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Pediatric Pain Management in the Emergency Department

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Abstract

Adequate analgesia is critical in the management of pediatric patients in the emergency department. Suboptimal treatment of pain can have deleterious effects in the short term, and it can also affect a patient's development and reaction to future painful experiences. Tools exist to quantify a patient's pain level regardless of age or developmental stage. Both pharmacologic and nonpharmacologic methods can be effective in the management of pediatric pain. Emergency clinicians must remain vigilant in the recognition, treatment, and reassessment of pediatric pain, as patients' developmental level may limit their ability to independently express their pain experience without prompting or tools. This issue reviews pain scales that are suitable for pediatric patients and discusses pediatric pain management using nonpharmacologic methods, topical, local, and regional anesthesia as well as systemic agents.

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This issue is eligible for 2 Pharmacology and 4 Pain Management CME Credits

Case Presentations

An 8-year-old boy presents to the ED after falling at a local playground. His mother, who was with him at the time of the injury, states that he was climbing out of a tree when he slipped and fell. He landed on his outstretched hands and is now complaining of right wrist pain. On examination, he has no open wounds, and he has a normal neurovascular examination, but he has an obvious deformity of his right forearm. The child describes his pain as 7/10. You ponder how best to treat the child's severe pain as quickly as possible...

Your next patient is a 7-year-old boy who is brought in for 1 day of fever and right lower quadrant abdominal pain. His examination is significant for rebound and guarding of his right lower quadrant. The boy rates his pain as 9/10. You order initial laboratory studies. The patient's mother pulls you aside to tell you that her son has had bad experiences with IV placement in the past, and she is very concerned about the associated pain. Meanwhile, one of the nurses tells to you that the on-call surgery resident will come to see your patient with possible acute appendicitis, but she will be delayed. The surgeon requested that you defer pain medication until her return to the ED, since pain medication will "ruin" her examination. You consider what to do next…

The last patient of your shift is a 21-day-old infant who presents with a fever to 38.3°C (100.9°F). The patient has had upper respiratory symptoms for 1 day. On examination, she has some upper respiratory congestion but is otherwise well appearing. You order blood, urine, and cerebrospinal fluid studies to conduct a full evaluation for occult infection. The parents expresses apprehension about the lumbar puncture, but eventually agree to the procedure. You begin to think about how best to treat your young patient's procedural pain while maximizing the likelihood of a successful lumbar puncture...

Introduction

Pain, as defined by the International Association for the Study of Pain, is "an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage."[1] The quality and location of pain may alert the emergency clinician to the presence of disease processes. Additionally, pain is a frequent—but often preventable—side effect of many of the diagnostic studies and treatments performed in the emergency department (ED), ranging from simple intravenous (IV) line placement to a complex fracture reduction.

For a variety of reasons, adequate treatment of pain can be one of the most challenging aspects of emergency medicine practice. First, pain is subjective. Despite the development of sophisticated pain scales, patient self-report is the best source of pain measurement in communicative patients. This can often lead to confusion when patient pain reports do not match emergency clinician expectations. Second, the pressures resulting from the volume of critical patients seen in the ED can make optimum pain management a seemingly impossible goal and lower its priority. Third, young patients' developmental levels can make quantifying and qualifying their pain difficult and can reduce their ability to advocate for the treatment of their pain. Fourth, unfounded concerns from both emergency clinicians and consultants regarding "masking" pain and interfering with accurate diagnoses may lead emergency clinicians to undertreat pain. Finally, the concerns emergency clinicians and patients' families have regarding side effects and the unclear potential for addiction may make emergency clinicians reluctant to use certain effective pain medications.

Despite these barriers, there are compelling reasons to treat pain in the ED. The relief of suffering is one of the fundamental goals of medicine. The adequate treatment of pain increases patient satisfaction.[2] Despite long-standing myths, all patients (including neonates) feel pain,[3] and there is convincing evidence that exposing young patients to painful stimuli can have both short-term and long-term negative consequences.[4-7]

Pain has been traditionally undertreated in all populations, but this is especially true in pediatric patients. The purpose of this issue of *Pediatric Emergency Medicine Practice* is to help emergency clinicians recognize pain in children, develop strategies to successfully manage pain in pediatric patients, and address specific areas where controversy in pain management exists.

Critical Appraisal of the Literature

A literature search was performed in Ovid MEDLINE® and PubMed using multiple combinations of the search terms *pain*, *pain management*, *analgesia*, *adverse events*, *side effects*, *children*, *pediatric*, and *emergency department*. The Cochrane Database of Systematic Reviews was also consulted. Articles relevant to pediatric pain management were selected, reviewed, and included in the references, as were citations that appeared in review articles, clinical practice guidelines, and policy statements. Articles were chosen for inclusion if they were published after 1995; however, important articles published before this date were included for completeness and historical perspective. Over 400 articles were reviewed, 201 of which were chosen for inclusion in this review.

For many years, there was a paucity of data on acute pain management in a few small, often contradictory, studies. Recently, the Cochrane Library has published more actionable recommendations, but there is still a lack of in multicenter randomized controlled trials. In addition, there are few data on the long-term effects of exposure of pediatric patients to pain in the ED.

The History of Pain Treatment

Despite the clinical and ethical imperative for clinicians to treat pain and reduce patient suffering, pain in both adult and pediatric patients has traditionally been undertreated.[8-11] Underutilization of pain medication has been particularly pronounced in children, since, historically, it has been though that children "…seldom need medication for relief of pain. They tolerate discomfort well."[12] This has frequently led to children either not receiving analgesics or receiving insufficient doses of analgesics. In the past, many believed that infants did not experience pain; historically, cardiac surgeries have even been performed on neonates without analgesia.[13] Numerous studies in the 1980s quantitatively demonstrated a pronounced lower usage of analgesics for definitively painful conditions in children versus adults.[8,14] A study published in 1990 documented this phenomenon in the ED, showing that children received analgesics significantly less frequently than adults (28% vs 60%, $P < .001$) when presenting with painful conditions.[9]

Despite improved understanding of pediatric pain as well as the introduction of newer, safer agents, the use of sedation and analgesia remains highly variable across patients and hospitals.[15-17] However, as a greater understanding of the negative consequences of untreated pain has developed, many in the medical community began to refute the misperceptions surrounding pediatric pain,[18] and a concerted effort to make the ED an "ouchless" place for children began to develop.[2] Today, a variety of modalities, both pharmacologic and nonpharmacologic, are available for pediatric patients to help minimize the pain and anxiety associated with an ED visit.

Physiology of Pain

The physiology of the pain response is complex and multifactorial. The traditional model of pain transmission is "bottom-up," wherein a specific level of painful stimulus causes a proportional signal from the periphery, through the spinal cord to the brain, and leads to a specific, predictable level of pain. New insights into the physiology of pain, however, have led scientists to reconsider this model. A new, "top-down" conception of pain has developed, in which painful stimuli are thought to be subject to modification in both the spinal cord and the brain.[19] The patient's age and temperament, past experience, personal and familial beliefs, culture, and genetics are a few of the factors that may alter the final perception of a single painful stimulus. Pain pathways also demonstrate significant plasticity. Unlike other processes, exposure to painful stimuli results in upregulation of pain pathways, potentially leading to pain hypersensitivity,[20] with these effects being greatest early in life.[21]

In both infants and children, painful stimuli can result in long-term harmful effects. Full-term infants who had circumcisions in the immediate neonatal period have been shown to have significantly greater pain response to vaccinations at 4 and 6 months than infants who were not circumcised.[22] One study of pediatric cancer patients receiving a lumbar puncture (LP) examined the relationship between procedural pain and past experience. It found that, despite all patients receiving the same analgesia during the study LP, patients who had received fentanyl during a previous LP had lower pain scores than those who had received placebo during a previous LP.[23] Another study found that the number of invasive procedures performed during a hospital stay was directly associated with ongoing posttraumatic stress responses 6 weeks after discharge, and increased medical fears 6 weeks and 6 months after discharge.[24] Psychological outcomes of painful procedures extend into adulthood, with people who experienced more medical fear and pain as children having more medical fear as adults.[25]

Prehospital Care

Prehospital care traditionally focuses on the stabilization of potential life-threatening issues; however, prehospital pharmacologic pain management and nonpharmacologic pain management (eg, with ice packs, immobilization of fractures, elevation of extremities, and distraction techniques) have been recognized and recommended by both the National Association of EMS (emergency medical services) Physicians and the American Academy of Pediatrics.[26,27] Additionally, guidelines for the care of pain in the prehospital setting have been disseminated[28] and implemented at the statewide level.[29] Despite these recommendations, pediatric pain is frequently underrecognized and undertreated in the prehospital and ED settings.[27,30-33]

Pain is a common prehospital symptom, with 37% to 69% of children estimated to experience acute pain and 48% to 67% of these children classified as having "intense to severe" pain.[34,35] One study found that most children (78%) receive prehospital analgesia either at home or from EMS providers; however, the majority of children (65%) with moderate to severe pain do not receive any prehospital pharmacologic analgesia.[36] Another study demonstrated that, in the prehospital setting, children and adolescents are much less likely than adults to have a pain score documented (4% vs 67%), and they are also less likely to receive an analgesic intervention.[37] Canadian paramedics report being similarly less likely to provide analgesics to children versus adults.[38] Pediatric trauma patients have also been identified as lacking adequate prehospital documentation of pain assessments and interventions.[39] EMS providers cite the inability to assess pain in children and adolescents and limited clinical experience with children as the most common reasons for withholding analgesia.[37,38] Pain documentation and treatment in the prehospital setting has remained suboptimal even after implementation of updated pain management protocols.[31,32]

Numerous studies of adult and pediatric patients have demonstrated safe administration of opioids in the prehospital setting.[40-45] Intranasal fentanyl has the advantages of rapid administration and efficacy comparable to IV administration; its use is supported in published guidelines.[4,28,45] The use of intranasal ketamine for prehospital analgesia has been described, but has not been widely studied or implemented to date.[46-48]

Emergency Department Evaluation

The Joint Commission (www.jointcommission.org) mandates pain assessment for all patients.[49] Pain should be assessed for all patients upon initial presentation to the ED and reassessed during the visit. Early and frequent pain assessment encourages and assists clinicians in the recognition and treatment of pain.

Pain Scales

Pain may be quantified by patient self-report, behavioral assessment, or physiologic indicators. The gold standard and most desirable method for pain assessment, when obtainable, is based upon self-report of pain by the patient. Pain assessment scales for self-reporting of pain exist for children as young as 3 years of age. These include the Faces Pain Scale-Revised (FPS-R) **(see Figure 1)**, the color analog scale (CAS), and the 11-point numeric rating scale (NRS-11). For younger children or for children unable to use self-report pain scales, behavioral scales such as the Faces, Legs, Activity, Cry, and Consolability (FLACC) Scale have been validated in the pediatric ED setting[50] **(see Table 1)** and may be utilized in conjunction with the child's history and physical examination. Behavioral scales may also be used in conjunction with self-reporting scales in preschool-aged children who may not be able to fully understand and use a self-report pain scale.[51] The NRS-11, FPS-R, and CAS are strongly recommended for self-report of acute pain.[52] The evidence for these 3 tools is not as strong for the measurement of postoperative pain, and no specific self-report tool can be recommended for pain assessment in children aged < 6 years.[52] A summary of the recommended pain scales for the intended age groups is listed in **Table 2, page 5**.

Regardless of which pain scale is chosen, the absolute value of the pain score is not as important as the change in the score for each individual child. Pain is an individual experience, and the perception of pain varies between individuals. Noting changes in pain scores can help emergency clinicians gauge the effectiveness of interventions.

Figure 1. Faces Pain Scale - Revised

Faces Pain Scale - Revised © 2001, International Association for the Study of Pain.

Hicks CL, von Baeyer CL, Spafford P, van Korlaar I, Goodenough B. Faces Pain Scale-Revised: Toward a Common Metric in Pediatric Pain Measurement. *Pain*. 2001; 93:173-183.

This Faces Pain Scale-Revised (www.iasp-pain.org/fpsr) has been reproduced with permission of the International Association for the Study of Pain® (IASP). The figure may NOT be reproduced for any other purpose without permission.

Table 1. Face, Legs, Activity, Cry, Consolability Scale

Categories	Scoring		
	0	1	2
Face	No particular expression or smile	Occasional grimace or frown, withdrawn, disinterested	Frequent to constant frown, clenched jaw, quivering chin
Legs	Normal position or relaxed	Uneasy, restless, tense	Kicking, or legs drawn up
Activity	Lies quietly, normal position, moves easily	Squirming, shifting back and forth, tense	Arched, rigid, or jerking
Cry	No cry (awake or asleep)	Moans or whimpers, occasional complaint	Cries steadily, screams or sobs, frequent complaints
Consolability	Content, relaxed	Reassured by occasional touching, hugging, or being talked to, distractible	Difficult to console or comfort

Each of the 5 categories (F) Face; (L) Legs; (A) Activity; (C) Cry; (C) Consolability is scored from 0-2, which results in a total score between 0 and 10.
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Though pain scales all measure the same phenomenon, they may not be interchangeable. One study found little agreement between 4 pain scales (visual analog scale, CAS, Wong-Baker FACES® Pain Rating Scale, and verbal numeric scale) in a pediatric ED.[53] Another study correlated pain scores on the FPS-R and CAS scales to perceptions of no pain, mild pain, moderate pain, and severe pain. On the FPS-R, they found that "no pain" correlated to scores of 0 and 2, "mild pain" to 4, "moderate pain" to 6, and "severe pain" to 8 and 10. For the CAS, scores of 0 to 1 correlated to "no pain," 1.25 to 2.75 to "mild pain," 3 to 5.75 to "moderate pain," and 6 to 10 to "severe pain."[54] Since different scales may provide different results, reassessment of pediatric pain should be completed using the same scale throughout the child's ED visit.

Treatment

Nonpharmacologic Management

When pain is recognized, nonpharmacologic pain management techniques should begin before medications are administered. The use of a multidisciplinary approach to pain management in pediatric patients has been shown to decrease pain scores, improve parental satisfaction, improve compliance, and decrease hospitalization rates for pain associated with conditions such as sickle cell disease and pediatric cancer.[55-57] Despite the report of pain by pediatric patients, nurses in multiple studies did not commonly administer prescribed pain medications to pediatric patients,[58,59] and the nurses often perceived that pediatric patients were overreporting their pain,[60] thereby decreasing the efficacy of pharmacologic pain regimens. It is therefore important to have an approach to pain management that does not rely only on medications, but instead incorporates multiple evidence-based approaches to the treatment of pain.

There is evidence that nonpharmacologic techniques can reduce patient procedural pain. A 2018 Cochrane review found that cognitive and behavioral interventions decreased needle-related procedure pain in patients aged 2 to 19 years. Although the evidence is not strong, techniques such as distraction and hypnosis may reduce procedural pain and distress.[61]

Distraction, one of the most well-established nonpharmacologic methods of procedural pain management, can be used in any setting. Many studies of distraction involve showing children cartoons or movies.[61] Music, computer games, blowing bubbles, and toys and games are alternate methods of distraction. With the ubiquity of smart phones, virtually all parents have a means of distraction in their possession. Age-appropriate distraction techniques include rattles and mirrors for infants; bubbles and blocks for toddlers; puzzles, toys, and stickers for preschoolers; modeling clay, music, and electronic devices for school-aged children; and movies and video games for adolescents.[62]

While discussing a procedure before its performance has not been shown to reduce procedural pain by itself, it has been combined with other techniques to reduce procedural distress.[61] Care must be taken before and during procedures to avoid focusing on the upcoming pain; instead, focus on distraction techniques. As part of combined interventions, deep breathing, relaxation techniques (eg, stress balls), and visualization techniques (eg, picturing yourself on vacation) may also reduce procedural distress.[61]

In younger patients, interventions such as nonnutritive sucking and swaddling have also been shown to reduce pain.[63] Breastfeeding has also been demonstrat-

Table 2. Summary of Recommended Pain Scales Used for Children

Name of Scale	Recommended Age Group	Notes
Faces, Legs, Activity, Cry, Consolability (FLACC) Scale	2 months–4 years	• Initially developed to evaluate postoperative pain • Some evidence to support use in acute pain and procedural pain • May not distinguish pain from anxiety
Faces Pain Scale-Revised (FPS-R)	4 years–12 years	• Quick and simple to use • Minimal instruction required • Translated into > 35 languages • Available free of charge • Strongest evidence for use in children aged > 7 years
Color analog scale (CAS)	5 years–16 years	• 10-cm vertical scale with increasing gradations of color and width to signify increasing pain • Severity of pain measured in 0.25 cm increments • Strongest evidence for use in children aged > 7 years
11-point numeric rating scale (NRS-11)	4 years–18 years	• Initially developed and studied for use in adults • Numerical scale from 0–10, can be administered verbally • Mild pain, 1–3; moderate pain, 4–6; severe pain, 7–10 • Best evidence in patients aged ≥ 6 years

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ed to reduce procedural pain in infants.[64] All of these nonpharmacological techniques can reduce pain and increase parental satisfaction in an efficient manner.

Topical Anesthesia

There are multiple options for topical anesthesia that are both safe and effective for use in the pediatric population. Topical anesthetics can decrease pain, increase cooperation in pediatric patients, and improve procedure success.[65] Topical anesthetics may be used either alone or in combination with other agents to reduce the need for systemic medications.[66]

EMLA®

EMLA® cream (with each gram of cream containing 25 mg lidocaine and 25 mg prilocaine as an oil-and-water emulsion) is commonly used to anesthetize the skin prior to invasive local procedures in children. It is typically used only on intact skin, to minimize systemic absorption,[67] although a nonsystematic review of studies using EMLA® on lacerations found that it was successful, without significant side effects.[68] EMLA® has been used clinically for over 25 years, and numerous studies have shown its effectiveness; a meta-analysis of 20 studies showed it to have a significant effect on both venipuncture pain and IV insertion pain.[69,70] The major disadvantage of EMLA® is its long onset of action (45 to 60 minutes to achieve the desired effect). A potential complication for neonates receiving topical EMLA® cream is methemoglobinemia from the metabolites of prilocaine secondary to low levels of methemoglobin reductase.[71,72] The incidence is highest in patients aged < 3 months and is related to the duration of skin application. EMLA® does not affect procedural success in IV cannulation.[73]

LMX® and Topical Tetracaine

LMX® is 4% lidocaine and is available in both a gel and cream. The most commonly used formulation of LMX® is the cream. The gel formulation of high-concentration lidocaine, LMX®, is similar to EMLA®. It is used topically to anesthetize intact skin, and its effects are seen more quickly than with EMLA®, sometimes as quickly as 20 minutes after application. Two studies that assessed pain with IV placement have found equivalent pain relief with a 30-minute application of LMX® or a 60-minute application of EMLA®, although these trials did not have a placebo control.[74,75] Topical tetracaine is also available outside the United States for local anesthesia prior to venipuncture, providing similar anesthesia to liposomal lidocaine.[76]

Needle-Free Lidocaine

Needle-free, local jet-injection of lidocaine can be used prior to IV catheter placement in children to reduce pain and facilitate patient cooperation. The single-use system uses a carbon dioxide gas cartridge under high pressure to deliver 1% buffered lidocaine through a micro-orifice into the subcutaneous layers of the skin. It provides almost immediate anesthesia and has been shown to be more effective than placebo, vapocoolant spray, and EMLA® for IV placement.[77-79] It also does not affect the rate of IV placement success.[80] Another study, however, showed no difference between jet-injection of lidocaine and jet-injection of placebo, although both were superior to controls receiving no anesthesia with IV placement.[81] Prior to LP, jet-injection of lidocaine has been shown to be superior to jet-injection of placebo.[82]

LET

Lidocaine, epinephrine, and tetracaine (LET) is a topical anesthetic that can supplement or replace local infiltration of lidocaine for laceration repair. Use of LET can facilitate cooperation and decrease anxiety because the topical application of the medications avoids needles. LET has been shown to be effective for laceration repair, with few side effects.[72,83] LET has an equal anesthetic effect compared to injected lidocaine, with less pain on application.[84] Additionally, application of LET reduces the pain associated with lidocaine injection, should it subsequently become necessary.[85] Placement of LET on lacerations by nurses in triage has been shown to decrease treatment time for children presenting with lacerations in need of repair.[86]

Vapocoolant

Ethyl chloride spray and other products (eg, Pain Erase®) are vapocoolant sprays used for cryoanalgesia for IV placement as well as incision and drainage procedures for pediatric patients. Its use has decreased with the advent of other forms of topical analgesia, but it is still commonly used in some settings. A Cochrane review found moderate evidence that use of vapocoolant immediately before IV cannulation reduced procedural pain,[87] although the clinical significance of the small improvement in pain observed is unclear.[88] In one study, vapocoolant was found to be inferior to EMLA® for the relief of IV catheterization-associated pain.[89]

Local Anesthesia

Local anesthetics can be delivered via needle into the area of a wound (or the area surrounding) or the area where a procedure is to take place. Lidocaine is the most commonly used agent. It has a rapid onset of action, with a duration of action of 30 to 60 minutes (without epinephrine). Commonly, epinephrine is used in combination with lidocaine, providing vasoconstriction, decreased bleeding, and delayed systemic absorption of lidocaine. The delayed absorption can increase the duration of anesthesia the produced to between 160 to 240 minutes. Maximum recommended doses of lidocaine are 4.5 mg/kg without epinephrine and 7 mg/kg with epinephrine.[90-92] Dysrhythmias, seizures, and cardiovascular collapse have been reported rarely with the use of local anesthetic agents, typically with supratherapeutic dosing.[92]

Because lidocaine has a low pH, studies have shown that using 9 mL of 1% lidocaine and combining it with 1 mL of 8.4% sodium bicarbonate (9:1 ratio) can decrease the burning that is often associated with its administration.[93] A Cochrane review of 23 studies showed that adjusting the pH of lidocaine both decreased observed pain scores and improved patient satisfaction.[94] Using 25-gauge or smaller needles, infiltrating slowly, and stimulating the skin just proximal to the site of injection can decrease pain sensation.[95] Additionally, in a systematic review and meta-analysis, warming lidocaine prior to injection was also shown to improve pain scores upon lidocaine administration.[96]

Other agents, such as mepivacaine, bupivacaine, prilocaine, and etidocaine can also be useful if administered before painful procedures because of their longer duration of action compared to lidocaine. These anesthetics are sometimes used in combination with lidocaine to prolong the duration of anesthesia, but many agents can be used singularly. Some disadvantages of these medications include a longer duration until onset of pain relief and more frequent reports of local anesthetic systemic toxicity[92] compared to lidocaine. The onset and duration of action of several common local anesthetics is listed in **Table 3**.

Regional Anesthesia

Regional anesthesia and peripheral nerve blocks may also be used to address pain associated with fractures and laceration repair in the ED. Regional anesthesia involves the injection of a local anesthetic in the area of a nerve in order to provide anesthesia to a particular nerve distribution. Compared to local infiltration, advantages of regional anesthesia include reduced pain, less anesthetic use, lower risk for systemic toxicity, and less tissue distortion.[97] Disadvantages include the need for a high degree of patient cooperation, a risk of systemic toxicity due to inadvertent intravascular injection, and a small risk of peripheral nerve damage.[97] Typical anesthetics used for regional anesthesia and nerve blocks include lidocaine, bupivacaine, and ropivacaine.

There are several indications for the use of peripheral nerve blocks in the ED. Digital blocks provide excellent anesthesia for nail bed repairs, laceration repairs, and foreign body removal from fingers and toes. Femoral nerve blocks can be used for immediate relief of femur fracture pain. Axillary blocks can be used for anesthesia during forearm fracture reductions. Facial nerve blocks, including infraorbital, supraorbital, and mental nerve blocks, are often used for regional anesthesia for facial laceration repair. The addition of ultrasound guidance has been shown to be more effective than traditional landmark techniques for nerve blocks of the extremities.[98]

Table 3. Onset and Duration of Action of Common Local Injectable Anesthetic Medications

Medication	Onset (min)	Duration (min)
Lidocaine	1-3	30-60
Lidocaine with epinephrine	1-4	160-240
Mepivacaine	4-7	120-180
Bupivacaine	5-10	120-360
Prilocaine	1-2	60-120

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Systemic Agents

Nonopioid Analgesics

Acetaminophen

Acetaminophen (paracetamol, APAP) is the most widely used analgesic and antipyretic in children. Its exact mechanism of action is unknown. Unlike nonsteroidal anti-inflammatory drugs (NSAIDs), acetaminophen does not have anti-inflammatory or antiplatelet properties.

While acetaminophen has an excellent safety profile overall, a risk for severe hepatotoxicity and necrosis in patients receiving supratherapeutic doses of acetaminophen exists, especially in patients receiving repeated dosing.[99,100] Families frequently give incorrect doses of acetaminophen at home, so it is important to provide explicit, appropriate dosing instructions.[101,102] Acetaminophen is typically administered orally or rectally, with maximum daily dosing varying by weight or age.[103] The oral dose of acetaminophen is 10 to 15 mg/kg, which may be repeated every 4 to 6 hours. The usual recommended rectal dosage of acetaminophen is 10 to 20 mg/kg/dose.[104] Given its variable bioavailability, caution should be used when administering rectal acetaminophen, especially in children in a catabolic state due to their underlying illness.[105] There is also an IV formulation of acetaminophen. Although its current use is limited by its expense, it has been used successfully in a pediatric ED setting.[106] **(See Table 4, page 8.)**

Nonsteroidal Anti-Inflammatory Drugs

NSAIDs have both analgesic and anti-inflammatory effects and are often used in the treatment of mild to moderate pain for pediatric patients in the ED.

Ibuprofen

Ibuprofen is the most frequently administered NSAID for pediatric patients. Although an IV formulation of ibuprofen exists (eg, to hasten patent ductus arteriosus closure in neonates), only the oral formulation is FDA-approved for the treatment of pain in children.[107] Dosing of ibuprofen is 10 mg/kg, with a maximum dose of 400 mg, not to exceed 40 mg/kg every 24 hours. **(See Table 4.)** The risk of harm from overdose is less with ibuprofen than acetaminophen, although significant acidosis, renal failure, coma, and death have been reported from massive (> 400 mg/kg) overdoses of ibuprofen.[108,109]

Several meta-analyses have compared the efficacy and safety profile of acetaminophen and ibuprofen in children. In all meta-analyses, the safety and side-effect profiles of acetaminophen and NSAIDs were similar, with fewer adverse events than with opioids.[110-113] Perrott et al concluded that both agents had similar efficacy against pain,[110] while Pierce and Voss found that ibuprofen may be more efficacious in treating pediatric pain.[112] Similarly, Le May et al found ibuprofen to be superior to acetaminophen in the treatment of mild to moderate musculoskeletal pain.[114] A Cochrane review of medications for pain in otitis media found insufficient evidence of a difference between ibuprofen and acetaminophen.[115] Additionally, a recent multicenter prospective trial found no difference in asthma exacerbation frequency in children with mild asthma subsequent to using acetaminophen or ibuprofen.[116]

Other NSAIDs

Other NSAIDs have also been used in pediatric patients. Aspirin was the first NSAID developed for clinical use; however, its association with Reye syndrome has led to its discontinuation for use in children with pain or fever.[117] Naproxen has similar efficacy to ibuprofen but has the advantage of a longer half-life.[118] It has not been studied for use in infants. Ketorolac is the only NSAID with an IV formulation approved for analgesia in pediatric patients. While it has been associated with cases of renal failure[119] and gastrointestinal bleeding[120] in pediatric patients, short courses (< 5 days) of ketorolac are safe in patients without baseline renal or gastrointestinal issues.[121] A tablet form of ketorolac exists, but there have been few studies regarding its use in children. Indomethacin has not been studied in patients aged < 14 years,[122] but it has been used in patients with rheumatic diseases. Dosing of nonopioid analgesics is summarized in **Table 4.**

Side Effects of NSAIDs

With typical usage, NSAIDs are well tolerated in children, although side effects do exist. Case reports demonstrate NSAID-associated renal failure in pediatric patients using NSAIDs for short periods, although all cases were self-limited with drug discontinuation.[123] Despite a high prevalence of NSAID-induced bronchospasm in adults, at least 1 randomized controlled trial showed a reduced risk of outpatient visits for asthma in pediatric patients with a history of asthma and an acute febrile illness who were prescribed ibuprofen versus those given acetaminophen.[124] Two meta-analyses showed no evidence of a significant difference in postsurgical bleeding in tonsillectomy patients receiving NSAIDs perioperatively versus other tonsillectomy patients.[125,126] A randomized double-blind office-based study enrolling over 80,000 patients showed no difference in rates of hospitalization for gastrointestinal bleeding, renal failure, or anaphylaxis in patients prescribed ibuprofen versus those prescribed acetaminophen.[127]

Table 4. Dosing of Nonopioid Analgesics

Medication	Route	Dosing	Frequency
Acetaminophen	Oral	10-15 mg/kg/dose (max 650 mg), infants and children	Every 4-6 hr, infants and children
	Rectal	10-20 mg/kg/dose (max 650 mg)	Children, every 6 hr Neonates, every 12 hr
	Intravenous	• Age < 2 yr: 7.5–15 mg/kg/dose (max 60 mg/kg/day) • Age ≥ 2 years, weight < 50 kg: 15 mg/kg (max 75 mg/kg/day or 3750 mg) • Age ≥ 2 years, weight ≥ 50 kg: 1 g (max 4 g/day)	Every 6 hr
Ibuprofen	Oral	10 mg/kg/dose (max 400 mg)	Every 6 hr
Naproxen	Oral	5-6 mg/kg/dose (max 500 mg)	Every 12 hr
Ketorolac	Intravenous	0.5 mg/kg/dose (max 30 mg)	Every 6 hr for ≤ 5 days

Neonate: aged < 1 month
Infant: aged < 12 months
Child: aged 1 to 18 years

Opioid Analgesics

Opioids are the mainstays of treatment of moderate to severe pain in children in the ED. While opioids have a significant side-effect profile that must be recognized, these side effects can be minimized when opioids are used appropriately. For severe pain, opioids should be given concurrently with NSAIDs and/or acetaminophen, when possible. For mild to moderate pain, opioids should be given only for breakthrough pain after NSAIDs and/or acetaminophen have been administered. Dosing of opioid analgesics is summarized in **Table 5**.

Codeine

Codeine, once a mainstay in pain management, is now recognized as a high-risk medication and its use has been greatly restricted in children in the United States,[128] Canada,[129] and Europe.[130] Codeine itself has an extremely weak affinity for opioid receptors. Its analgesic effect comes from the approximately 10% of ingested codeine that is metabolized into morphine by the CYP2D6 enzyme in the liver.[131] However, there are a number of CYP2D6 genetic polymorphisms that affect its rate of catalysis. In North America, 7% to 10% of white people have a polymorphism of CYP2D6, which causes the enzyme to have little function; thus, these patients receive virtually no analgesic effect from codeine.[132] Conversely, 1% to 7% of white people and > 25% of Ethiopians, among others, have a polymorphism of CYP2D6 that causes very fast metabolism of codeine, creating a high potential for toxicity and death;[133] this polymorphism has been linked to multiple fatalities.[134,135] Additionally, ibuprofen has been shown to provide greater pain relief than codeine in pediatric patients with acute musculoskeletal injuries,[136] and the addition of codeine to ibuprofen has not been shown to provide additional benefit in pediatric patients with acute limb injuries.[137] With better alternatives available, use of codeine for analgesia should be avoided.

Tramadol

Tramadol is a prodrug, that, similar to codeine, is metabolized by the CYP2D6 enzyme into its active form, desmetramadol. Like codeine, depending on an individual's CYP2D6 polymorphism, tramadol may provide either minimal analgesia or toxic effects even when given at previously recommended doses.[138] Tramadol is not recommended for children aged < 12 years. In all ages, it is not a first-line medication, and should be used selectively, if at all.[128]

Oxycodone

Oxycodone is frequently used and prescribed in pediatric EDs in the United States.[139] Unlike codeine, it does not need to be metabolized to an active form. Caution should be used in dosing oxycodone in patients with renal failure, since they may develop toxic levels of its metabolites.[140]

Hydrocodone

Hydrocodone is an oral opioid with similar potency to oxycodone; however, the most common formulations are combined with acetaminophen and ibuprofen, which may limit its utility.

Morphine

Morphine is a mainstay of treatment of severe pain in pediatric ED patients. It is metabolized in the liver to inactive morphine-3-glucuronide and active morphine-6-glucuronide, both of which are excreted by the kidneys. Caution should be used in giving morphine to patients in renal failure, since the active toxic metabolite can accumulate.[141] Morphine is metabolized predominantly into the active metabolite in infants. It has both a smaller volume of distribution and a longer clearance time in these patients;

Table 5. Dosing of Opioid Analgesics

Medication	Route	Dosing	Frequency
Oxycodone	Oral	0.05–0.2 mg/kg/dose (initial max 5–10 mg)	Every 4–6 hr
Hydrocodone	Oral	0.1–0.2 mg/kg/dose (max 10 mg)[a]	Every 4–6 hr
Morphine	Intravenous	0.05–0.1 mg/kg/dose (initial max 4 mg, titrate as needed)[b]	Every 2–4 hr
	Oral	0.2–0.5 mg/kg/dose (max 15–30 mg)	Every 4 hr
Hydromorphone	Intravenous	0.01–0.015 mg/kg/dose (max 0.2–0.6 mg)	Every 3–6 hr (infants and children weighing < 50 kg) or every 2–4 hr (children/adolescents > 50 kg)
	Oral	0.03–0.06 mg/kg/dose (max 1–2 mg)	Every 4–6 hr
Fentanyl	Intravenous	0.5–1 mcg/kg/dose (max 50 mcg)	May repeat every 30–60 min
	Intranasal	1–2 mcg/kg/dose (max 100 mcg)	Additional 0.3–0.5 mcg/kg every 5 min, if needed

[a]Usually paired with acetaminophen; dosing hydrocodone component.
[b]Initial dosage for neonates, 0.025 mg/kg/dose

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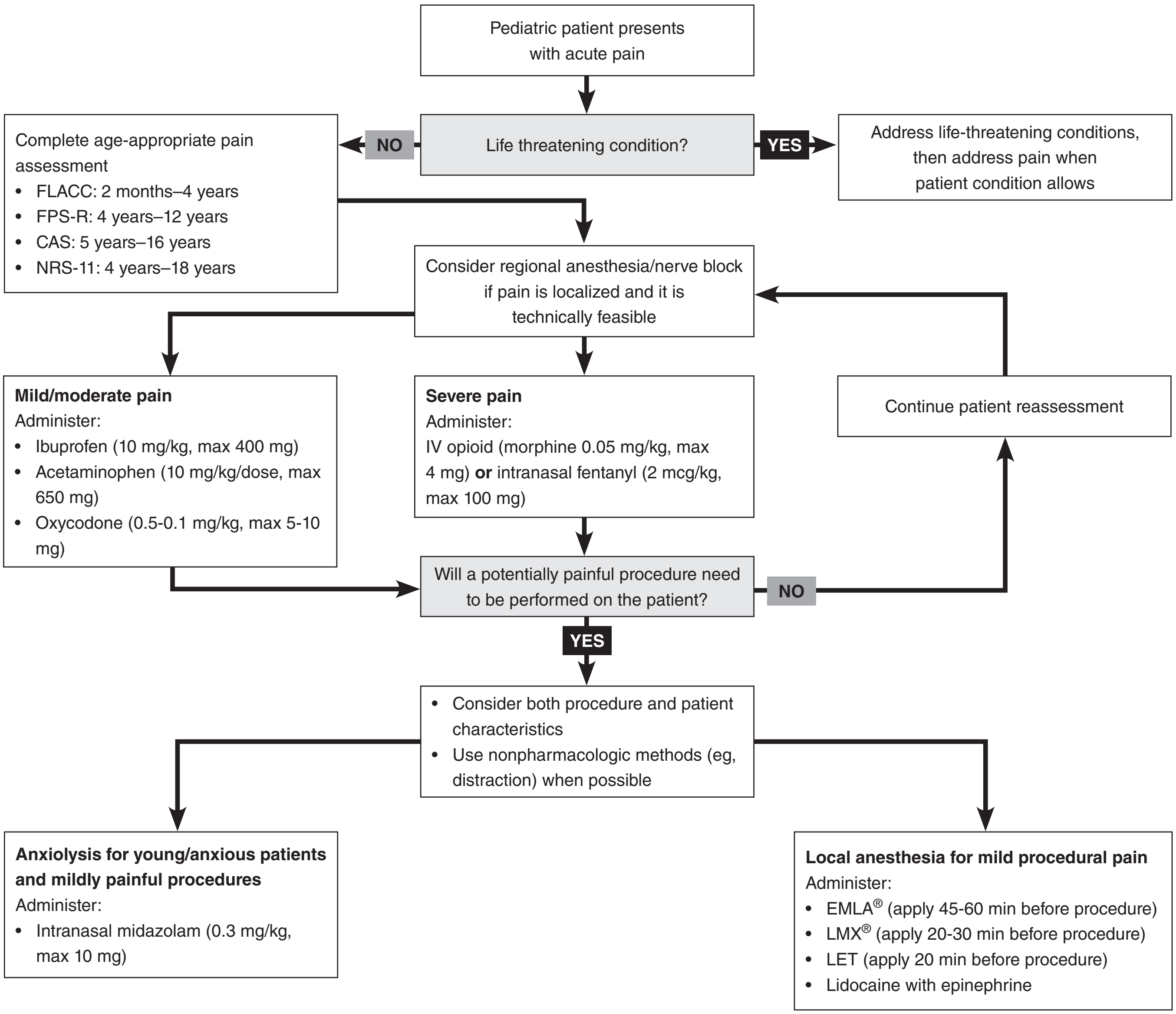
Clinical Pathway for the Management of Pain in Pediatric Patients



Abbreviations: CAS, color analog scale; FLACC, Faces, Legs, Activity, Cry, Consolability Scale; FPS-R, Faces Pain Scale-Revised; IV, intravenous.

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
- Nonrandomized or retrospective studies: historic, cohort, or case control studies
- Less robust randomized controlled trials
- 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

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.

therefore, the dosing should be reduced.[142,143] Morphine is often given intravenously; an oral formulation is available, but it has not been shown to be superior to ibuprofen for musculoskeletal injuries, and it has more frequent side effects.[144]

Hydromorphone
Hydromorphone is a synthetic opioid with an onset and duration similar to morphine. It is thought to have less associated nausea and pruritus than morphine; however, the increased euphoria associated with hydromorphone makes this a potential drug of abuse.

Fentanyl
Fentanyl is a synthetic opioid with rapid onset and offset, making it an excellent agent for immediate pain treatment. It is highly lipid soluble and, therefore, rapidly penetrates the central nervous system. It then diffuses from the central nervous system into the systemic circulation, allowing for rapid termination of effect. The peak effect for IV fentanyl is 3 to 5 minutes, with a duration of effect of 30 to 60 minutes.[131]

There are a number of techniques for administration of fentanyl, several of which offer particular advantages in the ED setting. Intranasal fentanyl has been successfully used for pain relief in the pediatric ED[145] and in the prehospital setting.[45] A randomized controlled trial found that intranasal fentanyl had similar efficacy and time to onset as IV morphine in treating pediatric patients with fracture pain.[145] This study did not account for time to administration, which would presumably favor intranasal fentanyl, since there is no need for IV placement.

Using an atomizer and maximizing drug concentration are important to optimizing drug delivery of intranasal fentanyl,[146] although in one study, similar analgesia was achieved with either standard-IV-concentration or high-concentration intranasal fentanyl.[147] Another study showed that use of intranasal fentanyl for all pediatric patients presenting with pain from any cause led to decreased wait time to pain medication administration by approximately 30 minutes, compared to IV morphine, although the study did not assess time to pain relief.[148] Given the limited number of studies on the use of intranasal fentanyl, a 2014 Cochrane review could not reach a definitive conclusion regarding the efficacy of intranasal fentanyl when compared to morphine.[149]

Nebulized fentanyl has also been administered to pediatric patients in the ED setting. Two small pediatric studies also found comparable or improved analgesia with nebulized fentanyl compared to IV opioids.[150,151]

Side Effects of Opioids
Respiratory depression is the most significant potential side effect of opioids. Binding of opioids to receptors in the medullary respiratory center can lead to hypoventilation and apnea. Cardiopulmonary monitoring of all patients receiving IV opioids is, therefore, mandatory, to obviate this potentially fatal complication. The peak effect of an IV dose of morphine is 10 to 20 minutes, and 3 to 5 minutes after an IV dose of fentanyl.[141] Hypotension after administration of morphine is uncommon, but it can occur secondary to histamine release. Gastrointestinal side effects of opioids include ileus, constipation, and vomiting. Severe pruritus is occasionally a side effect of morphine. Chest-wall rigidity is a known complication of fentanyl, and it is associated with higher dosing and rapid IV administration of the medication.

Management of Opioid Overdose
In the event of accidental, recreational, or iatrogenic opioid overdose in children, naloxone reverses opioid effects with minimal side effects. Recommended dosing of naloxone for children is 0.1 mg/kg IV, with a 2-mg maximum dose. This dosing is higher than what is recommended for adults, as children are rarely chronic opioid users and will not experience withdrawal symptoms. Adolescents suspected of chronic opioid use should receive naloxone at adult doses. Higher doses of naloxone, up to 10 mg, may be necessary in cases of toxicity with synthetic opioids, such as fentanyl and its derivatives.

Special Circumstances

Abdominal Pain
Traditional surgical teaching about abdominal pain held that analgesia should be deferred in patients with acute abdominal pain so that clinical progression could be monitored. This practice is now obsolete, as deferring analgesia causes significant harm without any evidence of benefit. Kim et al were the first to examine the question of the use of pain medicine and the masking of clinically significant abdominal symptoms by comparing pain scores, examination findings, and the time to clinical decision-making in children aged > 5 years presenting with acute abdominal pain. Sixty patients were randomized to receive either morphine or placebo; patients and investigators were blinded to which medication the patients received. The study found improvement in pain scores with no changes in abdominal tenderness on examination or clinical diagnostic accuracy.[152] However, this study was limited in size, power calculations were performed post hoc, and the same physicians examined the patients both before and after the study medicine was given. A study by Green et al evaluated children presenting with abdominal pain requiring a surgical consul-

tation. It compared patients receiving placebo to those receiving morphine in a randomized blinded study. Again, pain was improved in the morphine group, with no change in either the pediatric emergency physicians' or the surgeons' confidence in the diagnosis, and there was no difference in patient outcome. Nonetheless, as the authors point out, the study was limited in its ability to account for the potential of missed appendicitis; such a study would require over 1000 participants in order to detect any potential difference.[153] Similar results were found in a study comparing oxycodone to placebo[154] as well as a study examining time to surgical decision-making, although the latter showed no difference in pain scores between patients receiving morphine and placebo.[155]

Despite the absence of evidence that analgesia masks examination findings or alters outcomes in pediatric patients with abdominal pain, there is still skepticism that patients can safely receive pain medicine prior to surgical decision-making. In an editorial by Vane that accompanied the study by Green et al, the author questions the absence of a study decision-making algorithm, and states, "This article has not definitively demonstrated the best algorithm or timing for [analgesia] administration in children with acute abdominal events."[156] Nevertheless, accumulating evidence continues to support the use of analgesia in patients with acute abdominal pain. A meta-analysis of adult and pediatric studies showed that, although there was a change in physical examination findings with analgesia, there was no increase in clinical errors with its use.[157] Similar results were also found in a Cochrane review of adult patients.[158] Use of pain medications for acute abdominal pain in children is reportedly increasing.[159] However, pain is still undertreated, and racial disparities in analgesia exist, as black children are less likely than white children to receive analgesia for abdominal pain.[15] Given all of the current evidence, it is not justifiable to withhold analgesics in pediatric patients with acute abdominal pain.

Lumbar Puncture

LP is performed frequently for pediatric patients in the ED. There is a potential for undertreatment of procedural pain with LP, especially in infants who have limited ability to express pain and discomfort. In a survey of pediatric and emergency medicine residents, residents thought LP pain was less in neonates than toddlers, children, and teens.[160] In a separate survey of emergency medicine attending physicians and pediatric emergency medicine fellows, only 19% of respondents felt that pain experienced by infants during an LP would have any long-term developmental effects.[161] These attitudes may lead to less use of analgesia in infants. At a tertiary care children's hospital, pharmacologic procedural pain relief during LP was used in only 6.5% of neonates and 14.3% of infants, compared to 60% of preschoolers and 85.9% of older children.[162] In a survey of Canadian pediatric emergency medicine physicians, 68% reported using topical anesthesia "often or always,"[163] while in a separate survey of Canadian general and pediatric ED physicians, 13% of respondents said they would provide no anesthesia to a 3-week-old infant before a lumbar puncture.[164]

Despite unfounded attitudes and practices of avoiding analgesia in infants, there is ample evidence suggesting its benefit. In a randomized double-blind placebo-controlled neonatal intensive care unit study, LP was associated with increases in heart rate and behavioral pain scores, but these increases in scores were attenuated with use of EMLA® cream.[165] In a prospective unblinded study, use of injectable lidocaine was associated with decreased behavioral pain scores without affecting LP success rate.[166] A similar success rate was found in a second study of injectable lidocaine for LPs, although there was a slight but significant increase in the rate of traumatic LPs in the lidocaine group.[167] Use of topical analgesics has also been associated with decreased used of propofol for sedated LPs.[66] Improved procedural pain scores have been found with jet-injected lidocaine compared to placebo.[82] One study found that LPs were significantly more likely to be successful if local analgesia, either topical or injected, was used.[168]

The best modality for local anesthesia for LPs is unclear. A recent study found no difference in pain scores in infants receiving needle-free lidocaine versus topical lidocaine, although LP success was higher in the former group.[169] In a study of adult patients, administration of needle-free lidocaine was less painful than injection of lidocaine with no difference in pain scores during the subsequent LP.[170]

In summary, strong evidence exists that local anesthesia ameliorates pain during LP in infants. Additionally, using local anesthesia does not decrease—but may improve—LP success rate. Given our knowledge of the detrimental effects of pain in infants and young children, local anesthesia should be utilized in all patients undergoing an LP, regardless of patient age. Adjunct treatments, such as a pacifier dipped in sucrose may also provide some benefit.

Fracture Management

Extremity fractures are often very painful injuries. Despite this, pain in pediatric patients with a fracture is not always recognized and addressed. In a retrospective study of 773 patients presenting to a Level I pediatric trauma center with isolated long-bone fracture requiring hospital admission, only 10% received adequate analgesia, while 59% received no pain medication.[171]

Younger patients with musculoskeletal injuries are less likely to receive analgesia than older children, likely due to their inability to express pain they are experiencing.[171,172]

There is a wide range of potential treatment options for fracture pain. One of the first decisions to be made is whether to begin with IV, intranasal, or oral medications. In one study, patients aged > 6 years who did not have an IV but were to receive IV morphine for analgesia for a musculoskeletal injury were randomized to receive either IV morphine or oral oxycodone. Despite longer times to morphine administration, pain scores were lower and patient satisfaction was higher in the IV morphine group.[173]

There are also several studies comparing oral analgesics for fracture pain at ED presentation. One study found a small but statistically significant improvement in pain scores in patients given oxycodone versus codeine, although large doses (0.2 mg/kg oxycodone and 2 mg/kg codeine) were used for both agents.[174] Other similar studies have found ibuprofen for musculoskeletal injuries to be equivalent to acetaminophen with codeine,[175] equivalent to oxycodone or ibuprofen/oxycodone combined,[176] and equivalent to morphine,[144] while another study found it to be superior to codeine or acetaminophen.[137]

Studies on analgesic use at discharge have found similar results. In a double-blind study of 336 pediatric patients with arm fractures who were discharged from the ED, ibuprofen performed at least as well as acetaminophen with codeine for pain control, with fewer adverse effects and greater parental satisfaction.[177] A randomized blinded study found no significant difference in analgesic efficacy between oral ibuprofen and oral morphine in patients discharged from a pediatric ED who had fracture-related pain. Patients in the morphine group had a significantly higher number of adverse events.[178] A smaller study found acetaminophen to be equivalent to ibuprofen in 72 pediatric patients with extremity fractures who were discharged from the ED, although the study was not blinded and ibuprofen was dosed every 8 hours.[179] There is evidence that COX-2 (cyclooxygenase-2) inhibition caused by NSAIDs may delay fracture healing in animal models; however, no definitive clinical effects of this phenomenon have been found in humans.[180]

In summary, it is important to recognize the need for pain management in patients with a fracture, particularly in younger patients. For severe pain, IV morphine appears to be superior to oral medications. Intranasal fentanyl appears to be equivalent to IV morphine for pain relief, and it may provide more rapid analgesia in patients with difficult or no IV access. Numerous studies have found no difference between NSAIDs and oral opioids in the treatment of fracture-related pain, both in the ED and at discharge.[137,144,175-178] Given the risks and side-effect profiles of opioids, ibuprofen should be the initial medication of choice for mild to moderate fracture pain.

Controversies and Cutting Edge

Regional Anesthesia

Epinephrine-Containing Anesthetics

The use of epinephrine-containing anesthetics on distal body parts such as the nose, penis, fingers, and ears has historically been discouraged for fear of compromising blood flow to these areas. However, multiple studies have not shown any major ischemic complications attributed to epinephrine.[181-186]

Femoral Nerve Blocks for Femoral Fractures

Due to concern for masking the early signs and symptoms of compartment syndrome, controversy exists concerning the use of femoral nerve blocks for femoral fractures in the ED. However, there are no reports of a femoral nerve block masking acute thigh compartment syndrome or leading to a delay in diagnosis following an acute injury,[187,188] and complication rates are low.[189] Multiple studies show superior analgesia in patients receiving femoral nerve blocks than those receiving systemic analgesics alone.[189,190] Opioids are used extensively in the management of pediatric pain associated with femur fractures; however, they have many side effects, including respiratory and cognitive depression, which are not desirable in trauma or pediatric patients. Femoral nerve blocks show promise as a means to reduce the utilization of opioid analgesia and the undesirable side effects, but their use is not yet widespread for pediatric patients in the ED.

Intranasal Ketamine

While ketamine is most frequently used as a dissociative anesthetic for pediatric ED patients, at subdissociative doses, it has analgesic effects. The ability to administer ketamine intranasally makes it a potentially attractive agent to be used in the prehospital setting or when IV access is not immediately available. Multiple studies have prospectively compared intranasal ketamine to intranasal fentanyl. Three studies have compared 1.5 mcg/kg fentanyl to 1 mg/kg ketamine in children with extremity injuries. All of the studies found equivalent pain relief in each group, with greater side effects in the ketamine group.[191-193] Another study found similar results comparing 2 mcg/kg fentanyl to 1.5 mg/kg ketamine.[194]

While intranasal ketamine shows promise, its side effect profile and the absence of a large multicenter trial of its effectiveness and the risk of serious adverse events preclude its routine use at this time. Further study of the analgesic effects of ketamine is warranted.

Opioid Misuse

The misuse of opioids is an epidemic. In the United States, drug overdose deaths tripled between 1999 and 2014, with 60.9% of drug deaths in 2014 involving opioids.[195] Rates of intensive care unit admissions for opioid overdoses at children's hospitals doubled between 2004 and 2015, with the majority of these patients being aged 12 to 17 years.[196] The rate of hospital admissions for opioid overdoses in pediatric patients increased by 165% between 1997 and 2012.[197] In many cases, the beginnings of opioid abuse involve contact with the medical community. Thirty-one percent of adults misusing opioids reported that the medication was initially prescribed by a physician for medical reasons.[198] Twenty-two percent of adolescents who were prescribed controlled substances report misusing the medication.[199] Additionally, a prospective survey study found that having a legitimate opioid prescription by twelfth grade was associated with a 33% increase in the risk of future opioid misuse after high school.[200]

Emergency clinicians need to be judicious about their opioid prescribing patterns without compromising patient analgesia, as the risk of future opioid misuse after a short course of opioids prescribed to a pediatric patient in the ED is unknown. For fracture management, nonopioid analgesics provide analgesia comparable to oral opioids and should be preferentially prescribed. Emergency clinicians should be similarly thoughtful about the need for opioids in other conditions and should also be judicious in the number of doses of medication they prescribe. In one study of 343 discharged pediatric inpatients, 58% of prescribed opioid doses were not consumed.[201] Quality improvement efforts may help limit numbers of dispensed doses. A study of pediatric EDs and urgent care centers found numbers of dispensed doses of opioids were associated with prescriber training level and care site, independent of patient characteristics.[139] Limiting patient exposure to opioid medications without compromising care can help limit unintended harm to patients and those around them.

Risk Management Pitfalls for Pediatric Pain Management

(Continued on page 15)

1. **"The patient was wide awake after I pushed his IV morphine, so I thought it was OK to leave him off the monitor."**
   Cardiopulmonary monitoring is required for all patients who have been given IV opioids. The time to peak onset of IV morphine is at least 20 minutes. Failure to properly monitor a patient on IV opioids could lead to hypoventilation, apnea, and death.

2. **"The kid was faking it. I had a patient with the same problem last week, and she didn't complain nearly as much!"**
   Pain is a multifactorial process. It is influenced not only by the stimulus that is causing the pain but also by the patient's age, temperament, past experiences, and understanding. All of these factors may lead to real, physiologic amplification of a given painful stimulus. It is important to recognize these differences and not minimize patients' self-report of pain.

3. **"Even though I saw the obvious extremity fracture, I thought I should get x-rays to see the extent of the fracture before I gave her pain medication or placed a nerve block."**
   Children with pain associated with suspected injuries and/or fractures should be given pain medication prior to imaging. Placing a peripheral nerve block can improve pain associated with obtaining radiographs and splinting.

4. **"I always prescribe opioids to patients with musculoskeletal injuries at the time of discharge to make sure their pain is well controlled."**
   Numerous studies have found no difference between NSAIDs and oral opioids in the treatment of fracture-related pain after ED discharge, with opioids having more side effects. Additionally, in one study, receipt of a legitimate opioid prescription as an adolescent was associated with a 33% increase in the risk of opioid misuse later in life.[200] While opioids do have a role in the outpatient management of musculoskeletal pain, they should be used judiciously and as part of a care plan that also includes ibuprofen or acetaminophen.

5. **"He's only 4 and would not talk to me. I thought he was just scared; how was I supposed to know he was in pain?"**
   The gold standard and most desirable method for pain assessment is based upon self-report of pain by the patient. All children should have pain measured, and pain scales have been validated and developed to assist with pain measurement in preverbal children. The FLACC **(see Table 1, page 4)** is used to assess preverbal children or children who are unable to communicate pain. The FPS-R and CAS are self-report pain scales that have been used in children as young as 4 years.

Summary

While children with pain may have historically been undertreated or ignored in the name of efficiency, this practice no longer meets acceptable standards of care. We now know that pain causes significant harm to pediatric patients both in the short term and the long term. Techniques have been developed to quantify pain in all age groups and developmental levels. Nonpharmacologic methods have been refined and studied to reduce patients' pain and anxiety in a safe and effective way. The development of newer agents, a greater understanding of older medications, improved experience with and use of procedural sedation, and newer treatment modalities such as ultrasound-guided regional anesthesia have all expanded the armamentarium and approach of emergency clinicians to treating pain in the pediatric population. By being both mindful of the need to treat pain and thoughtful in developing strategies to do so, we may move closer to the goal of the "ouchless" ED for pediatric patients.

Case Conclusions

To quickly address the 8-year-old boy's arm pain, you ordered a dose of intranasal fentanyl at 1.5 mcg/kg. You instructed the nurse to draw up the IV formulation of fentanyl in a syringe and then attached an atomizer to the syringe. The nurse then administered half the dose into each of the patient's nostrils. When you re-evaluated him 5 minutes later, his pain was significantly improved to 3/10. Eventually, the team was able to place an IV, and the boy's fracture was successfully reduced while he was sedated with ketamine. The boy was discharged home, and dosing instructions for ibuprofen as needed for pain were given to his parents. You also provided a prescription for oxycodone for breakthrough pain, with specific instructions on its administration, storage, and disposal.

Since there is no evidence that giving analgesia for pain secondary to an acute abdomen alters either diagnostic confidence or patient outcomes, you discussed with the surgical resident your plan to give the 7-year-old boy with right lower quadrant pain 0.1 mg/kg of IV morphine. You asked the nurse to give him lidocaine at the IV site

Risk Management Pitfalls for Pediatric Pain Management

(Continued from page 14)

6. **"I didn't need to explain how to dose acetaminophen; it's an over-the-counter drug."**
   Multiple studies have shown that parents are often inaccurate in their dosing of common analgesics when administering them to their children. This can result in both underdosing and overdosing of these medications. Therefore, it is vital to take the time to make sure parents understand the correct dosing of medications you recommend, even those that are over-the counter.

7. **"I placed my dialysis patient on every-4-hour dosing of morphine, and now he is somnolent and hypoventilating."**
   One of the molecules morphine is metabolized into is morphine-6-glucuronide, which is an active metabolite. Typically, it is renally excreted, so patients in renal failure may build up toxic levels of this metabolite. In patients with significant renal failure, it is important to renally dose morphine.

8. **"No one told me the patient I placed on ketorolac had a history of gastrointestinal bleeding."**
   Although NSAIDs are frequently used in pediatric patients, they are not without potential side effects. Additionally, as the efficacy of an NSAID increases, so too does its propensity to cause side effects. Take a thorough medical history before deciding which medication to administer to a patient.

9. **"The vomiting, dehydrated patient was still febrile, so we repeated the dosing of rectal acetaminophen."**
   Acetaminophen has a highly variable bioavailability when administered rectally. Additionally, patients in catabolism may be deficient in glutathione, an antioxidant critical in preventing acetaminophen toxicity. Caution should be used to make sure rectal acetaminophen is dosed properly in these patients.

10. **"We didn't need to sedate the patient. We just held him down to complete the procedure."**
    Due both to their size and their developmental limitations, children have limited ability to express pain and advocate for themselves. Although it may be physically possible to perform a painful procedure without analgesia or sedation, this pattern of practice can harm the patient both immediately and into the future. For this reason, it is imperative that emergency clinicians be thoughtful in choosing how to minimize pain during procedures on pediatric patients.

via a needleless syringe prior to IV placement. The IV was placed, and within 5 minutes of morphine administration, his pain improved to 2/10. Later, the surgical team came to evaluate him, and the surgical attending agreed with your decision to treat your patient's pain. The patient was eventually diagnosed with acute appendicitis and underwent a successful removal of a nonperforated appendix.

For the 21-day-old infant who presented with a fever to 38.3°C (100.9°F), you recognized that minimizing procedural pain was beneficial both to the well-being and development of your young patient and has been associated with increased procedural success. You therefore ordered topical lidocaine (LMX®) to be placed on the patient's lower back. Thirty minutes later, after the patient's blood and urine studies were obtained, you performed the patient's lumbar puncture. The patient was also provided a small amount of sucrose solution on a pacifier during the procedure. You successfully completed the procedure, and the patient was subsequently admitted to the medical floor on antibiotics pending the results of blood, urine, and cerebrospinal fluid cultures.

Time- and Cost-Effective Strategies

- **Apply topical analgesics early during a patient's visit.** LET requires 20 minutes to achieve the desired effect, LMX® requires 30 minutes, and EMLA® requires 60 minutes. Early application of these agents can allow for procedures to be completed faster, thereby hastening patient disposition. To this end, a number of centers have established standing orders for the use of topical anesthetics, allowing them to be applied as early as patient triage.
- **Consider using local anesthesia.** Using both local and regional anesthesia can reduce the need for systemic pain medications and potentially eliminate the need for procedural sedation in certain situations. This will decrease both the risk of complications of systemic agents as well as the patient's length of stay.
- **Recognize the value in adequately treating patient pain.** Studies have shown that families are willing to spend both time and money to have their children's procedures be less painful. By appropriately treating patient pain, you will increase patient satisfaction, thereby encouraging future selection of your institution.

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 is included in bold type following the references, where available. The most informative references cited in this paper, as determined by the authors, are noted by an asterisk (*) next to the number of the reference.

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1. **Which of the following medications has been shown to be safe and efficacious in children when given intranasally?**
   a. Morphine
   b. Ibuprofen
   c. Codeine
   d. Fentanyl

2. **The most important factor in accurate pain assessment for a verbal child is:**
   a. Choosing the best pain scale tool
   b. Reassessing the score to monitor change during treatment
   c. Parent reports
   d. Nurse reports

3. **Which of the following pain scales should be used to assess pain in a preverbal 2-year-old child?**
   a. Wong-Baker FACES® Pain Rating Scale
   b. Oucher™ Pain Scale
   c. FLACC Scale
   d. Visual analog scale

4. **Which of the following is a potential complication of the use of EMLA® in infants?**
   a. Methemoglobinemia
   b. Carboxyhemoglobinemia
   c. Aspirin toxicity
   d. Lidocaine toxicity

5. **A 6-year-old girl presents to the ED for vomiting. She is tachycardic and her mucous membranes appear dry. She continues to vomit despite a dose of oral ondansetron. You decide to rehydrate the patient intravenously. Which of the following would NOT be an acceptable method of local anesthesia prior to IV placement?**
   a. EMLA® cream
   b. LMX®
   c. Jet-injected lidocaine
   d. Lidocaine, epinephrine, and tetracaine (LET)

6. **Which of the following is NOT a side effect of lidocaine administration or overdose?**
   a. A burning sensation at the site of injection
   b. Seizures
   c. Dysrhythmias
   d. Hypoxia

7. **For which of the following patients should ketorolac be avoided?**
   a. A 4-year-old boy with severe asthma
   b. A 6-year-old boy post-tonsillectomy
   c. An 8-year-old boy with gastric ulcers
   d. A 10-year-old boy with idiopathic hypertension

8. **Which of the following analgesics has a high potential for adverse effects due to high variability in genomic profiles?**
   a. Ibuprofen
   b. Codeine
   c. Oxycodone
   d. Morphine

9. **A 16-year-old girl is rushed back to the resuscitation room in an unresponsive state. She was brought to the ED by her friends, who have since left. On examination, the patient is responsive only to painful stimuli. Her vital signs are: temperature, 36.1°C (97°F); heart rate, 55 beats/min; respiratory rate, 10 breaths/min; oxygen saturation, 92%; and blood pressure, 100/50 mm Hg. On examination of the patient's belongings, an empty bottle of oxycodone is found. She is given 2 mg of naloxone without improvement in her clinical status. The next step in the management of this patient is:**
   a. Order a head CT scan
   b. Observation with cardiopulmonary monitoring
   c. Immediate endotracheal intubation
   d. Administration of an additional dose of naloxone

10. **A 10-year-old boy presents to the ED with 2 days of abdominal pain. It started periumbilically but has since migrated to the right lower quadrant. The patient also reports vomiting and fevers. On examination, the patient is obviously uncomfortable and rates his pain a 9/10. He has a soft abdomen but has localized right lower quadrant tenderness with rebound and voluntary guarding. The next step in the management of this patient is:**
   a. Immediate general surgery consult to allow the surgery service to examine the patient's abdomen prior to administration of analgesia
   b. Administration of IV morphine
   c. Ultrasound of the right lower quadrant
   d. CT scan of the abdomen with IV and oral contrast

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