A Little Housekeeping

Disclosures

- I have no financial or other conflicts of interest related to this talk

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Your Neuroimaging Guide

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Objectives

• Understand the basics of and indications for neuroimaging
• Develop a fundamental ability to utilize and understand scans
• Be able to read, understand, and utilize imaging reports
Why Study Neuroimaging?

• Radiology interpretation may be subjective and qualitative
  • Thus, seeing the actual images is helpful to better gauge or understand findings

• Fluency with other diagnostic studies for assistance with conceptualization

• Being able to read and understand reports makes you a better health care provider and streamlines care
  • E.g., knowing if and when to recommend neuroimaging to the referring provider
Basic Principles and Terms

• 2-dimensional scans are used to analyze a 3-dimensional object (i.e. the brain)
  • Axial/horizontal
  • Coronal/frontal
  • Sagittal
• Scans are typically backwards (left is right and right is left)
Computed Tomography (CT)
CT Background

- CT is based on X-rays
- X-rays interact with tissues in different ways depending on their densities
- In general, denser tissues appear whiter
- Scans typically presented as a series of slices along 3 axes
CT: Medical Uses and Indications

• CT is quick, relatively cheap, and widely available
• Most frequently used for emergent conditions
  • E.g. TBI, SAH, stroke
• Very sensitive to blood products and foreign bodies
  • E.g. hemorrhage
• Also helpful for examining possible calcifications
• Used when patients cannot undergo MRI due to shrapnel or metal implants
Appearance of Tissues on CT

Tips:
- In general, denser tissues appear whiter.
- Fresh blood appears white (hyperdense), it will be less apparent as it resolves.
- Lack of grey/white differentiation suggests an acute stroke (typically ischemic).
- Tumors are hypodense (without contrast).
- Look for midline shift.

Prendergast (2009)
Loss of Grey-White Differentiation

- Strokes may take ~4 hrs to appear on CT
- Lack of differentiation on middle slide
- Due to edema
Contrast agents

• Typically iodine-based
• Used to enhance the visibility of blood vessels or highly perfused tissues
• Clinically most often used to evaluate for abscesses or malignancies.
Artifacts

- Degradation of scan quality
- Frequently related to:
  - Movement
  - Metal
    - Aneurysm coil or implant
    - GSW or other metal
  - Miscalibration or defective scanner

Boas & Fleischmann (2012)
Some Practice
More Practice
Too much space or too much fluid?

- Hydrocephalus and the Callosal Angle
  - NPH is 50-80
  - Normal is 100-120
CT: Drawbacks and Contraindications

• CT is not as detailed as MRI
• Radiation dose (head CT is ~1-2mSv, or nearly the average yearly dose from naturally occurring background radiation
• Contraindications:
  • Pregnancy
  • Contrast allergy
  • Other considerations for contrast and radiation exposure
Rest Stop
Magnetic Resonance (MR) Imaging
MR Background

- MRI utilizes magnetic fields and radio waves to visualize parts of the body
  - A superconducting electromagnet
  - Smaller coils allow for cross-sectional slices
  - Radio frequency used to conduct different types of scans
- Strength of the magnet is measured in Tesla (typically 1.5 – 3)
  - Directly affects the detail
MR: Medical Uses and Indications

- Much better resolution/contrast than CT
- Fewer artifacts than CT (except movement)
- Multiple techniques means MR is more flexible
- Used for visualizing normal anatomy, non-emergent pathology, inflammation, demyelination, and other white matter changes
- Also helpful for examining changes in blood flow (MRA)
MR Sequences: T1

- Good for anatomy, border between brain and CSF
  - Less sensitive to lesions
- Black on T1 (no water)
  - Air, calcium, bone
- Dark on T1
  - CSF, edema, lesions
- Grey on T1
  - White/gray matter
- Bright on T1
  - Fat, blood, contrast agents
MR Sequences: T2

- Best for pathology, including most lesions
  - Can’t distinguish lesions from CSF
- Black on T2 (no protons)
  - Air, calcium, bone
- Dark on T2
  - White/grey matter
- Bright on T2
  - CSF, blood, edema, lesions
MR Sequences: T2 FLAIR

- Same as T2, but suppresses CSF
- Very useful for lesions, particularly near ventricles
  - Can improve grey/white distinction
- Looks like T1
- Pathology is bright
T1 With and Without Contrast
T2 and FLAIR
MR Sequences: DWI and ADC

- Diffusion-weighted (DWI) is sensitive to water diffusion due to edema
  - Ischemic stroke, seizures, abscesses
  - Edema is bright
  - Based on T2
- Apparent Diffusion Coefficient
  - Based on actual diffusion
  - Edema is dark
- Tip: Areas that are bright on DWI and dark on ADC are edema
Types of MR Scans: GRE

- Gradient Recalled Echo
  - Technique to highlight tissue differences
  - Particularly useful for hemosiderin and other non-oxygenated blood products
- T2* (“T two star”)
- SWI
  - Susceptibility-weighted
  - More sensitive than T2*
Contrast agents

• Typically gadolinium based
  • Gadolinium is a paramagnetic element and responds to the magnetic pulses
  • Useful for imaging highly vascularized objects, vasculature, scars, inflammation, or infiltration
  • Thus, useful for tumors, active MS lesions, vessels, or lesions in the blood-brain barrier
Artifacts

• Also encountered with MRI

• May be related to:
  • Movement: MR is particularly prone to movement artifacts
  • Metal: Often causes black holes
  • CSF Flow: Typically appears as a white “ghost”
  • Poorly calibrated hardware

Krupa & Bekiesinska-Figatowska (2015)
MORE PRACTICE!!!
MR: Drawbacks and Contraindications

- MRI is more expensive and slower than CT
- Possible claustrophobia
  - Pre-MR benzos are commonly prescribed
- Agitated/dyskinetic patients unless sedated
- Contraindications:
  - Items which are MR-unsafe (e.g. ferric implants, shrapnel, some pacemakers, etc.)
  - Contrast allergy
  - Other considerations for contrast and radiation exposure
  - Generally pregnancy-safe, although contrast agents are not recommended
  - Contrast not recommended for those with kidney impairments
The Short Version…

- **CT**
  - Rapid, 15 minutes for full head imaging
  - Blood, bone, fractures, malignancy, hydrocephalus

- **MRI**
  - Long, 45 minutes for full head imaging, double if contrast
  - Contrast for malignancy, infection, MS, CN lesions, vascular study
Functional Imaging

- **fMRI**
  - Measures changes associated with blood flow caused by brain activity
  - More activity generally leads to more blood flow
  - Changes in blood O2 (BOLD contrast)
  - Sometimes used for pre-surgical planning

- **PET**
  - Measures glucose metabolism using a radioactive tracer (e.g. FDG)
  - Emitted positrons create opposing gamma rays that are picked up by a detector
  - Useful when there are no noted structural abnormalities
  - Typically not diagnostic
EVEN MORE PRACTICE!!!
Atrophy? Pathology?

Low SC MV burden, no significant atrophy

Cortical atrophy, ventricular enlargement, low SC MV burden

Significant SC MV burden, modest cortical atrophy
What’s Wrong with this Picture?

- Bifrontal degeneration
- Asymmetric temporal pole atrophy
- Asymmetric perisylvian atrophy
- Parieto-occipital atrophy
Pathology?

- Uniform cortical metabolism
- Parieto-occipital hypometabolism
- Frontal hypometabolism
Questions?