Lumbar puncture (LP) is used in the diagnostic evaluation of central nervous system (CNS) processes, most commonly in cases of suspected infection and subarachnoid hemorrhage. Less commonly, the procedure is used for therapeutic purposes (eg, in cases of idiopathic intracranial hypertension).

Head Games
Defined by a complex constellation of physical, cognitive, and emotional symptoms, concussion is among the most common injuries seen in the emergency department. Although it falls on the mild end of the TBI continuum, this seemingly benign diagnosis can have life-altering — even deadly — consequences if not properly identified and managed. These diagnostic pressures may be further compounded when providers feel rushed to determine the presence or absence of injury to clear an athlete for return to play.

Growing Pains
Pain is a universal and uniquely subjective experience — one that is notoriously difficult to measure from the outside looking in. The assessment and management of pediatric pain can be particularly challenging for emergency physicians, who must rely on the nebulous reports of patients who may be incapable of clearly communicating their discomfort. As a result, it is not uncommon for clinicians to underestimate a child's pain, delay treatment, or administer subtherapeutic doses of analgesics.
Head Games

Traumatic Brain Injury – Concussion

LESSON 9

By Rachel R. Bengtzen, MD; Melissa A. Novak, DO; and James C. Chesnutt, MD

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Reviewed by Daniel A. Handel, MD, MPH, FACEP

OBJECTIVES

On completion of this lesson, you should be able to:

1. Describe the physical examination findings that should raise concern for concussion.
2. Identify the most common complications of acute concussion and second impact syndrome.
3. Explain the options for treating concussion in the emergency department.
4. Explain the underlying pathophysiology of concussion.
5. Detail when and how patients can be cleared to resume physical activities following head injury.

FROM THE EM MODEL

18.0 Traumatic Disorders
   18.1.6 Head Trauma

CRITICAL DECISIONS

- What is a concussion, and what presentations should raise suspicion for this diagnosis?
- What role does the pathophysiology of concussion play in patient management?
- What diagnostic tools are most valuable for the evaluation of concussion?
- What are the best options for treating acute concussion in the emergency department?
- How should prolonged symptoms be managed?
- What critical information should be included in a concussive patient’s discharge instructions, and how should return to play be approached?

Defined by a complex constellation of physical, cognitive, and emotional symptoms, concussion is among the most common injuries seen in the emergency department. Although it falls on the mild end of the traumatic brain injury (TBI) continuum, this seemingly benign diagnosis can have life-altering — even deadly — consequences if not properly identified and managed.1,2
Critical Decisions in Emergency Medicine

CASE PRESENTATIONS

CASE ONE

A 17-year-old athlete “got her bell rung” by taking an elbow to the head during a soccer match; she presents to the emergency department at her coach’s insistence. The patient denies loss of consciousness, but reports experiencing pain, dizziness, and a “dazed” feeling before being removed from the field. Her symptoms (which lasted less than 10 minutes) now have resolved completely, and she insists being “back to normal.”

Her vital signs are normal; she appears alert and shows no signs of head trauma. The patient’s trauma and neurologic examinations are unremarkable (e.g., mental status, cranial nerves, cerebellar signs, motor and sensory testing, reflexes, and gait). Her Glasgow Coma Scale (GCS) score is normal. The girl and her father are eager for her to be discharged so she can return to play out the rest of the game, which is being attended by college scouts.

CASE TWO

A 54-year-old woman returns to the emergency department after a recent motor vehicle collision. She was traveling 45 miles per hour when she hit an oncoming car head on; the airbags deployed, and she did not lose consciousness.

Her previous evaluation included computed tomography (CT) scans of the head and neck, which were negative; and a radiograph of her forearm, which showed no signs of fracture or dislocation. She was placed in a wrist brace and instructed to follow up with a primary care provider. Since then, she says she has struggled with work and reports sleeping longer than usual. She complains of continued headaches, photophobia, phonophobia, and neck pain.

Her vital signs are normal. A trauma examination reveals left wrist bruising and paraspinal cervical neck tenderness to palpation, but no midline pain with range of motion. The GCS score and neurologic examination are normal, including assessments of mental status, cranial nerves, cerebellar signs, motor and sensory testing, reflexes, and gait.

Because no single test or biomarker currently is capable of confirming concussion, physicians must rely solely on clinical judgement and patient history when managing such cases. These diagnostic pressures may be further compounded when providers feel rushed to determine the presence or absence of injury to clear an athlete for return to play.

There is a growing body of research to suggest concussions may last longer, occur more often, and pose a greater risk of long-term sequelae than previously recognized. In response, diagnostic definitions and guidelines continue to evolve as more becomes understood about the complex metabolic crisis brewing below the brain’s surface.

CRITICAL DECISION

What is a concussion, and what presentations should raise suspicion for this diagnosis?

The diagnosis and evaluation of concussion can be complicated by the ambiguous nature of its symptoms. A patient may present with an isolated head injury, multiple traumatic injuries, or a constellation of post-concussive symptoms manifesting after the initial trauma. Concussion, as defined in a recently published evidence-based systematic literature review, is:

1. A change in brain function;
2. Following a force to the head (a potentially concussive event);
3. May (or may not) be accompanied by temporary loss of consciousness;
4. Identified in awake individuals; and
5. Includes measures of neurologic and cognitive dysfunction. The injury can result from acceleration or deceleration with or without an actual impact to the head. Loss of consciousness occurs in less than 10% of patients, but is found in about 40% of those who present to the emergency department.4

The systematic review also identified a set of “consistent and prevalent diagnostic indicators,” including:

1. Observed and documented disorientation or confusion immediately after the event;
2. Impaired balance within 1 day after injury;
3. Slower reaction time within 2 days after injury; and/or
4. Impaired verbal learning and memory within 2 days after injury.

Symptoms of concussion generally are divided into four main categories: physical, cognitive/thinking, emotional/mood, and sleep. The most frequent signs are headache (75%), dizziness (60%), blurred vision (75%), nausea (54%), double vision (11%), noise sensitivity (4%), and light sensitivity (4%).1 Symptoms are variable for each individual and can become more prominent with an increased cognitive or physical load, especially with return to school or work.

Patients with suspected concussion can be assessed with the symptom log in the Sport Concussion Assessment Tool (SCAT3), which is available online and can be incorporated into an electronic medical record flowsheet for use in the emergency department.5

Risk Factors

Certain risk factors may increase a patient’s susceptibility to injury or complicate recovery. A prior history of head trauma increases the likelihood of subsequent injury. Concussions clustered together within a short period of time or sustained before the full resolution of a prior injury may alter a patient’s prognosis significantly.

Younger athletes, who are at an increased risk of injury, may experience
to significant changes in the brain and potentially lead to chronic traumatic encephalopathy (CTE), which has effects similar to other neurodegenerative disorders such as Alzheimer and Parkinson diseases.9

**CRITICAL DECISION**

What role does the pathophysiology of concussion play in patient management?

Concussion represents a functional metabolic crisis in the brain, rather than a structural injury.6 These forces result in shearing of axons — a stretch that spurs a pathologic release of neurotransmitters that can trigger short- or long-term functional disturbances in the brain.

The symptoms of head injury result from derangements in the subsequent neurometabolic cascade.10 This disruption of neuronal cell membranes leads to fluctuations in ion levels, including an efflux of potassium and glutamate release; in turn, the ion gradient is altered across the membrane.2

In an attempt to restore ionic balance and normalize membrane gradients, sodium-potassium ion pump activity is enhanced, resulting in a greater demand for energy in the form of adenosine triphosphate (ATP).

Regional changes in cerebral blood flow, however, fail to match this increased need — a mismatch between energy needs and the delivery of glucose that can exacerbate the metabolic crisis. The increased cellular ATP metabolism leads to a relative energy deficit and resultant intracellular calcium accumulation, mitochondrial dysfunction, free radical production, impaired glucose metabolism, cytoskeletal injury, abnormal axonal transport, and alterations in neurotransmission.1,2

These physiologic perturbations correlate with concussion symptoms and a period of further metabolic vulnerability. In time, however, ionic balance is restored and neuron metabolism and blood flow normalize.2 Metabolic derangements long have been thought to resolve in 1 to 2 weeks; however, magnetic resonance spectroscopy and neuropsychological assessments suggest a longer road to recovery (up to 45 days).

Additionally, young developing brains may be even slower to heal; and children are at increased risk for long-term functional impairments — factors attributed to immature myelination, brain/water volume, and neuronal plasticity.2

**CRITICAL DECISION**

What diagnostic tools are most valuable for the evaluation of concussion?

Historically, the ability of emergency medicine providers to accurately diagnose concussion has varied widely.11,12 In recent years, however, significant efforts have been made to elucidate clinicians and standardize the assessment and treatment of brain injuries, particularly in young athletes, who frequently are encouraged to return to play prematurely.

Furthermore, previous grading systems for diagnosing concussion, which focused on the timing of symptoms and presence of loss of consciousness, have been outmoded in light of evidence that even “mild” concussions can cause significant problems.1,10

**Trauma and Neurologic Examinations**

The initial stages of concussion assessment should focus on ruling out more serious problems such as intracranial hemorrhage (ICH) or cervical spine injury. Depending on a patient’s presentation, the examination may start with a typical trauma assessment, including a primary survey (with GCS) and a secondary survey to rule out signs of head trauma, neck injury, or gross neurologic deficits. A trauma survey may be unwarranted unless other injuries are noted or a patient presents at the time of acute head injury.

The next step in neurologic screening includes assessments of the cranial nerves, reflexes, balance, sensation, motor strength, and coordination (including gait). If a structural brain injury (eg, ICH) is not suspected and the clinical evaluation suggests a concussion, there are a number of assessment tools that can be used in conjunction with med-
Concussion Examinations

Among the most commonly used concussion assessment tools is the SCAT3. Developed in 2012 by the Concussion in Sport Group, the guidelines feature a symptom scale and physical examination protocol that can be used on the sidelines, in the emergency department, or in outpatient follow up to assess and track the symptoms of athletes 13 years and above. (A Child-SCAT3 is available for younger patients.)

The SCAT3 physical examination goes beyond the standard neurologic evaluation to evaluate cognition, motor control, balance, immediate memory, concentration, and delayed recall (including Maddocks questions and the Standardized Assessment of Concussion). A balance test (modified balance error scoring system) is used to assess static postural stability with a sensitivity of 34% to 60%. Newer, more sensitive (about 80%) balance tests incorporate wearable wireless inertial sensors to digitally record and compare a patient’s balance to normative values.

Oculomotor Testing

Vestibular and oculomotor deficits, including nystagmus, saccades, trochlear nerve palsies, convergence, and anisocoria all have been documented after concussion. Visual function testing can be a sensitive means for assessing minor head injury, and may aid in the diagnosis of concussion. Although there is no rapid clinical tool specifically designed to evaluate for these deficits, the King-Devick Test shows promise with its ability to assess saccadic eye movements by measuring a patient’s speed and accuracy while reading aloud a series of numbers on test cards.

Computer-Based Neuropsychologic Testing

It has become increasingly common for athletes to undergo computerized assessments when asymptomatic to obtain data about their baseline levels of neurocognitive functioning. These tools, including the ImPACT test, can help clinicians track a patient’s progress following concussion and guide decisions about return to play by comparing pre- and post-injury scores.

Neuroimaging

Because concussions are due to functional rather than structural brain injuries, clinically available neuroimaging with CT and MRI is non-diagnostic and not recommended. Furthermore, CT poses a measurable risk of radiation exposure, and may be an impractical use of resources in such cases.

Diagnostic imaging should be considered, however, when structural injuries (eg, intracranial hemorrhage) are suspected. It also is indicated for patients older than 60 years or those taking anticoagulants, and in cases of multiple or severe traumatic injuries, possible skull fracture, or dangerous mechanism.

The Canadian CT Head Rule (Table 1) has 100% sensitivity for injuries requiring neurosurgical intervention, and is more specific than the New Orleans Criteria. It remains the most accurate and cost-effective decision instrument for safely reducing unnecessary neuroimaging in cases of minor head trauma (defined as a witnessed loss of consciousness, definite amnesia, or witnessed disorientation in a patient with a GCS score of 13 to 15). This rule does not apply to patients with GCS scores below 13, those taking blood thinners, or children younger than 16 (additional criteria are available for pediatric patients).

<table>
<thead>
<tr>
<th>TABLE 1. Canadian CT Head Rule</th>
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<tr>
<td>A minor head injury is defined as a witnessed loss of consciousness, definite amnesia, or witnessed disorientation in a patient with a GCS score of 13 to 15.</td>
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<table>
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<tr>
<th><strong>A minor head injury is indicated by any one of the following symptoms.</strong></th>
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<tr>
<td><strong>High Risk</strong> (for neurological intervention)</td>
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<tr>
<td>GCS score &lt;15 at 2 hours after injury</td>
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<tr>
<td>Suspected open or depressed skull fracture</td>
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<tr>
<td>Any sign of basal skull fracture (eg, haemotympanum, “raccoon” eyes, cerebrospinal fluid otorrhoea/rhinorrhea, Battle sign)</td>
</tr>
<tr>
<td>Vomiting (two episodes)</td>
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<tr>
<td>Age &gt;65 years</td>
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**Critical Decision**

What are the best options for treating acute concussion in the emergency department?

Return-to-Play Restrictions

Since 2014, all 50 states and the District of Columbia have enforced concussion laws to protect youth athletes. The first such regulation to be developed was Washington State’s Zackery Lystedt Law, named for a middle school athlete who prematurely — and catastrophically — returned to play after suffering a seemingly minor head injury during a football game. The boy’s near-fatal case inspired a 2009 law mandating that any athlete who has sustained a suspected head injury (including concussion) must be
Cognitive and Physical Rest

In the past 10 years, concussion recommendations have appeared at opposite ends of the spectrum — some allowing same-day return to play if symptoms resolve in less than 15 minutes, while others suggesting confinement in a dark room for several days of complete rest (ie, “cocoon” therapy). Current guidelines are not nearly as extreme; however, they caution against relative overexertion, which can worsen symptoms and prolong recovery times. Importantly, a repeat head injury prior to the resolution of a previous concussion can lead to severe or long-term neuropsychologic consequences, including learning and memory problems, depression, and even death.

The mainstay of acute concussion management is physical and cognitive rest in the 24 to 48-hour symptomatic period after injury.1,2,4 Following the acute phase, patients may begin a gradual return to academic and social activities at a pace that doesn’t exacerbate symptoms.1 An early transition back to school and noncontact physical activity appears to benefit recovery, although further research is needed to gauge the safety and efficacy of active rehabilitation in the acute post-injury period.1,25

For asymptomatic pediatric patients, many clinicians recommend a longer period of relative rest before resuming activities (eg, 2 weeks at Step 1, according to the protocol in Table 2). However, there is a paucity of evidence about the value of rest and the optimal amount and type required. When compared to usual care (ie, recommendations at the physician’s discretion), strict rest for 5 days appears to provide no added benefit in adolescent patients, and may — in fact — increase psychosocial symptoms.6,23-26

Sleep Hygiene

Approximately half of concussion patients will experience some sleep dysfunction, including persistent sleepiness, even with adequate rest; latency in sleep initiation; and frequent waking.27 In the acute setting, these issues can be treated conservatively with sleep hygiene techniques and behavioral modifications such as establishing regular bedtime and wake time routines, allowing more time for sleep, and avoiding naps. Sleep aids are reserved for persistent sleep disturbances, and should be managed by a clinician who can provide close follow up.

Medications

In the acute setting, medications for concussion management should be limited and carefully considered. Agents that can alter mental status (eg, benzodiazepines and narcotics) generally should be avoided; therapy should be aimed at specific symptom control, with a focus on minimizing risk. Acetaminophen, for example, may be the first-line treatment for headache, the most common symptom of concussion (occurring acutely in more than 90% of patients). No controlled trials have demonstrated increased bleeding with post-injury anticoagulation with NSAIDs; however, due to its theoretical risk, patients often are counseled to avoid the drug in the 24 to 48 hours following injury.28

Narcotics also should be avoided in concussive patients. The side effect profiles of these drugs often overlap symptoms of the diagnosis and can magnify fogginess, nausea, and confusion; they also are commonly associated with rebound headaches. Alternative treatments for pain include environmental modifications such as the reduction of stimulation (eg, avoidance of loud and bright places), and physical modalities such as massage and the application of ice.

A concomitant migraine induced by a traumatic head injury may be alleviated by abortive treatments for overlying migraine components in

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TABLE 2. Gradual Return-to-Play Protocol†

| Step 1. No same-day return to play; physical and cognitive rest. Objective is recovery. |
| Step 2. Light aerobic exercise (eg, walking, swimming or stationary cycling), while keeping intensity <70% maximum heart rate. Objective is to increase heart rate.* |
| Step 3. Sport-specific exercise (eg, skating drills in ice hockey, running drills in soccer); no head impact activities. Objective is to add some movement. |
| Step 4. Non-contact training → progressing to more complex drills (eg, passing in football and ice hockey) → progressing to resistance training. Objective is to gradually add exercise, coordination, and cognitive load.* |
| Step 5. Full-contact practice (following medical clearance, participates in normal training activities). Objective is to restore confidence and allow coaching staff to assess functional skills. |
| Step 6. Return to gameplay. |

Patient must be symptom-free for 24 hours before progressing to the next step. Emergency providers should direct patients to follow up with a concussion specialist or primary care physician prior to advancing to Steps 2 and 5. *Patients should consider seeing a primary care provider or concussion specialist prior to advancing to the next step in the protocol.

†Patients should consider seeing a primary care provider or concussion specialist prior to advancing to the next step in the protocol.
Critical decisions in emergency medicine

CRITICAL DECISION
How should prolonged symptoms be managed?

A solid awareness of long-term concussion treatments can help clinicians counsel patients and set expectations, despite the fact that these therapies are unlikely to be initiated in the emergency department. The majority of concussion symptoms resolve within 7 to 10 days (perhaps longer in younger children); however, they may persist for months — possibly even years — in a small portion of patients.

During outpatient follow up, some patients benefit from shortened work/school days, rest breaks, extended assignment deadlines, and restrictions on exercise or physically demanding work environments. For the minority whose concussion symptoms linger, there are a number of interdisciplinary rehabilitation protocols that may aid in recovery.

While there is no clear data on the best time to initiate the following therapies, current guidelines endorse starting individual treatment plans for persistent symptoms approximately 3 to 4 weeks post-injury.

- **Physical therapy:** Vestibular/balance therapy, gait stabilization, neck rehabilitation, and exercise prescription
- **Occupational therapy:** Concentrates on visual and functional therapy
- **Speech therapy:** Directed at cognitive and executive function, memory, speed of processing, attention, planning, problem solving, organization, social cognition, and school interventions
- **Neuropsychology:** Cognitive testing to determine brain function, assessment to determine other mental illness (eg, anxiety, depression, ADHD)
- **Psychology:** Cognitive behavioral therapy; cognitive restructuring; biofeedback; and strategies to address emotional and psychological effects to improve coping skills, resiliency, and function

The pharmaceutical management of protracted symptoms can include different medications than those initiated in the emergency department, where patient monitoring often is limited. Headache and sleep derangements can be treated with tricyclic antidepressants, beta-blockers, topiramate, or triptans.

Longtime treatment with NSAIDs or acetaminophen may cause rebound headaches that can be relieved with ceasing daily use of the medication. Narcotics also should be avoided for the treatment of headaches; these agents typically worsen symptoms of concussion such as fatigue, memory loss, and mental fog. Dizziness and disequilibrium may be treated with meclizine, scopolamine, and dimenhydrinate. Melatonin and diphenhydramine commonly are recommended as first-line treatments for sleep disturbances, in the event that sleep hygiene recommendations fail; amitriptyline or trazodone also may be considered. Concussive patients commonly experience increased irritability, depression, anxiety, post-traumatic stress disorder, personality changes, and apathy. Selective serotonin reuptake inhibitors (SSRIs) have become the primary treatment for TBI-associated depression because of their perceived clinical efficacy and relatively few side effects.

CRITICAL DECISIONS
What critical information should be included in a concussive patient’s discharge instructions, and how should return to play be approached?

**Diagnosis**

When appropriate, patients should receive an explicit diagnosis of concussion. If the diagnosis is uncertain at the time of discharge, providing a list of closed head injury and “at-risk” concussion precautions can trigger earlier follow up for patients who become aware of concussive symptoms after they’ve left the emergency department.

**Treatment**

**Patients should be advised to adhere to the following guidelines in the days following discharge.**

**Cognitive rest**

- Consider taking a day or two off from school/work to maximize rest acutely; return gradually to prevent worsening symptoms (eg, work partial days).
- Avoid screen time by limiting the use of televisions, computers, cell phones/texting, and video games.
- Avoid areas of significant visual/auditory stimulation (eg, movie theaters, sports arenas)
- As you feel better, introduce these activities back into your everyday routine at a level that doesn’t worsen symptoms or cause them to return.

**Physical rest**

- Avoid sports, physical education classes, and recreational activities (eg,
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riding skateboards or playing pickup games in the park).
• As you begin to feel better, light aerobic exercise can be helpful in recovery (eg, walking for 10 to 20 minutes).
• Before you return to sports or exercise, follow up with a primary care physician or concussion specialist to develop a gradual, stepwise return-to-play protocol.

Reintroduction of Exercise
Information about return to play can temper expectations and help patients avoid resuming physical activity too quickly. The 2012 Zurich consensus statement recommends no same-day return to play and an initial period of rest, followed by six-step return protocol that can be followed once the concussion symptoms have abated (Table 1).

If symptoms return at any point, the athlete should regress to the last step in which they were asymptomatic. Theoretically, the gradual reintroduction of metabolic demand on the brain may help patients identify the return of symptoms and discourage maximum exertion, thereby reducing the risk of repeat head injuries. Additionally, early intervention seems to impact recovery, as adolescents who rest for several days before resuming a modified schedule appear to recover faster.25

Return to Driving
Safe driving is a complicated endeavor under any circumstances. In concussed patients, attention and reaction time can be impaired and worsen in the few days following injury. In addition, common concussion symptoms include dizziness and blurred vision, which can significantly impact safety. Despite these overt risks, 52% of patients report no intention of altering their driving habits following a traumatic head injury.29

There is evidence to support driving restrictions in the 24-hour period following injury; however, there is limited research to support any specific timeframe or measurement of fitness. This clearance is best made in a follow-up visit to assess balance, vision, and cognitive function. In general, any patient with a diagnosed concussion should avoid driving acutely, and be warned that the ability to do so safely may be diminished.

Sleep
Sleep is therapeutic and constitutes a treatment for concussion. If level of consciousness and neurologic serial examinations are warranted, the patient should undergo head imaging and/or observation in a hospital setting. Previous advice to periodically wake patients from sleep is no longer recommended; after discharge, a patient may sleep without interruption.30 Return precautions should include a sudden change in mental status, severe headache, vomiting two or more times, and seizure activity.

Precautions
Patients with closed head injuries should be advised to return to the emergency department for neurologic changes indicative of intracranial bleeding. Additionally, patients with head trauma or acceleration-deceleration injuries who may have sustained upper-extremity or neck injuries may be at risk for concussion, even in the absence of acute concussion symptoms. Patients and their families should be educated about the potential for delayed signs, advised about what to watch for, and directed to seek primary care follow up in the event they occur.

Concussion Precautions
Patients and their families should be advised to watch for the following signs after discharge and, if indicated, seek advice from a provider who cares for patients with concussions.

Physical
• Dizziness, headaches, balance problems, nausea, vision changes, hearing changes, sensitivity to light, excessive fatigue or sleepiness, sleep problems

Cognitive
• Difficulty remembering things; confusion; difficulty concentrating; slower to answer questions, think of words, or solve problems; feeling “foggy” or “funny”

Emotional
• Restless, angry, cranky, tearful, frustrated

Sleep
• Increased amount of sleep (longer night sleep, or naps), difficulty falling or staying asleep, or decreased sleep

Common symptoms in infants/toddlers
• Headache or rubbing of the head, inability to carry out newly learned skills (eg, toilet training, speech), disinterest in favorite toys, crankiness, irritability, difficult to comfort, changes in eating and/or sleeping patterns, tiring easily, or listlessness, bothered by light or noise

Summary
Concussion is a functional metabolic crisis in the brain that manifests in a wide variety of physical, cognitive, and emotional symptoms. Clinical findings include a normal traditional neurologic screening examination; however, patients often fail to remember the traumatic
CASE RESOLUTIONS

CASE ONE

Because the young soccer player’s symptoms extended beyond pain at the site of contact, a concussion was suspected. The clinician advised against same-day return to play; and the patient was told to follow up with a concussion health care provider. While the player and her father were unhappy with the restrictions, they understood the increased risk of further injury.

The patient did, in fact, develop more symptoms the following day, including fogging, fatigue, headache, nausea, difficulty concentrating, and irritability. She continued with cognitive and physical rest, and embarked on a successful gradual return to play.

CASE TWO

During her repeat visit to the emergency department more than a week after a major car accident, the patient received a diagnosis of concussion. She did not require repeat head imaging or a lumbar puncture, and was prescribed cognitive and physical rest. She began to feel considerably better over the next week, and the intensity and number of her complaints improved.

However, several symptoms persisted for nearly 4 months during follow-up treatment, which entailed physical, occupational, and speech/cognition therapies. The patient was given strategies to modify her screen time and prevent eye strain, and a temporary change in her glasses prescription helped relieve her headaches.

REFERENCES

A 58-year-old man with diaphoresis and dyspnea.

The Critical ECG

ST with first-degree AV block, rate 130, right bundle branch block (RBBB), premature ventricular complexes, acute anterior myocardial infarction (MI), inferior MI of uncertain age.

The ECG shows evidence of a RBBB, including a wide QRS complex (≥120 msec), qR complex in V₁, and widening of the S wave in leads I, V₅, and V₆. The normal RBBB also is characterized by isoelectric or depressed ST segments and inverted T waves in leads V₁-V₃. In this case, there is marked ST-segment elevation in V₁-V₅, diagnostic of acute anterior MI. Q waves already have developed in these leads. The presence of Q waves in leads II, III, and aVF without ST-segment changes indicates a prior inferior MI of uncertain age. Emergency cardiac catheterization revealed a completely occluded left anterior descending artery.

By Amal Mattu, MD, FACEP

Dr. Mattu is a professor, vice chair, and director of the Emergency Cardiology Fellowship in the Department of Emergency Medicine at the University of Maryland School of Medicine in Baltimore.

The gastrostomy tube (G-tube) has grown to become a widely accepted treatment for patients suffering from problems related to oral intake. Replacement of a leaking or dislodged tube in the emergency department is a fairly simple and increasingly common procedure; however, the risk of complications escalates as time passes and the stoma begins to close.

The Critical Procedure

By Linda L. Herman, MD, FACEP
Dr. Herman is the director of the Emergency Medicine Residency Program at Kaweah Delta Medical Center in Visalia, California.

GASTROSTOMY TUBE REPLACEMENT

CONTRAINDICATIONS
- New G-tubes that have been placed within the past 2 to 3 weeks should not be removed in the emergency department without first consulting the physician who performed the original procedure. Infection of the abdominal wall and stoma site also is a contraindication to tube replacement.

Benefits and Risks
Patients who are unable to ingest through the upper-pharyngoesophageal system due to illness or disability often rely on G-tubes to provide hydration, nutrition, and medications. Early replacement helps prevent the stoma site from narrowing or closing, which can happen without a tube to maintain the opening.

The most serious risk of the procedure is the inadvertent insertion of the tube into the peritoneal cavity. Infusion of any material through the misplaced device can cause peritonitis, sepsis, or even death. Other less common complications include pain, minor bleeding, infection, and soft tissue damage.

Alternatives
If an emergency physician is uncomfortable performing the procedure, it is reasonable to request further guidance from the specialist who placed the device. Unfortunately, these consultations require time, which is of the essence in these cases; a stoma can close within hours, even if it has been present for months. If the necessary equipment is unavailable, the insertion of a urinary catheter may prevent closure and enable the delivery of hydration or nutrition.

Reducing Side Effects
Replacing the G-tube as soon as possible after displacement improves the likelihood of a successful and pain-free insertion. An anesthetic lubricant (eg, xylocaine jelly) can be used to reduce discomfort during the procedure; however, there is no literature regarding its safety or efficacy.

Following the procedure, an x-ray of the abdomen with gastrografin contrast should be performed to confirm placement of the tube in the lumen of the GI tract. Of note, gastrografin does not cause significant histological reactions.
**TECHNIQUE**

1. **Document** the patient’s medical history, including details about the G-tube and when it was placed, prior problems with the infusion of substances, and when and how the device was dislodged.

2. **Obtain** consent from the patient and/or caregiver prior to beginning the procedure.

3. **Read** the package insert concerning tube placement and balloon inflation.

4. **Prepare** the equipment and patient for the procedure.
   a. **Obtain** the necessary equipment: gloves, similar size and type of G-tube (also have several smaller sizes available), syringe to inflate balloon (can use saline or air), saline, water-soluble lubricant, suture set, and suture.
   b. **Remove** the device from its packaging and check the balloon for leaks by infusing it with air or saline.
   c. **Inspect** the stoma site for any signs of infection.

5. **Disinfect** the insertion site with skin cleanser.

6. **Lubricate** the end of the G-tube and insert it into the stoma until the bolster is against the skin.

7. **Inflate** the balloon, and gently pull back on the G-tube until it is abutted against the inside of the stoma.

8. **Manipulate** the bolster until it is against the skin, and either tape or suture it into place.

9. **Order** a KUB with 20 to 30 mL of gastrograffin injected through the G-tube to confirm its placement in the lumen of the stomach or bowel.

10. **Consider** alternatives if the device is difficult to insert. Available options include placing a G-tube that is one size smaller, or dilating the stoma with red rubber catheters (of varying sizes) with lubricant. (Use caution. Aggressive force can dislodge the stomach wall from the stomal tract.)

**Special Considerations**

It takes about 2 to 3 weeks for a G-tube to form a tract. If the dislodged device is new, the physician who placed it should be consulted regarding the next steps. Leaking or clogged G-tubes must be removed before they can be replaced. (This can be done by deflating the balloon and gently applying traction until the device slips out.)

A leaking feeding tube without a balloon cannot be removed through the stoma; the silicone portion may be affixed to the stomach. It is best to consult with the physician who originally inserted the device, who may elect to replace it, or — if necessary — severe it at the abdominal wall prior to placing a G-tube. The silicone portion eventually will be eliminated through the digestive tract.

J-tubes, which are placed in the jejunum, are alternatives to G-tubes and can be replaced using the same technique outlined below. A G-tube has a much larger diameter than a J-tube, however, and generally cannot be used to replace the narrower device. If neither a J-tube nor G-tube of the same gauge is available, a pediatric urinary catheter or feeding tube of comparable size can be used to keep the stoma open.

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All photos courtesy of Applied Medical Technology, Inc.
Procedural sedation and analgesia are essential clinical tools for improving patient comfort and creating the best conditions possible for interventions. ACEP’s clinical policy regarding procedural sedation and analgesia in the emergency department is a revision of the organization’s influential 2005 document.

Since the original report, additional literature has become available and the Centers for Medicare and Medicaid Services (CMS) have issued guidelines on the topic, which reinforce the principle that hospital policy should be based on nationally recognized protocols.

CMS also states, “Emergency medicine-trained physicians have very specific skillsets to manage airways and the ventilation necessary to provide patient rescue. Therefore, these practitioners are uniquely qualified to provide all levels of analgesia/sedation and anesthesia (moderate to deep to general).”

Critical Definitions
ACEP’s updated guidelines clarify several important definitions:

• **Procedural sedation** is a technique for administering medications to suppress the level of consciousness to enable a patient to tolerate a procedure, while still maintaining cardiorespiratory function. The continuum of sedation ranges from minimal to general anesthesia.

• **Minimal sedation** creates a near-baseline level of alertness; the patient can respond to verbal commands, but cognitive function may be impaired.

• **Moderate sedation** causes a depression of consciousness. Patients may have a delayed response to verbal commands, eyelid ptosis, slurred speech, and event amnesia.

• **Deep sedation** occurs when a patient has a depressed level of consciousness and only can be aroused by repeated or painful stimuli; respiratory support may be required.

• **General anesthesia** causes unresponsiveness to all stimuli and the absence of airway protective reflexes. It can lead to cardiovascular compromise; ventilator support is required.

Critical Questions
The policy also aimed to answer four clinical questions:

1. Does preprocedural fasting reduce the risk of emesis or aspiration?

According to a review of recent literature, procedural sedation...
should not be delayed based on fasting times. Fasting has not demonstrated a reduction in the risk of emesis or aspiration (*level B recommendation*), and aspiration was a rare event in all studies reviewed.

2. Does capnography reduce the incidence of adverse respiratory events? Capnography is an additional tool used to detect hypoventilation and apnea. It has been shown to reduce hypoxia and identify respiratory depression more consistently than pulse oximetry (*level B recommendation*). However, there is no evidence to support its ability to reduce serious adverse events.

3. What is the minimum number of personnel needed to perform the task and manage complications? In addition to the clinician performing the procedure, a nurse or other qualified provider should be available to continuously monitor any patient receiving procedural sedation (*level C recommendation*). Clinicians performing sedation should have an understanding of the medications used, the ability to monitor the patient, and the skills to intervene should complications arise. The literature does not provide clear evidence on the number or type of providers required for safe sedation.

4. Can ketamine, propofol, etomidate, dexmedetomidine, alfentanil, and remifentanil be safely used? Multiple medications have been used for sedation and analgesia — all with varying levels of success and risk.

The following agents are determined to be safe in the patient populations described below.

**LEVEL A**
- ketamine (children)
- propofol (adults and children)

**LEVEL B**
- etomidate (adults)
- ketamine and propofol combination (adults and children)

**LEVEL C**
- ketamine and alfentanil (adults)
- etomidate (children)

Notes: Patients receiving alfentanil may require more stimulation to maintain respirations during procedures. The combination of propofol and ketamine allows for decreased doses, and reduces the side effect profiles of both medications.

---

**KEY POINTS**
- Sedation should never be delayed based on fasting time.
- Capnography can help detect hypoventilation and apnea.
- An additional provider should be in the room to monitor any patient undergoing sedation; the minimum number of personnel needed is unspecified.
- Multiple agents have been proven safe in procedural sedation and analgesia.

---

**TABLE 1. Classes of Evidence and Recommendation Levels**

<table>
<thead>
<tr>
<th>Level A</th>
<th>Generally accepted principles for patient care that reflect a high degree of clinical certainty (ie, based on evidence from 1 or more Class of Evidence I or multiple Class of Evidence II studies).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level B</td>
<td>Recommendations for patient care that may identify a particular strategy or range of strategies that reflect moderate clinical certainty (ie, based on evidence from 1 or more Class of Evidence II studies or strong consensus of Class of Evidence III studies).</td>
</tr>
<tr>
<td>Level C</td>
<td>Recommendations for patient care that are based on evidence from Class of Evidence III studies or, in the absence of any adequate published literature, based on expert consensus. In instances in which consensus recommendations are made, “consensus” is placed in parentheses at the end of the recommendation.</td>
</tr>
</tbody>
</table>

There are certain circumstances in which the recommendations stemming from a body of evidence should not be rated as highly as the individual studies on which they are based. Factors such as heterogeneity of results, uncertainty about effect magnitude and consequences, and publication bias, among others, might lead to such a downgrading of recommendations.
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Growing Pains

Pediatric Pain Assessment and Management

LESSON 10

By Shailesh Khetarpal, MD; and Emily Gale Scott, MD

Dr. Khetarpal is a pediatric emergency medicine fellow, and Dr. Scott is a pediatric emergency attending physician at Akron Children’s Hospital in Akron, Ohio.

Reviewed by Michael S. Beeson, MD, MBA, FACEP

OBJECTIVES
On completion of this lesson, you should be able to:
1. Describe the benefits and limitations of popular pain assessment tools for both verbal and nonverbal patients.
2. List the common barriers to adequate pediatric pain management.
3. Identify appropriate narcotic and non-narcotic analgesics that can be safely initiated in the emergency department.
4. Explain when and how to use nonpharmacological methods to alleviate pediatric pain.
5. Evaluate the role of pain medication in children with acute abdominal pain.

FROM THE EM MODEL
1.0 Signs, Symptoms, and Presentations
   1.2 Pain (Unspecified)

CRITICAL DECISIONS
- What are the most common barriers to pediatric pain management in the emergency department?
- What is the most accurate method for measuring pain in children?
- What medications are safe for treating pediatric pain in the emergency department?
- What nonpharmacological techniques can be used to decrease pediatric pain in the emergency department?
- When and how should analgesics be used in children with acute abdominal pain?

Pain is a universal and uniquely subjective experience — one that is notoriously difficult to measure from the outside looking in. The assessment and management of pediatric pain can be particularly challenging for emergency physicians, who must rely on the nebulous reports of patients often incapable of clearly communicating their discomfort. As a result, it is not uncommon for clinicians to underestimate distress, delay treatment, and administer subtherapeutic doses when treating children.
Despite enormous advancements in the recognition and management of pediatric pain in the last 40 years, fears and myths abound, and inadequate treatment remains commonplace. Appropriate pain management in this vulnerable population not only requires an understanding of each child’s developmental age, but a mastery of available pain assessment tools and both pharmacological and non-pharmacological options for alleviating discomfort and anxiety.

**CRITICAL DECISION**

**What are the most common barriers to pediatric pain management in the emergency department?**

There are many misconceptions about how pediatric patients experience pain. Among the most egregious myths is the belief that children neither feel pain as potently as their adult counterparts nor suffer long-term consequences. Children and adults do, in fact, feel pain equally. Even a quick, minor procedure such as an injection or the placement of an intravenous catheter can create substantial discomfort and fear in a child that carries over into subsequent visits.

Self-reporting is the gold standard for gauging pain in adults and verbal children, but the inability of preverbal and developmentally delayed patients to reliably describe their symptoms can be problematic. Not only are many children unable to communicate their discomfort, they cannot verbalize complaints about inadequate management of their pain. In addition, pediatric patients often present with a multitude of vague signs; a physician who is hyperfocused on pinpointing a diagnosis might delay analgesia for fear of “masking” the symptoms.

The emergency department environment is stressful and full of uncertainties, a reality that can create anxiety in both young patients and their parents. Child life specialists, patient advocates, and social workers can offer guidance to anticipatory patients and their families prior to a procedure, allay fears, and aid with nonpharmacologic distraction techniques.

Parental anxiety can increase a child’s perception of pain, further complicating treatment (Table 1). However, there is strong evidence to suggest that the presence of family members during painful procedures — when well controlled — can calm pediatric patients and help alleviate their fears.

---

**CASE PRESENTATIONS**

■ **CASE ONE**

A previously healthy 15-year-old boy presents with worsening abdominal pain, which began about 36 hours ago and woke him from sleep. He has an associated low-grade fever (38.6°C [101.5°F]), and reports nausea and three episodes of vomiting. The pain started in the mid-epigastric region, but has moved into the right lower quadrant. Ibuprofen failed to alleviate his symptoms at home, and he says the pain is the worst he’s ever experienced.

The patient denies diarrhea, constipation, rashes, sore throat, dysuria, hematuria, testicular pain, or any trauma. He is not sexually active. Vital signs are blood pressure 124/72, heart rate 95, respiratory rate 24, and oxygen saturation 100%. He reports his pain at a level 8 out of 10, and requires his father’s assistance to walk.

A physical examination reveals tenderness in the right lower quadrant, with guarding and rebound. Rovsing and McBurney signs are positive. Examinations of the heart, lungs, and genitals are normal. Laboratory tests reveal a white blood cell count of 16,000, and C-reactive protein of 3.2; urine and basal metabolic panel tests are normal. An ultrasound examination is ordered.

■ **CASE TWO**

A previously healthy 8-year-old boy presents with right shoulder pain, which began after he fell while riding his skateboard. He was wearing a helmet and denies hitting his head, losing consciousness, or vomiting; he remembers the accident and his vital signs are stable. The patient reports his pain at a level 3 out of 10, and is given liquid oral ibuprofen.

The physical examination is remarkable for tenderness to palpation over the right shoulder; several minor abrasions are noted. External rotation and abduction are limited due to pain, but the patient has a full range of motion in the right elbow, wrist, and fingers. The neurovasculature of the upper limb is intact with normal sensation. A radiograph of the right shoulder reveals a mid-shaft clavicle fracture.

■ **CASE THREE**

A febrile 18-month-old girl is brought in by her mother, who reports that the baby has had an axillary temperature as high as 39.4°C (103°F) for the past three days and is refusing to eat. She will take sips of juice, but cries when swallowing. The number of wet diapers is lower than usual, and the mother is concerned about dehydration. The patient has had no coughing, congestion, diarrhea, or constipation. She has no sick contacts, but does attend daycare. The mother tried acetaminophen at home, but the child continued to refuse oral intake.

Vital signs are heart rate 120, capillary refill less than 2 seconds, respiratory rate 24, oxygen saturation 100%, and temperature 38.6°C (101.5°F). The physical examination is normal; the pupils are equal, round, and reactive to light; and the conjunctivae are clear with no nasal discharge. Multiple white ulcerative lesions are noted on the posterior pharynx, but no exudate is present on the tonsils. Small, white vesicular lesions are noted on the baby’s hands and the bottoms of her feet.
CRITICAL DECISION

What is the most accurate method for measuring pain in children?

Pain can have both adverse psychological and physiological effects with long-term consequences if not appropriately managed. Short-term problems such as dehydration due to pain with pharyngitis, and long-term effects such as anxiety about future medical visits are minimized when pain is accurately measured using a systematic approach.3

Research suggests that health professionals often underestimate pain in children, scoring it significantly lower than the patients themselves. As with adult patients, self-reporting remains the gold standard for gauging pediatric pain; however, in its absence, parental scoring may be more reliable than assessments by health care professionals.5

In recent years, additional tools and approaches have been created to help evaluate nonverbal and developmentally delayed children, including QUESTT. This mnemonic guideline addresses many of the key intricacies of pediatric pain by taking into account the child’s appropriate developmental level, behavioral changes, parental involvement, and re-evaluation.6

The QUESTT protocol advises clinicians to:

• Question the child.
• Use the age and developmentally appropriate pain rating scales.
• Evaluate behavior and physiological changes.
• Secure parental involvement.
• Take the cause of pain into account.
• Take action and evaluate results.

The most common pain assessment tools are the Wong-Baker Faces Pain Scale (WB-FPS) for preverbal children, and the numerical rating scale (NRS) for older children and adults (Figure 1). The Wong-Baker scale displays a series of six faces with associated numbers and words; children are asked to point to the face that best represents their level of discomfort. The NRS features a graduated numerical spectrum, ranging from 0 (no pain) to 10 (worst possible pain).

Both scales pose limitations, especially when used in preverbal or cognitively impaired children, as observed behavior sometimes can be attributed to other causes (eg, hunger, anxiety, or fatigue) that can make it difficult to distinguish true pain.5-8

Providers must rely on clinical observation and details provided by parents or caregivers when examining patients who cannot reliably communicate the intensity or even the resolution of their symptoms.5-8

Physiological indicators such as sweating; rapid breathing; visible changes in breathing, skin color, sleep patterns, or posture can signal discomfort — but they cannot be used in isolation to measure pain.

Behavioral assessment tools, including the Face, Legs, Activity, Cry, Consolability (FLACC) scale, have been used successfully to evaluate pain in children as young as 2 months, and are frequently used to assess critically ill adult patients who are unable to speak (Table 3).

TABLE 1. Common Barriers to Adequate Pediatric Pain Management15-17

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Belief that children do not feel pain, or that pain is a beneficial “life lesson” of childhood</td>
</tr>
<tr>
<td>2</td>
<td>Difficulty in assessing pain in children</td>
</tr>
<tr>
<td>3</td>
<td>Myth that pain medication use (especially opiates) will result in addiction, or carries an exceptionally high risk of adverse effects in children</td>
</tr>
<tr>
<td>4</td>
<td>Concern that emergency department flow would be slowed considerably by using pain management methods</td>
</tr>
<tr>
<td>5</td>
<td>Clinicians unknowledgeable about pediatric pain management methods, particularly nonpharmaceutical techniques</td>
</tr>
<tr>
<td>6</td>
<td>Belief that children prefer “one needle” to two needles for local anesthesia</td>
</tr>
<tr>
<td>7</td>
<td>Staff and parents more focused on diagnosis and management of primary condition</td>
</tr>
<tr>
<td>8</td>
<td>Staff uncomfortable with parental presence during pediatric procedures</td>
</tr>
<tr>
<td>9</td>
<td>Lack of coordination between various care providers in efforts to reduce pain</td>
</tr>
<tr>
<td>10</td>
<td>Lack of clinician accountability and feedback regarding pain management practices</td>
</tr>
</tbody>
</table>
CRITICAL DECISION

What medications are safe for treating pediatric pain in the emergency department?

Non-Narcotics

Acetaminophen and nonsteroidal anti-inflammatory drugs (NSAIDs) remain the first choice for treating mild to moderate pediatric pain. These agents (eg, acetaminophen, ibuprofen, and naproxen) are readily available over the counter in oral, chewable, and even rectal suppositories. These agents are relatively safe when used in short duration and tolerated well. Combination therapy with both acetaminophen and NSAIDs has been associated with better postoperative pain, fewer side effects, and improved patient satisfaction.

However, clinicians must be careful to obtain an accurate current medication list for each patient, including over-the-counter drugs. Many cough and cold remedies contain acetaminophen and NSAIDs, which can increase the danger of overdose if a child is taking them in combination with additional antipyretics. These risks can be mitigated by obtaining an accurate history and educating parents about weight-specific doses and appropriate time intervals.

Salicylates are not widely prescribed for pediatric patients due to the risk of Reye syndrome, a rare but serious complication that affects the liver and brain. The most common side effects of NSAIDs (eg, gastrointestinal bleeding and renal insufficiency) are rare in children; however, they should be considered in patients with long-term use.2

<table>
<thead>
<tr>
<th>Medication</th>
<th>Indication</th>
<th>Dosage Guidelines and Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-Opioids</strong></td>
<td>Mild to moderate pain</td>
<td>Potential adverse effects include gastric upset, renal insufficiency, hypersensitivity reaction, and platelet dysfunction.</td>
</tr>
<tr>
<td>Acetaminophen</td>
<td>Mild to moderate pain</td>
<td>15 mg/kg (max 650 mg per dose or 4 g/day, whichever is less) PO or PR q4-6 hrs; antipyretic</td>
</tr>
<tr>
<td>Ibuprofen</td>
<td>Mild to moderate pain</td>
<td>10 mg/kg (max 800 mg per dose or 2,400 mg/day) PO q6-8 hrs; anti-inflammatory and antipyretic</td>
</tr>
<tr>
<td>Naproxen</td>
<td>Mild to moderate pain</td>
<td>5-7 mg/kg PO q8-12 hrs for children ≤2 yrs (max 1,250 mg/day); anti-inflammatory</td>
</tr>
<tr>
<td>Ketorolac</td>
<td>Moderate pain, short-term use (&lt;5 days)</td>
<td>0.5 mg/kg IV or IM (max 30 mg per dose or 90 mg/day) q6 hrs; anti-inflammatory, particularly effective for renal colic</td>
</tr>
<tr>
<td><strong>Opioids</strong></td>
<td>Moderate to severe pain</td>
<td>Potential adverse effects include nausea, constipation, pruritis, respiratory depression, sedation, and hypotension. Tolerance and dependence are very unlikely with acute use and appropriate doses in children. Naloxone 0.1 mg/kg (max 2 mg) IV, IM, subQ, or ET may reverse adverse effects. If one opiate is ineffective, consider switching to another.</td>
</tr>
<tr>
<td>Morphine</td>
<td>Severe pain</td>
<td>0.1 mg/kg IV or IM (max 15 mg) q1-2 hrs; 0.5 mg/kg PO (max 30 mg for adults) q4-6 hrs</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>Severe pain</td>
<td>1 mcg/kg IV or IM (max 100 mcg) q30-60 min; shorter duration of action</td>
</tr>
<tr>
<td>Hydromorphone</td>
<td>Severe pain</td>
<td>0.015 mg/kg (max 1 mg) q4-6 hrs; 0.05 mg/kg PO (max 5 mg) q4-6 hrs; less pruritis than morphine</td>
</tr>
<tr>
<td>Meperidine</td>
<td>Severe pain</td>
<td>1 mg/kg IV or IM (max 100 mg) q3-4 hrs; high incidence of dysphoria, agitation; not preferred</td>
</tr>
<tr>
<td>Codeine</td>
<td>Moderate pain</td>
<td>1 mg/kg PO (max 60 mg) q4-6 hrs. Often given with acetaminophen in premixed preparations: elixir, 12 mg codeine and 120 mg acetaminophen in 5 mL; 325 mg acetaminophen/15 mg codeine (Tylenol #2); 325/30 (Tylenol #3); 325/60 (Tylenol #4). Must be metabolized to be effective; 10% or more of patients may not be able to metabolize to effective metabolite.</td>
</tr>
<tr>
<td>Oxycodone</td>
<td>Moderate pain</td>
<td>0.1 mg/kg PO (max 5 mg) q4-6 hrs. Often given with acetaminophen in premixed preparations: 325 mg acetaminophen + 5 mg oxycodone (Percocet) is most common form.</td>
</tr>
<tr>
<td>Hydrocodone</td>
<td>Moderate pain</td>
<td>0.15 mg/kg PO (max 10 mg) q4-6 hrs. Often given with acetaminophen in premixed preparation of 500 mg acetaminophen + 5 mg hydrocodone (Vicodin) or 7.5 mg hydrocodone (Vicodin ES) or premixed with ibuprofen 200 mg + 7.5 mg hydrocodone (Vicoprofen).</td>
</tr>
</tbody>
</table>
Narcotics

When a child’s pain is severe or over-the-counter medications are ineffective, opioid medications should be considered. Codeine, hydrocodone, oxycodone, and morphine — the most commonly prescribed pediatric oral opioids — are highly effective for managing breakthrough or acute pain, and can decrease hospital admissions when used appropriately.

Although these potent agents provide the next level of pain control, they must be dosed accurately and used in moderation to reduce the risk of side effects such as nausea, pruritus, ileus, urinary retention, and respiratory depression. Because opioids often are combined with acetaminophen, care must be taken to adhere to appropriate weight-based dosing to prevent overdose. While it is important to recognize the potential dangers of these medications, the fear of complications should not prevent treatment (Table 2).4-9

In 2013, the FDA issued a black box warning for oral codeine in response to several pediatric deaths following tonsillectomy. Codeine, which metabolizes into morphine, can cause serious side effects in patients who metabolize rapidly. Although the drug remains popular, many clinicians have turned to other opioids for the management of severe pediatric pain.

Morphine, which remains the gold standard for treating acute pain in children, and oxycodone are active drugs and do not require biotransformation. Morphine has a short duration of action, and usually is given in the parenteral form because of its relative low oral bioavailability. Intranasal fentanyl is another alternative for achieving rapid analgesia when intravascular access cannot be established.

Topical Agents

Children frequently are subjected to unexpected — and poorly explained — procedures in the emergency department that can cause pain and increase anxiety and distress. The use of topical creams, including lidocaine and prilocaine (EMLA), can reduce the discomfort associated with these procedures.

These agents can take up to 1 hour to reach maximum potential — an impractical delay that often limits their use in the emergency department; however, they can play a valuable role in wound care. Notably, lidocaine-epinephrine-tetracaine (LET) has decreased the use of intradermal analgesics for stitches in the pediatric population.10

CRITICAL DECISION

What nonpharmacological techniques can be used to decrease pediatric pain in the emergency department?

Nonpharmacological options are excellent adjuncts to pediatric pain management, but should not replace necessary medications.11,12

Distraction

The capacity to concentrate on painful stimuli is hindered when a child’s focus is shifted to something engaging and attractive, making distraction a popular nonpharmacological technique among both

### TABLE 3. FLACC Scale (Face, Legs, Activity, Cry, Consolability)

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

Each of the five 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.


---

**Pearls**

- Self-reporting is the gold standard for assessing pain in verbal children, but is unreliable in those younger than 3 years.
- Nonpharmacological methods are effective adjuncts to medications for reducing anxiety in pediatric patients.
- Prior to discharge, patients and their caregivers should receive explicit instructions on the proper use of pain medications, including information about weight-specific dosing and reducing the risk of overdose.
- Parental involvement is a crucial component of any systematic pediatric pain management plan, and family presence can have a calming effect on the child.
health care professionals and parents. Active forms of distraction include interactive toys or electronic games, controlled breathing, and guided imagery/relaxation; patients typically are coached by an adult to engage in the activity. Passive forms of the method include listening to stories or music, or watching a television program or video during the procedure. The sense of control pediatric patients gain by choosing a distracting activity often compensates for the lack of control involved in treatment.

Family Support

The presence of family during resuscitation and invasive procedures is endorsed by many health care organizations and can be an effective component of a pediatric pain management plan. Even so, many providers remain apprehensive about potential parental critiques and unwanted distractions that could increase stress and impair the care of the child. Clinicians also fear that allowing family members to witness a child’s resuscitation could cause psychological harm and possibly promote litigation.

A 2014 systematic review debunks this old adage, however, indicating that parents want to be present during invasive procedures and resuscitation, would choose to be present again would recommend it to others, and would not have changed anything about the experience of being present. The presence of family members during painful procedures also appears to reduce anxiety, and increases patient and parental satisfaction alike.5,13

CRITICAL DECISION

When and how should analgesics be used in children with acute abdominal pain?

Abdominal pain is the most frequent clinical feature of acute appendicitis, the most common pediatric condition requiring urgent surgical intervention. Historically, many clinicians were reluctant to provide analgesic agents to patients with acute abdominal complaints out of concern for obscuring symptoms and delaying management treatment. Despite evidence to the contrary, pain medications continue to be underutilized and suboptimally dosed in children with these symptoms; significant delays in time to analgesia also have been identified.

Untreated pain in childhood may lead to chronic conditions such as anxiety, hyperesthesia, and needle phobia. One recent study compared a single-dose parenteral opioid to

CASE RESOLUTIONS

■ CASE ONE

The adolescent boy was given parenteral morphine (4 mg), which reduced his discomfort to a level 2 out of 10. The physical examination was not hindered by the morphine; the patient’s abdomen remained tender to palpation, but he became more comfortable and cooperative. An ultrasound scan was positive for acute appendicitis for which he underwent a laparoscopic appendectomy. The boy recovered well in the hospital with the use of oral pain medications, and was discharged home 2 days later on acetaminophen, as needed, with instructions for surgical follow up.

■ CASE TWO

The skateboarder with a mid-clavicle fracture continued to have pain, which increased to a level 6 out of 10. He was given a weight-based dose of hydrocodone/acetaminophen, which improved his discomfort. He was splinted with a sling and swathe, and was discharged home with a prescription for liquid hydrocodone/acetaminophen, which he was advised to use for a few days for severe pain. The patient and his parents were instructed to switch to ibuprofen once the boy began feeling better, and warned against the possibility of overdose when using opioids and acetaminophen simultaneously.

■ CASE THREE

The febrile toddler was given an oral challenge and refused both food and fluids. She received a weight-based dose of hydrocodone/acetaminophen; after 30 minutes, she tolerated a cup of juice, which resulted in a wet diaper. The patient was discharged home with a prescription for an opioid medication, and her mother was educated about appropriate dosing and intervals, and advised to encourage fluids and offer supportive care.

Pitfalls

■ Buying into common myths and misconceptions associated with pediatric pain management, including the old adage that children do not feel pain.
■ Withholding analgesics in children with undifferentiated acute abdominal pain due to fear of obscuring the clinical examination.
■ Underestimating or undertreating a child’s pain.
■ Discouraging the presence of family members during invasive procedures and resuscitations.
a placebo, providing data on 342 children age 5 to 18 years. The pooled mean pre/post difference in self-reported pain scores was 19.61 mm (95% confidence interval [CI] = −1.16 to 40.37 mm) – lower in those receiving opioid analgesia. There was no significant increase in the risk of perforation or abscess associated with opioids in cases of appendicitis (relative risk [RR] = 1.03, 95% CI = 0.55 to 1.93).

The risk of side effects was significantly greater in patients who received opioids (RR = 6.06, 95% CI = 1.10 to 33.49). Subtherapeutic dosing was detected in all six trials analyzed. The findings suggest the need for vigilance in providing adequate analgesia; the clinician should continue to resist the misconception that pain control obscures the clinical examination.9,14

Summary

The effective management of a child’s pain, which can be particularly challenging in the busy emergency department environment, requires a keen understanding of pediatric pathophysiology and the ability to employ age-appropriate pain assessment tools.

Clinicians must guard against underestimating a child’s discomfort, provide timely and appropriate pharmaceutical management, and set aside unreasonable fears regarding commonly used analgesic agents. By using a systematic approach to address and treat pediatric pain, providers can improve the experience of both patients and their families.

REFERENCES


ADDITIONAL READINGS

CASE
A 27-year-old woman with no past medical history presents with sudden and severe right lower quadrant abdominal pain and emesis. She denies fever, diarrhea, vaginal bleeding or discharge, or urinary symptoms.

Vital signs are blood pressure 162/85, pulse rate 70, temperature 37.2°C (99.0 °F), respiratory rate 18, and oxygen saturation 98% on room air. The patient appears distressed and is clutching her abdomen. She has moderate right lower quadrant tenderness without rebound or guarding, and no costovertebral angle tenderness. Her pelvic examination is normal.

While awaiting laboratory test results, the physician proceeds to imaging to evaluate for serious and time-dependent concerns such as ovarian torsion and ectopic pregnancy, renal colic, pelvic inflammatory disease, tubo-ovarian abscess, epiploic appendagitis, and appendicitis.

The patient undergoes transvaginal pelvic ultrasound and transabdominal ultrasound examinations.

A. Transabdominal ultrasound. The right kidney demonstrates mild hydronephrosis.
B. Transabdominal ultrasound. The normal left kidney is shown for comparison.
C. Transvaginal ultrasound. A hyperechoic ureteral stone is seen near the bladder, with proximal right ureteral dilatation (the cause of the hydronephrosis seen in image A).

REFERENCES
CASE RESOLUTION

The ultrasound was normal, except for the findings noted above. The urine HCG was negative, and a urinalysis showed no evidence of infection; the complete blood count and creatinine levels were normal. Once adequate pain control had been achieved, the patient was discharged with return precautions and follow-up instructions.

KEY POINTS

- Transabdominal ultrasound is relatively insensitive for the detection of ureteral obstruction from stones compared to CT (median sensitivity 61%), although it is highly specific (97%). Urinary stones typically are hyperechoic and may demonstrate posterior acoustic shadowing, although this is not seen in this case. Ureteral stones are seldom visualized by transabdominal ultrasound; however, hydronephrosis resulting from ureteral obstruction is readily seen.

- Although pelvic ultrasound more commonly is used to evaluate adnexal and uterine pathology, the distal ureters also are within the field of view. In one small study, distal ureteral stones were diagnosed in 13 of 13 patients by transvaginal ultrasound, compared with only 2 of 13 patients (15%) evaluated by transabdominal ultrasound.2

- Pelvic ultrasound can visualize appendicitis, ectopic pregnancy, ovarian torsion, tubo-ovarian abscess, and obstructing ureteral stones. It is essential to understand the limits of diagnostic imaging when evaluating these conditions. Because pelvic imaging is subject to false-negative results for many common diagnoses, it is particularly important to confirm the diagnosis in female patients of child-bearing age with right lower quadrant abdominal pain whenever possible, rather than simply relying on imaging to “rule out” various entities. Exclusion of ectopic pregnancy relies on identification of an intrauterine pregnancy in a patient without risk factors for an additional ectopic (heterotopic) pregnancy (eg, ovarian stimulation fertility therapy). In cases of suspected appendicitis, failure to identify the appendix results in a nondiagnostic test, requiring additional imaging or clinical observation/re-evaluation.

There is a surprising paucity of high-quality research on ovarian torsion. Although the specificity of transvaginal ultrasound is high, low sensitivity (approx. 70% in some studies) means that normal blood flow cannot exclude the diagnosis when clinical suspicion is high, particularly if the affected ovary is enlarged (thus at risk of intermittent torsion).3 When evaluating for pelvic inflammatory disease, ultrasound can be ambiguous; findings may be normal or nonspecific (eg, free pelvic fluid).
1. A 16-year-old football player was tackled and hit in the head during a game. The boy was slow to get up, but responsive to his name. His initial complaints of headache, visual blurriness, and dizziness resolved within 10 minutes. What should be the next step in managing this patient while on the sideline?
   A. Contact EMS for transfer to the nearest emergency department
   B. Initiate ImPACT testing
   C. Perform sideline neurocognitive testing and a focused neurological examination
   D. Refer the patient to an ambulatory clinic for head imaging within 24 hours

2. While on the sideline, the patient in Question #1 asks when he can return to play. What is the most appropriate response?
   A. After a 1-week period of complete rest
   B. In 1 week if symptoms have resolved and he has completed a structured, graded exertion protocol over 5 to 7 days without symptoms
   C. In 30 days, following a normal CT scan and complete neuropsychological testing
   D. Immediately (same-day play)

3. What percentage of concussions involve loss of consciousness?
   A. Less than 10%
   B. 20%
   C. 30%
   D. 50%

4. Which criterion is most useful for determining the need to perform brain imaging in an adult patient with head trauma?
   A. American Head CT Rule
   B. Canadian Head CT Rule
   C. GCS <14
   D. Loss of consciousness

5. According to current concussion guidelines, which statement is true?
   A. Relative overexertion in the acute phase should be avoided
   B. Grade 1 concussions resolve in less than 15 minutes
   C. Strict rest for 5 days can improve psychosocial symptoms in adolescents
   D. If there was no loss of consciousness, the injury is graded as “mild”

6. Which medication is appropriate for the treatment of acute concussion?
   A. Acetaminophen
   B. Aspirin
   C. Diazepam
   D. Oxycodone

7. What process is most likely to be involved in the pathophysiology of a concussion injury?
   A. Axonal shearing
   B. Cerebral contusion
   C. Cerebral edema
   D. Global ischemia

8. Which of the following is the leading cause of sports-related concussions in girls?
   A. Basketball
   B. Lacrosse
   C. Soccer
   D. Softball

9. Over what period of time do most (>80%) concussions resolve in athletes?
   A. 24 hours
   B. 3 to 5 days
   C. 7 to 10 days
   D. 5 to 6 weeks
10. When is the best time to reintroduce light physical activity (eg, walks) in concussed athletes?
   A. After 24 to 48 hours, when the patient feels better
   B. Following a few weeks of rest, even if symptoms persist
   C. On the sidelines (to test if activity worsens symptoms)
   D. Only after all symptoms resolve

11. Who is most likely to significantly underestimate a child’s pain?
   A. Health care providers
   B. The child life specialist
   C. The parent
   D. The patient

12. What is the most reliable tool for assessing pain in verbal children older than 3 years?
   A. A behavioral assessment performed in the emergency department
   B. A clinical assessment of physical parameters
   C. A report from the patient’s parents or caregivers
   D. A self-report

13. What is the appropriate pediatric dose of acetaminphen?
   A. 10 to 15 mg/kg
   B. 25 to 50 mg/kg
   C. 50 to 75 mg/kg
   D. 100 to 150 mg/kg

14. A 6-year-old girl presents with right lower quadrant pain that began 3 days ago. She is febrile and also complains of nausea and vomiting. An IV line is inserted, blood tests are ordered, and the patient is scheduled for an abdominal ultrasound. What should be the clinician’s next step?
   A. Administer IV morphine
   B. Give oral acetaminphen
   C. Withhold pain medication since it may lead to adverse effects or obscure the clinical examination
   D. Withhold pain medication until the patient can be seen by a surgeon

15. Which of the following mnemonics describes a recommended assessment tool for pediatric pain?
   A. QUESTION
   B. QUESTTT
   C. REST
   D. WEST

16. What morphine dose is appropriate for the initial management of moderate to severe pediatric pain?
   A. 0.1 mg/kg
   B. 1 mg/kg
   C. 10 mg/kg
   D. 15 mg/kg

17. Reye syndrome affects which of the following organs?
   A. Brain and heart
   B. Brain and liver
   C. Liver and heart
   D. Lungs and heart

18. Which statement is accurate in the setting of invasive procedures and resuscitations?
   A. Family presence escalates the likelihood of ligation
   B. Family presence is comforting and reduces anxiety in both patients and their families
   C. The presence of family members is distracting to clinicians and can lead to multiple attempts at the same procedure
   D. Witnessing procedures is more stressful for family members

19. An 11-year-old boy arrives with a 2-cm laceration to the right side of his forehead. Which of the following medications is optimum for treating his pain?
   A. Acetaminophen
   B. Ketamine 2 mg/kg
   C. Morphine IV 0.1 mg/kg
   D. Topical lidocaine-epinephrine-tetracaine

20. A 10-year-old boy with a known history of nephrolithiasis presents with intermittent hematuria and right flank pain for the last 2 days, which has worsened and now has become persistent. The patient rates his pain at a level 8 out of 10. What should be the next step in his management?
   A. Consult urology immediately
   B. Consult surgery and request an exploratory laparotomy
   C. Establish IV access, and administer pain medications and fluids
   D. Prescribe oral acetaminphen
Droxidopa is a prodrug that metabolizes to norepinephrine and is used to treat orthostatic dizziness and lightheadedness in adult patients with symptomatic neurogenic orthostatic hypotension (NOH) caused by primary autonomic failure (e.g., Parkinson disease, multiple system atrophy, and pure autonomic failure), dopamine beta-hydroxylase deficiency, and non-diabetic autonomic neuropathy. It is important to note that the medication carries a black box warning for supine hypertension, although the risk of this side effect may be reduced by elevating the head of the patient’s bed; blood pressure should continue to be monitored.

Mechanism of Action
Synthetic amino acid analog that is converted to norepinephrine, which induces peripheral arterial and venous vasoconstriction

Indication
Symptomatic neurogenic orthostatic hypotension

Dosing
Adults: 100 to 600 mg by mouth 3x/day; take no later than 3 hours before bedtime
Start: 100 mg by mouth 3x/day; may increase by 300 mg per day every 24 to 48 hours (max dose 1800 mg/day)

Side Effects
Common side effects include dizziness, falls, headache, syncope, and urinary tract infections.

Precautions
Contraindications: Hypersensitivity to droxidopa/components of medication
Considerations: Use with caution in individuals with ischemic heart disease, arrhythmias, or congestive heart failure.
Pregnancy: Category C; excreted in breast milk (Consider alternatives in breastfeeding women.)

Presentation
When exposed to oxidant stress, the ferrous (2+) iron in hemoglobin needed for oxygen binding is oxidized to ferric (3+) iron, ultimately impairing oxygen delivery to the tissues. This stress can come from myriad sources, including nitrates/nitrites in medications, recreational “poppers,” and well water; industrial sources such as naphthalene and aniline dyes; and house fires, wherein nitrogenous compounds undergo combustion. The most frequent causative ingestion is dapsone, but the most serious presentations result from benzocaine.

Level | Presentation
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3% to 15% | “slate gray” skin, low pulse oximetry
15% to 19% | central and peripheral cyanosis,* chocolate brown blood
20% to 49% | dizziness, fatigue, headache, dyspnea with exertion
50% to 69% | lethargy, stupor, seizure, dysrhythmia, acidosis
>70% | likely lethal

Laboratory Evaluation
Normal methemoglobin (MetHb) levels (1-3%); can be followed by measurements of venous blood gasses. Partial pressure of oxygen will be normal since dissolved oxygen is normal. Standard pulse oximetry measurements are inaccurate and can vary by manufacturer, but they approach a nadir of ~85% in significant cases.

Treatment
Activated charcoal usually is not helpful, unless there is suspicion for the ongoing absorption of the causative agent.

Disposition
Asymptomatic patients with mildly elevated levels (MetHb <15%) that are continuing to decrease may be discharged. Patients with symptoms, significant comorbidities, or increasing levels merit continued observation or admission.