable diluent when given by the intramuscular route [101]. Ceftazidime may also be mixed with 1% lidocaine as a diluent [102]. To reduce the pain of intramuscular injections, checking a standard drug reference text for the compatibility of the drug with lidocaine can reduce the pain of the injection.

Lumbar puncture

Febrile neonates and other small children who require a spinal tap can have EMLA or ElaMax applied to their lower back soon after arrival in the ED, in order to reduce the pain of the needle stick. The use of 1% local lidocaine into the skin overlying the interspace is important for neonates as well as older children and adults, to reduce the pain of the spinal tap. Allowing a neonate to suck on a sugar-coated pacifier during procedures can also help soothe the small infant [10].

Wounds requiring suture repair

LET is a combination of lidocaine, epinephrine, and tetracaine, which is compounded into a gel or viscous solution or liquid by the local hospital pharmacy. The application of LET to an open wound with a cotton ball will anesthetize a superficial wound. If further anesthesia is needed for deeper effect, lidocaine can be injected with a fine gauge needle into the area where LET has already initiated anesthesia. TAC is a combination of tetracaine,
adrenaline, and cocaine, which can also be used for similar wounds. Due to the expense, toxicity, and risk of a controlled substance with the use of TAC, it has been largely replaced by the safer and less expensive LET [95].

When injecting children’s wounds with a local anesthetic, care should be taken not to exceed the maximum safe recommended doses. The maximum safe dose of lidocaine without epinephrine is 4 mg/kg, but the quantity increases to 5 to 7 mg/kg if lidocaine with epinephrine is used. The maximum recommended dose of bupivocaine, with or without epinephrine, is 2.0 mg/kg in neonates and 2.5 mg/kg in children. Injectable diphenhydramine also has local anesthetic properties, and can be injected when the maximum amount of other local anesthetics has already been reached.

**Scalp lacerations**

One technique that has received recent attention in the literature is the hair apposition technique (HAT) for scalp lacerations. This method reduces the pain associated with scalp laceration repair and also reduces the time required for the repair in comparison with sutures. After cleaning the wound and achieving hemostasis, small clumps of hair on either side of the wound edges are gently pulled together to reapproximate the wound edges. Then the two small clumps of hair are twisted together with a single twist. A cyanoacrylate tissue glue is placed on the top of the twisted hair to secure the hair and the wound in place. This method avoids cutting hair and knotting hair. Patients also do not have to experience the discomfort of suture removal, because the glue will fall out after a few weeks of normal hair washing. This technique is not appropriate for wounds that have ongoing bleeding, because it does not result in hemostasis. The study achieved success in scalp lacerations that were linear, nonstellate wounds less than 10 cm in length [103,104].

**Creating the pain-free pediatric emergency department**

Eliminating every bit of pain in every pediatric patient throughout his or her entire ED stay may be impossible; however, it is a humane goal for clinicians to continually strive for a systematic approach to reducing pain and anxiety in all children who present to the emergency department. To achieve the greatest improvements, a department needs the commitment of all the physicians, nurses, and ancillary care providers to create a culture in which the prevention and treatment of pain is given a high priority. We now know about many ways to decrease pain in children, but using these methods in a coordinated fashion requires an organized approach and a staff that is committed to recognition and treatment of pain.
From the moment a patient comes to the attention of the triage nurse, children can be screened for their degree of pain as a “fifth vital sign.” The triage area can be equipped with various pediatric pain assessment tools to help the nurse. A policy can be written to allow the triage nurse to administer appropriate doses of oral medication for those children in mild to moderate pain for conditions such as ear pain or musculoskeletal injuries. Children in severe pain should be brought to the attention of a physician immediately for guidance in treatment of pain. The triage nurse can also screen for conditions that might require an intravenous line, blood draws, or spinal tap. Then EMLA or ELA-Max can be placed on two appropriate extremity sites when the patient first arrives for care. A febrile neonate could also immediately have EMLA or ELA-Max placed on the lower back in anticipation of a spinal tap. Likewise, topical LET could be applied by the triage nurse under the guidance of a protocol for small lacerations that will later need irrigation and repair.

The waiting room and each examination room can be child-friendly with games, decorations, and videos that help a child relax while awaiting evaluation and management. Even the radiology suite can be made child-friendly with decorations on the walls. Staff could all be trained in distraction and imagery techniques to help children cope with their anxiety.

Once the patient is awaiting care in an examination room, additional techniques can be employed. When the ED is stocked with iontophoresis equipment and its specific lidocaine preparation, that can be an additional method to help with more rapid intravenous placements. For intramuscular injections, topical vapocoolant spray could be quickly available in the ED. Alternatively, a ShotBlocker can be used to distract the pain of an intramuscular injection. If the drug is compatible with lidocaine, it can be mixed in lidocaine to further reduce the pain of the injection. Ceftriaxone is one commonly used drug in pediatric emergency care that is compatible with lidocaine.

Pacifiers and sucrose can also be stocked in the emergency department and given to small infants who are undergoing procedures such as intravenous lines, spinal taps, or urinary catheterization. For infants needing a spinal tap, local lidocaine should be injected with a fine gauge needle before insertion of the spinal needle.

Patient controlled analgesia (PCA) flow sheets and order forms can be available and the staff trained in their use for conditions characterized by chronic pain exacerbations, such as sickle cell disease [105]. The patient may then guide his or her own effective analgesia after the initial bolus of a narcotic while awaiting transfer to an inpatient bed.

For those patients who are discharged to home from the ED, pain management should continue with the appropriate analgesic prescriptions at discharge. Discharge instructions regarding home management of pain and information about any sedation medications that were administered in the emergency department should be given. Follow-up should be
ensured if it is anticipated that the condition could result in ongoing pain [106]. There have been impressive advances in our ability to address pediatric pain and anxiety in the ED over the past few decades. With ongoing investigations into better nonpharmacologic and pharmacologic methods to prevent and treat pain, we can anticipate further improvements in the decades to come. Changing our attitudes about the priority of pediatric pain management has the potential to yield enormous benefits for our patients with the use of our present technologies, drugs, and knowledge.

References

[13] Benumof JL, Dagg R, Benumof R. Critical hemoglobin desaturation will occur before return to an unparalyzed state following 1 mg/kg intravenous succinylcholine. Anesthesiology 1997;87:979–82.


