Pediatric Head Trauma

Carolina V. Guimaraes, MD
Pediatric Head Injury Pearls

- Sutures
- Occult Fractures
- Occult Hemorrhage
- BESS vs Low attenuation subdural
- Abusive head Injury
- Differential Diagnosis
Case 1
sagittal

lambdoid

mendosal

occipitomastoid

Innominate synchondrosis

parietomastoid

sphenoparietal

coronal

tsphenosquamosal
Initial study

Three week follow-up

Accessory Parietal Sutures
Wormian Bones
Initial study

Mendosal Suture

Fracture

Mendosal Suture
Don’t forget to look at the scout
Pediatric Head Injury Pearls

• Sutures
  - Normal sutures
  - Normal variants and Pitfalls
  - 3D evaluation
Case 2
Pediatric Head Injury Pearls

• Occult fractures
  - Soft tissue edema
  - Thin sections / 3D bony evaluation
  - Displaced air bubbles
Case 3
Ocult Hemorrhage
Anterior fossa hemorrhage
Occult Hemorrhage

High Parafalcine

Tentorium

Interpeduncular cistern

Ant. Brainstem

Middle fossa

Anterior fossa
Vertex Ocult Hemorrhage
Ant. Brainstem

Uplifted of the tectorial membrane
Pediatric Head Injury Pearls

- Occult hemorrhage
  - Coup / Contra-coup
  - Knowledge of common missed hemorrhage
  - Multiplanar reformats
Case 4
Benign Enlargement of Subarachnoid Spaces (BESS) vs Low attenuation Subdural Collection

- “If you see vessels crossing through an enlarged extra-axial space in pediatric, the enlarged space is subarachnoid and therefore BESS”
Cortical Vein Distribution

Superior sagittal sinus
Corticomeningeal veins/ bridging
Cortical Veins
Bridging veins drain into the superior sagittal sinus. Located at the frontoparietal convexity and do cross both the arachnoid and dura.

Subarachnoid cortical veins, smaller, multiple and do not cross the arachnoid membrane. These vessels are displaced medially by subdural collections.
Benign Enlargement of Subarachnoid Spaces (BESS) vs Low attenuation Subdural Collection

- Subtle difference in attenuation compared to CSF
- Mass effect / flattening of cerebral sulci
- Displaced Cortical Vein sign
Case 5
Pediatric Head Injury Pearls

- BESS vs Low density subdural collections
  - Extra-axial attenuation
  - Flattening of sulci
  - Displaced cortical vessel sign
Non-Accidental Trauma
Pattern of Skeletal Injury in Non-Accidental Trauma

• High Specificity
  • Metaphyseal fractures
  • Rib fractures
  • Scapular fractures
  • Spinous process fractures
  • Sternal fractures

• Moderate Specificity
  • Multiple fractures
  • Fractures of different ages
  • Epiphyseal separations
  • Vertebral body fractures
  • Digital fractures
  • Complex skull fractures

• Common, but low specificity
  • Subperiosteal new bone formation
  • Clavicular fractures
  • Long bone fractures
  • Linear skull fractures
Abusive Head Injury

MECHANISM OF TRAUMA

- Direct Trauma
  - Fracture, soft tissue edema, intracranial hemorrhage
- Shaken baby syndrome
  - Subdural hemorrhage
  - Bridging vein thrombosis and subarachnoid hemorrhage
  - Cerebral edema / HIE
  - Whiplash cervical spine injury
- Strangling
  - HII
  - Subdural hematoma
Abusive Head Injury

**IMAGING FINDINGS**

- Skull Fracture
- Hemorrhage
- Bridging vein thrombosis
- Hypoxic Ischemic Insult
Skull Fracture

- Fractures more suggestive of abuse
  - Multiple, bilateral and crossing sutures

- Unlike skeletal injuries, skull fracture do not heal with the typical periosteal reaction and cannot reliably be dated
Hemorrhage

- **Subdural Hemorrhage** - Classic neuro finding in abusive head injury due to rupture of the bridging veins

- Non-specific

- Hyperdense - 3hrs to 7/10 days

- Mixed attenuation – acute on chronic vs hematoxygroma – avoid datting
Hemorrhage

Assessment of the nature and age of subdural collections in nonaccidental head injury with CT and MRI

Gilbert Vezina

Table 1: Density evolution of hemorrhage on CT images.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Appearance</th>
<th>Estimate of age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperacute</td>
<td>Isodense</td>
<td>&lt;3 hours</td>
</tr>
<tr>
<td>Acute</td>
<td>Hyperdense</td>
<td>Few hours → 7–10 days</td>
</tr>
<tr>
<td>Subacute</td>
<td>Isodense</td>
<td>2–3 weeks</td>
</tr>
<tr>
<td>Chronic</td>
<td>Hypodense</td>
<td>&gt;3 weeks</td>
</tr>
</tbody>
</table>

Table 3: Signal evolution of SDH on MRI.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Hemoglobin breakdown/product/distribution</th>
<th>Time period</th>
<th>T1</th>
<th>T2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperacute</td>
<td>Oxyhemoglobin/intracellular</td>
<td>&lt;12–24 h</td>
<td>↓ or ↔</td>
<td>↑</td>
</tr>
<tr>
<td>Acute</td>
<td>Deoxyhemoglobin/intracellular</td>
<td>1–3 days</td>
<td>↓ or ↔</td>
<td>↑</td>
</tr>
<tr>
<td>Early subacute</td>
<td>Methemoglobin/intracellular</td>
<td>2–3 days → 1–2 weeks</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Late subacute</td>
<td>Methemoglobin/extracellular</td>
<td>1–2 weeks → 1–2 months</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Chronic</td>
<td>Hemoglobin (subdural membrane)</td>
<td>Few weeks → months/years</td>
<td>↔</td>
<td>↑</td>
</tr>
<tr>
<td>Chronic</td>
<td>Nonparamagnetic hemichromes (subdural content)</td>
<td>Few weeks → months/years</td>
<td>↓ (CSF)</td>
<td>↑</td>
</tr>
</tbody>
</table>

↔ = Intermediate (iso) signal, ↓ = Dark (low) signal, ↑ = Bright (high) signal.
Note: In the presence of sedimentation of blood products within a subdural collection, the most precise dating with MR comes from signal analysis of the blood sediment [12].
Adapted from reference [11].
Bridging Vein Thrombosis

- Rupture of the bridging veins secondary to shaken motion of the child’s head may present with thrombosis of the bridging veins and focal subarachnoid hemorrhage adjacent to the thrombosed vein – “Tadpole Sign”
HII

- Most common parenchymal finding of AHI

- Cerebral edema, loss of gray-white matter differentiation 1-2 hrs post insult

- Subdural/ subarachnoid hematoma and fracture can coexist

- Imaging follow-up may show increase extra-axial collection due to parenchymal volume loss
# Abusive Head Injury – Differential Diagnosis

<table>
<thead>
<tr>
<th>Table 4</th>
<th>SDH – differential diagnosis.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trauma (inflicted, accidental)*</td>
<td>Genetic disorders</td>
</tr>
<tr>
<td>Genetic disorders</td>
<td>Menkes kinky hair disease</td>
</tr>
<tr>
<td>Genetic disorders</td>
<td>Glutaric acidemia type I</td>
</tr>
<tr>
<td>Genetic disorders</td>
<td>Osteogenesis imperfecta, Ehlers-Danlos syndrome</td>
</tr>
<tr>
<td>Hematologic disorders/coagulopathy</td>
<td>Hemophilia, hemophagocytic lymphohistiocytosis</td>
</tr>
<tr>
<td>Dural arteriovenous malformation</td>
<td>Sinovenous thrombosis</td>
</tr>
<tr>
<td>Rupture of arachnoid cyst</td>
<td>Meningitis/encephalitis/vasculitis</td>
</tr>
<tr>
<td>Oncological disease</td>
<td>Leukemia, neuroblastoma</td>
</tr>
<tr>
<td>Hypoxic-ischemic injury</td>
<td></td>
</tr>
</tbody>
</table>

*Birth trauma usually not relevant after 3-4 weeks [15].
Adapted from reference [5].
Case 6
Metastatic Neuroblastoma
Metastatic Neuroblastoma
Case 7
Glutaric Aciduria Type 1
Case 8
Bacterial Meningitis
Bacterial Meningitis – Diffuse Brain Edema

DDX
- Meningitis
- Trauma
- HII
- Diabetic Ketoacidosis

Lack of sulci along the vertex
Pseudo Subarachnoid Hemorrhage
Low-lying tonsils
Pediatric Head Injury Pearls

- Depict and describe the findings
- Look at the chart and call referring MD
- Know differential diagnosis

• Abusive head injury
Pediatric Head Injury - Summary

• Sutures
• Occult Fractures
• Occult Hemmorhage
• BESS vs Low attenuation subdural's
• Abusive head Injury
• Differential Diagnosis
Thank you!