



Beth Israel Deaconess
Medical Center

John Dickson, MSIII
Gillian Lieberman, MD

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A Guide to the Radiologic Evaluation of Extra-Axial Hemorrhage

John Dickson, Harvard Medical School Year III

Gillian Lieberman, MD



Agenda

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

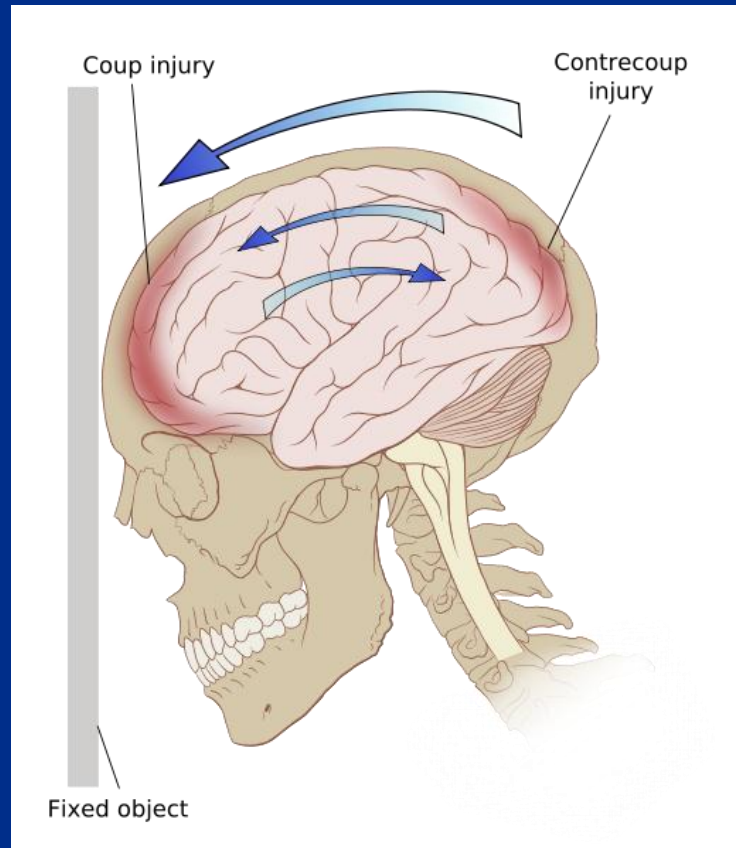


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Coup and Contrecoup Injuries

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



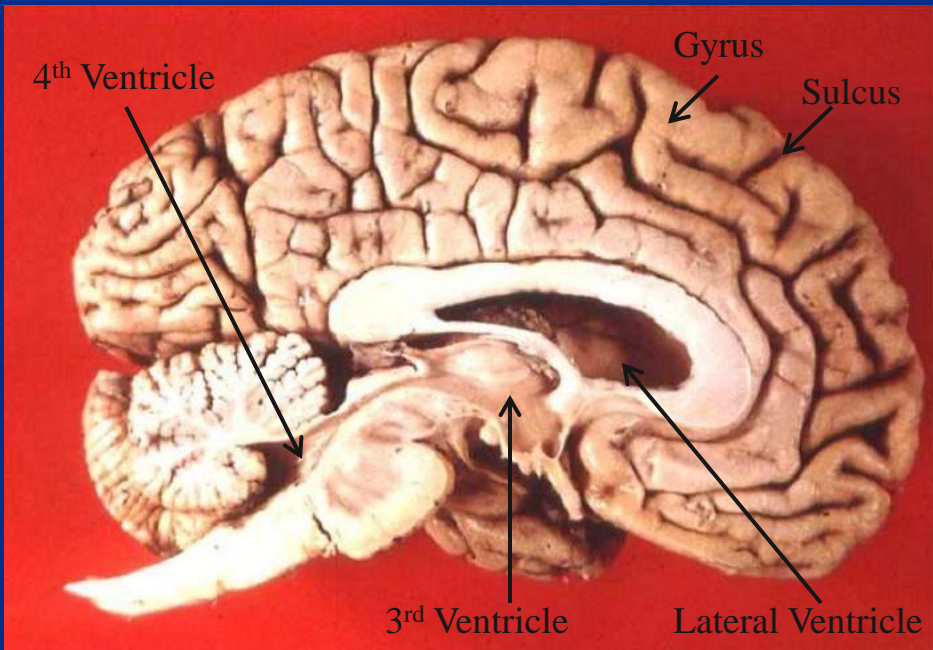
Coup and contrecoup injuries. From Patrick Lynch.
<http://en.wikipedia.org/wiki/File:Contrecoup.svg>



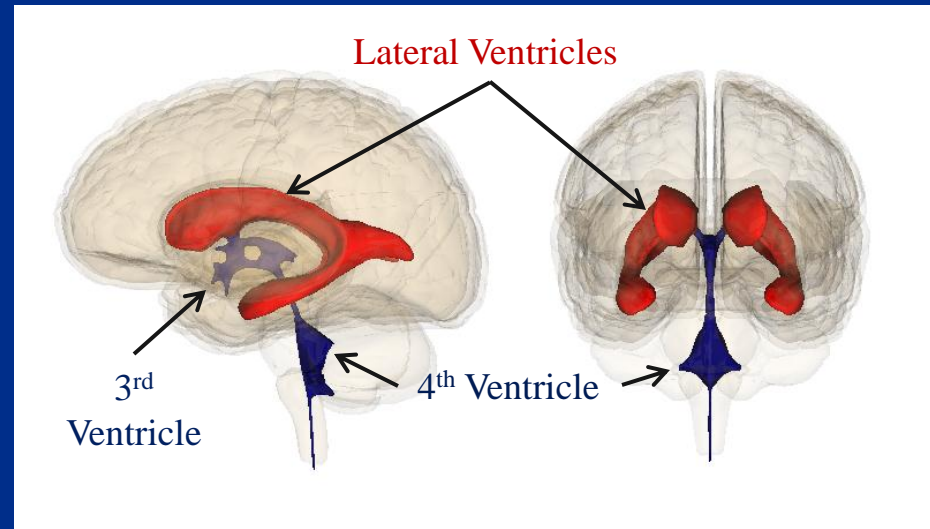
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Neuroanatomy: Brain and Ventricular System

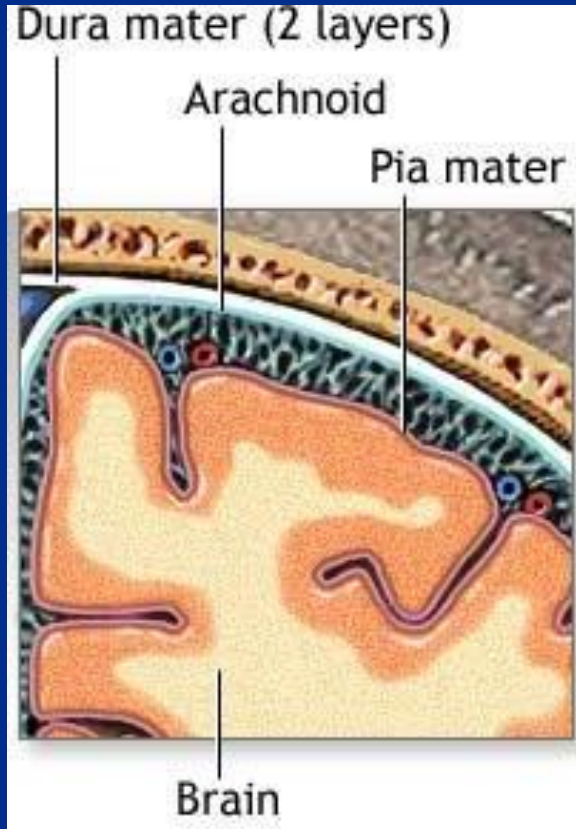


Midsagittal view of the human brain. From John Beal.
http://commons.wikimedia.org/wiki/File:Human_brain_midsagittal_cut_.JPG

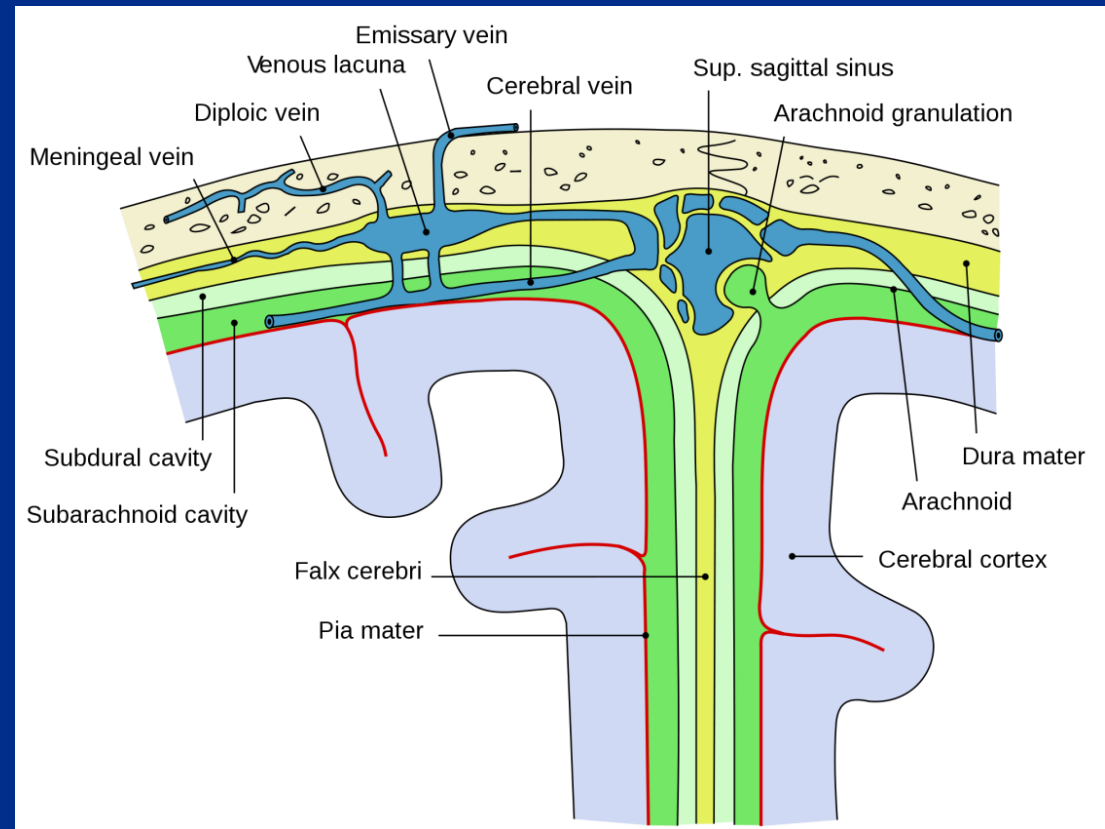


The ventricular system. From Life Science Databases.
http://commons.wikimedia.org/wiki/File:Lateral_ventricle.png

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

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

	CT	MRI
Availability	Widespread	More limited
Speed	Fast	Slow
Compatibility with trauma devices	Compatible	Incompatible with some devices
Best for acute trauma	Yes	No
Best for subacute trauma	No	Yes
Best for chronic trauma	No	Yes
Detects axonal injury well	No	Yes
Ionizing radiation	Yes	No



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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

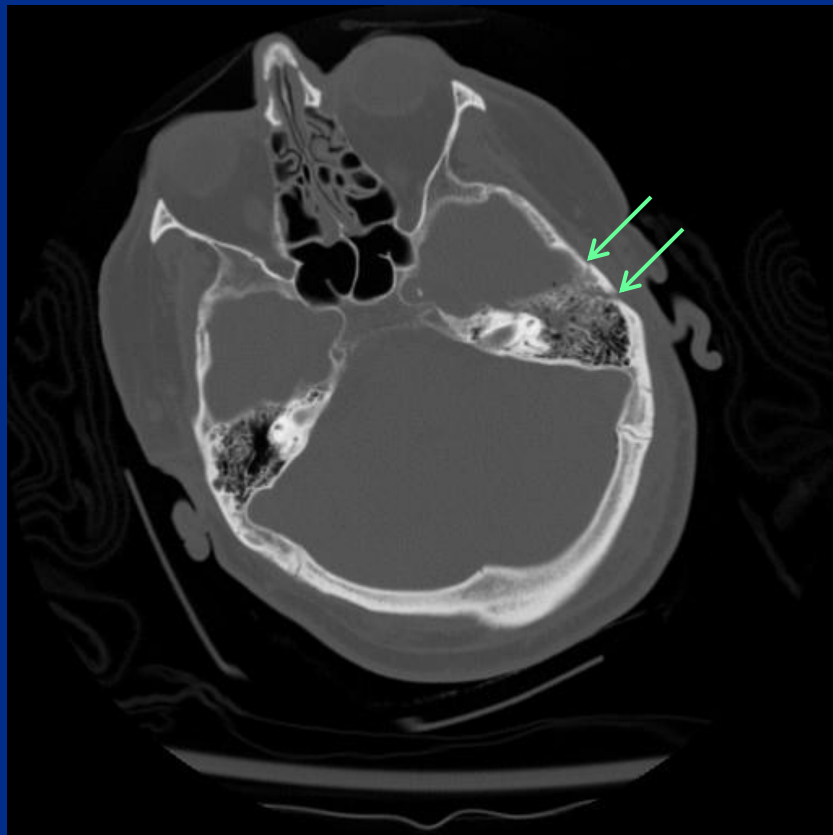
- HEENT: Intubated, cervical collar in place
- Neuro: Sedated



A noncontrast head CT was used
to evaluate our patient.

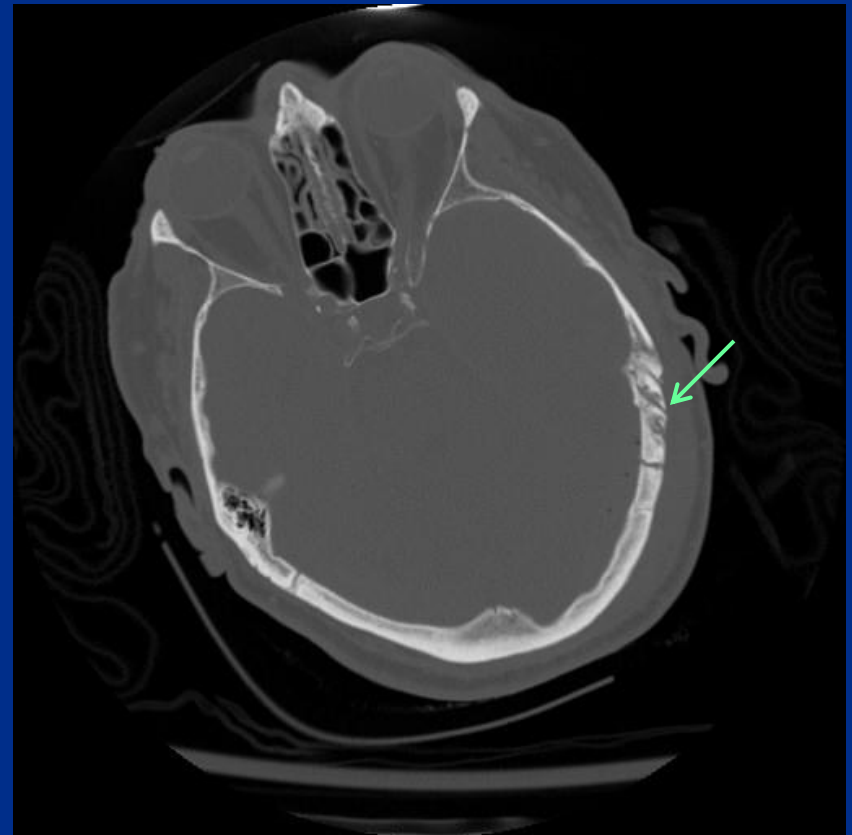


Our Patient AB: Skull Fracture on Head CT



(PACS, BIDMC)

NONCONTRAST HEAD CT, AXIAL VIEW



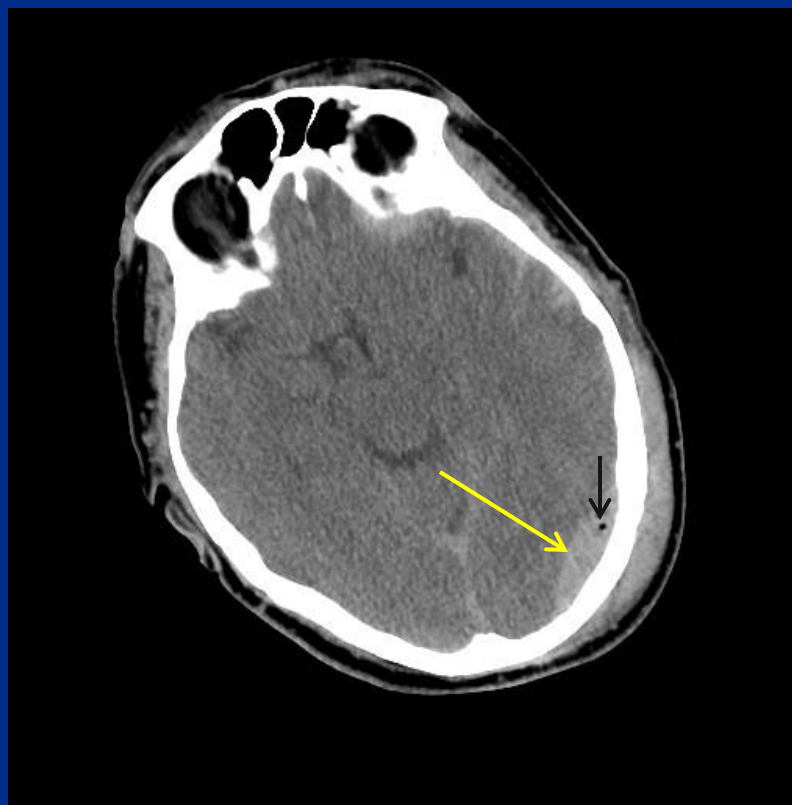
(PACS, BIDMC)

NONCONTRAST HEAD CT, AXIAL VIEW

Skull fracture



Our Patient AB: Epidural Hematoma on Head CT

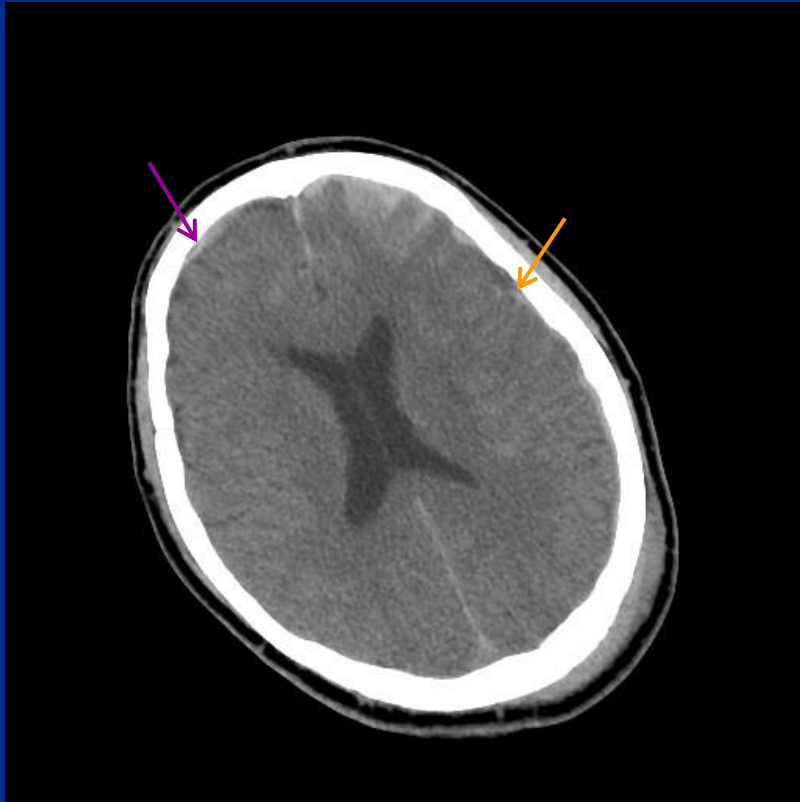


(PACS, BIDMC)

NONCONTRAST HEAD CT, AXIAL VIEW

Epidural hematoma containing air

Our Patient AB: Subdural Hematoma and Subarachnoid Hemorrhage on Head CT

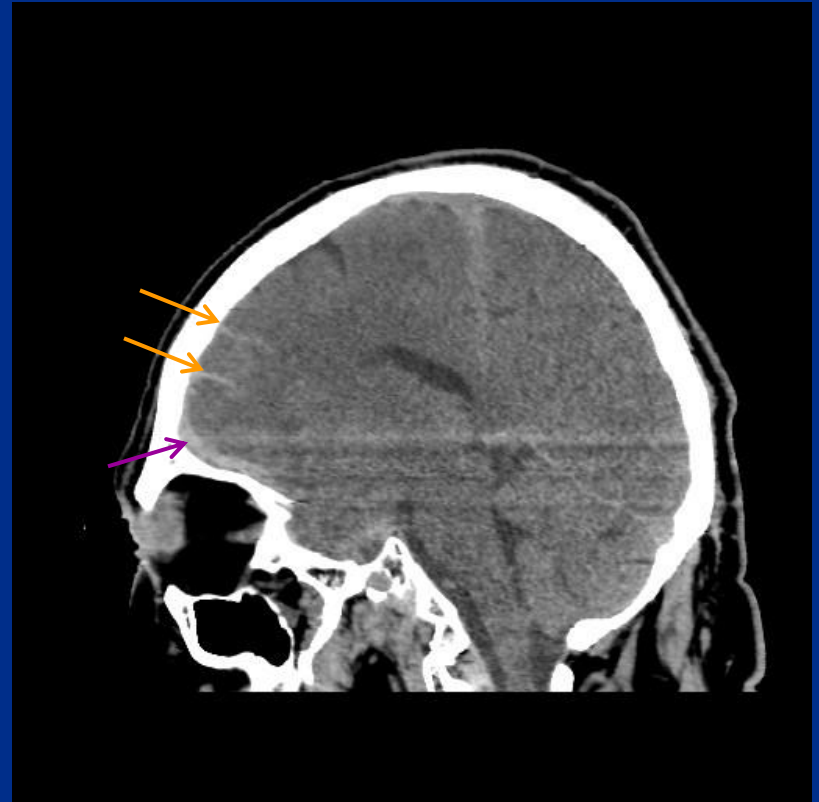


(PACS, BIDMC)

NONCONTRAST HEAD CT, AXIAL VIEW

Subdural hematoma

Subarachnoid hemorrhage

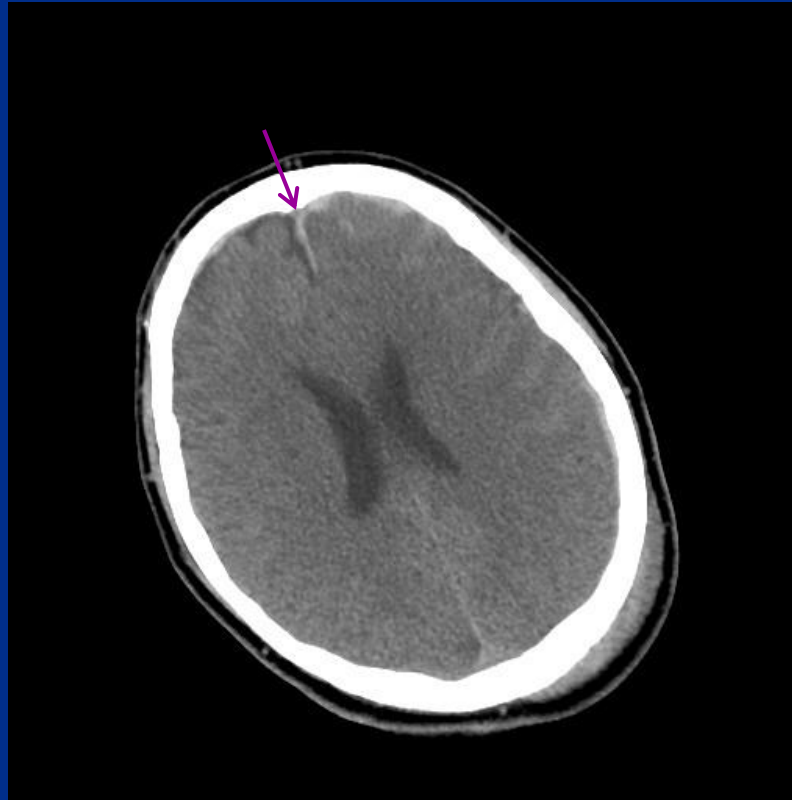


(PACS, BIDMC)

NONCONTRAST HEAD CT, SAGITTAL
VIEW



Our Patient AB: Parafalcine Subdural Hematoma on Head CT



(PACS, BIDMC)

NONCONTRAST HEAD CT, AXIAL VIEW

Parafalcine subdural hematoma: Subdural hematoma extending into the longitudinal fissure along the falx cerebri 19



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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



From Jpogi. http://en.wikipedia.org/wiki/File:Traumatic_acute_epidural_hematoma.jpg

NONCONTRAST HEAD CT,
AXIAL VIEW

Epidural hematoma



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



From James Heilman. <http://commons.wikimedia.org/wiki/File:Subduralandherniation.PNG>

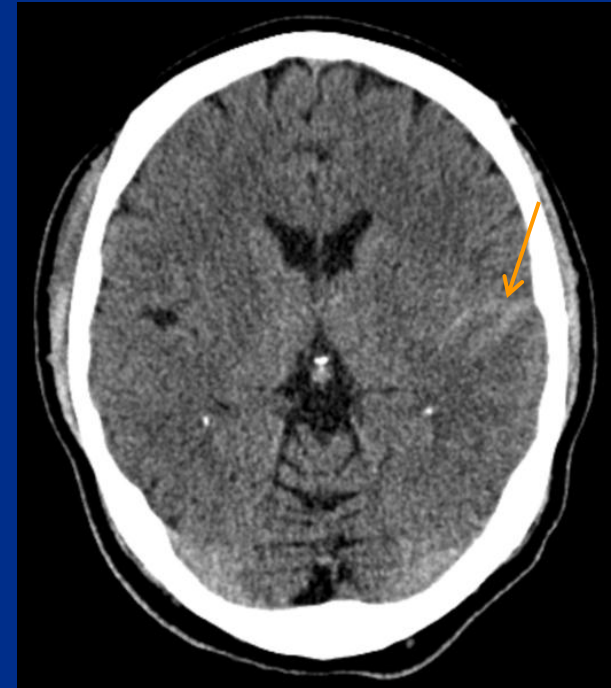
NONCONTRAST HEAD CT,
AXIAL VIEW

Subdural hematoma



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



From Hellerhoff. http://commons.wikimedia.org/wiki/File:Traumatische_SAB_003.png

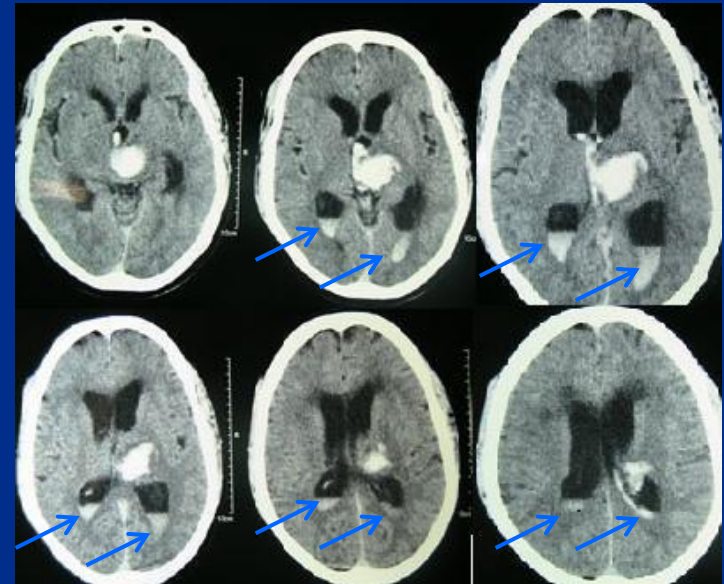
NONCONTRAST HEAD CT,
AXIAL VIEW

Subarachnoid hemorrhage



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



From Yadav et al. http://commons.wikimedia.org/wiki/File:Intracerebral_hemorrhage.jpg

NONCONTRAST HEAD CT,
AXIAL VIEW

Intraventricular hemorrhage



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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



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