A Guide to the Radiologic Evaluation of Extra-Axial Hemorrhage

John Dickson, Harvard Medical School Year III
Gillian Lieberman, MD
1. Define extra-axial hemorrhage and introduce its subtypes
2. Review coup and contrecoup head injuries
3. Review relevant brain, ventricular system, and meningeal anatomy
4. Present the menu of tests available for neuroimaging in the setting of head trauma
5. View several subtypes of extra-axial hemorrhages in our patient, AB
6. Describe the characteristic radiologic findings of each extra-axial hemorrhage subtype
7. Provide an update on our patient, AB
8. Summarize key points
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Extra-Axial Hemorrhage: The Basics

• Bleeding inside the skull but outside the brain parenchyma
• 4 Subtypes
  – Epidural hematoma
  – Subdural hematoma
  – Subarachnoid hemorrhage
  – Intraventricular hemorrhage
• Head trauma is most common cause
• Other causes include
  – Arteriovenous malformation
  – Infection
  – Coagulopathy
  – Complication of neurosurgery
  – Hemorrhagic tumors
  – SLE

(Kubal, 2012; McBride, accessed 2013)
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Coup and Contrecoup Injuries

• Coup injury: Injury at the point on impact
• Contrecoup injury: Injury opposite the point of impact


(Kubal, 2012)
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Neuroanatomy: Brain and Ventricular System

Midsagittal view of the human brain. From John Beal.  
http://commons.wikimedia.org/wiki/File:Human_brain_midsagittal_cut.JPG

The ventricular system. From Life Science Databases.  
http://commons.wikimedia.org/wiki/File:Lateral_ventricle.png
Neuroanatomy: The Meninges

The meninges. From Korribot.
http://commons.wikimedia.org/wiki/File:Meninges_diagram.jpg

The meninges and surrounding structures. From Mysid.
http://commons.wikimedia.org/wiki/File:Gray769-en.svg
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Menu of Tests: Neuroimaging in Head Trauma

• Skull Radiography: Penetrating trauma, foreign bodies

• Computed Tomography (CT) of the Head
  – CT without IV contrast: Hemorrhage, herniation, fractures
  – CT Perfusion (CTP): Prediction of enlarging contusion
  – CT Angiography (CTA): Pseudoaneurysm, dissection, extravasation

• Magnetic Resonance Imaging (MRI) of the Head
  – FLAIR: Contusions, traumatic axonal injury, subarachnoid hemorrhage
  – GRE T2* Weighted Imaging: Traumatic axonal injury
  – SWI: Traumatic axonal injury
  – TWI: Traumatic axonal injury, contusions
  – Diffusion Tensor Imaging: White matter tract integrity
  – Magnetization Transfer Imaging: Traumatic axonal injury

• Angiography: Traumatic fistula, dissection, pseudoaneurysm

(Aiken and Gean, 2010; Kubal, 2012)
Menu of Tests: CT vs MRI

- Comparison of CT and MRI for evaluation of head trauma
- Noncontrast head CT is the modality of choice for neuroimaging in the setting of acute head trauma

<table>
<thead>
<tr>
<th></th>
<th>CT</th>
<th>MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>Widespread</td>
<td>More limited</td>
</tr>
<tr>
<td>Speed</td>
<td>Fast</td>
<td>Slow</td>
</tr>
<tr>
<td>Compatibility with trauma devices</td>
<td>Compatible</td>
<td>Incompatible with some devices</td>
</tr>
<tr>
<td>Best for acute trauma</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Best for subacute trauma</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Best for chronic trauma</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Detects axonal injury well</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Ionizing radiation</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

(Aiken and Gean, 2010; Kubal, 2012)
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Our Patient AB: History and Physical

• History

AB is a 54 year-old man who fell from a height of >20 feet. He lost consciousness following the fall, temporarily regained consciousness with confusion, and lost consciousness again. He had a GCS score of 5-6 prior to being intubated in the field. He was brought to BIDMC by Boston MedFlight and was evaluated in the ED.

• Pertinent Physical Exam Findings
  – HEENT: Intubated, cervical collar in place
  – Neuro: Sedated
A noncontrast head CT was used to evaluate our patient.
Our Patient AB: Skull Fracture on Head CT

Skull fracture
Our Patient AB: Epidural Hematoma on Head CT

Epidural hematoma containing air

(PACS, BIDMC)

NONCONTRAST HEAD CT, AXIAL VIEW

Epidural hematoma containing air
Our Patient AB: Subdural Hematoma and Subarachnoid Hemorrhage on Head CT

Subdural hematoma
Subarachnoid hemorrhage

(PACS, BIDMC) NONCONTRAST HEAD CT, AXIAL VIEW
(PACS, BIDMC) NONCONTRAST HEAD CT, SAGITTAL VIEW
Our Patient AB: Parafalcine Subdural Hematoma on Head CT

Parafalcine subdural hematoma: Subdural hematoma extending into the longitudinal fissure along the falx cerebri.
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Companion Patient #1: Epidural Hematoma

- Blood in the potential space between the periosteum of inner table of the skull and the dura mater
- Arterial bleeding in 85% of cases
- Most often at the coup site
- Characteristic appearance on CT
  - Biconcave
  - Hyperdense
  - Does not cross sutures
  - May cross dural reflections
- Differential Diagnosis
  - Subdural hematoma


NONCONTRAST HEAD CT, AXIAL VIEW
Epidural hematoma

(Aiken and Gean, 2010; Dähnert, 1991; Hijaz, Cento, and Walker, 2011)
Companion Patient #2: Subdural Hematoma

• Blood between the dura mater and arachnoid mater
• Bleeding from bridging veins in more than 50% of cases
• More commonly found at contrecoup sites
• Characteristic appearance on CT
  – Crescentic
  – Hyperdense
  – May cross sutures (holohemispheric)
  – Does not cross dural reflections
  – May pool adjacent to dural reflections
• Differential diagnosis
  – Epidural hematoma
  – Arachnoid cyst
  – Subarachnoid hemorrhage


NONCONTRAST HEAD CT, AXIAL VIEW
Subdural hematoma

(Aiken and Gean, 2010; Dähnert, 1991; Hijaz, Cento, and Walker, 2011)
Companion Patient #3: Subarachnoid Hemorrhage

- Blood in the subarachnoid space (between arachnoid and pia mater)
- Bleeding from small pial or arachnoidal cortical vessels or extension of intracerebral bleeding
- More commonly found at contrecoup sites
- Characteristic appearance on CT
  - Hyperdensity in sulci
- Differential diagnosis
  - Pseudo-subarachnoid hemorrhage

NONCONTRAST HEAD CT, AXIAL VIEW
Subarachnoid hemorrhage

(Aiken and Gean, 2010; Dähnert, 1991; Hijaz, Cento, and Walker, 2011)
Companion Patient #4: Intraventricular Hemorrhage

- Blood within the ventricles
- Primary intraventricular hemorrhage is rare
- Secondary intraventricular hemorrhage is usually due to extension of a subarachnoid or intracerebral hemorrhage into the ventricles
- Characteristic appearance on CT
  - Hyperintensity within the ventricles
  - Hyperintensity in dependent position

NONCONTRAST HEAD CT, AXIAL VIEW
Intraventricular hemorrhage

(Aiken and Gean, 2010; Cuccharia, accessed 2013)
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Our Patient AB: Update

- Admitted to the trauma surgical intensive care unit (TSICU) following evaluation in the ED
- Gradually improved
- Extubated on hospital day 9
- Transferred to the floor on hospital day 10
- Discharged to a rehabilitation center on hospital day 16
- At the time of discharge, AB was alert and interactive. However, he has some receptive language delay and sometimes becomes confused.
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Summary of Key Points

1. Extra-axial hemorrhage is bleeding inside the skull but outside the brain parenchyma.
2. Coup injury occurs at the site of impact and contrecoup injury occurs opposite the site of impact.
3. Knowing brain, ventricular system, and meningeal anatomy is essential in understanding the appearance of extra-axial hemorrhage on CT images.
4. Several tests are available for neuroimaging in the setting of head trauma, but noncontrast head CT is the study of choice for the initial evaluation of acute head trauma.
5. Our patient, AB, developed three subtypes of extra-axial hemorrhage following trauma to the head.
6. Each extra-axial hemorrhage subtype has characteristic radiologic features on CT:
   - Epidural hematoma: biconcave hyperdensity that does not cross sutures
   - Subdural hematoma: crescent hyperdensity that may cross sutures
   - Subarachnoid hemorrhage: hyperdensity in sulci
   - Intraventricular hemorrhage: hyperdensity in the ventricles in dependent position
7. Our patient, AB, is improving at a rehabilitation facility.
References

• Aiken AH, Gean AD. Imaging of head trauma. *Semin Roentgenol* 2010;45:63-79.

• Cucchiara, Brett. Intraventricular hemorrhage. 


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