Welcome to the DCMC Emergency Department Radiology case of the month!

In conjunction with our pediatric radiology specialists from ARA we hope you enjoy these monthly radiological highlights from the case files of the Emergency Department at DCMC. These cases are meant to highlight important chief complaints, cases, and radiology findings that we all encounter every day.

If you enjoy these reviews we invite you check out Pediatric Emergency Medicine Fellowship Radiology Rounds, which are currently offered quarterly and are held with the outstanding support of the pediatric radiology specialists at Austin Radiologic Association.

If you have any questions or feedback regarding the Case of the Month format, feel free to email Robert Vezzetti, MD at rmvezzetti@seton.org.

**This Month:** Head injury...an inevitable part of pediatric practice is seeing children who hit their head. Most (the majority in fact) of these injuries are benign and need absolutely nothing in the way of imaging. Some injuries, though, involve more than meets the eye.

One of the more common injuries are skull fractures. There are different ways to find them, and treatment depends on the type of fracture. This month, let's look at how to pick up potential cranial bone injuries in children.

**Interesting May facts:** The month May was named for Maia, the Greek goddess of fertility and the mother of Hermes. The Romans had a similar goddess named Bona Dea. They held the festival for Bona Dea during the month of May, which they called Maius.
CASE 1: The volume doesn’t seem to let up tonight in the Pediatric ED, as more patients check in with Springtime injuries: lacerations, fractures, insect stings, animal bites. Of course, you are not wishing for Winter (and RSV/FLU/URI season) to return, but still.....

A mother brings her 6 month old infant into the ED. She states the child was on a bed, rolled off, and fell, striking an iron bedpost on the way down. Specifically, she states that the child hit the foot of this elaborate and very ornate bedpost. There was no loss of consciousness and the child appears to be acting normally. She did note, however, that her child’s head did not look right. She took the infant to her pediatrician, who recommended that they come to the ED for a skull xray.

On exam, the child is alert and playful. Her vitals look normal for age and she has a completely unimpressive physical examination except for an obvious abnormality to her left parietal skull: it appears to be depressed. Now what......?

CASE 2: A distraught mother brings her 7 month old male into the Department with a head injury. Apparently, the infant was on a kitchen counter (what?) and rolled off, while playing with his father. The child struck the tile floor. He cried immediately and did not have loss of consciousness. He has had 2 episodes of emesis; this occurred within 30 minutes of the injury, and he has had none since. The parents report the counter is about 4-5 feet off the ground.

On exam, the child is playful and vigorous. He interacts with you and seems perfectly fine. He does, however, have swelling to the left parietal aspect of his head. The swelling is boggy and there does not seem to be a step-off; there is no crepitus. He does not like it if you touch it, though, and seems to be in pain.

As you discuss what may be happening with her son, the infant’s father arrives and the mother immediately starts to become angry and says “You see? This idiot let him fall!” Great. You ask the mother to calm down (the father too, because he has started to verbally defend himself), and think about if imaging is needed. If so, what? Xray? CT? MRI?

Kupperman, et al published an excellent study concerning the identification of children at very low risk of clinically important brain injury. This study addressed which children, based on history and physical exam findings are at risk for intracranial injury, as well as fractures. It’s worth checking out: The Lancet volume 374 Oct 3, 2009.
Skull Fractures: Who Should Get Imaged?
Previously, we have discussed neuroimaging in children with headaches (see February 2014 issue). As in children with headache, not all children with scalp hematomas need imaging. The reasons are the same: the attempt to lower radiation exposure over a child’s lifetime.

When there is a concern for cranial bone fractures, imaging is indicated. Although the majority of fractures require little more than careful observation and neurosurgical followup, some fractures require repair. Other fractures are associated with intracranial hemorrhage, which may or may not require surgical intervention.

Generally, children who sustain low impact, short distance falls, who have no physical exam findings or historical concerns (i.e. loss of consciousness or high impact injuries) do NOT need imaging. Parents should be advised that it is possible for a hematoma to appear later on from the injury (such as a day later) and if this occurs or if there are any concerning symptoms, then repeat evaluation and imaging may be needed.

Historical findings that may warrant imaging include high impact trauma (i.e. MVC, high velocity wounds, forceful blunt trauma), true loss of consciousness, mental status changes (extremely irritability or sleepiness), repeated vomiting, or if the mechanism of injury does not match the injury. Physical exam findings include hematoma to the scalp (except the frontal area, unless it is a high risk injury), bogginess to the scalp, crepitus, or step-off.

NOTE: Frontal hematomas are not often associated with fractures unless it is a high risk injury, so imaging is generally not indicated.

What Imaging Test to Obtain?
Deciding on which imaging test to order in children with head trauma is easy if you are trying to rule out intracranial injury: noncontrast head CT is best imaging test to look for epidural/subdural bleeds, and, in most pediatric cases, subarachnoid bleeds. It’s fast and requires, in many cases, no sedation. But what if you are trying to see if there is a fracture or not? What about plain x-rays? Is there a role for ultrasound in evaluating children with suspected skull fractures? Certainly plain films can detect skull fractures, but is one imaging modality superior to the other? Here is a brief review:

Skull Xrays: As an easy to obtain imaging modality, skull films are great. They are often used to screen for fractures. Problem is, they will tell you nothing about underlying intracranial injury (which may be present in the absence of a fracture). Plain films should not be used as a screen to determine if a CT is needed. They are useful in the setting of uncertain injury, such as in a skeletal survey in a child undergoing evaluation for nonaccidental trauma.

CT: This is the diagnostic modality of choice: good at detecting fractures and good at detecting intracranial injury. It is quick and contrast is not required. Radiation is an issue, but this can be minimized using appropriate pediatric protocols.

US: Some studies have suggested that ultrasound is sensitive and specific for detecting skull fractures. However, this is still under investigation.

MRI: Not used as a first line imaging test. While radiation is not an issue, MRI is more time-consuming than CT and often requires sedation. It is also not as readily available as other imaging modalities in most center.

Bottom Line: CT is the imaging modality of choice when evaluating children with suspected skull fractures; it can detect fractures and intracranial injury at the same time.

What Typically Causes Skull Fractures?
Falls - 35%
Recreational Activities - 29%
MVC - 24%
Falls are more common in children under 2 years of age.
MVC/Trauma are more common in older children.
Source: Alison Chantal Caviness, MD. UpToDate: Skull fractures in children.

As always, be sure to keep in the differential nonaccidental trauma. In children under 1 year, a fracture triggers labwork, skeletal survey, and a social services consult, and sometimes a CARE team evaluation. It is always appropriate for send a child to the ED for consultation with CARE and Trauma Services if NAT is suspected.

See the May 2014 issue for more information.
Here we see 3D reconstruction of the CT scan. This really shows the fracture, which is, believe it or not, called a "Ping Pong Ball" fracture. Blue arrows are sutures.

Well, after consideration of all of your imaging options, you decide to obtain a noncontrast CT scan of the head. This will give you a nice view of the suspected fracture, which, as it turns out, is there (red arrow). There also appears to be a very small cortical hemorrhage (yellow arrow). Overall, there is no mass effect, but there is a small amount of mass effect on the brain adjacent to the fracture itself. The ventricles, sulci, and cisterns all look normal (green arrows).

Well, that's an interesting finding! Now what? Is surgery needed immediately? What about nonaccidental trauma? Does this story match up with the injury?
OK, as in the first case, this child has some physical examination findings that are concerning for a fracture; specifically the location of the scalp hematoma. Being parietal, this increases the risk of a fracture. Additionally, the countertop was reported to be approximately 5 feet off the ground (a risk factor) and the child landed on a tile floor (also a risk factor, being harder than other surfaces, like hardwood or carpet).

See anything that looks unusual on this scan?

For starters, the CT shows a scalp hematoma (green arrow). If you look a little more carefully, on the bone windows, there is a nondisplaced parietal skull fracture that is underlying the hematoma (red arrow). There is, however, no evidence of epidural, subdural, or subarachnoid hemorrhage. There is also no shift from the midline.

Sir Godfrey Hounsfield: father of the CT scanner (along with Allan McLeod McCormack, working separately). While on an outing, he devised the idea that one could see what's inside a box by taking multiple x-rays from different angles. He set about constructing a computer to take all of those images (“slices”) and put them together to form a composite image. He was working for EMI (the Beatles’ record company, but they also produced electronics) at the time as an electrical engineer. It is said that the greatest legacy of the Beatles, at least for medicine, was the fact that a lot of the profit EMI made from their record sales was used to fund CT research and development.

He won the Noble Prize for Medicine in 1979 and shared it with Allan McCormick. He died in 2004 at the age of almost 85. His name is given to the Hounsfield Scale, used to quantify radiodensities in CT scanning.
Types of Skull Fractures:

**Linear**: The majority of fractures in children. Typically a single fracture line. May disrupt vascular structures.

**Comminuted**: Multiple fractures lines.

**Depressed**: Can be associated with underlying brain injury and are often the result of significant force. They are associated with a higher rate of post injury seizures.

**Open**: Can be associated with an overlying laceration or with disruption of the sinuses, leading to CSF leak.

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**Notable Skull Fractures: Basilar Fractures**

These are fractures that involve the base of the skull (temporal, occipital, sphenoid, and ethmoid bones can all be involved.)

Clinical Signs: Battle Sign, Raccoon eyes, CSF leak from nose/ears, cranial nerve palsy, hemotympanum.

**Complications**: Hearing loss (up to 1/3 of patients), Cranial nerve damage (VI, VII, VII most commonly), and CSF leaks/infection (most CSF leaks resolve on their own).

**Battle Sign**: Subcutaneous bleeding over the mastoid process

**Raccoon Eyes**: Subcutaneous periorbital bleeding

**Hemotympanum**

**Treatment**: Aside from neurosurgical and, in some cases, ENT consultation, these children are typically admitted for observation. Prophylactic antibiotics have been prescribed in the past, but currently this practice is discouraged (though there are no randomized, controlled studies). Anecdotal evidence does suggest that children with CSF leak are at risk for meningitis, but prophylactic antibiotics do not appear to reduce infection. Surgical intervention is sometimes indicated, especially with persistent CSF leaks or facial nerve entrapment.

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**Notable Skull Fractures: Open Skull Fractures**

These fractures are at risk for infection, including meningitis and osteomyelitis, and antibiotic prophylaxis is recommended.

**Notable Skull Fractures: Growing Skull Fractures**

These fractures are caused by a mass filled with CSF and is usually associated with linear parietal skull fractures. The dura is torn and accumulation of CSF in a cyst-like mass develops.

This CT shows a nonhealing fracture and a cystic structure along with encephalomalacia. This is typical of a growing skull fracture. Surgical management is needed. Complications include neurological and cranial bone defects.

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**Notable Skull Fractures: Depressed Skull Fractures**

30% have an associated intracranial injury. As the depth of the depression increases, so does the risk for vessel and cerebral injury. Neurosurgical intervention may be required (but not in all cases).
Case Resolutions:

**Case 1**: This child sustained a ping-pong ball fracture, so named because it resembles what happens when a ping pong ball is pushed with a finger, causing the characteristic indentation. Because of the elasticity of the skull, this type of fracture is typically seen in infants and the fracture line itself may not be seen on imaging tests, although the depression certainly is. The periosteum and dura of the skull are intact and there is typically not neurologic injury. Interestingly, this fracture can be seen in birth trauma in newborns. Treatment can be observation (in less depressed fractures) or surgical elevation. In newborns, spontaneous elevation has been reported but this is rare in infants. Due to this patient’s age, a social services consult was obtained, as well as labs (AST, ALT, UA) and additional imaging (skeletal survey) per the DCMC NAT protocol. All results were negative and social services had no concerns for NAT. Pediatric Neurosurgery was consulted and the child was admitted for observation due to the cortical hemorrhage. After discharge, 2 weeks later, the child was taken to the operating room for elevation of the fracture. He did well.

**Case 2**: This child suffered an injury that led to the very-commonly seen linear, nondisplaced parietal skull fracture. There was, luckily for him, no evidence of intracranial injury. Again, because of his age and injuries, a non-accidental trauma workup was initiated, the results of which were normal. Social work, as well as the ED staff, had no immediate concerns for NAT, although the parents were counseled regarding safety practices. He did not require admission to the hospital and was discharged home. He had neurosurgical followup and was reported to be doing well.

Fractures such as these often heal very well without complication. Neurosurgical followup is not necessarily indicated, as long as the child is clinically well and the fracture appears to be healing. In children with suspected growing fractures (clinically evident by persistent swelling and palpable deformities or step-off), then referral is indicated to avoid the aforementioned complications of growing skull fractures.

Image Judiciously! There are plenty of guidelines available to consult who should get imaged!

**Teaching Points:**

1. **Skull fractures are usually evident on clinical examination, manifesting as a boggy hematoma, often with step-off. Crepitus may be present.**

2. **Skull fractures may be linear, basilar, depressed, and open. They may be displaced or nondisplaced. Clinical hints that a basilar skull fracture is present include Battle sign, Hemotympanum, Raccoon eyes, and CSF otorrhea/rhinorrhea. The majority of skull fractures are linear, nondisplaced.**

3. **Noncontrast CT examination is the imaging modality of choice when evaluating pediatric skull fractures. Plain radiographs of the skull are part of the skeletal survey when evaluating a patient for nonaccidental trauma. US is an imaging modality that has the potential to identify fractures, but more study is needed. MRI is a tertiary study that is utilized in cases of undetermined intracranial injury.**

4. **Imaging is indicated by age (< 2 years are at higher risk), mechanism (falls more than 4 feet, MVC, etc), history (vomiting, etc), physical examination findings (hematoma to parietal, temporal, occipital areas are higher risk for fracture).**

5. **Most skull fractures can be treated non-surgically by careful observation and followup. Basilar, depressed, and open skull fractures require pediatric neurosurgical and pediatric ENT consultation. The presence of intracranial injury or complex fractures mandate admission.**

6. **Routine antibiotic prophylaxis is not indicated in most fractures; open fractures should have antibiotic prophylaxis.**

7. **Always have NAT in the differential when evaluating children with skull fractures.**

**References**

8. Caviness AC. Skull fractures in children. In uptodate.com