Neuroimaging Basics

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Outline

CT
- Basics
- Stroke
  - Bland
  - Hemorrhage
- TBI

MRI
- Basics
  - T1, T2
- FLAIR
- GRE/SWI
- DWI/PWI
- DTI
CT Scan Basics

Right is left and Left is right
CT Scan Basics

Right is left and Left is right

Gray matter is lighter than white matter
CT Scan Basics

Right is left and Left is right

Gray matter is lighter than white matter

White matter is darker than gray matter
CT Scan Basics

Right is left and Left is right

Gray matter is lighter than white matter

White matter is darker than gray matter

Water (CSF) is dark
CT Scan Basics

Right is left and Left is right

Gray matter is lighter than white matter

White matter is darker than gray matter

Water (CSF) is dark

Bone and calcifications are bright
Acute blood is bright

Edema is dark
(Implies the blood is intraparenchymal i.e.: intraparenchymal vs. extra-axial)
Chronic blood is dark (the darker the older)
CT and Standard MRI Scan

- You can see the big stuff
- You can’t see
  - Microscopic
  - Function
--52-year-old woman with acute stroke

Parrish, F. J. Am. J. Roentgenol. 2007;189:528-534
Acute stroke
Acute stroke
Acute Stroke
HTN-related Hemorrhage

- Basal Ganglia
- Thalamus
- Cerebellum
- Pons
Other Cerebral Hemorrhages

- AVM
- Trauma
- Neoplasm
- Amyloid Angiopathy
TBI - Focal Injury

- Focal Contusions
  - Inferior Frontal Lobe
TBI - Focal Injury

- **Focal Contusions**
  - Inferior Frontal Lobe
  - Anterior Tip Temporal Lobe
Extra-axial Hemorrhage Anatomy

Dura mater
Arachnoid
Arachnoid trabeculae
Pia mater
Cerebral cortex
Subdural space
Subarachnoid space
Artery
Perivascular space
Epidural Hemorrhage

- Epidural space is a potential space between the skull and dura.
Epidural Hemorrhage

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- Dura is very strongly adherent to the skull at the sutures
Epidural Hemorrhage

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- Arterial (usually)
Epidural Hemorrhage

- Epidural space is a potential space between the skull and dura
- Dura is very strongly adherent to the skull at the sutures
- Arterial (usually)
- Associated with skull fracture and injury to the middle meningeal artery (sometimes dural sinus)
Subdural Hemorrhage

- Subdural space is located between the dura and the arachnoid
Extra-axial Hemorrhage Anatomy
Subdural Hemorrhage

- Subdural space is located between the dura and the arachnoid
- Venous
Subdural Hemorrhage

- Subdural space is located between the dura and the arachnoid
- Venous
  - Tearing of bridging veins
    - Cerebral Atrophy results in increased tension of bridging veins
    - Increased incidence of SDH in elderly
Subarachnoid Hemorrhage

- Subarachnoid space is located between the arachnoid and the pia
Extra-axial Hemorrhage Anatomy

- Dura mater
- Arachnoid
- Arachnoid trabeculae
- Pia mater
- Subdural space
- Subarachnoid space
- Artery
- Perivascular space
- Cerebral cortex
Subarachnoid Hemorrhage

- Subarachnoid space is located between the dura and the pia
- Arterial
Traumatic Axonal Injury

Mechanism of Closed Head Injury

Deceleration

Acceleration

Head thrown backward while brain hits front of skull

Head thrown forward while brain hits back of skull
CT of DAI
Traumatic Axonal Injury

Axons and cerebral vessels subjected to shear and torque

- Results in microhemorrhages typically too small to be imaged by conventional scans
DAI

Petechial Hemorrhage
T1 MRI

Gray matter is darker than white matter

CSF is dark

Air is darkest
T1 MRI

Gray matter is darker than white matter

CSF is dark

Air is darkest
Gray matter is darker than white matter.

CSF is dark.

Air is darkest.
T2 Weighted MRI

Gray matter is lighter than white matter

CSF is bright (Water, edema)

Air is still darkest
T2 Weighted MRI

Gray matter is lighter than white matter

CSF is bright (Water, edema)

Air is still darkest
T2 Weighted MRI

Gray matter is lighter than white matter

CSF is bright (Water, edema)

Air is still darkest
MRI and acute stroke

MRI of Acute Stroke

T2
T1-non
T1-gad

Source: South Med J © 2003 Lippincott Williams & Wilkins
Diffusion Weighted Images

- Detects the movement/speed of water diffusion
  - Decreased
    - Cytotoxic edema
  - Increased
    - Vasogenic edema
Diffusion Weighted MRI

CT Scan Slice of Brain (taken just before MRI at right)

MRI (diffusion) Scan (can show stroke much earlier than CT scan)
DWI, PWI, and ADC
FLAIR (FLuid Attenuated Inversion Recovery) vs T2

- FLAIR
  - Heavy T2 weighted image
  - Attenuates signal coming from fluid
Gradient Echo
Susceptibility Weighted MR

- Takes advantage of contrast differences in tissue with different susceptibility than surrounding tissue with long echo times
- Hemoglobin breakdown products have high susceptibility
- Permits imaging of microscopic hemorrhages associated with DAI
  - GRE kicked up a notch
Susceptibility Weighted Imaging

High-spatial-resolution susceptibility MR

- Significantly greater sensitivity than GRE in detecting lesions re:
  - Size (<10mm²)
  - Number
  - Volume
  - Distribution

- Longer acquisition time increases potential for motion artifact (n.b. less time in 3T vs. 1.5T)
Susceptibility Weighted Imaging

High-spatial-resolution susceptibility MR

- Significantly greater sensitivity than GRE in detecting lesions re:
  - Size (<10mm²)
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- Longer acquisition time increases potential for motion artifact (n.b. less time in 3T vs. 1.5T)
Diffusion Tensor Imaging

**Anisotropy**

- Water diffuses faster along an axon than across it.

- Fractional Anisotropy (FA) indicative of axonal (fiber tract) integrity.
normal volunteers

traumatic brain injury patients
Thank you