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Managing Pediatric Procedural Pain and Anxiety in the Emergency Department

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CME Objectives

Upon completing this article you should be able to:
1. List pharmacologic analgesics appropriate for treating children in the emergency department.
2. Describe the risks and benefits of using etomidate to sedate children in the emergency department.
3. Explain the role of topical anesthetics to facilitate in pediatric laceration repair in the emergency department.

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See "Physician CME Information" on back page.

A 4-year-old male with a history of asthma presents to your emergency department after falling off his bicycle one hour ago. The patient sustained a 4-centimeter laceration to his forearm, but his arm does not appear to be fractured. He does not appear to have any other injuries. His parents are asking if he will receive sedation. They are concerned because he had an abscess on his buttock drained a year ago without any medication for pain, and the experience was extremely unpleasant. In the exam room he is very anxious and will barely allow you to look at the wound. As you approach the bedside, several questions come to mind. Will this child need to be sedated? If so, what are my options with regard to medications? Are there any topical treatments that might be useful? How long is this going to take?

PAIN and anxiety are inevitably encountered by children in the emergency department. It is extremely important for emergency practitioners to properly treat children's pain and anxiety. An evidence-based review of how to deal with children who are experiencing pain and anxiety in the emergency department is presented in this issue of *Pediatric Emergency Medicine Practice*.

Critical Appraisal Of The Literature

Over the last 20 years there has been increased interest and research in the reduction of patient pain and anxiety. So much interest that the American Academy of Pediatrics (AAP), American College of Emergency Physicians (ACEP), the American Society of Anesthesiologists (ASA) and the Canadian Association of Emergency Physicians have published guidelines on

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sedation and analgesia in recent years.[1-8] These published recommendations provide practitioners with an expert opinion to help facilitate the safe utilization of procedural sedation and analgesia. However, the level of evidence available for pediatric pain management and procedural sedation is varied and largely consists of class II-III studies. Due to the lack of clinical evidence in children, emergency practitioners are often forced to make clinical judgments based on studies of adults.

Abbreviations Used in this Article

AAP – American Academy of Pediatrics
ACEP – American College of Emergency Physicians
ALA – Adrenaline, Lignocaine (Lidocaine), Amethocaine
ASA – American Society of Anesthesiologists
CNS – Central Nervous System
EM – Emergency medicine
EMLA – Eutectic mixture of lidocaine and prilocaine
EMTP – Emergency medicine technician-paramedic
$ETCO_2$ – end tidal carbon dioxide
F/M – Fentanyl/Midazolam
GABA – Gamma-aminobutyric acid
ICU – Intensive care unit
IM – Intramuscular
IQ - Intelligence quotient
IV – Intravenous
JCAHO – Joint Commission on Accreditation of Healthcare Organizations
K/M – Ketamine/Midazolam
LAT – Lidocaine, Adrenaline, Tetracaine
LET – Lidocaine, Epinephrine, Tetracaine
LP – Lumbar puncture
npo – nil per os (nothing by mouth)
NSAID – Non-steroidal anti-inflammatory drug
RSI – Rapid sequence intubation
TAC – Tetracaine, Adrenaline, Cocaine
VAS – Visual analogue scale

Epidemiology, Etiology, And Pathophysiology

Currently, there is no published data that accurately describes the prevalence of pain in children who present to the emergency department. However, most emergency practioners understand that routine care for children often involves painful procedures within an unfamiliar environment. Since pain and anxiety are inevitably encountered in the emergency department, studies performed in adult populations help reveal the extent of this extremely large problem. In a study in an academic emergency department, 79% of the adult patients surveyed had a chief complaint of pain during the study period of 7 days.[9] Another study of adults found that 61% of patients in the emergency department had a complaint of pain documented in the chart, and for 85% of this group pain was the chief complaint.[10]

"Oligoanesthesia" is a term first used by Wilson in 1989 describing the inadequate treatment of patients' pain in the emergency department from a descriptive chart review.[11] Unfortunately, the literature reflects that children often receive even less analgesia than adults.[12-15] There are several reasons why pain is addressed less frequently in children than in adult patients. Some important barriers include the difficulty in measuring the adequacy of pain control, the concern of over-sedation due to the different metabolic rates and body composition, and the concern of altering subtle physical findings.[13,16-18] In spite of these reservations, it is important for emergency practitioners to properly treat pain and anxiety, and a routine pain assessment is now considered by many clinicians to be the "fifth" vital sign.[9,19]

The anatomic and physiologic basis for the perception of pain begins in utero. It is during the second trimester that afferent pathways from the peripheral nervous system to the spinal cord as well as the rostral projections to the thalamus and cortex are developing.[18,20] Pain is a basic chemical reaction, and as a result of tissue injury numerous chemical mediators are released including leukotrienes, bradykinins, serotonin, histamine, potassium, acetylcholine, thromboxanes, Substance P and platelet aggregating factor.[21] Pain receptors or nociceptors are located in various parts of the human body such as the integument, periosteum, arterial walls, teeth, and joint surfaces.[21] Nociceptors are divided into two categories: polymodal A∂ receptors and polymodal C receptors. Polymodal A∂ receptors are attached to myelinated neurons that can transmit an electrical impulse at a high velocity of about 5-10 m/second. This type of pain is often categorized as "fast" pain and is perceived as sharp or burning. Polymodal C receptors are attached to unmyelinated neurons, and transmit a slower signal at around 0.5-2 m/second. The perceived sensation from these fibers is a dull aching or throbbing, and these sensations are classified as "slow" pain or visceral pain.[21] Nociceptors located throughout the body are one end of a peripheral nerve whose cell body lies within the dorsal root ganglion. Another branch of this nerve synapses with higher order neurons within the central nervous system (CNS) at the dorsal horn of the spinal cord. The synapse occurs at the level of the peripheral nerve, but may also ascend or descend spinal segments prior to making their connection.

From the dorsal horn, the vast majority of second order neurons cross over to the contralateral anterolateral area of the spinal cord and ascend to the thalamus via the spinothalamic pathway. A minority of neurons will remain and ascend to the cerebral cortex by the spinothalamic tract on the ipsilateral side. The spinothalamic pathway is the most important pathway in the transmission of pain and temperature. These second order neurons carry impulses of both "fast" and "slow" pain and transmit them to the thalamus. Once these impulses reach the lateral and medial thalamus they are interpreted as noxious stimuli and forwarded to the cerebral cortex.[21] Within the CNS there are both inhibitory and excitatory neuromodulators that affect and regulate propagation of the neurological impulses. Those acting in the dorsal horn include: opioid (mu, kappa, delta), alpha adrenergic, gamma-aminobutyric acid (GABA), serotonin,

and adenosine.[22]

The dogma that neonates and young children are not affected by pain has been challenged by recent studies. Painful and anxiety-provoking experiences in early development may affect future interactions with medical providers. In a prospective cohort study, the subsequent effects of pain were exhibited in male infants undergoing neonatal circumcision.[23] Eighty-seven male infants were randomized into three groups; a non-circumcised control group, a circumcised group using eutectic mixture of lidocaine and prilocaine (EMLA) cream as a topical anesthetic, or a circumcised group with a placebo cream. The infants were then filmed at their 4-month or 6-month routine vaccination visit. These films were viewed by trained research assistant to measure facial action, cry duration and visual analog pain scores. The circumcised infants were found to have a greater response to pain from the routine vaccinations than did the uncircumcised infants. Furthermore, among the circumcised infants, the utilization of EMLA appeared to have attenuated the pain response when compared to infants who had received placebo.[23] Another study looking at pediatric oncology patients undergoing a painful procedure found that oral fentanyl failed to produce adequate analgesia

Table 1: Sedation continuum and terminology

	Level of Consciousness (LOC) / Response	Airway	Spontaneous Ventilation	Cardiovascular Function
Minimal Sedation/ Anxiolysis	Depressed LOC; Normal response to verbal commands	Maintained independently	Maintained independently	Maintained independently
Dissociative Sedation* * Dissociative sedation is a form of sedation separate from moderate, deep and general anesthesia sedation	Trancelike state with significant analgesia and amnesia	Maintained independently	Maintained independently	Maintained independently
Procedural Sedation	Depressed LOC or dissociation; Tolerance of painful stimulation	Maintained independently	Maintained independently	Maintained independently
Moderate Sedation/ Conscious Sedation	Depressed LOC; Purposeful response to verbal ± tactile stimulation	Maintained independently	Maintained independently	Typically maintained independently
Deep Sedation	Depressed LOC; Not easily aroused; Purposeful response to repeated or painful stimulation	May require support in maintaining airway patency	May require support with ventilation	Typically maintained independently
General Anesthesia	Loss of consciousness; Cannot arouse; No response to standard surgical stimulus	Frequently requires intervention to maintain airway patency	Usually requires support with ventilation	May require support of cardiorespiratory function

American Society of Anesthesiologists Task Force on Sedation and Analgesia by Non-Anesthesiologists. Practice guidelines for sedation and analgesia by non-anesthesiologists. *Anesthesiology* 2002 Apr;96(4):1004-1017.
American College of Emergency Physicians Clinical Policies Subcommittee (Writing Committee) on Procedural Sedation and Analgesia. Clinical policy: Procedural sedation and analgesia in the emergency department. *Ann Emerg Med* 2005 Feb;45(2):177-196.
American Academy of Pediatrics, Committee on Drugs. Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures: Addendum. *Pediatr* 2002 Nov;110(4):836-838.

in a small population of patients in whom pain control was inadequate during a previous procedure, where as the oral fentanyl appeared adequate for patients who had received proper analgesia during the previous procedure.[24] Of note, this difference was not found in children older than 10 years old.[24] Thus, it does appear that the effects of procedural pain may transcend beyond the present physician-patient interaction in the young child and infant.

Differential Diagnosis

The decision to use a particular procedural method or pharmacologic intervention depends on the desired level of sedation and analgesia compared to the discomfort and anxiety caused by the procedure being performed. Emergency practitioners who possess advance airway skills are capable of safely providing sedation and analgesia to patients that range from mild to moderate in depth according to the currently accepted definitions. (**Table 1**) One problem is that there is no current data to standardize and quantify the pain induced by the various procedures. Furthermore, pain is an individual and personal process that is multifactorial in origin. Each individual may perceive and express pain in a different manner as a result of previous experiences (developmental maturity, cultural differences, mental illness or abuse/neglect).

When administering sedation or anxiolysis, it is optimal to select a set medication regime, and titrate the dose to the depth of sedation needed to safely complete the procedure. Changing medication regimes during the procedure is not encouraged. While a greater number of adverse events have not been associated with one class of medications in particular, there is an increase in the number of negative outcomes when greater than 2 drugs are used in combination.[25,26] There is no association between the route of administration and the occurrence of adverse events.[26] Not surprisingly however, medication errors resulting in a drug overdose are a great contributor to negative outcomes, including death and permanent neurologic injury.[26] Thus, diligence must be taken to assure patient safety, and the emergency practitioner must be knowledgeable about the efficacy, limitations, and side effects of the medications administered.

The medications commonly available to the emergency practioner can be divided into five general categories: analgesics, sedative/hypnotics, dissociative agents, topical/local anesthetics, and inhaled agents. The following is a summary of the different pharmacologic and non-pharmacologic agents utilized by emergency practitioners to care for children undergoing painful procedures in the emergency setting. (**Table 2**)

Analgesics

Non-opioid analgesics

Acetaminophen is a non-opioid analgesic safe for the treatment of acute pediatric pain.[27,28] It increases the pain threshold peripherally by impeding the creation of a pain impulse, and centrally by inhibiting the synthesis of prostaglandins. Acetaminophen is metabolized in the liver and reaches peak serum concentration 10 to 60 minutes after a standard oral dose.

Ibuprofen and ketorolac are non-steroidal anti-inflammatory drugs (NSAIDs) that can be used for analgesia. The proposed mechanism of action for both medications is by inhibiting the production of prostaglandins. Caution must be used with NSAIDs as they inhibit platelet aggregation and can lead to gastrointestinal bleeding with chronic use.

Short-term ibuprofen use has been found to be safe in children with pain.[27-29] Ibuprofen is rapidly absorbed after an oral dose and is metabolized in the liver. The time to peak serum concentration after taking the liquid suspension is 1 hour, while after taking the tablet form is 2 hours. Ibuprofen is primarily excreted in the urine.

A single dose of ketorolac has recognized safety in pediatric patients greater than 2 years of age.[30,31] For children less than 2 years of age there is a lack of evidence, but a small study of neonates and premature infants who received a post-operative dose of ketorolac reported no hematologic, hepatic, or renal complications.[32] Ketorolac is well-absorbed and reaches peak serum concentrations in 45 minutes when given orally, 30 to 45 minutes via the intramuscular route, and 1 to 3 minutes when given intravenously. Ketorolac is metabolized in the liver and is excreted mainly in the urine.

Ketorolac is an attractive agent because it can be given intravenously and is non-opioid; therefore, it is without respiratory depression. For post-myringotomy pain in children, oral ketorolac decreased pain at 5 and 10 minutes over oral acetaminophen, but no difference in analgesia was seen at time of discharge.[33] In the adult emergency department setting, intramuscular (IM) ketorolac was found to have a similar analgesic effect as oral ibuprofen for acute pain.[34-36] The analgesic effect of ketorolac is comparable to acetaminophen and ibuprofen, but the availability of an intravenous (IV) and IM routes for ketorolac may be beneficial under certain circumstances.

In comparing the efficacy of ibuprofen and acetaminophen in children for the treatment of pain associated with otitis media, sore throat, and post-dental extraction pain, there was no significant difference in their ability to reduce pain.[28,37] In treating orthopedic-related pain in children, ibuprofen was as effective as acetaminophen with codeine.[38,39] Acetaminophen, ibuprofen, and ketorolac are effective non-opioid medications to consider when managing acute pain in the emergency department.

Opioid analgesics

This family of analgesic medications is well-known among emergency practitioners. These medications have a diminished clearance in neonates and young infants; however this process reaches maturity over the first two to six months of life.[18] Narcotic drugs commonly used in the emergency department include fentanyl, morphine sulfate, meperidine, hydrocodone, and codine. Fentanyl

Table 2: Suggested medication dosages for painful procedures

Medication	Suggested Dosages
EMLA	*Topical:* Minor Procedures: 2.5 grams/site for 60 minutes Major Procedures: Maximum dose, application area and application time 0-3m or <5kg: 1 gram to 10 cm^2 for 1 hour 3-12m & >5kg: 2 grams to 20 cm^2 for 4 hours 1-6y & >10kg: 10 grams to 100 cm^2 for 4 hours 7-12y & >20 kg: 20 grams to 200 cm^2 for 4hours
LET	*Topical:* Apply 1.5 ml to area
Lidocaine	*Injectable Anesthetic:* max 4.5 mg/kg/dose (plain), max 7 mg/kg/dose (with epinephrine)
Acetaminophen	*Oral:* Term infants < 10 days: 10-15 mg/kg/dose q 6 hours (max 60 mg/kg/day) Term infants ≥ 10 days: 10-15 mg/kg/dose q 4-6 hours (max 90 mg/kg/day) Infants & Children < 12y: 10-15 mg/kg/dose q 4-6 hours (max 5 doses in 24 hours) Children ≥ 12y: 325-650 mg/kg/dose q 4-6 hours or 1000mg TID-QID (max 4 grams/day) *Rectal:* Term infants < 10 days: Load 30 mg/kg, then 15 mg/kg/dose q 8 hours (max 60 mg/kg/day) Term infants ≥ 10 days: Load 30 mg/kg, then 20 mg/kg/dose q 6-8 hrs (max 90 mg/kg/day) Infants & Children < 12y: 10-20 mg/kg/dose q 4-6 hours (max 5 doses in 24 hours) Children ≥ 12y: 325-650mg q 4-6 hours or 1000mg TID-QID (max 4 grams/day)
Ibuprofen	*Oral:* 4-10 mg/kg/dose q 6-8 hours (max of 4 doses/day)
Ketorolac	*IV:* Children 2-16 y: 0.5 mg/kg as a single dose (max 15 mg) Children >16y & >50 kg: 30 mg every 6 hours (max 120 mg/day) *IM:* Children 2-16 y: 1 mg/kg as a single dose (max 30 mg) Children >16y & >50 kg: 60 mg as a single dose, then 30 mg q 6 hours (max 120 mg/day) *Oral:* Children >16y & >50 kg: Initial 20 mg, then 10 mg q 4-6 hours (max 40 mg/day)
Fentanyl Citrate	*IV:* Neonates & young infants: 1-4 mcg/kg/dose q 2-4 hours Older infants & Children 1-12y: 1-2 mcg/kg/dose q 30-60 minutes Children > 12y: 0.5-1 mcg/kg/dose q 30-60 minutes *IM:* Older infants & Children 1-12y: 1-2 mg/kg/dose q 30-60 minutes
Morphine Sulfate	*Oral:* Infants & Children: 0.2-0.5 mg/kg/dose q 4-6h *IV:* Neonates: 0.05 mg/kg q 4-8 hours (max 0.1 mg/kg/dose) Infants & Children: 0.05-0.1 mg/kg 5 minutes prior to procedure (max 15 mg/dose) Adolescents > 12y: 3-4 mg prior to procedure, may repeat in 5 minutes *IM, Subcutaneous:* Neonates: 0.05 mg/kg q 4-8 hours (max 0.1 mg/kg/dose)
Midazolam Hydrochloride	*Oral:* Infants ≥ 6m & Children: 0.25mg-0.5 mg/kg as a single dose (max 20 mg) *Intranasal:* 0.2-0.3 mg/kg/dose, may repeat in 5-15 minutes if needed *IV:* Infants ≥ 6m & Children ≤ 5y: Initial 0.05-0.1 mg/kg, then titrate as needed (max 6 mg) Children 6-12y: Initial 0.025-0.05 mg/kg, then titrate (max 10 mg) Children 12-16y (adult dosage): 2.5-5mg, titrate as needed every 2-3 minutes (max 10 mg) *IM:* 0.05-0.15 mg/kg 30-60 minutes prior to procedure (max 10 mg)
Ketamine Hydrochloride	*Oral:* Children: 6-10 mg/kg for 1 dose 30 minutes prior to procedure *IV:* Children: 0.5-2 mg/kg (for minor procedures consider 0.5-1 mg/kg) *IM:* Children: 3-7 mg/kg
Etomidate	*IV:* Children: 0.1-0.3 mg/kg
Nitrous Oxide	*Inhalation:* 25-50% mixture with oxygen

Adapted from the Children's Medical Center of Dallas Formulary. Lexi-Comp Online; 2006. Last accessed online on 3/1/2006.

is a short-acting opioid analgesic that works by interacting with the opioid mu-receptors of the central nervous system and smooth muscles. Fentanyl is popular for procedural sedation because of its rapid onset, and its relatively short duration of action (30 to 60 minutes) that is dose-dependant. One hundred times more potent than morphine, fentanyl has the advantage of not inducing significant histamine release. This drug is lipophilic and is initially distributed to the brain, heart, lungs, kidneys, spleen and secondarily to the muscles and fat. Fentanyl is metabolized in the liver and its metabolites are excreted primarily in the urine.[40-42] Drug clearance may be delayed with any condition that compromises blood flow to the liver.[43]

A feared, but rare side effect of fentanyl is chest wall rigidity. This phenomenon has not been reported in low doses, but has been reported in higher doses in preterm and term neonates.[44,45] Thus ideally, a lower initial fentanyl dose should be used and care should be taken to not to infuse fentanyl rapidly. The treatment for rigid chest syndrome is respiratory support and naloxone, an opioid antagonist. Intubation and chemically induced paralysis may also be required if these initial measures do not resolve the respiratory compromise.[44,45]

Morphine is another opioid antagonist that has a long track record. However, this drug can release histamine, which can lead to hypotension, nausea, vomiting and pruritus.[40-42] Morphine is conjugated in the liver and excreted in the urine. The onset time for IV morphine sulfate is 4 to 6 minutes, with a duration of action of 2 to 3 hours.[40-42] The longer duration of action compared to fentanyl somewhat limits its popularity with procedural sedation, but as a sole agent for analgesia morphine is commonly used. Along these lines the oral narcotic medications such as hydrocodone and codeine are limited to analgesia as they are only available by the oral route. Meperidine, another narcotic agent, can also be given intravenously. However, this agent should be avoided in children due to the potential for seizures as a result of its metabolic by-product; normeperidine.[18,40,41]

The effects of narcotic analgesics are easily reversed with the opioid antagonist, naloxone. This can be used as a rescue medication in the setting of respiratory depression due to acute narcotic toxicity.[40,41]

Sedative/Hypnotic agents

Benzodiazepines

Multiple benzodiazepines (Diazepam, Lorazepam, and Midazolam) are available for use in the emergency department. Due to its rapid onset and short duration of action, midazolam has gained significant popularity when used for procedural sedation and anxiolysis compared to its peers. Midazolam is a short-acting benzodiazepine that depresses the central nervous system by directly acting on the benzodiazepine receptor to cause sedation, anxiolysis, anterograde amnesia, but no analgesia.[46] Midazolam is metabolized in the liver by the cytochrome P450 system, and excreted in the urine.[47]

Midazolam is water-soluble and can be safely administered in variety of ways. It appears that midazolam can be given effectively and safely by the oral route for anxiolysis.[48-52] The onset of action is around 15-30 minutes.[47] Collectively looking at three studies with approximately 70 patients who received 0.5 mg/kg of oral midazolam, no respiratory events were reported.[48,51,52] However, in another study the incidence of adverse events reported by Aydintug, using a similar oral dose of 0.5 mg/kg, was 56%.[50] The most common of the adverse events were paradoxical reactions and hypoxemia in 42%, followed by vomiting and nausea in 14%.[50] The further description of the adverse events was not discussed, and the number of patients in the study undergoing dental procedures was relatively small with 25 patients receiving midazolam.[50] The reason for the high incidence of adverse events in this study is unknown, but may also be attributed to the setting of the sedation and the fact that dental procedures were being conducted.[50] One disadvantage to oral midazolam is the bitter taste of the medication, which despite flavoring was still detectable and disliked by patients.[48,49,52]

Midazolam can also be administered by the rectal route for procedural sedation. Kanegaye found that when comparing two doses of rectal midazolam—standard dose (0.5 mg/kg) with high dose rectal midazolam (1 mg/kg)—the higher dose was more likely to maintain sedation throughout the ED procedure.[53] Standard dosing only produced adequate sedation 50% of the time while the high dose provided adequate sedation 73% of the time. No cardiopulmonary events were reported, and in the high dose group there were a significantly larger number of patients who experienced agitation (2% SD vs. 27% HD) which contributed to the study being terminated early.[53] It has been previously documented that patients often prefer the oral route to the rectal route, particularly children older than 6 years, due to modesty.[50,54]

Intranasal midazolam is another needleless option for midazolam administration for procedural sedation. The benefit of intranasal midazolam is the shorter onset time of 10 to 20 minutes, which is approximately 10 minutes faster than oral or rectal administration.[52,54] Unfortunately, the administration by the intranasal route caused a significantly increased rate of crying with administration as compared to the rectal and oral routes.[52] Due to this fact, this delivery system has not gained significant popularity. In fact, Lejus compared nasal administration with rectal administration, and an interim statistical analysis found that the intranasal route was more painful than the rectal route. This resulted in early termination of the study.[54] Another disadvantage with nasal administration is that it is difficult to administer in older patients, as the larger dose often causes the patient to swallow a considerable portion of the medication that is introduced into the nasopharynx.[54] A recent study of 2- to 3-year-old children found intranasal administration with an atomizer to deliver a spray of medication was better tolerated than drop medication with equivalent efficacy.[55] This method of administration warrants further study.

Despite the fact that midazolam can be administered

intramuscularly (IM), probably the most common way that midazolam is administered is IV. The benefit of the IV route is the ability to easily titrate the dose as needed for the procedure at hand. In pediatric patients, intravenous midazolam can cause desaturation (4.6%), apnea (2.8%), hypotension (2.7%), paradoxical reaction (2-3.4%), and hiccups (1.2%).[56] Midazolam can cause a dose-related respiratory depression, thus caution must be used in larger doses and if concurrently used with opioids.[40,41] Respiratory depression and paradoxical reactions can be reversed with the benzodiazepine antagonist, flumazenil.[57] Flumazenil has a short duration of action of 20 to 60 minutes, possibly necessitating multiple doses.[42] An important contraindication to the administration of flumazenil is a known seizure disorder. To treat midazolam-induced hiccups, two sprays of intranasal ethyl chloride to the nasal mucosa can be used.[58]

Etomidate

Etomidate is a carboxylated imidazole that works in the central nervous system via the GABA receptor.[59-61] Etomidate is an intravenously administered hypnotic agent that has recently gained some attention and popularity within the context of procedural sedation and rapid sequence intubation (RSI). The drug's extremely short duration of action makes it an attractive sedative in the emergency department. Two small prospective studies in adults undergoing short orthopedic procedures found that etomidate had significantly shorter recovery times with an equal rate of procedural success when compared with midazolam.[62,63]

Although it is not a currently recommended by its manufactures for use in children less than 10 years old, there are reports of its safe use in younger children in the literature.[59,64] This drug has an onset of action of one minute and the duration of action appears dose-dependant. A dose of 0.2-0.3 mg/kg provides about 3 to 15 minutes of sedation.[59,65] Etomidate does not have analgesic properties, and an analgesic medication (i.e., fentanyl) should be administered concurrently for painful procedures. Drug metabolism occurs in the liver and etomidate is excreted mostly in the urine. The advantages of etomidate are its minimal effect on cardiopulmonary circulation, transient (20-30%) decrease in cerebral blood flow resulting in a decreased intracranial pressure, and its amnestic properties.[59,66] A main disadvantage of etomidate is transient adrenal suppression due to a decreased 11-beta-hydroxylase activity.[67] This has been seen even after a single dose of etomidate for rapid sequence intubation in septic patients. However, the lower dosages used for procedural sedation is less likely to be problematic, but this is unstudied.[67]

Common adverse events seen with etomidate include vomiting (1.7% to 9.9%), desaturation (2% to 8.3%), apnea (2%), and myoclonus (6.7% to 17.8%).[60,61,66,68] None of the episodes of vomiting resulted in clinically apparent aspiration.[60,68] One patient in the study by Ruth did have intractable vomiting that was refractory to anti-emetic therapy, resulting in an additional ED stay of 3 hours.[66] The reported respiratory events were easily cared for with supplemental oxygen or bag-mask ventilation; none of the patients in the series were intubated.[60,61,66,68] The patients who experienced agitation recovered without the administration of additional medication.[60] Reported myoclonic events ranged from brief tremors to a one-minute episode of body stiffness.[66,68] All of the myclonic events resolved without intervention or morbidity.[66,68] There is no reversal agent for etomidate.

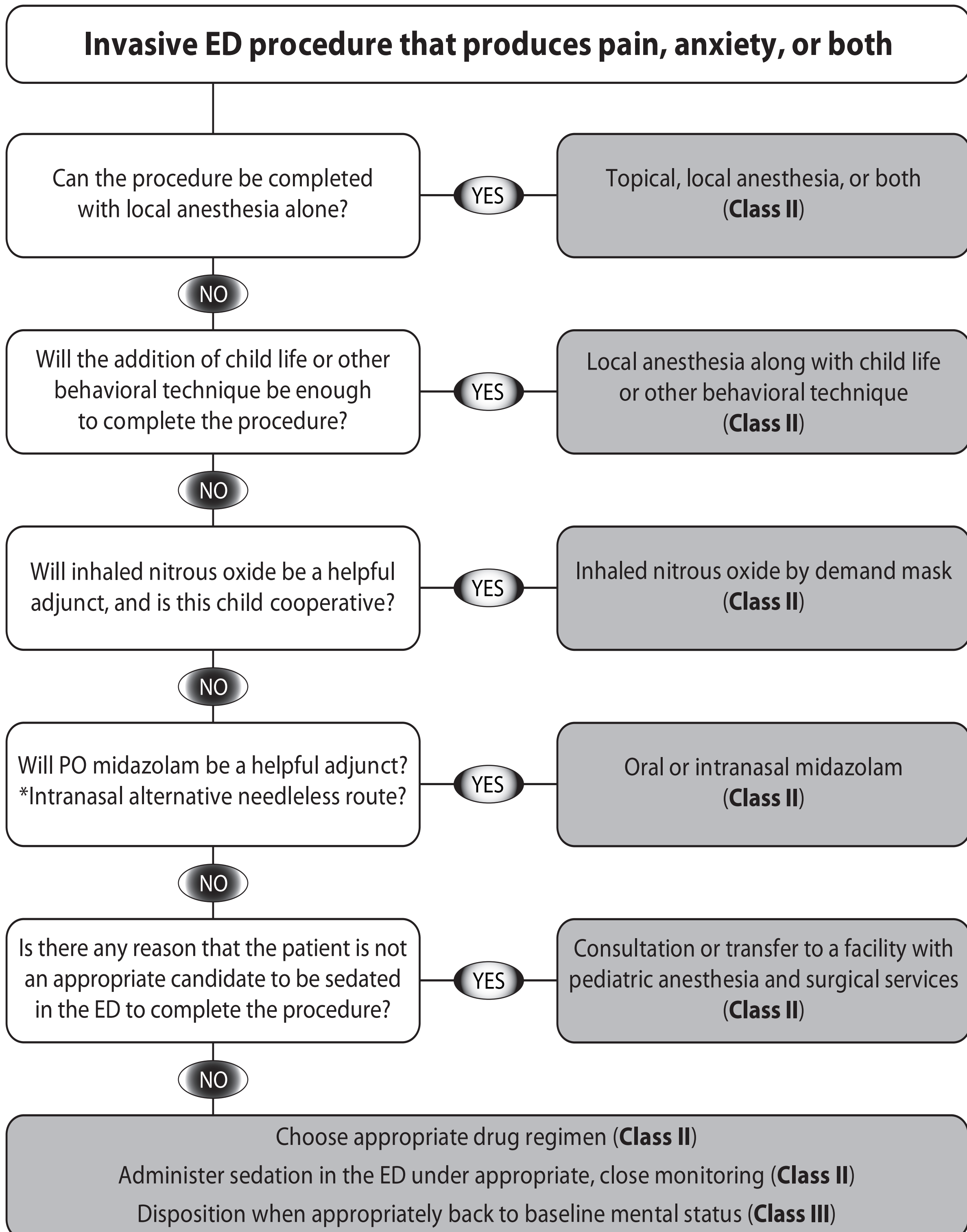
Dissociative agents

Ketamine

Ketamine is a dissociative sedative that has a long record of safety and efficacy.[69] For procedural sedation it is usually administered intravenously or intramuscularly, but it can also be administered orally and rectally, however these routes are not as easily controlled. Ketamine is a good drug for pediatric procedural sedation as it provides strong sedative, analgesic, and amnestic properties.[70,71] By definition, a dissociative agent chemically disconnects the higher order neurons from the thalamus to the cortex, and in a sense "disconnects the mind from the body." This produces a "trance-like cataleptic state" which has no depth continuum, and thus either the dissociative state is attained or it is not. Unlike other sedation agents, ketamine does not cause patients to lose protective airway reflexes with increasing doses.[70] While under the effects of ketamine, invasive procedures are well-tolerated while protective reflexes are maintained, arterial blood pressure may be elevated, and respiratory drive remains uncompromised.[72,73] The only absolute contraindications for ketamine use are age under 3 months and established clinical psychosis.[74,75] Relative contraindications are age less than 12 months, procedures that involve laryngeal stimulation, upper respiratory infection, acute asthma, cardiac disease, increased intracranial pressure, increased intraocular pressure, seizure disorder, porphyria, and thyroid disease.[74]

Adverse events with ketamine are mostly transient. Mild hypersalivation occurs in 13% of patients and can be decreased with the addition of an anti-sialogogue such as atropine or glycopyrrolate.[70] Vomiting is seen in 3.8% to 19.4% during the ED recovery period.[72,73,76-80] Green found that a dose of 4 mg/kg to 5 mg/kg administered IM provided adequate sedation 93% to 100% of the time without substantial adverse events.[77,78] At the dose of 4 mg/kg IM, there were two pediatric case reports of respiratory arrest within three to six minutes of medication administration.[81,82] In both of the cases, the patients received bag-mask ventilation and returned to baseline within two to three hours.[81,82] In examining 1022 patients given IM ketamine, patients achieved adequate sedation 98% of the time, and no clinically significant side effects occurred.[72] Temporary airway problems (laryngospasm, malalignment and apnea) occurred in 1.4% of patients, but all were quickly treated and resolved. Vomiting was reported in 6.7% of patients, and agitation in 17.6%, with considerable agitation in 1.6% of patients.[72] A lower dose of 2 mg/kg to 2.5 mg/kg IM was used in

Clinical Pathway: Pediatric pain and anxiety in the ED



This clinical pathway is intended to supplement, rather than substitute for, professional judgment and may be changed depending upon a patient's individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

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another study by McGlone.[83] However, even though 26 of 501 patients required an additional dose of 1 mg/kg, the authors felt that the sedation achieved by this lower dose was adequate. Thus, perhaps, the lower IM ketamine dose of 2 mg/kg warrants further study.

Intravenous access is not an absolute requirement when using ketamine, and administration of ketamine by this route should be over 60 seconds to decrease the likelihood of respiratory complications. However, it is not known if administration time is truly a factor in causing apnea. The recommended IV dose is 1.5 mg/kg to begin with, as one study using this dose produced adequate sedation in 94% of patients.[76]

One of the reasons emergency practitioners are hesitant to use ketamine for procedural sedation is the occasional occurrence of an emergence reaction. Mild to severe recovery agitation with ketamine has been reported in the range of 0.9% to 20.3% of patients.[72,73,76-78,80] The incidence of recovery agitation is thought to occur more often in adolescent patients. However, Hostetler did not find any significant difference when comparing children less than 10 years old with children older than 10 years old receiving ketamine.[84] In this study the overall incidence of mild or severe agitation was only 1.7%.[84] Furthermore, in another small study of 26 patients aged 16 to 21 years old, no episodes of recovery agitation were reported.[85] Thus, it appears that ketamine can be safely used in older children and adolescents.

If recovery agitation does occur, it is currently recommended that a dose of intravenous midazolam be given to ease the transition to consciousness. Despite the recommendation to use midazolam in the presence of an emergence reaction, its routine concurrent use with ketamine is not recommended. The addition of routine intravenous midazolam concurrently with ketamine did not show a statistically significant reduction in recovery agitation in pediatric patients.[80,86] However, the use of midazolam in combination with ketamine is safe, and seems to help to decrease the incidence of post-procedure vomiting.[69,79,80,87,88]

Inhalation agents

Nitrous oxide

Nitrous oxide has been successfully used for sedation in pediatric patients.[89,90] In a prospective, randomized, double-blind trial in children, 50% nitrous oxide was significantly able to reduce pain scores and to increase patient satisfaction.[90] Nitrous oxide is an inhaled anesthetic agent that is administered in a mixture with oxygen.[46,91] In 3 to 5 minutes after inhalation, nitrous oxide causes amnesia, anxiolysis and some analgesia.[47] The effects of nitrous oxide wear off in 3 to 5 minutes after the gas is removed. The administration of nitrous oxide is usually via a demand valve mask, which requires a certain level of cooperation and cognitive maturity. The gas is tasteless and odorless. Children 6 years of age and older tend to tolerate the application of a facemask better than younger children, as the mask itself can be intimidating for a young child.[46,89] The use of flavored lip balm, or a flavored mask along with creative imagery can be used to make the experience less noxious in younger children.[47] Oxygen is often applied to prevent hypoxia after the procedure is complete.

Adverse events associated with nitrous oxide use range from 5.3% to 16.8%.[89,90,92,93] In one study, adverse events were reported to occur in the emergency department at 16.8%.[93] However, in this study population 82.3% of patients received 70% nitrous oxide.[93] This use of a higher percentage of nitrous oxide may have contributed to the increased rate of adverse events. In an Australian study of 751 sedation cases with 50% nitrous oxide, researchers reported a major adverse event rate of only 0.3%.[92] Nitrous oxide can rapidly diffuse into and expand in gas-filled cavities so it should be avoided in patients with a bowel obstruction, pneumothorax, or otitis media.[47] Lastly, for the safety of health care professionals, pregnant employees should not be administering the nitrous oxide due to its teratogenic effects.[91,94]

Local and topical anesthetic agents

Local anesthesia blocks sodium channels in peripheral nerves, resulting in an inhibition of the conduction of neuronal messages.[95] Severe toxicity can occur with local anesthetics in high dosages resulting in cardiac toxicity (dysrhythmias, myocardial depression) or CNS toxicity (light headiness, slurred speech, altered mental status, or seizures).[95] Lidocaine is a drug that is commonly used for local anesthesia. Both 1% and 2% solutions are available. The maximum safe dose is 3 to 5 mg/kg (by volume, this equals 0.3 to 0.5 mL/kg of a 1% solution). The maximum single dose is 300mg (30 mL of 1% solution).[95] If epinephrine is added, a larger quantity can be administered (7 mg/kg) as this decreases systemic absorption.

Although very popular, lidocaine injection burns on infiltration into the tissue. Thus, topical delivery of local anesthetics have been created. Eutectic mixture of local anesthetic (EMLA) is a mixture of 2.5% lidocaine and 2.5% prilocaine in a ratio of 1:1 based on weight. These drugs are mixed along with water, carboxypolymethylene (a thickening agent), polyoxyethylene fatty acid esters (emulsifiers), and sodium hydroxide. The melting point of this concoction is below room temperature, so EMLA exists as liquid oil.

For topical anesthesia, EMLA is applied to intact skin with an overlying occlusive dressing to keep it in place, but a dressing is not needed for absorption. EMLA should be left in place for 45 to 60 minutes, and the anesthetic effect lasts for 1 to 2 hours.[96] This application will produce anesthesia from 3-5 mm in depth when applied for 60-120 minutes.[97] The length of time to efficacy often deters practitioners from using EMLA. However, triage nurses can predict subsequent IV placement 66% to 72% of the time, thus EMLA could be applied at triage and an IV conveniently placed after the practitioner's assessment, which 88.4% of the time occurs 45 to 60 minutes later.[98,99,100]

The major concern of EMLA is that significant systemic absorption can cause methemoglobinemia

due to the prilocaine component. In a case report of a 7-month-old infant who was very ill on a ventilator and nitric oxide, clinically significant methemoglobinemia developed. This was thought to be due to prolonged EMLA cream administration; however there were other confounding factors.[101] In patients with congenital or idiopathic methemoglobinemia and patients less than 12 months of age who are taking methemoglobin inducing agents such as sulfonamides, acetaminophen, phenytoin, or phenobarbital, caution should be taken with the use of EMLA. EMLA is not recommended for use in neonates with a gestational age less than 37 weeks. However, a study of preterm neonates less than 6 days of age and 30 to 37 weeks found no difference in methemoglobin levels after 0.5 grams of EMLA applied to the heel for one hour.[102]

An alternative to EMLA is another topical anesthetic ELA-Max (4% lidocaine cream), which has been promoted to achieve analgesia in 30 minutes. The advantages of ELA-Max are the shorter absorption time and the lack of prilocaine which has the potential to cause methemoglobinemia.

For open wounds, topical gel or solution anesthetics such as LET (Lidocaine: Epinephrine: Tetracaine) or TAC (Tetracaine: Adrenaline: Cocaine) have been successfully used. These drugs are mostly utilized for local wound anesthesia during laceration repair. These compounds are directly placed into the wound and produce a small margin of anesthesia to the laceration borders. The efficacy of these compounds appears to be dependent on the body region used.[103]

Non-pharmacologic interventions

Sucrose pacifier

A non-pharmacologic intervention that has been shown to decrease procedural pain in the newly born (< 28 days old) and premature population is the sucrose pacifier.[104-109] It is theorized to work via both endogenous opioid and non-opioid pathways.[104] The application of a sweet-tasting solution along with the sucking reflex promoted with a pacifier provided about two minutes prior to a painful procedure has been shown to decrease visible and physiological stress responses in newly born infants.[104-108] Evidence to support its efficacy in older infants is optimistic, but not completely clear.[110,111] It even appears to be equal to or possibly better than EMLA cream in this population at attenuating pain from venipuncture.[112] Sucrose has been shown to be effective for single painful events (e.g., venipuncture or heel lancing). It is unclear if there is any benefit from multiple dosing. No negative side effects have been reported from its use.

Behavioral techniques

Behavioral techniques such as child life resources, distraction, parental presence, and parental preparation have been shown to be of benefit in decreasing pain and anxiety during painful procedures.[113-118] All possible attempts should be made to provide a positive environment for the child undergoing a painful procedure. However, it must be remembered that these techniques are an adjunct, and not a substitute for providing adequate pharmacologic sedation and/or analgesia to children in the emergency department undergoing a painful experience.

Prehospital Care

The assessment and management of pain by emergency personnel prior to emergency department arrival has been investigated in adult and pediatric populations. Similar to emergency department studies, prehospital providers have also been found guilty of “olilgoanesthesia.” In retrospective studies of prehospital pain management in pediatric and adult patients with traumatic fractures, the majority of patients received little or no analgesia prior to emergency department arrival.[119,120] In comparing prehospital analgesics for similar lower-extremity fractures between adults and children, the rate of pediatric prehospital analgesics was less, but the difference was not statistically significant.[120] The reason for this may be a lack of education, as emergency medical technician-paramedics (EMT-Ps) report being able to assess and administer analgesics to adults for pain, but 93% of EMT-Ps report withholding analgesics to children and adolescents due to the inability to assess pediatric pain.[121] Since adult protocols on the evaluation and management of pain have been shown to be safe with minimal side effects in the prehospital setting, the emergency medical system should strive to create similar educational and quality-controlled protocols for children.[122-128]

ED Evaluation

History

There is a lack of published research in this area, but expert panel consensus suggests improved care and outcome with proper pre-sedation evaluation.[4-6,8,129] A thorough history and review of medical records should be performed for patients undergoing procedural sedation. Important questions to inquire include past medical history, surgical history, psychiatric history, current medications, allergies, previous problems with sedation or anesthesia, abnormalities in any major organ system, snoring or sleep apnea, last solid and oral intake and any use of tobacco, alcohol or drugs.[4,5,129]

nil per os (npo)

The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) requires that each institution create a standardized protocol that is adhered to by those administering sedation.[130] This includes determining pre-procedural fasting times and sedation depth. However, the specifics of each guideline are not determined by JCAHO, but rather are institution-dependant. The ASA released a practice guideline statement in 1999 regarding preoperative fasting for elective procedures recommending a 6-hour fasting period for light meals, non-human milk, and infant formula; a 4-hour period for breast milk; and a 2-hour period for clear liquids.[131] The guideline was intended for all ages and was devised

to maximize gastric emptying. However, it should be mentioned that these guidelines were intended for elective procedures under general anesthesia and not necessarily for procedural sedation in the ED. The bulk of the literature in the area on pre-sedation fasting and the risk of aspiration are largely based on general anesthesia data, and it is unclear how it translates to the setting of an acute emergency and procedural sedation.[132,133] In the absence of true evidence, this conservative guideline—although done in the name of safety—may not be completely practical or accurate as the risk of aspiration with procedural sedation may be low. Of the studies conducted in the setting of a pediatric emergency department, no significant association between length of pre-sedation fasting and adverse events was found.[25,134,135] No clinically apparent cases of pulmonary aspiration were reported in these studies.[25,134,135] However, although no events of aspiration were found, these studies did not have the power to truly answer this specific question properly. The incidence of this complication is so low that it would require a very large study population to properly assess its true risk.

Physical examination

There is a lack of evidence to outline the extent to which a pre-sedation physical exam should be conducted. At a minimum, the physical exam should include vital signs, weight, mental status, and airway and cardiopulmonary evaluation.[4-6,8,129] The airway assessment should include habitus, neck (short length, limited movement), jaw (micrognathia, retrognathia), and mouth (small opening, loose teeth, braces, macroglossia, tonsillar hypertrophy), with the intention to look for potential obscurities that could hinder mask ventilation and/or intubation.[4] However, there is no available literature that describes a method to accurately determine prospectively whether a child will be difficult to control. The aforementioned anatomic components are helpful, and previous literature has helped to define risk factors for a difficult airway in adult patients.[136-139]

During pre-sedation evaluation, the patient's ASA physical classification status should be determined. Emergency department sedations usually consist of class I (healthy patients) and class II (mild systemic disease without functional limitations) patients, with class III (severe systemic disease with functional limitation), class IV (severe systemic disease that is a constant threat to life) and class V patients (unable to survive without the operation) reserved for sedation by anesthesiologists.[2,4,8] If the emergency practitioner determines that the procedure is emergent, an E should be added to the defined ASA class (i.e., ASA II E). As a general rule ASA class I and II patients can be safely sedated in the emergency department. Deferring sedation of ASA physical class III and IV patients is recommended, because Malviya found that sedation of ASA physical status III and IV patients by non anesthesiologists resulted in an increased risk of sedation-related adverse events as compared to ASA physical status I and II children.[140]

Diagnostic studies

There are no studies to support routine diagnostic studies prior to procedural sedation. Diagnostic testing should be done prior to procedural sedation when there are clinical indications for such tests.

Physiologic monitoring

Pulse oximetry measures hemoglobin oxygen saturation with the use of absorption spectrophotometry and red and infrared light. It is a non-invasive device used in the emergency department to quickly determine patients' oxygen saturation. Interestingly, although it is widely used clinically, ACEP does not routinely recommend the use of a pulse oximeter, but does recognize its usefulness when patients are at increased risk of developing hypoxia due to an underlying medical condition or multiple drug administration.[5,6] In contrast, the AAP and ASA recommend the routine use of continuous pulse oximetry to aid clinical assessment in detecting early hypoxemia.[3,4] Despite these recommendations, there is no published evidence that the use of a pulse oximeter decreases adverse outcomes with procedural sedation.

The pulse oximeter detects hypoxemia prior to the appearance of clinical symptoms.[141] It provides an accurate measurement of arterial oxygen saturation above 70% to 80%.[142-144] Pulse oximetry can detect hypoventilation when patients are breathing room air with an immediate decrease in oxygen saturation levels. However, caution should be used when interpreting oxygen saturation values in patients who are given supplemental oxygen (fraction of inspired oxygen of 0.25-0.3) because a decrease in values may not be seen.[145] There is no evidence that the use of a pulse oximeter decreases adverse outcomes with procedural sedation. Nevertheless, the non-invasive, real-time information that a pulse oximeter provides is a minimal cost to the patient and is a simple measure to implement.[142]

Capnometry detects the partial pressure of expired carbon dioxide with an end tidal carbon dioxide monitor and a nasal cannula. It is commonly used in intubated patients and recently has gained popularity in sedated patients. The use of capnometry is recommended for moderate- to deeply-sedated patients by the ASA and AAP.[3,4] ACEP recommends that capnometry be used when ventilatory efforts are not able to be directly visualized and monitored.[5,6]

Prospective studies of pediatric patients undergoing procedural sedation demonstrate that end tidal carbon dioxide ($ETCO_2$) values increase with the depth of sedation.[146-149] The use of $ETCO_2$ measurements was helpful to detect sub clinical respiratory depression and airway obstruction.[146,147] In adult patients undergoing procedural sedation, the changes in $ETCO_2$ values had no correlation with physician assessment of depth of sedation.[150] $ETCO_2$ values greater than 50 mmHg, a change greater than 10 mmHg above baseline, or an absent waveform were able to detect all cases of subclinical respiratory depression not detected by pulse oximetry in one study of adult patients.[150] Of note, over half of the

patients in the study who had respiratory depression received supplementary oxygen, which has previously been found to misleadingly boost pulse oximetry values.[145,150] Capnometry provides useful information about ventilation that may help identify those individuals requiring intervention during procedural sedation in the emergency department.

Lastly, age-appropriate equipment to provide a full resuscitation should be readily available and functional. This includes, but is not exclusive to oxygen, anesthesia bag and mask, wall suction, advanced airway equipment, and code medications. Available personnel with adequate training in the resuscitation of children should also be involved in the monitoring of the child undergoing sedation.

Pain assessment scales

Patient self-reporting is considered the most reliable indicator of the existence and intensity of patient pain. Since pain is an individualized experience, numerous pain scales have been created to quantify pain in children older than 3 years of age. One-dimensional pain scales such as the Visual Analogue Pain Scale (VAS), OUCHER scale, and Faces Pain Scale have been validated and are common practice in many settings.[151-155] However, a problem arises when children are too young or are developmentally unable to accurately verbally express their pain. In these instances, rating tools that assess both behavioral and physiological components are utilized.[156,157] Unfortunately, the evidence is lacking as to exactly which method is most accurate, and thus no clear recommendation can be made as to which pain scale is most appropriate for use in the emergency department. Regardless, it is up to the institution to choose a pain scale and properly educate the medical staff in its uses and shortcomings.

Treatment

Individual methods of providing sedation and analgesia to children in the emergency department may be more or less appropriate for any given procedure. The nature of the experience involved in undergoing a particular procedure may guide the emergency physician in selecting a particular method likely to provide comfort and facilitate the completion of the procedure in the emergency department.

Peripheral intravenous catheter placement

Peripheral IV catheter placement is a common procedure in the emergency department that causes children anxiety and pain. The primary cause of the pain resulting from IV cannulation is through nerve endings in the epidermis. Thus, intradermal lidocaine and topical anesthetics have been investigated to alleviate this pain.

Brown conducted an unblended, controlled study to determine if intradermal lidocaine was useful in decreasing IV cannulation related pain.[158] In adult patients, IV placement was significantly less painful in patients who were administered intradermal lidocaine (0.1ml of 1% lidocaine).[158] There was no significant difference in the number of IV attempts or in the time necessary for completion of IV placement between the intervention and control group. However, data in this study may be biased in that the patients were not blinded or randomized, and the pain of lidocaine injection was not assessed.[158]

Since the injection of lidocaine can cause pain itself, needle-less anesthetic methods have been investigated. Investigators conducted a randomized controlled trial of 28 adult subjects to see if ice applied for 10 minutes significantly reduced the pain of IV insertion.[159] This intervention resulted in reduced reported pain scores, but the decrease was not significant.[159] Furthermore, when surveyed, most patients (61%) preferred to receive no ice treatment prior to IV placement.[159] Another delivery method with a device called a J-Tip syringe, a needle-free syringe that delivers medication subcutaneously under high pressure over 0.2 s to 5-8mm in depth, was used to deliver 1% buffered lidocaine prior to IV placement.[160] It was found to effectively provide anesthesia without causing significant delivery pain or difficulty with successful cannulation in patients 7-19 years of age.[160] The J-Tip system is a reasonable method for anesthesia prior to IV placement in older children.

Topical anesthetics, another needleless modality, have been investigated to reduce IV placement pain. In two randomized, double-blinded clinical trials of pediatric patients, EMLA was placed 45-60 minutes prior to IV placement.[96,161] In both studies, the pain of IV placement was significantly less in the patients who received EMLA as opposed to placebo. This suggests that an application time of 45 minutes is adequate for pain reduction.[96] No serious adverse events occurred with EMLA in either study, but there were a few local reactions (erythema, blanching) that resolved within 2 hours.[96,161] In the study by Maunuksela, some of the patients did receive diazepam or flunitrazepam prior to IV placement, as the study was conducted under pre-operative circumstances. However, the number of patients receiving benzodiazepines was not significant between the EMLA and placebo groups.[161]

Since EMLA and intradermal lidocaine have both been found to be effective in decreasing pain associated with IV cannulation, investigators questioned as to which agent was superior.[96,158,161] In a randomized clinical trial comparing lidocaine (0.2ml of 1% with a 30-gauge needle) versus EMLA (2.5g of 5% applied for 60 minutes) in pre-operative children, researchers found no significant difference in pain with IV placement between patient pain scores.[162] None of the children in this study were pre-medicated. No events with the lidocaine group were mentioned, but in the EMLA group, itching and transient blanching occurred. The pain associated with the intradermal lidocaine administration was not measured.[162] In a study by Jimenez in 7 to 19 year olds comparing 1% buffered lidocaine delivered by a J-tip syringe versus EMLA, the pain experienced with the administration by J-tip syringe was significantly less than the pain experienced by the patients with the removal of the occlusive dressing in the EMLA group.[160] Furthermore,

significantly better analgesia was reported in the J-tip lidocaine group with IV cannulation.[160] This study was not blinded and was conducted in the pre-operative setting rather than in the emergency department.[160] Since lidocaine and EMLA both provide adequate anesthesia, it is reasonable for the practitioner to choose the appropriate method for the patient based on time constraints and preference.

With EMLA being similar in efficacy to lidocaine, the main disadvantage to EMLA is the time required to achieve analgesia. One investigator postulated that a shorter application time might be enough to produce a difference in pain score. However, in a blinded, randomized, placebo-controlled, paired trial of 50 adult subjects by Yamamoto, EMLA applied for 20 minutes was found to be ineffective in decreasing pain associated with IV placement.[163] Since it appears that application time cannot be shortened, adjunctive methods to increase the rapidity of EMLA absorption were examined.

Singer looked at whether tape stripping (to do away with the cornified layer of skin), would decrease the time to EMLA absorption and effectiveness.[164] A total of 68 adult patients were randomized to undergo tape stripping and EMLA for 15 minutes or just EMLA for 15 minutes. The group with preceding tape stripping experienced less pain with IV insertion, but the tape stripping procedure did result in pain itself. The success rate of IV cannulation was not different between the two groups, and no patients in the tape stripping group had any adverse effects.[164]

A second, less painful method to decrease the length of time to EMLA effectiveness is to use warming methods. In a randomized, double blinded trial by Liu, 76 adult research subjects were divided into a 20-minute or 60-minute application group.[165] Each subject received a site with placebo, placebo with heat, EMLA, and EMLA with heat, which was generated by a hot pack that was applied over the occlusive dressing (maximum temp 43°C).[165] There was no difference in the success rate of IV cannulation in one attempt between the 20- or 60-minute application groups or between the heat and no heat groups.[165] There was, however, an increased success rate with EMLA (95%) versus placebo (88%).[165] There was no increased rate of erythema, blanching, or itching with the heat-applied groups.[165] The researchers found that at 20 minutes, the reduction in pain with IV cannulation was statistically significant with both EMLA groups.[165] However, a clinically significant reduction in pain over placebo—change in VAS score of 13mm as determined by Todd—was seen only with the EMLA plus heat group.[165,166] This is contradictory to earlier findings by Yamamoto, which could be due to the fact that in the study by Liu, all subjects were included even if IV cannulation was not successful.[163,165] In comparing the 20-minute groups, the EMLA group with heat did reduce pain more than the EMLA group without heat, but the difference was not statistically significant.[165] Nevertheless, it appears that EMLA applied for 60 minutes without heat was superior to EMLA with or without heat at 20 minutes.[165]

It is unclear why heat helps to increase EMLA absorption. It was postulated that heat causes peripheral capillary vasodilation which would increase EMLA absorption.[165] However, testing this principal by mixing EMLA with glyceryl trinitrate, a vasodilator, did not work in a similar manner to decrease the time to anesthesia.[167] Findings from this study revealed that EMLA with glyceryl trinitrate was equal to EMLA alone.[167] Even though the mechanism of heat with EMLA is unclear, in cases where it is not possible to wait 60 minutes until IV placement, 20 minutes of EMLA with heat is an alternative to consider.

Lastly, in addition to the attempts to determine methods to decrease the application time of EMLA cream, two studies have shown that experienced triage nurses can consistently identify patients who will eventually receive an intravenous catheter.[98,100] Thus, this drug can be administered in triage or when the patient is initially placed into a room to avoid unwanted increase in patient care time. Thus, the slow inset of action should not be

Ten Key Points

- Pain and anxiety are inevitably encountered by children in the emergency department. It is important for emergency practitioners to properly treat children's pain and anxiety.
- Emergency practitioners provide safe sedation and analgesia to patients in the emergency department. This includes mild, moderate, deep, and dissociative sedation.
- When sedation medications are utilized in combination, there is a greater chance of adverse events.
- A quantitative pain assessment is considered a "fifth vital sign" by some practitioners.
- Intradermal lidocaine, EMLA, ELA-MAX, oral midazolam and nitrous oxide decrease pain associated with IV catheter insertion.
- EMLA, applied 60 minutes before injected lidocaine, is helpful in decreasing the pain of a lumbar puncture.
- When using lidocaine for wound repair, injecting slowly through a small caliber needle minimizes pain.
- Fentanyl/midazolam, ketamine, etomidate, and nitrous oxide are sedation regimens well suited to fracture reduction in the emergency department.
- Developmentally delayed children often express pain differently than other children.
- Propofol appears to be a promising drug for use by emergency practitioners to sedate children.

a barrier to routine use of EMLA in a busy emergency department for children who will most likely receive an IV.

An alternative to EMLA is another topical anesthetic ELA-Max (4% lidocaine cream). In a randomized, double-blinded, controlled trial in patients 1 month to 17 years of age, 4% liposomal lidocaine was found to reduce pain with IV cannulation.[168] Intravenous access was achieved on the first attempt in 74% of patients in the ELA-Max group as opposed to 55% in the placebo group (p=0.03).[168] There were no significant dermal changes between the treatment and placebo groups.[168] Furthermore, three randomized trials with pediatric patients were conducted to compare the efficacy of EMLA versus ELA-Max.[169-171] ELA-Max for 30 minutes, with or without an occlusive dressing, was found to be as effective as EMLA for 60 minutes with an occlusive dressing in reducing pain with IV placement or venipuncture.[169-171] EMLA did result in more skin blanching than ELA-Max, which is felt to make IV placement more difficult, but the rate of successful procedure completion was not statistically significant between the two groups.[169-171] Thus, the fear of a more difficult IV cannulation with topical agents is not founded in the literature. ELA-Max appears to be a safe alternative in providing speedy topical anesthesia prior to IV placement.

Orally administered midazolam was postulated to be a painless method to decrease pain with IV cannulation.[48] A randomized, double-blind, placebo controlled trial conducted by McErlean, found that in children between the ages of 9 months to 6 years of age, a single oral dose of midazolam (0.5 mg/kg, maximum 20 mg) significantly decreased parental pain scores.[48] The observers' pain scores were lower for the midazolam than the control group, but were not significantly lower.[48] Of note, the patients' reported pain scores were not recorded.[48] There were no hypoxic or hypoventilation events reported.[48] Although, orally administered midazolam appears to be a safe means to decrease pain scores with IV placement, the decrease in level of consciousness may not be acceptable in some cases.

In addition to topical anesthetics and midazolam, inhaled nitrous oxide has been postulated to be a safe and effective way of decreasing pain and anxiety involved with peripheral IV placement.[172] In adult patients undergoing IV cannulation, a 50:50 mixture of nitrous oxide and oxygen inhaled for 120 seconds was found to significantly decrease pain and anxiety over oxygen alone.[173] In this study, no adverse effects were noted, except dizziness in one patient with the nitrous oxide mixture.[173]

Two prospective randomized studies were found that compared nitrous oxide (70:30) mixture for 120 seconds with EMLA applied with an occlusive dressing for 60 minutes in children.[174,175] Vetter studied children 6 to 12 years of age, and found that nitrous oxide significantly reduced observer and patient pain scores over the EMLA group.[174] However, this is contradictory to findings by Paut, who studied patients of similar age but found nitrous oxide and EMLA groups to have no significant difference in pain scores.[174] The reason for this difference may be due to bias on the part of the patient and investigator of the Paul study, since this study was not blinded. Furthermore, the VAS scores in this study were much lower than other similarly designed studies.[174,175] A comparison of VAS pain scores to the studies completed by Koh and Hee with a similar application protocol, revealed VAS pain scores similar to those reported by Vetter.[171,176]

In a randomized, controlled trial conducted in children 3 weeks to 18 years of age, nitrous oxide mixtures of 50% and 70% inhaled for 180 seconds were found to significantly decrease pain and anxiety over oxygen alone or no gas.[177] The 70% nitrous oxide mixture significantly reduced pain behavior over 50% nitrous oxide, 100% oxygen and no gas.[177] However, the 70% mixture of nitrous oxide resulted in side effects in 28% of patients, which included excitement, dysphoria, nausea,

Cost-Effective Strategies

The use of procedural sedation versus no sedation increased patient charges and length of stay in children undergoing simple laceration repairs.[206] However, the comfort of the patient and desires of the family should be considered. If sedation and/or analgesia are to be used, the lowest level and least amount of medications necessary to carry out the procedure should be used. For example in a cooperative patient, laceration repair may be possible with local anesthesia alone. If sedation is to be done, titration should be used to prevent over-sedation, which can lead to a prolonged recovery time. Attention should also be taken to provide caregivers with detailed post-sedation instruction to prevent unnecessary return to the emergency department.

Prior to undergoing a procedure, steps can be taken to assure a successful endeavor to avoid preventable cost, time and suffering. For example, prior to performing a urine catheterization, bladder ultrasonography to detect ample urine volume could be done.[264,265] Using bedside ultrasound, Milling found that a urinary bladder index less than 2.4 cm^2 would yield less than 2 ml of urine, thus urine catheterization should be withheld to prevent unnecessary re-catheterization.[264] For abscess incision and drainage, ultrasound can be used to help determine the presence of an abscess in difficult cases.[266]

Additionally, interventions can be introduced at the time of triage, as the time interval between registration and procedure commencement may be lengthy. For example, triage nurses were found to be reliable in identifying patients who would require an intravenous catheter. Thus, skilled nurses can be a vital resource to initiate the administration of EMLA cream in triage to help avoid increasing patient care duration, while still providing appropriate analgesia.[98,100]

restlessness and opisthotonic movements.[177] The side effects occurred mostly in the patients greater than 5 years of age.[177] Authors note that the patients subjected to excitement were not responsive to verbal stimuli, which implies an altered level of consciousness; consequently, authors warn that there is a potential for patients to lose protective airway reflexes.[177] No side effects were seen in the 50% nitrous oxide group, thus suggesting that a 50% mixture may be the best possible amount for analgesia and anxiolysis in children.[177]

Nitrous oxide and EMLA in combination appears to be the ideal combination when resources permit its utilization. When 50% nitrous oxide, EMLA for 60 minutes or ELA-Max for 30 minutes are used alone, they each appear to have equivocal effectiveness. Studies of nitrous oxide have primarily been conducted in the pre-surgical arena, thus more studies in the emergency department setting are needed. At this time, patient and physician preference along with availability of modalities should be used to determine the appropriate method of analgesia for IV placement.

Thus, liberal use of topical anesthetics for intravenous catheter placement in children in strongly encouraged. The placement of this medication can be strategically done in triage or when the patient is initially placed into the room. The J-tip delivery method of buffered lidocaine is a reasonable alternative to topical agents for children greater than 7 years old. Other pharmacologic adjuncts such as oral midazolam and inhaled nitrous oxide appear to be helpful and can be used at the discretion of the emergency practitioner.

Urine catheterization

Urine catheterization is a common painful procedure performed in infants and young children.[178] For the procedure of urine catheterization, an observational study found that parents who use distraction were able to comfort the child more than half of the time, suggesting a parental intervention opportunity.[179] However, a randomized control trial to teach parents to interact and distract patients found no significant reduction in procedural pain experienced by the child.[180]

Topical lidocaine gel may be effective in decreasing pain associated with urine catheterization. A randomized, double-blinded, placebo controlled trial conducted by Gerard in a urology clinic for pediatric patients requiring urine catheterization for cystograms found that 2% lidocaine gel effectively reduced self-reported pain and observed distress associated with urine catheterization.[181] However, a randomized, double-blinded, placebo controlled trial conducted in the pediatric ED on children less than 2 years old using 2% lidocaine gel versus a placebo lubricant found no significant difference in FLACC scores between the two groups after a 2-3 minute application period.[178] A possible reason for finding a difference in the first study was that the 2% lidocaine gel was applied using a very involved technique where the lubricant was first placed at the urethral meatus for 1 to 2 minutes, and secondly instilled into the urethra for 2 minutes for a total of 3 times.[181] Furthermore, the children were older and perhaps a difference in pain was easier to detect using a self-reporting pain score. There is currently a lack of evidence to determine if the length of time the lidocaine gel was applied or the method of application was the key component in decreasing pain experienced with urine catheterization. The onset of action for 2% lidocaine jelly is 3-5 minutes, suggesting that the application period may not have been adequate in the study conducted by Vaughan. Currently, the evidence is lacking to recommend routine use of lidocaine gel for bladder catheterization in young children, however further study in this area is warranted.

Lumbar puncture

Lumbar punctures (LPs) are a common practice in the pediatric emergency department. In one survey of members of the AAP Section on Pediatric Emergency Medicine, 68% percent of respondents did not routinely use analgesia (sucrose pacifiers, injectable lidocaine, and topical creams) for neonatal LPs, but reported analgesia usage with older patients.[182] Overall, one-fifth of the 188 physician respondents reported using no analgesia for LPs regardless of the patient's age. Most respondents did not use topical creams due to the length of time needed for effectiveness and secondly for the belief that topical agents do not work well.[182]

In randomized control trials, the placement of EMLA decreases pain experienced by pediatric patients undergoing an LP.[183-185] The use of an EMLA patch versus EMLA cream with Tegaderm dressing were found to provide equivalent pain relief, but the EMLA patch may have the advantage of easier application and a more controlled dose administration per use.[183] One prospective observational study found the use of analgesic agents such as EMLA, 4% liposomal lidocaine, and injectable lidocaine doubled the success rate of lumbar punctures.[186]

The use of injected lidocaine in newborn infants has also been shown to decrease struggling in newborn infants undergoing an LP, while not affecting the success rate, occurrence of traumatic LPs, or number of attempts needed to complete the procedure.[187] In a similar study in patients under the age of 3 years, investigators found no change in the success rate of LPs when injectable lidocaine was administered prior to the procedure.[188] No clinical trial has been found comparing pain reduction with EMLA versus injected lidocaine for pediatric LPs.

In the area of hematology/oncology, other methods to decrease pain have been investigated. Oral transmucosal fentanyl has been shown to significantly decrease pain with LPs, but the side effect of vomiting may limit its use.[189] Also, midazolam administered intravenously 3-5 minutes before undergoing the LP decreased the post-procedural pain without adverse medication effects.[190]

The use of analgesia adds to patient comfort and does not decrease the success rate of the procedure. The use of EMLA and injected lidocaine is recommended prior to lumbar puncture, but there is no evidence to determine which is the preferred method. Oral fentanyl and midazolam can also be used at the discretion of the practitioner.

Laceration repair

Lacerations are a common pediatric complaint to the pediatric emergency department. Of those that require suturing, pain is controlled by a variety of techniques. Available methods of providing analgesia include injected lidocaine, topical agents, and procedural sedation. These drugs can be used as single agents or in combination.

Injected lidocaine is a common local anesthetic used prior to closure of lacerations. Unfortunately, the administration of lidocaine is painful. Brogan Jr, examined if warming or buffering lidocaine decreased pain associated with injection.[191] In this prospective, randomized, single-blinded study, warmed (plain lidocaine warmed to 98.6°F) and buffered had equivalent analgesia to plain lidocaine, but with significantly less pain with injection.[191] Additionally, patients who received warmed lidocaine injections required less supplemental lidocaine injections throughout the procedure, but the difference was not significant.[191] Buffered lidocaine does not appear to have a higher wound infection rate.[192] Lidocaine is buffered by mixing it in a 9:1 ratio of 1% lidocaine and sodium bicarbonate. Two studies of adult patients looking at pain on infiltration found a statistically significant difference favoring buffered lidocaine, while another study only found a trend towards less pain with buffered lidocaine.[193-195]

Proper technique may be a factor in patient discomfort, as the location of the injection and rate of injection appears to make a difference in pain perception. Investigators found that injection through open skin produced less pain than injection through intact skin.[196] Two prospective single-blinded studies of adult volunteers received 1 ml of buffered and plain lidocaine at slow and rapid injection speeds. Krause found no significant difference on pain with lidocaine injection between the slow (10 seconds) and rapid (1 second) administrations speeds.[197] However, Scarfone found that the speed of administration (30 seconds versus 5 seconds) did significantly alter pain perception, as it was greater in the rapid administration groups. Furthermore, the effect of administration speed affected pain perception more than did buffering of the lidocaine.[198] Scarfone hypothesized that the rapid administration rate causes a brisk distention of injected tissue and activation of a smaller number of nerve endings, thus causing more pain.[198] These studies were conducted in adult volunteers to intact tissue, thus studies in children with lacerations are needed.[197,198]

Since the injection of lidocaine is painful and uncomfortable for patients, alternative topical agents have been studied. Clinical trials in pediatric patients comparing TAC with injectable 1% lidocaine found no significant difference in analgesic effect for face and scalp lacerations.[103,199] However, for extremity lacerations, TAC was significantly less effective than injected 1% lidocaine (43% vs. 89%) in providing adequate analgesia.[103] This may be due to the relative decreased vascularity in the extremities compared to the scalp and face.[103]

Since TAC contains cocaine, a schedule II controlled substance with grave adverse events, alternative agents have been developed and tested. Other available topical analgesic agents include prilophen (3.56% prilocaine-0.99% phenylepherine), tetraphen (1% tetracaine-5% phenylephrine), tetralidophen (1% tetracaine-1% lidocaine-2.5% epinephrine), LAT (4% lidocaine-0.05% [1:2000] epinephrine/adrenaline-0.5% tetracaine), and LET (4% lidocaine-0.1% [1:1000] epinephrine/adrenaline-0.5% tetracaine). A prospective, randomized trial in adult and pediatric patients comparing LAT gel with 1% buffered lidocaine injection found no significant difference in anesthesia efficacy. However, injected lidocaine was found to be significantly more painful than LAT gel application.[200]

Prospective, randomized, double-blinded controlled trials of LAT gel and LET solution compared to TAC for pediatric face and scalp lacerations found both to provide similar efficacy in providing anesthesia.[201,202] The duration of anesthesia after LET solution and TAC were similar as well, with a mean of 19 minutes.[202] A randomized, single-blinded controlled trial of LET gel versus LET solution in pediatric patients with face and scalp lacerations, found no significant difference between the adequacy of anesthesia before suturing was begun.[203] However, significant differences for the length of anesthesia were found between the gel and solution.[203] There were more patients with complete anesthesia (no supplemental lidocaine) and fewer patients with partial anesthesia (requiring further lidocaine between 15-30 minutes after topical agent removal) in the LET gel group, but a higher number of patients with incomplete anesthesia (require further lidocaine within 15 minutes after topical agent removal) were also seen with LET gel.[203] The reason for this is unclear, but overall, the study proposes that LET gel is at least as effective as LET solution.[203]

For simple finger lacerations, a prospective case series in pediatric patients between 5 to 18 years of age, found that LAT gel achieved anesthesia 53.7% of the time, which is similar to the rate with TAC in extremity lacerations.[204] LAT gel provided significantly better anesthesia for dorsal (68.6%) versus ventral (37.5%) surface lacerations.[204] No patients experienced ischemia or infection.[204]

Amid the emerging use of topical anesthetic agents, the issue of treatment time for lacerations has been investigated. In a randomized, double-blinded, controlled trial of pediatric patients conducted in an urban Australian ED, the topical application of adrenaline, lignocaine, amethocaine (ALA) solution or placebo (adrenaline 1:1,000) was applied to simple lacerations.[205] The median treatment time for the ALA group was 77 minutes and 108 minutes for the control group, which suggests the application of topical agents at triage may help to decrease treatment time.[205]

In addition to local methods of anesthesia, procedural sedation for laceration repair can be used. Reluctance to use sedation can be attributed to factors related to expense and prolongation of ED treatment time. A retrospective cohort study of children treated for simple facial lacerations found that patient charges and length of stay were higher for ketamine and midazolam groups compared to the no-sedation group.[206] The clinical

significance of these differences has to be considered while further exploring the use of procedural sedation with laceration repair.

Benzodiazepines have been used to provide anxiolysis for laceration repair. Oral midazolam (0.3 mg/kg) is able to significantly decrease patient anxiety, without any adverse events (except one excitatory response) in a pediatric study of 107 patients between 10 and 119 months.[207] A similar study of oral midazolam (0.2 mg/kg) in high-anxiety pediatric patients also illustrated a significant decrease in anxiety scores without adverse effects or delay in discharge.[208] Midazolam has been compared to diazepam in a single-blinded, randomized clinical trial, where midazolam was significantly superior to diazepam in reducing distress during suturing.[209] Alternative routes of midazolam administration have been studied. Investigators found that intranasal midazolam (0.4 mg/kg) significantly reduced cry and struggle scores when compared to the placebo and control group.[210] In two other clinical trials, the intranasal route (0.4 mg/kg and 0.25 mg/kg, respectively) and the oral route (1 mg/kg and 0.5 mg/kg, respectively) significantly decreased anxiety.[209,211] The decrease in anxiety was not significantly different between the nasal and oral administration groups. However, both studies concluded that the oral route was better tolerated by the study population than the intranasal route.[209,211]

Ketamine has also been studied for sedation during laceration repair. A 10 mg/kg dose of oral ketamine was found to be effective in decreasing perceived pain with lidocaine injection and suturing in 30 children between the ages of 1 and 7 years.[212] As compared to placebo, no significant cardiopulmonary adverse events were noted, but 26% of ketamine patients experienced minor side effects such as vomiting, nystagmus, and random extremity movement.[212]

In a comparison of oral ketamine (10 mg/kg) with oral midazolam (0.7 mg/kg) in 59 children, oral ketamine was found to significantly improve the tolerance/anxiety score with lidocaine injection (without previous topical anesthetic).[213] There was no significance in tolerance/anxiety score during suturing between the ketamine and midazolam group. The ketamine group reached adequate sedation significantly quicker than the midazolam group (20 minutes versus 43 minutes, respectively), and the discharge times from sedative administration to discharge were similar between the two groups.[213] Vomiting and oxygen desaturation below 94% were not significantly different between the two groups, but the incidence of dysphoric reactions in the midazolam group was significantly greater than the ketamine group (21% versus 0%, respectively).[213] The increased incidence of dysphoric reaction may be due to the relatively high dose of oral midazolam used (0.7mg/kg). Past studies have shown 0.5 mg/kg of oral midazolam to be safe and effective for pediatric procedural sedation, with the dose of 0.75 mg/kg found to cause more side effects (ataxia, dysphoria, and blurred vision) without additional sedative or anxiolytic benefit.[214,215]

At times, children are not cooperative enough to take oral medications. A comparative study between intramuscular ketamine (2.5 mg/kg) and intranasal midazolam (0.5 mg/kg) was conducted for providing sedation for laceration repair.[216] Both medications provided sedation, but the patients in the ketamine group were less likely to cry and the number of patients that needed to be restrained in the ketamine group (14%) was significantly less than in the midazolam group (86%).[216] Recovery behavior and discharge time were not significant between the two groups.[216]

Further investigation of intramuscular ketamine was done to compare it with intramuscular midazolam in 87 pediatric patients who underwent laceration repair.[217] Researchers found intramuscular ketamine (2.5 mg/kg) to be superior to intramuscular midazolam (0.4 mg/kg) in that a significant number of patients in the midazolam group had to be restrained.[217] Additionally, the agitation scores during local anesthetic administration and suturing were significantly decreased in the ketamine group.[217] With the dose of intramuscular midazolam being used (0.4 mg/kg)—which was chosen to provide amnesia and to decrease the use of restraints—there was a concern of creating an extended sedation period.[217] Therefore, intranasal flumazenil (25 mcg/kg) was also studied to decrease length of emergency department stay. Among the midazolam groups, intranasal flumazenil was effective in decreasing agitation during recovery and in decreasing discharge time (55 minutes versus 95 minutes).[217]

Nitrous oxide has been studied as a possible painless adjunct for laceration repair. An initial study by Gamis found continuous nitrous oxide (30% N_2O/70% O_2) mixture to be a safe analgesic for pediatric laceration repair.[218] In the study, there was a decrease in observed pain behavior in children less than 8 years of age during suturing in the nitrous oxide group, and a significant change in subjects 8 years or more.[218] The authors suggested that higher dosages (40% or 50%) of nitrous oxide might provide additional benefit.[218] Further investigation by Burton, in a prospective, randomized, placebo controlled, double-blind trial, found inhaled nitrous oxide (50% N_2O/50% O_2) mixture to significantly decrease anxiety scores in pediatric patients 2 to 7 years of age undergoing laceration repair.[219]

The supplementary benefit of oral midazolam (0.5 mg/kg) with continuously inhaled nitrous oxide mixture (50% N_2O/50% O_2) was studied by Luhmann in a prospective, randomized clinical trial in children undergoing facial laceration repair.[220] Patients 2 to 6 years of age were randomized to receive standard care (LET plus injected lidocaine), standard care with midazolam, standard care with nitrous oxide, or standard care with midazolam and nitrous oxide.[220] Results found the nitrous oxide groups had significantly lower distress rating scores during lidocaine injection, wound cleaning, and suturing.[220] The midazolam with standard care group had trends toward lower scores over the standard care group, but these findings were not significant.[220] In comparing the nitrous oxide plus midazolam and standard care group

with the nitrous oxide plus standard care group, there were no added benefits of combining the usage of nitrous oxide and midazolam.[220] No cardiopulmonary events occurred in any of the study participants. Vomiting in the emergency department occurred in 6% of patients who received nitrous oxide (1 in N_2O + midazolam group, 5 patients in N_2O alone group).[220] None of the patients who received midazolam alone vomited. None of the patients that vomited had detectable symptoms during recovery, at 24 hours, or at the suture removal follow-up visit.[220] Continuous nitrous oxide appears to be a safe, painless addition to standard care with minimal side effects.

Measures to decrease pain are recommended for laceration repair. When time permits, LET, LAT, and TAC are effective topical agents, with LET and LAT being recommended over TAC due to its cocaine component and associated risks. There is no evidence to suggest if LET or LAT is superior. If immediate closure is desired, 1% lidocaine is effective, but its administration causes pain. To decrease this pain, it is recommended to use warmed, buffered lidocaine, through the open margin of the wound. Adult studies recommend a slower injection speed over a rapid speed to decrease infiltration pain. Anxiolysis can be achieved with oral or intranasal midazolam, with the oral route being better tolerated. Intramuscular midazolam and ketamine can be used to decrease pain and anxiety, with intramuscular ketamine being more efficacious. Nitrous oxide (50%) can also be used in children 2 to 7 years of age to provide analgesia. Combination regimes are understudied, but it has been found that the combination of nitrous oxide with LET and injected lidocaine works better than each component alone. The addition of oral midazolam shows no added benefit. There is a lack of evidence to recommend other sedation regimes. The choice of sedation versus local anesthesia should be made on an individual basis by the emergency practitioner.

Fracture reduction

Orthopedic injuries are a common presenting complaint to the pediatric emergency department. In a retrospective chart review of one pediatric emergency medicine (PEM) staffed ED and 2 EDs staffed with general emergency medicine (EM) physicians, more than one-third of patients with a severe (angulated or displaced) forearm or lower extremity fracture did not receive pain medications.[221] More PEM physicians (94%) were likely to sedate for a reduction or immobilization procedure than the general emergency physicians (46%).[221] However, general EM physicians recommended (66% versus 45%) and prescribed (13% versus 2%) more analgesics for discharge than did PEM physicians.[221] Analysis of the National Center for Health Statistics National Hospital Ambulatory Medical Care Survey for 1997 through 2000 revealed that adults were significantly more likely to receive pain medication than children for closed extremity fractures.[222] Children in general EDs compared to pediatric EDs were as likely to receive pain medication for fractures in either setting.[222] VanderBeek found race to not be a factor in the use of procedural sedation for closed forearm fractures.[223]

Procedural sedation with fentanyl and midazolam was examined in a retrospective review of children undergoing reductions of fractures and dislocations.[224] There were 8.3% of patients who desaturated below 90% with 4.7% of patients receiving oxygen and 0.6% of patients receiving naloxone.[224] Vomiting was seen in 1.2% of patients, but no patients required intubation or admission.[224] Mean time to sedation was 11.3 minutes and the mean discharge time was 92 minutes.[224] Fentanyl and midazolam are a safe combination for orthopedic procedures in the pediatric ED.[224] The addition of ketoralac to the combination of fentanyl and midazolam was examined in a randomized, double-blind study in children 3 to 18 years of age undergoing reduction of a forearm fracture.[225] Although ketoralac appeared to add to patient comfort, an opioid sparing effect was not seen.[225]

Ketamine has been found to be an effective anesthetic for fracture reduction in children.[226] Researchers reported successful reduction in 111 of 114 patients.[226] The three failed reductions were not due to inadequate sedation, but to instability after reduction.[226] Oxygen desaturation below 90% was seen in 0.02% (2 patients), and no patients experienced hemodynamic instability.[226] A dysphoric reaction was seen in one patient that resolved with 0.2 mg/kg of midazolam.[226]

In comparing a combination of ketamine plus midazolam (K/M) versus fentanyl plus midazolam (F/M) in pediatric fractures and joint dislocations, both regimes had high success rates of reduction (99% versus 98%, respectively).[227] Induction times and recovery times were similar for both groups.[227] The pain and anxiety scores for the procedure were significantly less in the K/M group.[227] When controlling for the midazolam dose, the F/M group experienced more respiratory complications. An emergence reaction was reported in 2% of patients in the F/M group and 5% of patients in the K/M group.[227] More patients experienced vomiting in the ketamine group than in the fentanyl group, but no clinically apparent signs of aspiration occurred.[227] Both K/M and F/M appear to be safe and effective sedation combinations for orthopedic procedures, with K/M providing greater pain and anxiety relief.[227]

Etomidate has been suggested for sedation for pediatric fracture reduction in children. In a retrospective chart review of 53 children, etomidate allowed for successful reduction after one attempt in 83% of cases.[59] There were 13 patients (24.5%) who required additional doses of etomidate or midazolam.[59] All patients received supplementary analgesia, with 51 patients receiving morphine (mean dose 0.21 mg/kg) and 2 patients receiving fentanyl (mean dose 1.8 mcg/kg).[59] A mean discharge time of 94 minutes was found in 33 patients (62%), with 18 patients admitted for neurovascular checks, 5 for operative repair and one for prolonged sedation.[59] There were no patients with apnea, hypoxemia, vomiting or aspiration.[59] Etomidate appears to be an effective sedative agent for pediatric fracture reduction.

Etomidate has also been compared to midazolam for

procedural sedation for joint dislocations and long bone fracture reductions in adult patients. In two prospective, randomized, double-blinded trials, etomidate was found to provide equivocal sedation with midazolam.[228,229] The etomidate group provided a significantly shorter time from medication administration to procedure completion in both studies.[228,229] The incidence of adverse events collectively was similar in both groups, with no patients requiring intubation or hospitalization in either study.[228,229] Of note however, the overall time to discharge was not found to be any different between the groups.[229]

An alternative to parenteral medications is inhaled nitrous oxide. Nitrous oxide has been evaluated in two prospective studies for pediatric fracture reduction.[230,231] Wattenmaker reports that a 50% nitrous oxide and 50% oxygen mixture was a safe and effective means of providing analgesia for fracture reduction.[230] They report that when children were asked about pain after the completion of the procedure, 60% recalled no pain, 35% with minimal pain, and 5% with moderate pain.[230]

Ten Pitfalls to Avoid

1. **"I did not think that we needed to get out the anesthesia bag and face mask. I have never had problems with sedating children in the past."**
   Sedation should not be carried out without appropriate resuscitation equipment. The appropriate size airway equipment should be readily available as well as experienced personnel who can handle a level of sedation past what is anticipated for the procedure.

2. **"I didn't know that the patient had a large ventriculoseptal defect and was on all those heart medications."**
   There is a lack of evidence to suggest that obtaining a detailed history and physical examination prior to sedation are absolute necessities. However, a rough assessment based on the ASA physical classification status is useful. Children who are ASA class III or higher are at increased risk for complications related to sedation.

3. **"I thought it read 25 milligrams of fentanyl."**
   Medication errors are common. With sedation medications, as with all medications, meticulous care should be taken to reduce the likelihood of errors. Institutions should consider implementation of a double-check system between physicians, pharmacists and nursing staff to ensure intended medication dosages are given. Always remember the "one vial rule." This means that if you open up more than one vial of medication, double check your dosing as you may be administering an improper dose.

4. **"Versed and fentanyl did not sedate the patient to the point I would have liked so I decided to administer some etomidate as well."**
   Caution should be used when using multiple drugs. The use of multiple drugs has been found to increase the risk of having an unwanted complication. It is best to choose your medication wisely and titrate to effect.

5. **"The infant had a large laceration, and he was difficult to anesthetize. I ended up administering 8 ml of lidocaine, and the child had a seizure."**
   Inadvertent lidocaine toxicity (greater than 3-5 mg/kg plain and 7 mg/kg with epinephrine) can cause arrhythmias and seizures. Attention should be paid to the maximum volume of lidocaine recommended to prevent unnecessary side effects.

6. **"The ED is too busy to use EMLA cream, we don't have time to wait an hour."**
   Liberal use of topical anesthetics is crucial in decreasing pain for children undergoing IV catheterization and venipuncture. Proper timing of application, such as in triage or as soon as a patient in placed into a room, has been shown to provide an appropriate time for its efficacy without hindering ED flow.

7. **"This child did not cry with the IV start, so I don't think he needs any pain medication for the abscess drainage."**
   Pain and the response to pain is an individualized experience and should be treated as such. An atypical response to painful stimuli can be a result of multiple hidden factors such as a previous painful experience, depression, child abuse and neglect, or cultural norms. Just because a child does not outwardly express discomfort does not mean that he is not experiencing any pain.

8. **"The child life worker seemed to have him very calm. I don't know why he started screaming when we started the procedure."**
   Behavioral methods for easing a child's pain and anxiety are particularly effective if the environment does not change. When uncomfortable, cold, hot, scary, or simply different phenomena are introduced, a particular behavioral method may no longer be effective.

9. **"The patient is non-communicative at baseline so I didn't feel comfortable giving him pain medicines."**
   While providing care for special needs children can be difficult, children who are non-communicative at baseline still experience pain. The assessment of this pain can be difficult, but changes in vital signs and also the insight that caregivers provide can be useful. Caution should be used as special needs children can be on different medications that can interact with drugs that you are administering.

10. **"Why did this family come back complaining that their child is vomiting?"**
    Patients can experience a variety of side effects after procedural sedation. Properly preparing the families about these side effects prior to the procedure and providing post-sedation home care instructions can help families cope with these events and prevent unnecessary return to the emergency department.

The results from the study by Hennrikus differ, reporting that 46% of patients had significant pain (Children's Hospital of Eastern Ontario pain score > 10) with fracture reduction.[231] Both studies report no complications related to cardiopulmonary function with the use of nitrous oxide. The difference between the results of the two studies may be attributed to the fact that the Wattenmaker study did not use a standardized pain scale, which makes comparison difficult.[230]

Further investigation of nitrous oxide for pediatric fracture reduction was investigated by Evans who compared 50:50 nitrous oxide with intramuscular sedation with meperidine and promethazine.[232] Nitrous oxide was found to be as effective as intramuscular meperidine and promethazine.[232] The time to discharge was significantly shorter in the nitrous oxide group (30 minutes) than in the intramuscular group (83 minutes).[232] All of the nitrous oxide patients would use nitrous oxide sedation for a second time, as opposed to only 53% of patients in the intramuscular group who would elect to use that method again.[232]

Sedation can be safely recommended for fracture reduction. The K/M combination provides better analgesia and anxiolysis than F/M. Etomidate has also been shown to be safe and effective for pediatric fracture reduction. It has been shown to provide equivocal sedation to midazolam, but it is unknown if etomidate is better than or equal to ketamine. Nitrous oxide (50%) is safe and has the advantage of a short post-sedation time, but there is conflicting evidence about its analgesic properties. At this time, the sole use of nitrous oxide cannot be recommended. The emergency practitioner should select the sedation regime in collaboration with the orthopedist to assure adequate analgesia and anxiolysis.

Incision and drainage

Incision and drainage of superficial abscesses is becoming a more common pediatric procedure. Topical anesthetics injected along the anticipated incision may be effective for the incision, but the release of loculations requires more widespread anesthetics.[233] A ring block, where a local anesthetic is injected intradermally and subcutaneously around the edge of the abscess, can be useful for small abscesses but is usually not effective for large abscesses.[233] This is mostly due to the concern of injecting more local anesthetic than would be safely tolerated by the patient.[233] If the abscess is located on a distal extremity, a regional block may be an option.[233] Aside from local anesthesia, procedural sedation is another alternative.

In the recent literature, there is a lack of randomized controlled trials to determine the best sedatives to carry out this procedure. There are several studies of procedural sedation, which include a few abscess and drainage procedures. Chudnofsky found a combination of midazolam and ketamine was safe and effective in providing procedural sedation and analgesia in 46 adult ED patients.[234] Green determined that a 4 mg/kg IM dose of ketamine was effective and safe for procedural sedation in 25 pediatric patients.[72] In a second series, IV ketamine (mean loading dose 1.5mg/kg) was examined in 2 patients undergoing incision and drainage.[73] From this study it is difficult to determine if any side effects were seen specifically in the incision and drainage patients.[73] In three studies of IV etomidate, which combined included 9 adult patients undergoing abscess drainage, etomidate was found to be effective for procedural sedation.[60,61,66] In a pilot study of supplementary self-administered 50:50 nitrous oxide specifically for incision and drainage, patients experienced pain during the procedure, but there was an amnestic effect as after the procedure they reported significantly less pain.[235]

It seems that local anesthesia, ketamine, midazolam, etomidate and nitrous oxide may be effective in reducing pain while performing incision and drainage, but more studies are needed. A comparative study of these agents alone or in combination would be helpful to determine which modalities are the most effective for this procedure.

Special Circumstances

For many emergency practitioners, children with special healthcare needs pose a difficult challenge. In patients with an abnormal baseline mental status, it is often difficult to assess pain. However, in a study of patients with mild (IQ 70-55) to moderate (IQ 54-40) delay, the VAS was used most easily and was found to be consistent with neutral observers.[236] It was also noted that being scared may intensify the experience of pain in developmentally delayed children.[236] Furthermore, despite previous reports that children with autism may have a "reduced sensitivity to pain," a study of autistic children undergoing venipuncture found that compared to normal children, autistic children still exhibited similar facial expressions of acute pain.[237-239]

All of the medications mentioned in this review can be used safely in children with special healthcare needs or developmentally delayed children. However, some caution should be used, as very little evidence exists on the use of procedural sedation and analgesia in this population. Since there is little data available in providing procedural sedation for pediatric patients with special healthcare needs, Sacchetti suggests that emergency physicians utilize references to become familiar with rare conditions.[240] He also suggested to use a class of medication already on the patient's medication list, as patients with developmental delay may have an extensive list of medications.[240] This is advantageous, as it decreases the likelihood of a cross-reaction with one of the patient's existing medications, and it gives insight into how the child will tolerate the class of medication. In this case it would be prudent to start at a low dose and titrate upward as needed.[240] Of note, ketamine was safely used in a small number of developmentally delayed adults, but etomidate should probably be avoided in children with seizures.[240,241]

One paper addressing autistic children undergoing general anesthesia in the operating room stated that this alteration to their normal routine can cause temper tantrums, panic attacks, and even self-mutilation.[242] In

pediatric autistic patients undergoing general anesthesia, Van Der Walt suggest prescribing oral ketamine for premedication over no premedication or oral midazolam after conducting a retrospective chart review. Autistic children can be very agitated when placed within new surroundings. Thus, the reduction of pre-procedural noise and activity, and the reduction of pre-procedural waiting time can help to reduce sensory input and allow for a trouble-free transition to sedation.[242] Van Der Walt also adds that these techniques have also been helpful in their experience with patients with attention deficit hyperactivity disorder, developmentally delayed children, extremely anxious individuals and children with other behavioral issues.[242]

Controversies/Cutting Edge

Propofol is a water oil emersion that works as a sedative-hypnotic agent. Due to propofol's rapid blood-brain equilibrium half-life of 1 to 3 minutes, after initiation of propofol, a hypnotic state is usually seen within 40 seconds. The safety and efficacy have not been established for the use of propofol for induction in patients less than 3 years of age, maintenance in patients less than 2 months of age or for monitored anesthesia care sedation in children.

In the ED setting, propofol presents an attractive pharmacokinetic profile with rapid onset and short duration. However, there has been significant reluctance to its use in the ED by anesthesiologists. In five studies conducted in pediatric emergency departments, four in general emergency departments, and three in pediatric critical care units, propofol was found to be an efficacious agent for procedural sedation.[243-254] Recovery time from the last dose or discontinuation of the infusion to baseline status usually ranged from 19.8 to 23 minutes.[247,253,254] Adverse events with propofol use were minimal and transient in most cases.[243-254]

The main concern of the use of propofol is the significant vasodilatory properties of the drug and the depth of sedation it produces. A decrease in blood pressure occurred in 0-84% of cases with propofol use for procedural sedation.[243-249,253] In looking only at studies of pediatric patients, the range was still 0-84%.[243-247] Pershad reported a hypotension rate of 0% in a retrospective study of 52 patients.[244] This is consistent with a rate of 0.4% reported in a prospective case study by Charles of 500 patients and a prospective, partially-blinded controlled comparative trial of 59 pediatric patients receiving propofol in which 1 patient (1.7%) experience self-resolved hypotension.[245] However, in a prospective, randomized, blinded trial, Havel reported clinically insignificant transient hypotension in 42.9% of pediatric patients, as no patient in this group required a fluid bolus.[246] The reported rate of 84% of patients (n=331) occurred in a study by Bassett.[243] The decrease in blood pressure reported in 393 patients was transient in 92% of the cases, with the remaining 8% lasting for a median of 3 minutes.[243] They report that only 0.6% (n=2) of patients required an IV bolus for hypotension.[243] It is not clear to what extent the decrease in blood pressure entailed and it bears mentioning that patients were also given fentanyl or morphine one minute before propofol administration at the discretion of the sedating physician.[243] It appears that from these studies we can gather that the percentage of patients experiencing hypotension is varied, but most episodes are transient with a few requiring a fluid bolus. In a few of these studies it appears that moderate to deep sedation was achieved. An emergency practitioner has advanced airway management and resuscitation skills to handle deep sedation, but deep sedation is not desired in the ED setting for procedural sedation.

The reported rates of hypoxia with propofol use for sedation range from 2.8% to 37.9%.[245,247,252,253] Godambe studied a propofol/fentanyl regime and reported a rate of 31% (n=18), with 25% (n=15) requiring supplemental oxygen.[247] Studies by Vardi and Seigler reported similar rates of hypoxia of 37.9% and 36%, respectively.[252,253] In the Vardi and Seigler studies, all patients resolved with repositioning or bag-mask ventilation except one patient in the Seigler study.[252,253] This patient whom required intubation was a 1-month-old girl who developed hypoventilation and hypoxia.[252] A chest radiograph revealed hyperventilation and perihilar infiltrates which were indicative of bronchiolitis.[252] The patient was admitted to the intensive care unit and remained intubated for 4 days.[252] This was the only non-transient adverse event reported with the use of propofol for procedural sedation, but the need for intubation is likely related to sedation and patient age, rather than being directly attributed to using propofol.

Agitation was reported as 0% to 4.7% in pediatric patients undergoing sedation with propofol.[246,253] Pain on injection of propofol has been reported in 24 to 80% of patients, without relation to the size of the catheter or the speed of propofol injection.[255]

While not reported in the ED studies, propofol infusion syndrome—severe metabolic acidosis with or without myocardial dysfunction, rhabdomyolysis, and death—has been described in the pediatric literature.[256-259] Its occurrence is usually in the setting of the intensive care unit (ICU) and has been described with prolonged use (>24-48h) at high dosages (>66-75 mcg/kg/min).[256,257] There is one case found in a 31-year-old female who received an average of 83 mcg/kg/min over 395 minutes who developed metabolic acidosis while undergoing radiofrequency ablation.[256] The interesting point about this case is that there is a paucity of confounding factors that are seen in ICU patients, and when the propofol was discontinued, post-procedure values were normal, suggesting the reversibility of early propofol infusion syndrome.[256] Propofol does have the potential of causing severe metabolic acidosis, but it is unlikely to occur in the ED setting where procedures are usually less than 60 minutes. None of the ED studies previously mentioned had any problems with metabolic acidosis, but blood gases were not routinely measured. Propofol remains an optimistic agent for procedural sedation in the ED.

There have also been reports in the literature of bacterial infections occurring after the use of propofol.[260] This is attributed to the lipid-base of propofol, which can support the growth of microorganisms. Propofol is not an antimicrobially preserved product, but it does contain 0.005% disodium edetate that is used to hinder the growth of microorganisms. When propofol is used, strict aseptic technique must be utilized to prevent the introduction of a contaminating microorganism. Once prepared, the administration of the propofol should commence without delay and the unused portion of the propofol should be disposed of at the end of the procedure or at 6 hours, whichever comes first. It should also be noted that each vial should be visually inspected for particulate matter and discoloration, and that each emulsion should be prepared for single patient use only. Propofol does not have a higher incidence of infection when aseptic precautions are used.[261]

The use of propofol in the emergency department setting looks promising. Studies suggest propofol is a safe and efficacious sedative/hypnotic agent for the ED setting. As further experience is gained, more information will be obtained and better clinical decision-making can be achieved.

Disposition

After the medical procedure is completed, monitoring should continue. After the stimulation of the procedure is removed, the child may experience a deepening of their level of sedation with resultant complications.[4,5] Interestingly, in one study, this intuitively appealing phenomenon as uncommon with 92% of adverse events occurring during the procedure.[262] The appropriate duration of monitoring following a procedure is not known. It seems reasonable to monitor patients until they have returned to their baseline status.[4,5,263] Specific characteristics of individual patients and the sedation agents used probably should have an impact on the duration of monitoring.

In a study of adverse events after pediatric procedural sedation, 13.7% of patients experienced an adverse event, with 11.9% of them being serious adverse events (hypoxia, stridor or hypotension).[262] Overall, the most common adverse event was hypoxia (84%) with emesis (6%) being the second most common event.[262] None of the patients required intubation or hospital admission, but reversal agents were administered to 6 patients.[262] As a whole, 92% of the adverse events occurred during the procedure, while 8% occurred after the procedure.[262] The median time of adverse events occurring after the last administration of the sedative or analgesic was 2.5 minutes.[262] For the category of serious adverse events, the median time was 2 minutes.[262] There were no primary serious adverse events occurring after 25 minutes post the last medication administration.[262] There were secondary events of hypoxia that occurred at 26, 30 and 40 minutes, but again, these were not primary events.[262] Interestingly, the median time for vomiting was 42.5 minutes after the last medication administration, none of which required hospitalization or resulting in aspiration.[262] Cote suggests that a longer time of post-sedation supervision may also be prudent with use of medications with a long half life.[26] Data from Newman suggests that for patients who did not have serious adverse events during the procedure sedation, a discharge time of 30 minutes may be appropriate.[262] However, prior to implementing such a protocol, a prospective study is needed to confirm this recommendation.

Summary

Children frequently present to emergency departments with injuries and complaints requiring procedures. Procedures often cause pain and anxiety. These feelings should be addressed as part of comprehensive care of the pediatric patient. The use of topical and local anesthetics can help ease the pain with some procedures, while sedative and analgesic agents can help with others. The optimal sedation and analgesic medications for every procedure are unknown, but there are a variety of regimes that have been shown to be effective. Emergency physicians have the tools to safely provide sedation and analgesia, and when appropriate, should use these resources to ease the pain and anxiety of the patients that they are treating. ▲

References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study, will be included in bold type following the reference, where available. In addition, the most informative references cited in the paper, as determined by the authors, will be noted by an asterisk (*) next to the number of the reference.

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93. Babl FE, Puspitadewi A, Barnett P, et al. Preprocedural fasting state and adverse events in children receiving nitrous oxide for procedural sedation and analgesia. Pediatr Emerg Care 2005 Nov;21(11):736-743. **(Prospective observational study; 220 patients)**
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95. Crystal CS, Blankenship RB. Local anesthetics and peripheral nerve blocks in the emergency department. Emerg Med Clin N Am 2005 May;23(2):477-502. **(Review article)**
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97. Kennedy RM, Luhmann JD. Pharmacologic management of pain and anxiety during emergency procedures in children. Paediatr Drugs 2001;3(5):337-354. **(Review)**
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100. Fein JA, Gorelick MH. The decision to use topical anesthetic for intravenous insertion in the pediatric emergency department. Acad Emerg Med 2006 Mar;13(3):264-268. **(Random, clinical trial; 5,312 patients)**
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105. Abad F, Diaz-Gomez NM, Domenech E, et al. Oral sucrose compares favourably with lidocaine-prilocaine cream for pain relief during venepuncture in neonates. Acta Paediatr 2001 Feb;90(2):160-165. **(Prospective, randomized, blinded trial, 55 venepunctures)**
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115. Kolk AM, van Hoof R, Fiedeldij Dop MJ. Preparing children for venepuncture. The effect of an integrated intervention on distress before and during venepuncture. Child Care Health Dev 2000 May;26(3):251-260. **(Prospective, controlled clinical trial; 31 patients)**
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117. Kleiber C, Craft-Rosenberg M, Harper DC. Parents as distraction coaches during i.v. insertion: a randomized study. J Pain Symptom Manage 2001 Oct;22(4):851-861. **(Randomized study; 44 patients)**
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122. Galinski M, Dolveck F, Borron SW, etal. A randomized, double-blind study comparing morphine with fentanyl in prehospital analgesia. Am J Emerg Med 2005 Mar;23(2):114-119. **(Randomized, double-blind; 54 patients)**
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130. Joint Commission on Accreditation of Hospital Organizations. Accreditation manual for critical access hospitals, 2nd edition. Oakbrook Terrace:JCAHO;2005. **(Textbook)**
131. American Society of Anesthesiologist Task Force on Preoperative Fasting. Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedures. Anesthesiology 1999 Mar; 90(3):896-905. **(Practice guidelines)**
132. Green SM, Krauss B. Pulmonary aspiration risk during emergency department procedural sedation-An examination of the role of fasting and sedation depth. Acad Emerg Med 2002 Jan;9(1):35-42. **(Review article)**
133. Brady M, Kinn S, O'Rourke K, et al. Preoperative fasting for preventing perioperative complications in children. The Cochrane Database of Systemic Reviews 2005, Issue 2. Art. No.: CD005285. COI: 10.1002/14651858.CD005285. **(Systematic Review)**
*134. Agrawal D, Manzi SF, Gupta R, etal. Preprocedural fasting state and adverse events in children undergoing procedural sedation and analgesia in a pediatric emergency department. Ann Emerg Med 2003 Nov;42(5):636-646. **(Prospective observational study; 1,014 patients)**
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137. Janssens M, Hartstein G. Management of difficult intubation. Eur J Anaesthesiol 2001 Jan;18(1):3-12. **(Review)**
*138. Wilson ME, Spiegelhalter D, Robertson JA, Lesser P. Predicting difficult intubation. Br J Anaesth 1988 Aug;61(2):211-216. **(2 parts: Descriptive study; 633 patients and Prospective clinical trial; 778 patients)**
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141. Cote CJ, Goldstein EA, Cote MA, et al. A single-blind study of pulse oximetry in children. Anesthesiology 1988 Feb;68(2):184-188. **(Single-blind study; 152 patients)**
142. Council on Scientific Affairs, American Medical Association. The use of pulse oximetry during conscious sedation. JAMA 1993 Sept;270(12):1463-1468. **(Council report)**
143. Aughey K. An evaluation of pulse oximetry in prehospital care. Ann Emerg Med 1991 Aug; 20(8):887-891. **(Prospective, cross-sectional, paired measurement study; 30 patients)**
144. Tachibana C, Fukuda T, Hasegawa R, et al. Accuracy of a pulse oximeter during hypoxia. Masui 1996 Apr;45(4):479-482. **(Comparative study; 90 events)**
*145. Fu ES, Downs JB, Schweiger JW, et al. Supplemental oxygen impairs detection of hypoventilation by pulse oximetry. Chest 2004 Nov;126(5): 1552-1558. **(2 part study: Prospective, patient controlled, clinical trial; 45 patients and Prospective, randomized, clinical trial; 2,288 patients)**
146. Hart LS, Berns SD, Houck CS, et al. The value of end-tidal CO2 monitoring when comparing three methods of conscious sedation for children undergoing painful procedures in the emergency department. Pediatr Emerg Care 1997 Jun;13(3):189-193. **(Prospective, randomized study; 42 patients)**
147. Tobias JD. End-tidal carbon dioxide monitoring during sedation with a combination of midazolam and ketamine for children undergoing painful, invasive procedures. Pediatr Emerg Care 1999 Jun;15(3):173-175. **(Cohort study; 50 patients)**
148. McQuillen KK, Steele DW. Capnography during sedation/analgesia in the pediatric emergency department. Pediatr Emerg Care 2000 Decl;6(6):401-404. **(Prospective, observational patient series; 106 patients)**
149. Yldzdas D, Yapcoglu H, Ylmaz HL. The value of capnography during sedation or sedation/analgesia in pediatric minor procedures. Pediatr Emerg Care 2004 Mar;20(3):162-165. **(Prospective, randomized, clinical trial; 126 patients)**
150. Miner JR, Heegaard W, Plummer D. End-tidal carbon dioxide monitoring during procedural sedation. Acad Emerg Med 2002; Apr 9(4):275-280. **(Prospective, observational study; 74 patients)**
151. McCormack HM, Horne DJ, Sheather S. Clinical applications of visual analogue scales: a critical review. Psychol Med 1988 Nov;18(4):1007-1019. **(Review)**
152. Wong DL, Baker CM. Pain in children: comparison of assessment scales. Pediatr Nurs 1988 Jan/Feb;14(1):9-17. **(Prospective study; 150 patients)**
153. Bieri D, Reeve RA, Champion GD, et al. The Faces Pain Scale for the self-assessment of the severity of pain experienced by children: development, initial validation, and preliminary investigation for ratio scale properties. Pain 1990 May;41(2):139-150. **(Prospective cohort; 553 subjects)**
154. Beyer JE, Denyes MJ, Villarruel AM. The creation, validation, and continuing development of the Oucher: a measure of pain intensity in children. J Pediatr Nurs 1992 Oct;7(5):335-346. **(Review)**
155. McGrath PA, Seifert CE, Speechley KN, et al. A new analogue scale for assessing children's pain: an initial validation study. Pain 1996 Mar;64(3):435-443. **(Parallel group design; 104 patients)**
156. Breau LM, Finley GA, McGrath PJ, et al. Validation of the non-communicating children's pain checklist-postoperative version. Anesthesiology 2002 Mar;96(3):528-535. **(Prospective study; 24 patients)**
157. Manworren RCB, Hynan LS. Clinical validation of FLACC: preverbal patients pain scale. Pediatr Nurs 2003 Mar-Apr;29(2):140-146. **(Prospective study; 147 patients)**
158. Brown J, Larson M. Pain during insertion of peripheral intravenous catheters with and without intradermal lidocaine. Clin Nurse Spec 1999 Nov;13(6):283-285. **(Non-randomized, non-blinded, comparative study; 100 patients)**
159. Richman PB, Singer AJ, Flanagan M, et al. The effectiveness of ice as a topical anesthetic for the insertion of intravenous catheters. Am J Emerg Med 1999 May;17(3):255-257. **(Paired clinical trial; 28 subjects)**
160. Jimenez N, Bradford H, Seidel KD, et al. A comparison of a needle-free injection system for local anesthesia versus EMLA for intravenous catheter insertion in the pediatric patient. Anesth Analg 2006 Feb;102(2):411-414. **(Prospective, randomized, study; 116 patients)**
161. Maunuksela EL, Korpela R. Double-blind evaluation of a lignocaine-prilocaine cream (EMLA) in children. Br J Anaesth 1986 Nov;58(11):1242-1245. **(Randomized, placebo controlled trial; 60 patients)**
162. Soliman IE, Broadman LM, Hannallah RS, et al. Comparison of the analgesic effects of EMLA (eutectic mixture of local anesthetics) to intradermal lidocaine infiltration prior to venous cannulation in unpremedicated children. Anesthesiology 1988 May;68(5):804-806. **(Randomized, controlled clinical trial; 42 patients)**
163. Yamamoto LG, Boychuk RB. A blinded, randomized, paired, placebo-controlled trial of 20-minute EMLA cream to reduce the pain of peripheral IV cannulation in the ED. Am J Emerg Med 1998 Nov;16(7):634-636. **(Randomized, blinded, paired, placebo-controlled trial; 50 subjects)**
164. Singer AJ, Shallat J, Valentine SM, et al. Cutaneous tape stripping to accelerate the anesthetic effects of EMLA cream: A randomized, controlled trial. Acad Emerg Med 1998 Nov;5(11):1051-1056. **(Prospective, randomized, controlled trial; 68 patients)**
165. Liu DR, Kirohner HL, Petrack EM. Does using heat with eutectic mixture of local anesthetic cream shorten analgesic onset time?: A randomized, placebo-controlled trial. Ann Emerg Med 2003 Jul;42(1):27-33. **(Prospective, double-blind study; 76 research subjects)**
166. Todd KH, Funk KG, Funk JP, et al. Clinical significance of reported changes in pain severity. Ann Emerg Med 1996 Apr;27(4):485-589. **(Prospective, descriptive study; 48 subjects)**
167. Nott MR, Clemson CJ, Peacock JL. Onset time of topical analgesia with EMLA 5%: No reduction with glyceryl trinitrate. Eur J Anaesthesiol 1996 Jan;13(1):17-20. **(Randomized, controlled trial; 100 patients)**
168. Taddio A, Soin HK, Schuh S, et al. Liposomal lidocaine to improve procedural success rates and reduce procedural pain among children: A randomized controlled trial. Can Med Assoc J 2005 Jun;172(13):1691-1695. **(Randomized, double-blind, controlled trial; 142 patients)**
169. Eichenfield LF, Funk A, Fallon-Friedlander S, et al. A clinical study to evaluate the efficacy of ELA-Max (4% liposomal lidocaine) as compared with eutectic mixture of local anesthetics cream for pain reduction of venipuncture in children. Pediatrics 2002 Jun;109(6):1093-1099. **(Randomized, double-blinded, clinical trial; 120 patients)**
170. Kleiber C, Sorenson M, Whiteside K, et al. Topical anesthetics for intravenous insertion in children: A randomized equivalency study. Pediatrics 2002 Oct;110(4):758-761. **(Randomized, crossover study; 30 subjects)**
171. Koh JL, Harrison D, Myers R, et al. A randomized, double-blind comparison study of EMLA and ELA-Max for topical anesthesia in children undergoing intravenous insertion. Pediatr Anesthes 2004 Dec;14(12):977-982. **(Randomized, double-blind, comparison study; 60 patients)**
172. Ekbom K, Jakobsson J, Marcus C. Nitrous oxide inhalation is a safe and effective way to facilitate procedures in paediatric outpatient departments. Arch Dis Child 2005 Oct;90(10):1073-1076. **(Randomized, controlled trial; 70 children)**
173. Gerhardt RT, King KM, Wiegert RS. Inhaled nitrous oxide versus placebo as an analgesic and anxiolytic adjunct to peripheral intravenous cannulation. Am J Emerg Med 2001 Oct;19(6):492-494. **(Prospective, randomized, double-blind, placebo-controlled crossover design; 11 subjects)**
174. Vetter TR. A comparison of EMLA cream versus nitrous oxide for pediatric venous cannulation. J Clin Anesth 1995 Sept;7(6):486-490. **(Prospective, randomized study; 50 patients)**
175. Paut O, Calmejane C, Delorme J, et al. EMLA versus nitrous oxide for venous cannulation in children. Anesth Analg 2001 Sept;93(3):590-593. **(Prospective, randomized, double-blinded study; 40 patients)**
176. Hee HI, Goy RW, Ng AS. Effective reduction of anxiety and pain during venous cannulation in children: A comparison of analgesic efficacy conferred by nitrous oxide, EMLA and combination. Paediatr Anaesth 2003 Mar;13(3):210-216. **(Randomized controlled trial; 120 patients)**
177. Henderson JM, Spence DG, Komocar LM, et al. Administration of nitrous oxide to pediatric patients provides analgesia for venous cannulation. Anesthesiology 1990 Feb;72(2):269-271. **(Randomized, single-blinded, controlled trial; 165 patients)**
178. Vaughan M, Paton EA, Bush A, et al. Does lidocaine gel alleviate the pain of bladder catheterization in young children? A randomized, controlled trial. Pediatrics 2005 Oct;116(4):917-920. **(Randomized, double-blind, placebo-controlled trial; 114 patients)**
179. Kleiber C, McCarthy AM. Parent behavior and child distress during urethral catheterization. J Soc Pediatr Nurs 1999 Jul-Sep;4(3):95-104. (**Descriptive study; 9 patients)**
180. Bauchner H, Vinci R, Bak S, et al. Parents and procedures: a randomized controlled trial. Pediatrics 1996 Nov;98(5):861-867. **(Randomized controlled trial; 431 parents)**
181. Gerard LL, Cooper CS, Duethman KS, et al. Effectiveness of lidocaine lubricant for discomfort during pediatric urethral catheterization. J Urol 2003 Aug:170(2, part 1):564-567. **(Prospective, double-blind, placebo controlled trial; 20 patients)**
182. Baxter AL, Welch JC, Burke BL, et al. Pain, position, and stylet styles: Infant lumbar puncture practices of pediatric emergency attending physicians. Pediatr Emerg Care 2004 Dec;20(12):816-820. **(Survey, 188 participants)**
183. Calamandrei M, Messeri A, Busoni P, et al. Comparison of two application techniques of EMLA and pain assessment in pediatric oncology patients. Reg Anesth 1996 Nov-Dec;21(6):557-560. **(Randomized control trial, 24 patients)**
184. Juarez Gimenez JC, Oliveras M, Hidalgo E, et al. Anesthetic efficacy of eutectic prilocaine-lidocaine cream in pediatric oncology patients undergoing lumbar puncture. Ann Pharmacother 1996 Nov;30(11):1235-1237. **(Prospective, double-blind, randomized, placebo-controlled trial, 11 patients)**
185. Kaur G, Gupta P, Kumar A. A randomized control trial of eutectic mixture of local anesthetics during lumbar puncture in newborns. Arch Pediatr Adolesc Med 2003 Nov;157(11):1065-1070. **(Randomized double blinded placebo controlled trial, 60 patients)**
186. Baxter AL, Fisher RG, Burke BL, et al. Local anesthetic and stylet styles: Factors associated with resident lumbar puncture success. Pediatrics 2006 Mar; 117(3):876-881. **(Prospective observational study; 428 events)**
187. Pinheiro JM, Furdon S, Ochoa LF. Role of local anesthesia during lumbar punctures in newborns. Pediatrics 1993 Feb;91(2):379-382. **(Randomized control trial; 116 patients)**
188. Carraccio C, Feinberg P, Hart LS, et al. Lidocaine for lumbar punctures: A help not a hindrance. Arch Pediatr Adolesc Med 1996 Oct; 150(10):1044-1046. **(Randomized controlled trial; 100 patients)**
189. Schechter NL, Weisman SJ, Rosenblum M, et al. The use of oral transmucosal fentanyl citrate for painful procedures in children. Pediatrics 1995 Mar;95(3):335-339. **(Randomized, placebo controlled trial, 48 patients)**
190. Freidman AG, Mulhern RK, Fairclough D, et al. Midazolam premedication for pediatric bone marrow aspiration and lumbar puncture. Med Pediatr Oncol 1991Dec;19(6):499-504. **(Randomized, placebo-controlled, double blind trial, 23 patients)**
191. Brogan Jr GX, Giarrusso E, Hollander JE, et al. Comparison of plain, warmed, and buffered lidocaine for anesthesia of traumatic wounds. Ann Emerg Med 1995 Aug;26(2):121-125. **(Randomized, prospective, single-blinded study; 45 patients)**
192. Brogan GX, Singer AJ, Valentine SM, et al. Comparison of wound infection rates using plain versus buffered lidocaine for anesthesia of traumatic wounds. Am J Emerg Med 1997 Jan;15(1):25-28. **(Observational cohort study; 2,711 patients)**
193. Bartfiled JM, Gennis P, Barbera J, et al. Buffered versus plain lidocaine as a local anesthetic for simple laceration repair. Ann Emerg Med 1990 Dec;19(2):1387-1389. **(Prospective, randomized, double-blind clinical trial; 91 patients)**
194. Orliksky M, Hudson C, Chan L, et al. Pain comparison of unbuffered versus buffered lidocaine in local wound infiltration. J Emerg Med 1992 Jul-Aug;10(4):411-415. **(Prospective, randomized, double blinded study; 61 patients)**
195. Ernst AA, Marvez-Valls E, Nick TG, et al. Comparison trial of four injectable anesthetics for laceration repair. Acad Emerg Med 1996 Mar;3(3):228-233. **(Prospective, randomized, double-blind, comparison trial; 180 patients)**
196. Bartfield JM, Sokaris SJ, Raccio-Robak N. Local anesthesia for lacerations: pain of infiltration inside versus outside the wound. Acad Emerg Med 1998 Feb;5(2):100-104. **(Prospective, randomized, single-blind, experimental protocol; 63 patients)**
197. Krause RS, Moscati R, Filice M, et al. The effect of injection speed on the pain of lidocaine infiltration. Acad Emerg Med 1997 Nov;4(11):1032-1035. **(Prospective, randomized, crossover, laboratory study; 29 participants)**
198. Scarfone RJ, Jasani M, Gracely EJ. Pain of local anesthetics: Rate of administration and buffering. Ann Emerg Med 1998 Jan;31(1):36-40. **(Prospective, single-blind study; 42 participants)**
199. Smith GA, Strausbaugh SD, Harbeck-Weber C, et al. Comparison of topical anesthetics with lidocaine infiltration during laceration repair in children. Clin Pediatr 1997 Jan;36(1):17-23. **(Randomized, blinded; 71 patients)**
200. Ernst AA, Marvez-Valls E, Nick TG, et al. Topical lidocaine adrenaline tetracaine (LAT gel) versus injectable buffered lidocaine for local anesthesia in laceration repair. West J Med 1997 Aug;167(2):79-81. (**Randomized prospective comparison trial; 66 patients)**
201. Ernst AA, Marvez E, Nick TG, et al. Lidocaine adrenaline tetracaine gel versus tetracaine adrenaline cocaine gel for topical anesthesia in linear scalp and facial lacerations in children aged 5 to 17 years. Pediatrics 1995 Feb;95(2):225-258. **(Prospective, randomized, double-blinded clinical trial; 95 patients)**
202. Schilling CG, Bank DE, Borchert BA, et al. Tetracaine, epinephrine (adrenalin), and cocaine (TAC) versus lidocaine, epinephrine, and tetracaine (LET) for anesthesia of lacerations in children. Ann Emerg Med 1995 Feb;25(2):203-208. **(Randomized,**

double-blind, controlled trial; 171 patients)
203. Resch K, Schilling C, Borchert BD, et al. Topical anesthesia for pediatric lacerations: A randomized trial of lidocaine-epinephrine-tetracaine solution versus gel. Ann Emerg Med 1998 Dec;32(6):693-697. **(Randomized, single-blinded, controlled trial; 200 patients)**
204. White NJ, Kim MK, Brousseau DC, et al. The anesthetic effectiveness of lidocaine-adrenaline-tetracaine gel on finger lacerations. Pediatr Emerg Care 2004 Dec;20(12):812-815. **(Prospective case series; 67 patients)**
205. Priestley S, Kelly A, Chow L, et al. Application of topical local anesthetic at triage reduces treatment time for children with lacerations: A randomized controlled trial. Ann Emerg Med 2003 July;42(1):34-40. **(Prospective, randomized, double-blind, controlled trial; 161 patients)**
206. Lawrence LM, Wright SW. Sedation of pediatric patients for minor laceration repair: Effect on length of emergency department stay and patient charges. Pediatr Emerg Care 1998 Dec;14(6):393-395. **(Retrospective cohort study, 152 patients)**
207. Fatovich DM, Jacobs IG. A randomized, controlled trial of oral midazolam and buffered lidocaine for suturing lacerations in children (the SLIC trial). Ann Emerg Med 1995 Feb;25(2):209-214. **(Prospective, randomized, double-blind, placebo-controlled trial; 107 patients)**
208. Hennes HM, Wagner V, Bonadio WA, et al. The effect of oral midazolam on anxiety of preschool children during laceration repair. Ann Emerg Med 1990 Sept;19(9):1006-1009. **(Randomized, double-blind clinical trial; 55 patients)**
209. Everitt IJ, Barnett P. Comparison of two benzodiazepines used for sedation of children undergoing suturing of a laceration in an emergency department. Pediatr Emerg Care 2002 Apr;18(2):72-74. **(Block-randomized, single-blind trial; 129 patients)**
210. Theroux MC, West DW, Corddry DH, et al. Efficacy of intranasal midazolam in facilitating suturing of lacerations in preschool children in the emergency department. Pediatrics 1993 Mar;91(3):624-627. **(Randomized, double-blind, controlled trial; 59 patients)**
211. Connors K, Terndrup TE. Nasal versus oral midazolam for sedation of anxious children undergoing laceration repair. Ann Emerg Med 1994 Dec;24(6):1074-1079. **(Randomized, double-blind, double-placebo trial; 58 patients)**
212. Qureshi FA, Mellis PT, McFadden. Efficacy of oral ketamine for providing sedation and analgesia to children requiring laceration repair. Pediatr Emerg Care 1995 Apr;11(2):93-97. **(Prospective, randomized, double-blind, placebo-controlled clinical trial; 30 patients)**
213. Younge PA, Kendall JM. Sedation for children requiring wound repair: A randomised controlled double blind comparison of oral midazolam and oral ketamine. Emerg Med J 2001 Jan;18(1):30-33. **(Prospective, randomized, double-blinded trial; 59 patients)**
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252. Seigler RS, Avant MG, Gwyn DR, et al. A comparison of propofol and ketamine/midazolam for intravenous sedation of children. Pediatr Crit Care Med 2001 Jan;2(1):20-23. **(Retrospective chart review; 489 procedures)**
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255. Picard P, Tramer MR. Prevention of pain on injection with propofol: A quantitative systemic review. Anesth Analg 2000 Apr;90(4):963-969. **(Systematic review; 56 reports; 6,264 patients)**
256. Burrow BK, Johnson ME, Packer DL. Metabolic acidosis associated with propofol in the absence of other causative factors. Anesthesiology 2004 Jul;101(1):239-241. **(Case report; 1 patients)**
257. Bray RJ. Propofol infusion syndrome in children. Paediatr Anaesth 1998 Nov;8(6):491-499. **(Retrospective review; 128 patients)**
258. Cannon ML, Glazier SS, Bauman LA. Metabolic acidosis, rhabdomyolysis, and cardiovascular collapse after prolonged propofol infusion. J Neurosurg 2001 Dec;95(6):1053-1056. **(Case report; 1 patient)**
259. Cray SH, Robinson BH, Cox PN. Lactic academia and bradyarrhythmia in a child sedated with propofol. Crit Care Med 1998 Dec;26(12):2087-2092. **(Case report; 1 patients)**
260. Bennett SN, McNeil MM, Bland LA, et al. Postoperative infections traced to contamination of a intravenous anesthetic, propofol. N Eng J Med 1995 Jul;333(3):147-154. **(Case-control, cohort study; 62 patients)**
261. Seeberger MD, Staender S, Oertli D, etal. Efficacy of specific aseptic precautions for preventing propofol-related infections: analysis by a quality assurance programme using the explicit outcome method. J Hosp Infect 1998 May;39(1):67-70. **(Retrospective study; 6433 patients)**
*262. Newman DH, Azer MM, Pitetti RD, et al. When is a patient safe for discharge after procedural sedation? The timing of adverse effect events in 1.367 pediatric procedural sedations. Ann Emerg Med 2003 Nov;42(5):627-635. **(Retrospective chart review; 1,341 sedation events)**
263. American Society of Anesthesiologists Task Force on Postanesthetic Care. Practice guidelines for postanesthetic care. Anesthesiology 2002 Mar;96(3):742-752. **(Practice guidelines)**
264. Milling TJ Jr, Van Amerongen R, Melville M, et al. Use of ultrasonography to identify infants for whom urinary catheterization will be unsuccessful because of insufficient urine volume: Validation of the urinary bladder index. Ann Emerg Med 2005 May;45(5):510-513. **(Prospective, blinded, observational study; 44 patients)**
265. Chen L, Hsiao AL, Moore CL, et al. Utility of bedside bladder ultrasound before urethral catheterization in young children. Pediatrics 2005 Jan;115(1):108-111. **(Prospective, nonrandomized, controlled study; 248 patients)**
266. Squire BT, Fox JC, Anderson C. ABSCESS: Applied bedside sonography for convenient evaluation of superficial soft tissue infections. Acad Emerg Med 2005 Jul;12(7):601-606. **(Prospective clinical trial; 107 patients)**

Physician CME Questions

65. All of the following are true descriptions of polymodal C receptors except:

a. "Slow" pain
b. Visceral pain
c. Transmit electrical impulses
d. Myelinated neurons
e. Aching or throbbing pain

66. Negative outcomes with sedation are associated with:

a. Greater than 2 drugs used in combination.
b. The use of midazolam.
c. The use of the intravenous route.
d. The use of ketamine.
e. Food intake less than 6 hours prior to sedation.

67. An important difference between fentanyl and morphine is that fentanyl is:

a. Longer acting than morphine.
b. Less likely to induce significant histamine release.
c. Less potent than morphine.
d. A non-opiod analgesic.
e. Primarily metabolized in the kidney.

68. Chest wall rigidity is:

a. A commonly occurring side effect.
b. Usually seen with low dose fentanyl.
c. Associated with rapid administration.
d. Treated with flumazenil.
e. Usually seen with high dose morphine.

69. Histamine release seen with morphine can cause all the following except:

a. Hypotension
b. Pruritus
c. Nausea
d. Vomiting
e. Bronchodilation

70. Meperidine should be avoided in children because of the risk of inducing seizure with its metabolic by-product.

a. True
b. False

71. Benzodiazepines are able to provide all of the following except:

a. Sedation
b. Analgesia
c. Anxiolysis
d. Anterograde amnesia
e. CNS depression

72. Intranasal midazolam has the benefit of having a shorter onset time than oral midazolam.

a. True
b. False

73. Flumazenil can worsen paradoxical reactions caused by midazolam.

a. True
b. False

74. Midazolam-induced hiccups can be treated with:

a. Intravenous naloxone.
b. Intranasal ethyl chloride.
c. Inhaled nitrous oxide.
d. Oral codeine.
e. Nebulized albuterol.

75. The use of etomidate can:

a. Transiently increase cerebral blood flow.
b. Significantly decrease blood pressure.
c. Transiently decrease 11-β hydroxylase activity.
d. Provide analgesia.
e. Significantly increase adrenal activity.

76. The reversal agent for etomidate is:

a. Naloxone.
b. Flumazenil.
c. Pyridoxine.
d. Atropine.
e. There is no reversal agent.

77. Emergence reactions:

a. Usually occur in kids less than 10 years of age.
b. Can be treated with flumazenil.
c. Can be prevented with atropine.
d. Have been reported with the use of ketamine.
e. Often require intubation.

78. All are true of nitrous oxide except:

a. Commonly used in the treatment of severe asthma
b. Provides anxiolysis
c. Causes amnesia
d. Has some analgesic properties
e. Has effects that resolve 3 to 5 minutes after it is removed

79. Lidocaine toxicity can manifest as dysrhythmias, seizures, and altered mental status.

a. True
b. False

80. The following are true of pulse oximetry and capnometry measurements except:

a. Pulse oximetry readings of 100% are always indicative of adequate ventilation.
b. Pulse oximetry readings are accurate down to 50%.
c. Capnometry can only be used in intubated patients.
d. Supplemental oxygen can mask hypoventilation.
e. Pulse oximetry and capnometry are routinely recommended for all procedural sedations by the AAP, ACEP and ASA.

Disclosure of Off-Label Usage:

There are many medications approved by the FDA for sedation and analgesia; however, they are not all authorized for use in infants and children. For example, ketorolac is not recommended for children under the age of 2 years because safety is not established. Further, it is approved in children for a single IV or IV dose only, and the oral form is not approved for pediatrics at all. Fentanyl is widely used in pediatrics, but the safety and efficacy is not established in children < 2 years. Oral fentanyl is only approved for the management of breakthrough cancer pain in patients who are tolerant of their current opioid therapy, and the dosing and safety has not been established in children less than 16 years of age.

The use of propofol as discussed in this article is an off-label use. For laceration repairs, EMLA has been discussed. However, EMLA is only recommended for use on intact skin, not open wounds. It should also be mentioned that EMLA is not to be used in patients who are less than 37 week of gestational age, in patients less than 12 months old who are concurrently being treated with methemoglobin-inducing agents, or in patients with congenital or idiopathic methemoglobinemia.

Coming in Future Issues:

Eye Injuries • Head and Neck Infections

Class Of Evidence Definitions

Each action in the clinical pathways section of *Pediatric Emergency Medicine Practice* receives a score based on the following definitions.

Class I
- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness

Level of Evidence:
- One or more large prospective studies are present (with rare exceptions)
- High-quality meta-analyses
- Study results consistently positive and compelling

Class II
- Safe, acceptable
- Probably useful

Level of Evidence:
- Generally higher levels of evidence
- Non-randomized or retrospective studies: historic, cohort, or case-
- control studies
- Less robust RCTs
- Results consistently positive

Class III
- May be acceptable
- Possibly useful
- Considered optional or alternative treatments

Level of Evidence:
- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

Indeterminate
- Continuing area of research
- No recommendations until further research

Level of Evidence:
- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

Significantly modified from: The Emergency Cardiovascular Care Committees of the American Heart Association and representatives from the resuscitation councils of ILCOR: How to Develop Evidence-Based Guidelines for Emergency Cardiac Care: Quality of Evidence and Classes of Recommendations; also: Anonymous. Guidelines for cardiopulmonary resuscitation and emergency cardiac care. Emergency Cardiac Care Committee and Subcommittees, American Heart Association. Part IX. Ensuring effectiveness of community-wide emergency cardiac care. *JAMA* 1992;268(16):2289-2295.

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