Aurora Health Care
EMS Continuing Education
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PEDIATRIC SEIZURES

While en route to a burger shop for lunch, you and your partner are flagged down by a teenage boy at a skate park. He's standing next to another boy, who's lying on the ground at the bottom of a ramp. The boy on the ground appears to be approximately 10 years old, and the other boy explains that he's the patient's brother.

The patient is unresponsive and appears pale. He's smacking his lips and twitching his left arm. After a few moments, he slowly regains consciousness. You take his vitals: BP 104/70, HR 98 and RR 16, and his skin is pale and warm with normal moisture. He has no medical history, takes no medications and has no known drug allergies.

He has no obvious trauma other than abrasions. But, because of his initial presentation and the fact that he wasn't wearing a helmet, you place him in spinal precautions, administer oxygen via non-rebreather mask and transport to a local emergency department (ED). En route, he becomes unresponsive once more with similar signs. Concerned about head trauma, you obtain IV access and divert to the trauma center. You're later informed that the child experienced a new onset of seizures, which caused him to fall at the skate park. He was treated in the ED with midazolam and admitted for observation and follow-up with the pediatric neurologist.

Great Expectations

Although few pediatric neurological conditions require emergency treatment, paroxysmal disorders, or seizures, are a common neurological complaint that EMS providers encounter. Still, the public generally expects of EMS something that's expected of no other profession: They expect us to be able to care for any patient, at any time, regardless of their age or condition.

Pediatric patients make up a small percentage of EMS calls, and the need for ALS is even less. This requires us to commit to reviewing and updating our knowledge frequently.

Science and technology are helping us understand how the brain works, and the body of knowledge that informs our understanding of brain disorders is growing rapidly. So, let's review the current understanding of paroxysmal disorders, shed some light on assessing them to aid the pediatric neurologist in diagnosing the condition and discuss the current standards of prehospital care of the pediatric seizure patient.

Brain Development

To understand the pathophysiology of pediatric seizures, we should begin with a basic review of human brain development and how it changes throughout childhood. Often, the varied presentations of seizures are the result of the child's development level rather than the etiology of the seizure.

The adult brain contains one trillion neurons. This makes up only half of the brain's cellular volume. The other half is made up of glial and other cells. Glial cells transmit nutrients from the blood supply to the neurons. They serve as structural support, and they produce myelin. Most brain cells are formed during the fetal period and first two years of life.

Although the manufacture of neurons is completed prior to birth, brain development at birth is still far from complete. The development of axons, dendrites and myelin sheathing continues rapidly during the first three years and gradually slows, but it never stops. Neuronal myelination occurs at different life stages for different parts of the brain. This process favors the most vital functions first. For example, the neurons responsible for sucking and swallowing are completely myelinated at birth. The importance of myelin cannot be overstated; it increases the speed of nervous impulse conduction.

This is why newborn babies can have generalized seizures but not tonic or clonic motor activity. In fact, the only signs an infant is having a seizure may be related to their fully myelinated neurons (e.g., eye rolling to one side or automatisms, such as lip smacking). For example, Guillain-Barré syndrome and multiple sclerosis involve demyelination, or damage to the myelin. Affected people gradually lose function of various parts of the body and can become paralyzed. In all people, the neurons that connect the cerebellum to the cortex begin to myelinate after birth and continue until age four. This myelination brings about the precise control of voluntary movement. Other structures in the brain continue to myelinate until puberty or beyond.

If you were to compare the weight of the fetal brain to the adult brain, you'd see that it's closer to its adult weight than any other organ. By six months of age, the child's brain weighs half of its adult weight. By two years of age, it weighs two-thirds of its adult weight. This is why young children look as though their heads are too large for their bodies and why young children and toddlers can drown in toilets and buckets. In short, they're top heavy. What's interesting about the growth of the brain is that it isn't "growth" at all. Rather, it's significant remodeling taking place throughout life.

By three years of age, each neuron will have developed an average of 15,000 synapses. Neurons die off in large numbers, and axons and dendrites will often grow or retract. Synaptic connections create neural pathways for communication. Frequently used neural pathways are preserved, and those synaptic connections that are used the least are deleted. Thus, experience has a direct effect on the structure of the brain. That's why people, despite identical environmental inputs, may interpret those inputs differently.

Seizures

The assessment of seizures is straightforward once it's understood that they can present in a variety of ways, with motor signs affecting any part of the body when motor signs are present. Or the patient may present with autonomic signs and symptoms only or psychic symptoms. It's essential to obtain an accurate and detailed description of the seizure activity.

The term "seizure" refers to a transient change of behavior resulting from an abnormal firing of neuron groups. Seizures are not always accompanied by overt physical signs, especially in children, and are classified according as localized (involving a specific area of the brain) or generalized (involving the whole brain). Localized seizures are often referred to as partial or focal and can be subdivided into simple, complex or secondarily generalized.

Seizures can be described as primary, secondary or reactive. A primary seizure doesn't have an identifiable etiology, whereas a secondary seizure occurs as a result of an identifiable lesion, such as a tumor or injury. A reactive seizure is an abnormal response to a medical condition (e.g., a febrile seizure).

A seizure-prone neuron is more excitable than other neurons and is capable of sustaining autonomous discharges. These neurons are subject to external influences, allowing others

to influence their activity. It’s through this mechanism that a localized seizure can progress to become a generalized seizure if the surrounding neurons are seizure-prone.

Localized Seizures

In seizure activity, a group of neurons suddenly becomes depolarized, with thousands firing synchronously for prolonged periods. If adjacent neurons resist the spread of the electrical discharge, the seizure remains localized. However, if the activity spreads to the brainstem, the seizure becomes generalized. This oversimplification provides a snapshot of how seizures spread.

Localized seizures are commonly referred to as “partial seizures.” As the name implies, they involve an abnormality in a specific area of one hemisphere. In 75–90% of patients, there’s an identifiable cause for the seizures, which can include anything from congenital malformations to trauma.

The signs and symptoms of the seizure depend on the location within the brain where it originates and the developmental stage of the brain.

Simple partial seizures can occur with motor signs, autonomic signs or symptoms, or psychic symptoms. The difference between a simple partial seizure and a complex partial seizure is that simple partial seizures don’t impair consciousness, and complex partial seizures do. Commonly, simple partial seizures have minor motor signs that may involve any part of the body. They may also occur without motor signs, making diagnosis challenging. In simple partial seizures with such autonomic symptoms as flushing, pallor or visceral sensations, the diagnosis is often missed initially.

In fact, visceral sensations are common among children who experience simple partial seizures with autonomic signs or symptoms. These include abdominal cramping, bloating, periumbilical pain or any number of other visceral complaints. These children are often misdiagnosed as having psychosomatic pains.

Simple partial seizures may also occur with alterations in higher cerebral function as their only presentation; this includes dysphasia, hallucinations, fear, anger or other psychic symptoms. Simple partial seizures with psychic symptoms are usually followed by complex partial seizures.

Complex partial seizures impair consciousness and are often preceded by an aura. An aura is a simple partial seizure that lasts seconds to minutes preceding the alteration in mentation. Other signs, which can occur hours to days before the seizure, include unexplained nervousness, anxiety, dizziness and headache. The child may also become irritable or angry and aggressive.

Young children often run and cling to their mothers in fear when they experience the aura. As the child ages, the aura is more easily recognizable. The aura is followed by a complex partial seizure that's accompanied by partial or complete loss of consciousness. The majority of complex partial seizures originate in the temporal lobe. However, any seizure, regardless of origin or type, can spread to become a generalized seizure.

Generalized Seizures

The pathophysiology of generalized seizures isn't as well understood as partial seizures. It's believed that the cortex is in a diffusely hyperexcitable state, and seizure-prone neurons are spread throughout the cortex. Excitatory neurons can produce a synchronized discharge over a wide area of the cortex. This results in a grand mal or absence seizure.

Occasionally, children may become irritable or behave in an unusual manner for hours before the onset of the seizure. When the tonic phase of the seizure begins, the musculature of the body contracts, often resulting in the child screaming or letting out a high pitched cry, which can be followed by apnea. This is followed by the clonic phase, which is characterized by rhythmic jerking of the trunk and extremities. Seizures may last only a few seconds or for hours.

Studies demonstrate that new onset seizures last more than five minutes in 50% of kids, more than 10 minutes in 29%, more than 20 minutes in 16% and more than 20 minutes in 12%. The longer the seizure, the less likely it will cease without medical intervention.

Absence seizures, which are occasionally referred to as petit mal seizures, are a "transient loss of consciousness without conspicuous convulsions." The onset of absence seizures is abrupt, usually occurring without an aura, and children can have 20 or more per day. They often last 5–10 seconds.

Febrile seizures

A febrile seizure is a convulsion in a child triggered by a fever. These convulsions occur without any brain or spinal cord infection or other nervous system (neurologic) cause.

About 3 - 5% of otherwise healthy children between ages 9 months and 5 years will have a seizure caused by a fever. Toddlers are most commonly affected. Febrile seizures often run in families. Most febrile seizures occur in the first 24 hours of an illness, and not necessarily when the fever is highest. The seizure is often the first sign of a fever or illness. Febrile seizures are usually triggered by fevers from:

- Ear infections
- Roseola infantum (a condition with fever and rash caused by several different viruses)
- Upper respiratory infections caused by a virus

Meningitis causes less than 0.1% of febrile seizures but should always be considered, especially in children less than 1 year old, or those who still look ill when the fever comes down.

A child is likely to have more than one febrile seizure if:

- There is a family history of febrile seizures
- The first seizure happened before age 12 months
- The seizure occurred with a fever below 102 degrees Fahrenheit

A febrile seizure may be as mild as the child's eyes rolling or limbs stiffening. Often a fever triggers a full-blown convulsion that involves the whole body.

Febrile seizures may begin with the sudden contraction of muscles on both sides of a child's body -- usually the muscles of the face, trunk, arms, and legs. The child may cry or moan from the force of the muscle contraction. The contraction continues for several seconds, or tens of seconds. The child will fall, if standing, and may pass urine.

The child may vomit or bite the tongue. Sometimes children do not breathe, and may begin to turn cyanotic. Finally, the contraction is broken by brief moments of relaxation. The child's body begins to jerk rhythmically. The child does not respond to the parent's voice.

A simple febrile seizure stops by itself within a few seconds to 10 minutes. It is usually followed by a brief period of drowsiness or confusion. A complex febrile seizure lasts longer than 15 minutes, is in just one part of the body, or occurs again during the same

illness. Febrile seizures are different than tremors or disorientation that can also occur with fevers.

Status Epilepticus

Status epilepticus (SE) is a neurological emergency. Up to 66% of first seizures present as SE, which is either convulsive (grand mal) or nonconvulsive (as in absence SE) and is generally defined as two or more seizures without an intervening period of consciousness, or a single seizure lasting longer than 30 minutes. However, due to the high morbidity and mortality of SE, the 30-minute requirement has been reduced to five minutes to prompt early intervention.

Morbidity and mortality result from excitotoxic brain injury. Chemicals released during the seizure can injure or kill the involved and surrounding neurons. SE may also result in hypertension, cardiac arrest, tachycardia, bradycardia and other cardiac arrhythmias, hypoxia, pulmonary edema, rhabdomyolysis and other medical complications.

Mortality in the pediatric population is approximately 3%, with most deaths occurring in children one to four years old. Improper or delayed treatment can cause a previously neurologically healthy child to become permanently brain damaged.

Pseudoseizures

Pseudoseizures and conversion disorders are often neglected topics in EMS education. They can be present in those who are diagnosed with conversion disorders.

The best way to understand a conversion disorder is to imagine the mind converting psychological or emotional stress into physical symptoms. As stressors are suppressed or verbal expressions are prohibited, they’re converted to physical signs or symptoms. It’s important to note that the patient isn’t faking their conditions.

One way a conversion disorder is expressed is through pseudoseizures. In these cases, the patient demonstrates the signs and symptoms of a seizure without seizure activity in the brain. Note up to 30% of epileptics experience pseudoseizures. It’s important for EMS providers to be aware that pseudoseizures are frequently associated with family stress and sexual abuse and can often be halted through suggestion.

Factitious Seizures

Factitious seizures differ from conversion disorder because the patient is intentionally pretending to have a seizure. The causes for these factitious seizures are varied. When the

patient is a young and nonverbal child, providers should consider that the seizure might have been falsely reported by a parent, often a mother who represents herself as a conscientious and model parent. She's frequently young, articulate and middle class with some medical training, and she exhibits an unnatural attachment to her child. Occasionally, the child begins to believe the symptoms themselves and think they have a seizure disorder.

Several indicators a parent telling you this might be falsifying their reports include persistent and unexplained illnesses; clinical signs inconsistent with the child's health status; or unusual or remarkable signs or symptoms. Other indicators include if the caregiver appears unconcerned about the prognosis and there's a lack of clinical response to treatments.

Additionally, adolescents may simulate a seizure for attention. Signs a seizure may not be real include a generalized tonic-clonic seizure during which the patient is responsive and able to answer questions and responsiveness to noxious stimuli. Consciousness requires at least one hemisphere of the brain to be uninvolved in the seizure activity. A generalized seizure involves both hemispheres, making responsiveness unlikely.

Another indicator the seizure may not be real is if the patient's eyes are closed, because it's natural for the eyes to remain open during a seizure. In addition, repetitive pelvic thrusting is often indicative of a false seizure because seizures don't usually cause this type of activity.

Assessment

The postictal phase may last 30 minutes or longer, impairing your ability to communicate with the verbal child or adolescent. However, it's important to not assume the patient is postictal and confirm the seizure activity has terminated. Generalized convulsive seizures may become generalized nonconvulsive seizures with few outward signs.

Because caregivers won't likely know what information is important, EMS providers must ask about such motor signs as tonic activity (the rigid contraction of the involved muscle groups) and clonic activity (the rhythmic jerking of the muscle groups). Providers should also ask patients about the presence of an aura, autonomic signs or symptoms, psychic symptoms or any other unusual behaviors preceding the seizure.

It’s critical to rule out trauma and perform a rapid trauma assessment when necessary. Also inquire about any changes in the child’s medication, exposure to illicit drugs and compliance with existing seizure-control medications. Non-compliance is a common cause of seizures, particularly in adolescents. Also, many new medications are taken only once per day in hopes of increasing the likelihood of compliance among adolescents; therefore, one or two missed medications can result in the patient experiencing a seizure. So, it’s important to determine if the patient has skipped their medication.

Management

The goal of seizure treatment is to stop seizure activity and prevent trauma. Most deaths that result from seizures take place 15–30 days after the acute episode. This underscores the importance of appropriate medical interventions.

As with any patient, ABCs (airway, breathing, cardiovascular) and patient safety are primary concerns. If the patient is actively seizing, remove surrounding objects that may cause an injury. Provide oxygen via a bag-valve-mask and loosen restrictive clothing. Carefully roll the patient on their side to prevent aspiration when spinal trauma isn’t suspected. This is often all that’s called for in the treatment of uncomplicated seizures. If a febrile seizure is suspected, attempt to reduce the child’s body temperature without inducing hypothermia. Simply removing multiple articles of clothing or bedding is often all that is necessary to reduce the temperature enough to stop the seizure or prevent a recurrence.

During SE, IV or intraosseous access should be obtained with normal saline or lactated ringers at a to-keep-open rate. If needed, the provider should recruit the help of others to gently restrain the limb when access is being obtained. ALS should be considered as the patient should be given midazolam or diazepam in accordance with local protocols. It’s important to understand that intramuscular midazolam is at least as effective as IV diazepam. Also, note that the half life of midazolam is significantly shorter in children than in adults, increasing the likelihood of recurrence of the seizure during prolonged transports.

It’s critical that the provider understand that the use of paralytics may only halt convulsive motor activity, but it does not stop seizure activity in the brain.

Glucometry readings should be obtained on all seizure patients, and hypoglycemia treated as appropriate. Due to the risk of normal cardiac function alterations, cardiac monitoring

should be initiated on all seizure patients. Convulsive motor activity will interfere with the reading of the cardiac rhythm.

If the patient is a pregnant adolescent and showing signs of eclampsia, treatment usually calls for magnesium sulfate or midazolam in accordance with local protocol. Rapid transport should be initiated for all SE or eclamptic patients.

Conclusion

Pediatric seizures can manifest in a variety of ways. The majority of first seizures present as SE, which is a true medical emergency. In the pediatric population, how a seizure presents has a great deal to do with the development level of the brain, rather than the etiology of the seizure. Many children will experience one seizure in their lifetime; recurrent seizures are defined as epilepsy. Ensure you know when to treat aggressively to prevent the morbidity and mortality associated with SE.