Intracranial Hemorrhage and Sequelae

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Agenda

• Patient Presentation

• *Brief* review of neuroanatomy

• Causes of hemorrhage and radiologic appearance

• Imaging principles of blood

• Physiology and consequences of hemorrhage
Patient 1

• 83 y/o M with IDDM, CAD, and CRI presents s/p fall in home with RU extremity redness.
• Further history reveals multiple minor falls over past month associated with dizziness and minor head trauma.
• Current medications include ASA
• Any imaging?
Our Patient: Admission CT

Axial CT of head, initially read as “normal”
Our Patient: Head CT Hospital Day 3

Pt found unresponsive in a.m.
Our Patient: Subdural Hematoma

Layering Hemorrhage
Possible Subarachnoid
Midline shift
Compression of ventricles

Courtesy of Dr. Handwerker
Companion Pt 1: Epidural Hematoma on CT

- Usually due to trauma (deceleration)
- Brief lucid interval
- Laceration of the meningeal arteries (although can be venous!)
- “Lentiform”
- Does not cross sutures

http://www.muhealth.org/~neuromed/
Companion Pt 2: Epidural Hematoma on CT

Hematoma

 Courtesy of Dr. Handwerker
Companion Pt 2: Cranial Fracture on CT

Fracture

Courtesy of Dr. Handwerker
Companion Pt 4: Subdural Hematoma on CT

- Usually due to **trauma** (shearing)
- Gradual onset of sx
- Tears in the **small** bridging veins
- Crescent-shaped
- Can cross sutures, but **not** midline

http://www.sbhemresidency.com/
Companion Pt 5: Subdural Hematoma?

Hypodense lesion, possible chronic bleed?
Companion Pt 5: Subdural Hematoma?

Axial Diffusion Weighted MRI

Hyperintense lesion in subdural space
Companion Pt 5: Subdural Empyema

Coronal T1 MRI Post-Contrast

Hyperintense lesion in subdural space and in sinuses, found to be pus at surgery.
Companion Pt 6: Subarachnoid Hemorrhage on CT

- Causes include traumatic, aneurysm, AVM, tumor.
- Same space as intraventricular hem.
- “Worst headache ever”
- “Star pattern”

Blood in Suprasellar Sulcus

http://www.emedicine.com/
Companion Pt 7: Traumatic Subarachnoid Hemorrhage on CT

Peripheral blood in sulci

http://www.uth.tmc.edu/radiology/
Companion Pt 8: MCA Aneurysm

- Common locations:
  - Anterior communicating
  - MCA
  - Posterior communicating
  - Basilar
Companion Pt 9: Non-Aneurysmal Bleed
(Perimesencephalic Hemorrhage)

Blood in interpeduncular fossa

Blood peripheral to midbrain

Courtesy of Dr. Handwerker
Companion Pt 10: Intraparenchymal Hemorrhage on CT

- Causes include traumatic, CVA, HTN, tumor, coagulopathy, AVM.
- Commonly involve basal ganglia, thalamus, pons, and cerebellum
- Round or irregular lesions

http://www.uhrad.com
Diffuse Axonal Injury

- Results from shearing trauma
- Diffuse, bilateral injury at the grey-white matter junction
- CT: multiple small intraparenchymal hem.
- MRI may be more sensitive
Companion Pt 11: Diffuse Axonal Injury on CT

Courtesy of Dr. Kang
30 Days in the Life of a Hemorrhage

• Five distinct stages of a intracranial hemorrhage:
  – Hyperacute: <12 hours
  – Acute: 12 h – 2 days
  – Early subacute: 2 – 7 days
  – Late subacute: 8 days – 1 month
  – Chronic >1 month – years

• Imaging principles:
  – Clot density changes dominate on CT
  – Changes in hemoglobin dominate on MR
CT Appearance of Aging Hemorrhage

• Clot is initially liquid mix of RBC’s, WBC’s, platelets, and serum.
  – hyperacute = isointense

• As the clot contracts, the core becomes denser while the surrounding areas become edematous.
  – acute – early subacute = hyperintense

• Over time, the clot degrades, and the edema subsides.
  – late subacute – chronic = isointense-hypointense, may enhance with contrast due to BBB breakdown
## MRI Appearance of Aging in Hemorrhage

<table>
<thead>
<tr>
<th>Time</th>
<th>Iron</th>
<th>Magnetic Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperacute</td>
<td>Intracellular oxygenated hemoglobin</td>
<td>Diamagnetic</td>
</tr>
<tr>
<td>Acute</td>
<td>Intracellular deoxygenated hemoglobin</td>
<td>Paramagnetic</td>
</tr>
<tr>
<td>Early Subacute</td>
<td>Intracellular methemoglobin</td>
<td>Paramagnetic</td>
</tr>
<tr>
<td>Late Subacute</td>
<td>Extracellular methemoglobin</td>
<td>Paramagnetic</td>
</tr>
<tr>
<td>Chronic</td>
<td>Hemosiderin and ferritin in macrophages</td>
<td>Superparamagnetic</td>
</tr>
</tbody>
</table>
# Summary: Appearance of Hemorrhage on CT and MRI

<table>
<thead>
<tr>
<th>Time</th>
<th>CT</th>
<th>MR T1</th>
<th>MR T2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hyperacute:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 12 hours</td>
<td><img src="#" alt="Gray" /></td>
<td><img src="#" alt="Gray" /></td>
<td><img src="#" alt="Gray" /></td>
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<tr>
<td><strong>Acute:</strong></td>
<td></td>
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<tr>
<td>12 h – 2 days</td>
<td><img src="#" alt="White" /></td>
<td><img src="#" alt="Gray" /></td>
<td><img src="#" alt="Black" /></td>
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<tr>
<td><strong>Early subacute:</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>2 – 7 days</td>
<td><img src="#" alt="Gray" /></td>
<td><img src="#" alt="White" /></td>
<td><img src="#" alt="White" /></td>
</tr>
<tr>
<td><strong>Late subacute:</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>8 days – 1 month</td>
<td><img src="#" alt="Gray" /></td>
<td><img src="#" alt="Black" /></td>
<td><img src="#" alt="White" /></td>
</tr>
<tr>
<td><strong>Chronic:</strong></td>
<td></td>
<td></td>
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<tr>
<td>&gt;1 month – years</td>
<td><img src="#" alt="Gray" /></td>
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<td><img src="#" alt="White" /></td>
</tr>
</tbody>
</table>

- **Hyperintense**
- **Isointense**
- **Hypointense**
Herniation

http://uptodate.com

http://www.uth.tmc.edu/radiology/
Anatomy Review Part 2

(Tentorium
(Note the proximity of critical brainstem and cranial nerve structures)
Companion Pt 12: Subfalcine Herniation on CT

- Singulate gyrus on medial aspect of frontal lobe is displaced across the midline across the free edge of the falx
- May compromise ACA flow

Midline shift of singulate gyrus under falx

http://www.emedicine.com
Transtentorial Herniation

• Medial aspect of temporal lobe (uncus) migrates across tentorium
• Causes 3rd nerve compression
• Can also be ascending herniation, most often from tumor in posterior fossa
Companion Patients 13 and 14: Transtentorial Herniation on CT

http://rad.usuhs.mil/rad/herniation/

http://www.geocities.com/drweightloss
Central Herniation

• Diffuse increase in ICP displaces each cerebral hemisphere downward through tentorium

• Compresses upper brainstem
Companion Pt 15: Tonsilar Herniation on MRI

- Increased pressure develops in the posterior fossa, displacing cerebellar tonsils downward through the foramen magnum
- Compresses lower brainstem and upper cervical cord

Sagittal T1 MRI

Lesion (flow artifact indicates likely aneurysmal)
Companion Pt 16: Extracranial Hernation on CT
Summary

• Intracranial hemorrhage is defined by its location with respect to the meninges
  – Trauma is usually the most common cause

• Hemorrhage undergoes a predictable temporal sequence of changes that can be seen on MR and CT and used to estimate the age of the bleed.

• An increase in mass can cause increased ICP and can result in extremely dangerous herniations.
  – Dural reflections are commonly involved
Acknowledgements

Thanks to:

• Gillian Lieberman, MD
• Jason Handwerker, MD
• James Kang, MD
• Pamela Lepkowski
• Larry Barbaras
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