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Practical Application of the Latest Standards of Care

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ACTIVITY OBJECTIVES
After reading *Pediatric Trauma 2018: Practical Application of the Latest Standard of Care*, the participant will be able to:

1. Discuss conditions that should increase suspicion for traumatic injuries in pediatric patients.
2. Describe the various modalities used to identify different traumatic conditions.
3. Cite methods of quickly stabilizing and managing pediatric patients.
4. Identify possible complications that may occur with traumatic injuries in children.

Physicians and nurses participate in this CME/CE activity by reading the articles, using the provided references for further research, and studying the relevant questions at the end of the book. Participants will then be directed to a website, where they will complete an online assessment to show what they've learned. They must score 100% on the assessment in order to complete the activity, but they are allowed to answer the questions multiple times if needed. After they have successfully completed the assessment, they will be directed to an online activity evaluation form. Once that is submitted, they will receive their credit letter.

TARGET AUDIENCE
This activity is intended for trauma physicians and nurses, and emergency department physicians and nurses.

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Spinal Cord Injury

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Spinal cord injury (SCI) is a devastating disease for both the patient and the caregivers. The spinal cord, although well protected, can be injured in a variety of ways, including motor vehicle collisions and sporting events. The inability of the neurons to regenerate, and their sensitivity to anoxia and hypoperfusion, makes the timely diagnosis and treatment of SCI imperative to preserve as much function as possible. This article will cover the basic epidemiology, physiology, and treatments for SCI in an attempt to prepare the reader to manage these complex injuries.

Epidemiology

Incidence and Prevalence

Spinal cord injury is a devastating result of trauma, with profound consequences on quality of life. In 2012, an estimated 12,500 to 17,000 people in the United States sustained acute, traumatic SCI, translating to an incidence of 40 to 54 per 1 million Americans.[1,2] Compared with the incidence in the 1970s,[3] SCI has become less common among people who are 16 to 45 years of age and more common among those older than 65 years of age.[2] Its prevalence is difficult to calculate, but it is estimated that 276,000 people in the United States are living with SCI.

The costs associated with SCI are staggering. First-year costs range from $342,000 to $1 million, and the lifetime cost of care for a 50-year-old high-tetraplegic patient can reach $2.5 million.[4] In addition to the financial burden, the cost in regard to loss of life is also considerable. The survival rate is difficult to calculate, given the underreporting of SCI within the first 24 hours after injury; however, patients with SCI who survive 24 hours and are still alive one year after injury have reasonable life expectancies, depending on their American Spinal Injury Association (ASIA) score and level of injury. Among 20-year-olds with ASIA D at any level, the median life expectancy is 52.3 years (the median survival rate for people at this age without SCI is 59 years). A 60-year-old who is ventilator-dependent after SCI has a life expectancy of two years (22.7 years without SCI).[1]

Gender

Most SCIs are sustained by men.[1,3] In 2014, the National Spinal Cord Injury Statistical Center (NSCISC) reported that 80.7% of all reported SCIs occurred in males.

Age

As the average age in the United States rises, so does mean age at the time of injury. The U.S. Census Bureau predicts that the proportion of Americans 65 years of age and older will increase from 13.7% in 2012 to 20.3% in 2030, and to 20.9% in 2050.[5] The NSCISC calculated that the mean age at time of injury increased from 28.7 years between 1973 and 1979 to 42.2 years between 2010 and 2014.[1]

Etiology

Between 1997 and 2012, the most common causes of SCI were motor vehicle collisions (31.5-47.6%), falls (21.8-40.6%), and violence (5.4-14.6%), primarily shootings.[1,2,6] The proportion of SCIs resulting from falls has grown significantly since 1997, most likely because of the rising mean age in the United States; the numbers of SCIs associated with violence and sports have fallen.[1] A recent epidemiologic study by Jain et al found an increase in SCI resulting from falls between 1997 and 2012, from 19.3% to 40.4%. This increase was most pronounced in the over-65 age group: from 28% between 1997 and 2000 to 66% between 2010 and 2012.[2]

Pathophysiology

Spine Anatomy

The human spine is composed of 33 vertebrae: seven cervical, 12 thoracic, five lumbar, five fused sacral, and four fused coccygeal bodies. The resulting 26 units are held together by a complex system of intervertebral disks, articulations, and structural ligaments. The spinal column functions as a load-bearing column for the thorax and provides protection for the spinal cord.

Approximately 85% of all SCI are fractures, and 10% involve subluxation without associated fracture. The

EXECUTIVE SUMMARY

- The most common causes of spinal cord injury are motor vehicle collisions (31.5-47.6%), falls (21.8-40.6%), and violence (5.4-14.6%), primarily shootings.
- A recent epidemiologic study found an increase in spinal cord injury resulting from falls between 1997 and 2012, from 19.3% to 40.4%; the increase was most pronounced in the over-65 age group: from 28% between 1997 and 2000 to 66% between 2010 and 2012.
- There are four phases of spinal shock characterized by: 1) acute areflexia/hyporeflexia (0-1 day); 2) return of cutaneous reflexes (1-3 days); 3) early hyperreflexia (1-4 weeks); and 4) late hyperreflexia/spasticity (1-12 months). Lesions should not be referred to as "complete" prior to the resolution of acute hyporeflexia.
- The most common incomplete syndrome is acute traumatic central cord syndrome, which is characterized by weakness in the upper extremities (more than in the lower extremities) with some degree of sensory (decreased pain and temperature sensation) and bladder dysfunction.
- Anterior cord syndrome is rare, commonly occurring as a vascular insult to the anterior spinal arteries, resulting in ischemia of the anterior two-thirds of the spinal cord with motor weakness/paralysis, loss of pain and temperature sensation, and loss of voluntary bladder control, with preservation of vibration and position sense due to the sparing of the dorsal column medial lemniscus tracts.
- Brown-Séquard syndrome, also known as hemicord syndrome, occurs as the result of transection of half of the spinal cord with the resulting deficits of ipsilateral upper motor neuron weakness and impairment of vibration and position sense, with contralateral loss of pain and temperature sensation.
- The American Association of Neurological Surgeons and the Congress of Neurological Surgeons recommend aggressive treatment of hypotension by maintaining a mean arterial pressure at or above 85-90 mm Hg for the first seven days following injury to improve spinal cord perfusion. Although, no formal recommendations regarding the selection of vasoactive medications exist, norepinephrine, phenylephrine, and dopamine are reasonable first-line agents.
- Venous thromboembolism is a significant cause of morbidity and mortality, with pulmonary embolism accounting for nearly 10% of deaths within the first year after injury. Patients should have both mechanical and chemical VTE prophylaxis started upon admission and continued for three months.or severe mechanism of injury.
- In children younger than 2 years of age, risk factors in which imaging should be considered include a nonfrontal scalp hematoma, abnormal activity according to the parents, or a severe mechanism of injury.

remaining are SCI without radiographic abnormalities (SCIWORA) of the bones or ligaments.[7]

Acute spinal trauma is most likely to occur in areas of maximal mobility and generally is classified based on its location (craniocervical, subaxial cervical, or thoracolumbar) and the mechanism of injury. Either individually or in combination, flexion, extension, rotation, and axial compression are the most common mechanisms of injury,[8,9] resulting in fractures, disruption of ligamentous structures, and instability of the spinal column. The "three-column" concept of the spine, developed in 1984 by Denis, states that at least two of the three spinal columns must be disrupted to result in spinal instability.[10] However, in patients with underlying pathology (e.g., elderly patients with cervical spondylosis), this rule might not apply because forces can compress the spinal cord against pathologically enlarged elements.

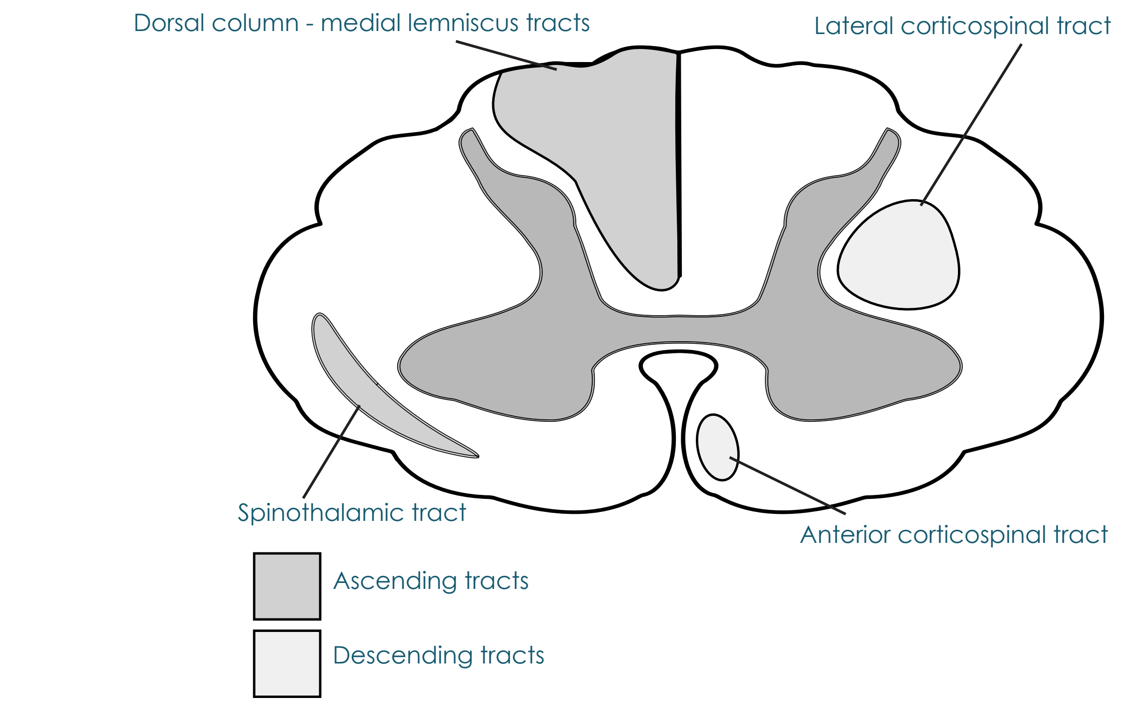
The anterior column is composed of the vertebral bodies and their stabilizing, ligamentous structures: the annulus fibrosus capsule and the anterior longitudinal ligament. The middle column is delineated anteriorly by the posterior longitudinal ligament and posteriorly by the articulating surfaces of the paired laminae and pedicles. The posterior column is largely ligamentous, consisting of the spinous processes, nuchal ligament, infra- and supra-spinous ligaments, and ligamentum flavum.[11]

Spinal Cord Anatomy

The spinal cord is the principal reflex center and conduit of information traveling between the body and the brain. Understanding the anatomy and physiology of the spinal cord is crucial in the determination of injury patterns. The cord begins as a continuation of the medulla, originating at the foramen magnum in the occipital bone, and extending to the L1–2 vertebral level. It is protected from injury by the cerebrospinal fluid (CSF); the meninges; the fat-filled epidural space; and the vertebral bodies, ligaments, and muscles that compose the spinal column.[11]

The spinal cord can be divided further into gray matter and white matter. Gray matter is composed largely of

Figure 1. Anatomy of the Spinal Cord



axonal bodies and acts as an intermediary between the peripheral nervous system and the central nervous system. White matter is composed mainly of highly myelinated axons, with very few axonal bodies, and is designed to carry information quickly.

Spinal gray matter is arranged in an "H" shape running centrally down the length of the spinal cord and is divided into anterior, lateral, and posterior columns. The anterior column contains motor neurons derived from the pyramidal tract, which are responsible for purposeful movement of muscles. The posterior column is largely committed to the synapse of sensory neurons coming from the body and intended for the brain. Information from the body enters through the dorsal root ganglion, synapses within the posterior gray column, and is transmitted via the dorsal column-medial lemniscus tract (fine touch, vibration, two-point discrimination, and proprioception) and the spinothalamic tract (pain and temperature). The lateral column is composed of neurons dedicated to the sympathetic division of the autonomic nervous system.

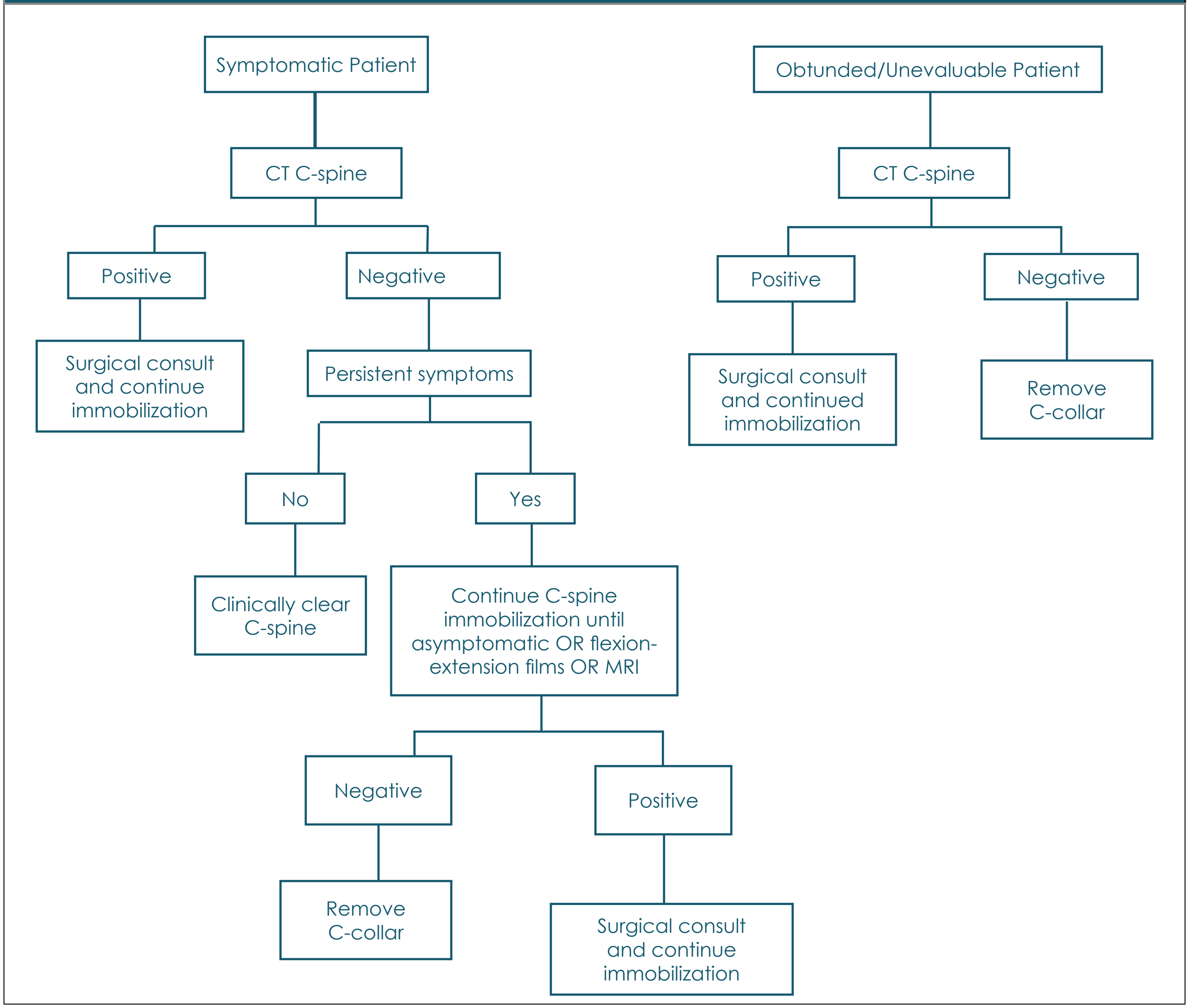
White matter is organized into groups of ascending (sensory) and descending (motor) tracts (*see Figure 1*). The major descending tract is the corticospinal tract, which is divided into the lateral (control of contralateral muscles) and anterior (control of contralateral axial and girdle muscles) tracts. The lateral corticospinal tracts are organized somatotopically (cervical fibers are more medial than thoracic than lumbar) and play a large role in the motor symptoms of spinal cord injury. The main ascending tracts are the spinothalamic and dorsal column-medial lemniscus tracts. The fibers of the spinothalamic tract enter the spinal cord and cross to the contralateral ascending tract within a few levels of entrance; the fibers of the dorsal columns do not cross until they reach the medulla. This leads to sensory dissociation in incomplete spinal cord injuries, as described below.

Spinal Cord Injury

Spinal cord injury occurs through two pathways: primary and secondary.[12,13] Primary injury occurs mechanistically, at the time of injury, and is irreversible.[14] It has four characteristic mechanisms.[15] The most common is impact that causes persistent compression of the spinal cord by extradural elements. Laceration or transection occurs most frequently via penetrating trauma or extreme blunt trauma, resulting in significant displacement of the spinal column. Distraction injuries arise as a result of stretching of the spinal cord and/or its blood supply and may occur without overt fracture or ligamentous injury. SCIWORA often is observed in children because of ligamentous laxity[16] but is being recognized more frequently in adults.[17] The last mechanism is impact with transient compression, as seen in patients with degenerative cervical spine disease who sustain hyperextension injuries.

Secondary injury results from a cascade of vascular,

Figure 2. Spinal Imaging of Symptomatic and Obtunded Patients



mised airway is recommended to avoid catastrophic airway loss. Traditionally, direct laryngoscopy with manual inline stabilization has been the standard of care and remains the recommendation of EAST.[43] Video laryngoscopy should be considered when stabilizing a patient with a difficult airway in cervical spine immobilization.[44,45] There are currently no formal recommendations on either induction agents or paralytic agents for rapid sequence intubation in SCI patients. Care should be taken to maintain adequate blood pressure during intubation attempts.

In addition to their immediate need for airway control, patients have severely altered breathing mechanics after SCI. The most common complications — atelectasis, pneumonia, and ventilatory failure — occur within the first five days.[46] Lesions between C5 and T11 will result in varying levels of respiratory dysfunction due to impaired inspiratory capacity, retained secretions, and autonomic dysfunction.[47] (*See Table 2.*)

Respiratory failure is caused by muscle fatigue, atelectasis, decreased surfactant production, and increased secretion production.[47] Paralysis of the intercostal muscles produces a paradoxic inward chest wall movement with respiration, leading to increased work of breathing. Furthermore, paralysis of the abdominal musculature impairs forced expiration and the patient's ability to cough and expel secretions. Pulmonary compliance decreases as secretions accumulate and atelectasis becomes more profound, leading to further increased work of breathing.

As spinal shock resolves and flaccid paralysis is replaced by spasticity, ventilatory mechanics tend to improve.

Pediatric Sports-Related Injuries of the Lower Extremity: Ankle

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Pediatric lower extremity injuries are common in the emergency department, especially with increasing sports specialization in young athletes. Acute care providers need to be familiar with common injury patterns, indications for radiographs, and more specialized imaging. Recognizing and maintaining a high degree of suspicion for high-morbidity injuries that may masquerade as an ankle sprain is critical. The authors review common injuries and also injuries that cannot be missed including Maisonneuve fracture, talar fractures, navicular fractures, Jones or pseudo-Jones fractures, Lisfranc injuries, and Salter-Harris fractures.

Epidemiology

Millions of children between the ages of 6-18 years participate in organized sports each year.[1] Athletic participation yields many health and wellness benefits for children, but with increased sport specialization comes an increased risk of traumatic and overuse injuries.[2] Pediatric sports injuries are estimated to make up more than 2 million emergency department visits every year,[3] with an incidence rate of up to 35 per 100 children annually.[4] In the adolescent population, sports are the leading cause of injury, accounting for more than 30% of adolescent injuries worldwide.[5] Of these injuries, 60% or more involve the lower extremity,[5,6] and a high proportion of these involve the ankle. This article will emphasize how to perform a focused physical exam to empower emergency medicine physicians to accurately diagnose and manage commonly encountered and commonly missed foot and ankle injuries in the emergency department.

Pathophysiology

Pediatric patients are at higher risk for sports-related injuries because of immature skeletal growth.[2] Especially at risk is the physis, the cartilaginous growth plate of long bones that accounts for longitudinal growth. Injuries that cause benign strains and sprains in adults can result in serious growth plate injuries in children, as ligaments are structurally stronger than the physis until it is closed. Gradual closure of the physis occurs with puberty, and prior to closure, the physis is at particular risk for injury.[7-10] Because of overuse secondary to sport specialization, subacute stress fractures and apophysitis are becoming increasingly common indications for presentation to the emergency department. An apophysis is a location where muscle tendon inserts into a secondary ossification center. Pediatric athletes are particularly vulnerable to overuse injuries because their bones are weaker than those of adults and because they still have open growth plates.[10,11]

Ankle Sprains — General, Epidemiology, Etiology

Of the many lower extremity injuries sustained every year by pediatric athletes, a high proportion of these are ankle injuries. In the general population, ankle sprains alone account for as many as 10% of emergency department visits[8] and as many as 15-20% of all sports injuries.[12] Serious ankle sprains are uncommon in the skeletally immature athlete.[13] This is because the ligaments of the ankle insert on the epiphyses distal to the physeal line, placing pediatric athletes at high risk for physeal fracture with injuries that would cause a sprain in adults. The physis often gives way when significant force is applied to the ankle, as it is the weakest link in the bone-tendon-bone interface.[10,13] Because some more serious injuries can mimic ankle sprains, it is important for emergency providers to recognize the normal pattern of injury in ankle sprains. This will allow the provider to identify when injury patterns deviate from the norm, thereby differentiating between a benign ankle sprain and more serious injuries that can mimic sprains. These injuries will be discussed later in the article.

Types of Sprains

The most common ankle injury seen in the emergency department and one of the most common sports-related injuries is a lateral ankle sprain, or inversion injury.[14] These account for more than 85% of all ankle sprains, with syndesmotic ankle sprains and medial sprains occurring much less frequently.[15] Lateral ankle sprains occur when the ankle is in a plantar flexed position and pathologically

Table 2. Six Foot/Ankle Injuries Not to Miss in the Emergency Department

Injury	Exam	Management
Maisonneuve fractures	Pain over the proximal fibula	Long-leg posterior splint Urgent orthopedic follow-up
Talar fractures	Pain over the talar dome/neck/lateral process	Non-weightbearing in walker boot or posterior splint Specialist follow-up in one week
Navicular fractures	Pain over the dorsal or medial navicular	Non-weightbearing in walker boot Specialist follow-up in one week
Fifth metatarsal fractures	Pain over the fifth metatarsal	Pseudo-Jones: Ortho shoe or walker boot Jones: Non-weightbearing in posterior splint Specialist follow-up in one week
Lisfranc injuries	Pain/bruising/swelling over the midfoot	Non-weightbearing in posterior splint Specialist follow-up in one week
Salter-Harris fractures	Pain over the tibial/fibial growth plate	Salter-Harris I & II: Non-weightbearing in posterior splint Specialist follow-up in one week Salter-Harris III & IV: Long-leg splint, urgent orthopedic follow-up

loss of function, and instability, a walker boot will immobilize the injury more aggressively and will allow functional return to activities of daily living. With the exception of syndesmotic ankle sprains, numerous studies show that early weightbearing and mobilization more rapidly improve functional return after an ankle sprain.[28,29,30] Syndesmotic ankle sprains are more severe and require more aggressive management with a walker boot and crutches.[14] The prolonged course of this injury, as well as the importance of following up with a specialist, should be discussed with the patient.

All ankle sprain patients should be advised of the importance of physical therapy in follow-up. Therapy that emphasizes ankle strength and proprioception can be effective for the prevention of ankle sprains in athletes with previous sprains.[12,32] Inappropriate follow-up can lead to chronic ankle instability, impingement, and early osteoarthritis.

What if It's Not an Ankle Sprain? Injuries Not to Miss in the ED

For emergency medicine physicians, ankle sprains are ultimately a diagnosis of exclusion. The emergency provider first must consider injuries that can mimic ankle sprains but are associated with a high morbidity. (*See Table 2.*) These include Maisonneuve fracture, talar fractures, navicular fractures, Jones or pseudo Jones fractures, Lisfranc injuries, and Salter-Harris fractures.

Can't-miss Injury #1: Maisonneuve Fractures

Proximal fibular fractures, or Maisonneuve fractures, are caused by external rotation of the ankle joint with force transmitted through the tibiofibular syndesmosis. Although proximal fibula fractures alone do not require surgical intervention, they do suggest an injury from a high degree of force and may be associated with a medial malleolus fracture or a rupture of the deltoid ligament, anterior talofibular ligament, or interosseous ligament.[33] Injuries to these ligaments may be difficult to appreciate on exam, but are associated with a high degree of ankle mortise instability that may require surgical intervention.[34] The presence of proximal fibular pain necessitates X-rays of the tibia/fibula and an ankle X-ray, including a gravity view. The gravity view will help ascertain if there is considerable mortise instability that will require operative intervention. Maisonneuve fractures should be placed in a long-leg posterior splint with urgent orthopedic follow-up.

Can't-miss Injury #2: Talar Fractures

Although less common than other ankle injuries, fractures to the talus (*see Figure 2*) can occur with rotational injuries to the ankle and have a high rate of complications. If the talar neck, dome, or lateral process is painful to palpation on exam, the provider should obtain ankle X-rays, including an oblique view. Talar neck fractures are the most common talar fracture but are often overlooked in the setting of ankle injuries.[35] These fractures are caused by extremes of dorsiflexion. On exam, patients will have focal tenderness over the talar neck associated with edema and pain with range of motion. Talar neck fractures are best viewed on the lateral view of the ankle X-ray. The blood supply to the talus is distal and there is a retrograde supply to the talar body from branches of the posterior tibial

Figure 5. Dorsal Navicular Avulsion

preciate on initial routine X-rays and may be visible only in about half of cases;[13] thus, they require a high index of suspicion. Dorsal avulsion fractures are best seen on lateral view, and tuberosity avulsion fractures on AP and external oblique views. Because of the high morbidity associated with these fractures, the emergency provider should palpate the medial navicular and N spot for every rotational ankle and foot injury. The medial navicular is the bony prominence just distal to the talus at the mid-arch of the foot. The N spot is the dorsal navicular between the anterior tibial tendon and the extensor hallucis longus tendon. Pain in these locations requires non-weightbearing and placement in either a walker boot or posterior splint, as well as specialist follow-up in one week.[45]

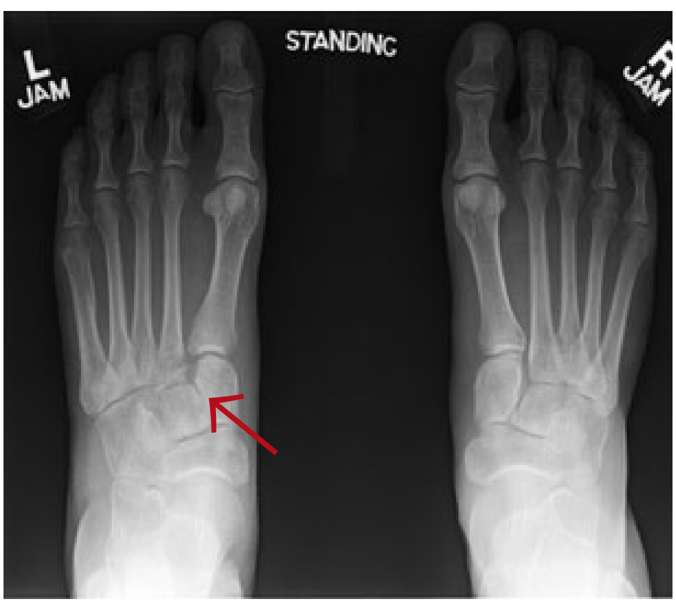
Can't-miss Injury #4: Jones and Pseudo-Jones Fractures

Fifth metatarsal fractures are the most common metatarsal fractures in children and comprise about 5% of all fractures in children.[46] These fractures occur with inversion ankle injuries or rotational foot injuries. Figure 7 depicts basic bony anatomy of the foot. Pain with palpation to the fifth metatarsal necessitates dedicated foot films to examine the zone-specific location of the injury. There are three zones of injury in which fifth metatarsal fractures can occur. Zone 1 injuries, also called pseudo-Jones fractures, occur during an inversion injury to the ankle when the peroneal brevis tendon or lateral band of the plantar fascia causes an avulsion injury to the base of the fifth metatarsal. These injuries can be appreciated on the lateral view of the ankle, but require a dedicated foot X-ray to determine displacement. Patients with pseudo-Jones fractures may bear weight as tolerated in a post-op shoe or walker boot and follow up with a specialist in one week. It is important to note that a fifth metatarsal apophysis can be mistaken as a zone 1 injury.[47] An apophysis is an ossification center to which a tendon or ligament attaches. The fifth metatarsal apophysis is a vertically oriented bony fragment that runs parallel to the metatarsal shaft. Avulsion fractures are oriented transversely. It is important to recognize differences on X-ray, as a fifth metatarsal apophysis can be painful and swollen in the setting of fifth metatarsal

Figure 9. Lisfranc Injuries

Figure 9a represents a Lisfranc injury. This occurred after an inversion injury of the ankle and was missed on the patient's initial emergency department visit.

Figure 9b shows weight-bearing images obtained on the same patient one month later, when she re-presented with ongoing midfoot pain and inability to bear weight. The stress view as well as visualization of the contralateral foot allows the lateral subluxation at the second tarsometarsal joint of the left foot to be identified.



is performed via axial traction and internal rotation. As with Salter-Harris III fractures, CT scan is helpful to determine the degree of displacement, and these patients should be placed in a long-leg splint with internal rotation.[66] These patients require urgent orthopedic follow-up and management. Open reduction is recommended for physeal fractures with a gap of 3 mm or more.[13,58,67]

Distal Fibula Fractures

Salter-Harris Fractures

The fibula is a non-weightbearing bone, so more aggressive weightbearing can be tolerated by patients with fractures to the fibula. Salter-Harris type I and II fractures comprise about 90% of distal fibula fractures.[58] Salter-Harris type I fractures of the fibula are common and often are missed or misdiagnosed as a sprain. The classic history is an external rotation force. It is important for the emergency provider to palpate over the fibular physis, about 2 cm from the distal fibula, and not to assume that lateral ankle pain is secondary to sprain. Localized pain and swelling over the distal fibular physis is diagnostic. X-rays are usually normal in these fractures, making it a clinical diagnosis. Patients should be placed in a walker boot, weightbearing as tolerated, and primary care follow-up for repeat exam in one week. Salter-Harris type II fractures are not commonly recognized in the fibula and management is the same as for Salter-Harris type I fractures. Fractures of the distal fibula combined with a Salter-Harris type II injury of the distal tibia are a common ankle injury in pediatric patients.[13] Isolated Salter-Harris type III and IV fractures of the fibula are rare and need to be distinguished from an accessory ossification center, os fibulare.[58]

Os fibulare is an accessory ossicle distal to the fibula that can be misinterpreted as a fracture.[68] It is thought to be secondary to an old avulsion fracture or non-union of an accessory ossification center. The os fibulare may become symptomatic with overuse, and especially is seen in ballet dancers and gymnasts.[69] Avulsion of the accessory ossification center also can occur and is based on clinical suspicion and pain with palpation.[70] These avulsion fractures can be considered Salter-Harris II fractures.[71] If painful with palpation on exam, the patient should be placed in a walker boot, weight-bearing as tolerated, with primary care follow-up.

Conclusion

Pediatric lower extremity injuries commonly present in the emergency department, especially with increasing sports specialization in young athletes. Injuries to the ankle and foot make up the majority of these injuries, and ankle sprains are a frequent occurrence. X-rays are not always necessary, as both the Ottawa Ankle Rules and the Low Risk Ankle Rule demonstrate. However, the emergency physician must be sure not to miss a high-morbidity injury that may masquerade as an ankle sprain. Thus, it is

Pediatric Pain Management in the Emergency Department

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Pain management in the pediatric population has long been a focus of healthcare providers; nevertheless, gaps in providing adequate and timely pain management remain an area of concern in emergency departments (ED). This article will provide guidance for the recognition and successful management of pediatric pain in the ED setting. The authors first present definitions of pain and discuss the assessment of pain in a child, as well as common barriers to appropriate pediatric pain management in the ED. Then, the article will focus on the different aspects of pain and techniques of managing discomfort, including: anxiolysis, non-pharmacological strategies, topical medications, oral analgesics, parenteral medications, discharge medications, and misconceptions and facts about opioid analgesics. Pain control in conjunction with procedural sedation is beyond the scope of this article.

Definition and Background

Pain is defined as an unpleasant somatic or visceral sensation associated with actual, potential, or perceived tissue damage.[1] Pain is a complex and unique experience for all individuals. It can be affected by factors including one's own anxiety or surrounding environment. Children suffer pain in the same way as adults; however, exposure to painful events in early childhood can have a direct effect on future neurobiological development. Studies have shown that early exposure to painful experiences and undertreated pain at crucial developmental periods can cause changes in the activity and structure of the central nervous system and cause long-term effects in a child's perception of pain at later stages of childhood.[2,3] In some instances, chronic pain originates from one or more acutely painful episodes early on that continues to resonate even throughout adulthood.[2] The goal of pediatric pain management is to prevent avoidable pain and to eliminate pain in the most timely, efficient manner possible.

It has been well documented that pain is widely undertreated, especially in the pediatric population.[4,5,6,7] In 2001, the U.S. Congress renewed its focus on the recognition and treatment of pain. With this came an emphasis on adequate and timely pain management. Shortly afterward, the Joint Commission on Accreditation of Healthcare Organizations established standards for pain assessment and management in response to the public outrage about the widespread problem of the undertreatment of pain.[8] This included a mandate that methods used to assess pain are consistent with a patient's age, condition, and ability to understand. Although several advances have been made in improving pediatric pain management since the publication of these standards, several gaps still exist. Children continue to receive less analgesia in general EDs than adults, and fever is treated more promptly than pain in pediatric EDs.[9,10] Even in the pediatric population, children younger than 2 years of age receive disproportionately less analgesia in the ED than school-age children, despite having obviously painful conditions.[10]

The barriers to identifying pain and delivering timely, appropriate, and safe analgesia for pediatric patients are multifactorial. Seventy percent of all patients presenting to the ED are in some pain and/or require a painful procedure.[11] Pediatric and adolescent patients account for one-third of all patients seen in general EDs.[11] Although pain assessment is required for all hospitals and all practicing professionals receive pain assessment training, there continue to be gaps in actual pain management. Common barriers to optimal pain management in general EDs include patient volume, staffing issues, failure to include non-pharmacologic strategies in the treatment of pain, generally inaccurate pain assessments, insufficient pain medications available at triage, and difficulty with timely reassessment of pain in a busy ED environment.[12] Some barriers that are more common to children presenting to a general ED include provider selection of inappropriate pain scales, the patient's own inaccuracy in using pain scales, the lack of awareness that pediatric pain continues to be undertreated, provider unfamiliarity with new pain management techniques, and medication dosing errors in pediatric populations (although less so with the emergence of electronic orders in the electronic medical record system).[12]

Table 4. Topical Anesthetics for Use in the Emergency Department

	LET (4% lidocaine, 1:2000 epinephrine, 0.5% tetracaine)	EMLA (eutectic mixture of local anesthetics) (2.5% lidocaine and 2.5% prilocaine)	LMX-4 (Lidocaine 4%)
Application	Apply 1-3 mL directly to wound for 15-30 min prior to procedure (max dose 4 mg/kg of lidocaine or 280 mg) Available as a topical cream or patch Should not be applied to mucous membranes or areas that are supplied by terminal arteries (i.e., fingers, nose, penis, toes)	Apply a thick layer of 1-2 g per 10 cm^2 to intact skin and cover with an occlusive dressing for 1 hr. Efficacy is variable depending on duration of application.	Apply a thick layer of 1-2 g per 10 cm^2 to intact skin. Max doses: 1 g if < 5 kg, 2 g if body weight 5-10 kg, 10 g if body weight 10-20 kg, 20 g if body weight >20 kg. Do not apply to an area greater than 100 cm^2 in children < 10 kg. Do not apply greater than 200 cm^2 in children between 10-20 kg Should not be applied to mucous membranes or areas that are supplied by terminal arteries (i.e., fingers, nose, penis, toes)
Onset of Action	20-30 min	1 hr	20-30 min
Duration of Action	1-2 hrs after occlusive dressing removal	30 min to 2 hrs after occlusive dressing is removed	1 hr
Adverse Events	May cause contact dermatitis or methemoglobinemia (rare)	May cause contact dermatitis or methemoglobinemia (rare) Has been used for anesthesia in laceration repair although not FDA-approved for this purpose	Some reports of local reactions (redness, irritation, itching, rash) when applied to intact skin

bination drug products that contain more than 325 mg of acetaminophen per tablet, capsule, or other dosage unit to prevent the risk of severe liver injury from inadvertent acetaminophen overdose.[35] Combined opioid/acetaminophen medications with smaller amounts of acetaminophen, such as hydrocodone/acetaminophen, since have come into favor among ED providers. (*See Table 3.*)

Common side effects of opioids include nausea and emesis. Several studies have demonstrated that the routine use of antiemetics is not necessary in adult ED patients, as the incidence of nausea and vomiting is relatively low; however, there are no major studies that have been conducted in pediatric patients to support or refute the benefit of routine use of antiemetics with opioids.[36,37,38]

Opioids generally are administered orally or intravenously in the ED. In emergency situations involving patients with difficult access, providers may attempt intraosseous, intranasal, intramuscular, and subcutaneous routes. Because opioids are most commonly delivered intravenously, providers should consider topical anesthetics during triage for patients who likely will require IV medications, as IV placement is often a painful procedure for most pediatric patients (see targeted pain section below). When administering opioids, it is important that the patient is placed on continuous oximetry because of the risk of respiratory depression.

Codeine (3-methylmorphine) is a naturally occurring methylated morphine that has been used for decades for its analgesic and antitussive properties; however, it has become widely unpopular because of its unpredictable effect and risk of respiratory depression and even death due to interpatient variation of its metabolism to morphine by the cytochrome P450 2D6 (CYP2D6) enzyme system. Pain medications containing codeine (i.e., Tylenol no. 3) were removed from the World Health Organization list of essential medications in March 2011 because the "efficacy and safety were questionable in an unpredictable portion of the pediatric population." It also received a "black box warning" by the FDA in February 2013 for its risk of respiratory depression when used in postoperative tonsillectomy and adenoidectomy patients.[39] Codeine still may be used in older pediatric patients without respiratory issues in the ED; however, extreme caution should be used when prescribing this drug.

Common opioids include morphine, hydromorphone, and fentanyl. (*See Table 3.*) Morphine is the recommended first-line treatment for moderate to severe pain because of its effectiveness and short half-life. Morphine commonly is given intravenously, but it also can be given intramuscularly or subcutaneously in patients without IV access.

Viscous lidocaine ("lidocaine jelly") has been used by providers to minimize pain associated with this procedure. This has been well supported in the literature for the adult population, although there is a paucity of data in the pediatric population.[52,53,54] In the few studies that exist for the pediatric population, the findings have shown mixed results. A 2009 randomized, double-blind study evaluated whether the use of topical and intraurethral lidocaine would decrease distress in infants ages 2 to 24 months receiving urethral catheterization; the authors found that its use resulted in lower distress than the topical lubricant with standard catheterization, although it did not completely eliminate pain.[55] A more recent 2015 randomized, blinded, placebo-controlled trial showed that in 133 infants, ages 0 to 24 months, a topical and intraurethral lidocaine was not associated with significant pain reduction during urethral catheterization, but significantly greater pain during instillation.[56] Despite the evidence to the contrary, many clinicians continue to use lidocaine to alleviate pain associated with urethral catheterization. Since the evidence is not strong enough to support such a practice, pain relief during these procedures should be focused on noninvasive methods and joint decision-making with parents.

Discharge Medications

Pain medication should be provided upon discharge for patients expected to continue to experience some level of pain after their visit. The physician should pay attention carefully to dosing and length of therapy when prescribing analgesics, especially with opioids. All patients should receive clear, written instructions that include information about expectation of pain duration, as well as medication dosing, duration, and adverse effects. Instructions for non-pharmacologic therapies (i.e., warm and cold compresses) also should be given routinely.

Outpatient Opioid Use in the Pediatric Population

The administration of opioids should not be delayed for severe pain; however, providers should be aware of increasing trends in opioid abuse over the past decade, especially among adolescents, and be able to mitigate those risks. Data from the National Survey on Drug Use and Health found that in 2014, more than 460,000 adolescents were current non-medical users of pain relievers and 168,000 adolescents had an addiction to prescription pain relievers. Data from the 2001-2010 National Hospital Ambulatory Medical Care Survey showed that the overall use of opioid analgesics in pain-related pediatric ED visits increased from 11.2% to 14.5% between 2001 and 2010, and the use of Drug Enforcement Agency schedule II agents doubled from 3.6% in 2001 to 7.0% in 2010.[57] Nearly 13% of high school seniors report nonmedical use of a prescription opioid, and the most common method of obtaining opioids was from a prior medical prescription.[58] These findings have medical implications, including an increase in accidental opioid-associated overdose and opioid-related deaths in this population.[57]

Inappropriate use of opioids can be combated by ED providers by educating patients and families on addiction and misuse, adhering to practices that limit the over-prescription of opioids, using prescription drug monitoring programs, and using adjunctive, non-opioid and non-pharmacologic treatments during and after the visit. Although screening for individuals at risk for opioid misuse would help prescribers cut down on opioid misuse, no validated screening measures have been created specifically for this purpose. Providers should pay attention to the indications for opioid prescribing, indications for short- vs. long-acting opioids, and appropriate duration for discharge prescribing. For example, providers should prescribe a short course (up to 3 days) of opioid or combination opioid/acetaminophen medication for acute pain conditions that require opioids.[59] Long-acting or controlled-release opioids, such as OxyContin, fentanyl patches, and methadone, should not be prescribed in the ED for acute pain, as these require long-term monitoring for pain relief and signs of dependence and addiction, which realistically cannot be provided by ED physicians.[60,61] Providers also should avoid providing replacement prescriptions for controlled substances that were lost, destroyed, or stolen, and should refer the patient back to the provider responsible for prescribing these long-term medications.[59,61]

Summary

Although major advancements have been made toward closing the gap of oligoanalgesia in pediatric patients in the ED, there remains room for improvement. These recommendations provide suggestions for improvement in today's setting, but newer techniques are developing, which challenge providers to continue to learn and adapt to the ever-changing ED environment.

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