## Neuroimaging 101



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# Gray matter vs. White matter What is the difference???

#### Gray matter

A bit-o-trivia: Gray matter in a live brain is actually more of a pink color

But...

White matter is actually white!!!



## Brain Injury Damage - Primary (primary means immediate!)

- Tissue/vascular destruction
  - Tearing
  - Shearing
  - Compression
  - Penetration
- Coup
- Contrecoup injury

#### Brain Injury Damage - Secondary (secondary means delayed)

- swelling (edema)
- movement of brain tissue, CSF, and blood vessels away from their usual position inside the CV (brain herniation)
- lack of blood flow to tissue (ischemia)
- blood clotting (coagulopathy)
- obstruction of the blood supply (infarction)
- Encephalomalacia (softening)

- partial lack of oxygen to tissue (hypoxia)
- total lack of oxygen to tissue (anoxia)
- increased ICP
- cell death (necrosis)
- programmed cell death (apoptosis)
- Infection
- Diffuse axonal injury (DAI)
- Traumatic axonal injury (TAI)
- Contusion (bruising)

## Contrecoup damage



## How to Read a Neuroimage

Step 1: Identify the image orientation

















#### Axial









## Common types of neuroimages used in ER and research

- X-ray
  - Computed tomography (CT)
- MRI
  - T1-weighted
  - T2-weighted
  - Fluid Attenuated Inversion Recovery (FLAIR)
  - Gradient Recalled Echo (GRE)
  - Susceptibility Weighted Imaging (SWI)
  - Diffusion Tensor Imaging (DTI)
  - Functional MRI (fMRI)
  - Resting State fMRI (rs-fMRI)
  - Voxel-based Morphometry (VBM)



### Appearance of Commonly Scanned Tissues

Tissue	T1 – Weighted	T2 – Weighted	X-RAY
Gray Matter	Gray	Light gray	Shades of gray
White Matter	White	Dark gray	Shades of gray
CSF or water	Black	White	Shades of gray
Fat	White	Black	Shades of gray
Air	Black	Black	Black
Bone or Calcification	Black	Black	White
Edema	Gray	White	Shades of gray

## Tl-weighted vs T2-weighted

- T1-weighted shows better anatomical detail than T2-weighted scans
- T2-weighted show pathologic abnormalities, including fluid abnormalities

### GRE (gradient recalled echo)

Adept at showing byproducts left over from bleeding (i.e., hemosiderin, ferritin) especially what are referred to as Susceptibility Weighted Images (SWI is a type of GRE)

#### Susceptibility Weighted Imaging (SWI)

#### FLuid Attenuated Inversion Recovery (FLAIR)

White indicates extensive white matter pathology (this is not observable on SWI, TI, or T2)

Diffusion tensor imaging (DTI) Provides information about specific white matter tracts in the brain and their connectivity between regions

## How to read a neuroimage

Step 1: Identify image type and orientation

Step 2: Look for symmetry and similarity

Step 3: Conduct a general inspection of the entire image, looking for dissimilarity (both striking and subtle)

Step 4: Decide if any dissimilarity is within normal limits

#### Pathology commonly seen on TBI Neuroimaging

#### Hematoma (bleeding/collection of blood)

- Epidural
  - Bleeding between skull & dura mater
  - Usually an artery; occasionally large veins (e.g., venous sinus)
  - Generally caused by skull fracture tearing blood vessels
  - Symptom onset is minutes to hours
- Subdural
  - Bleeding between dura mater & arachnoid
  - Usually a vein; occasionally arteries
  - Symptoms may not be apparent for several days or weeks
  - 3 types
    - Acute (severe TBI occurs within 2 days of injury)
    - Sub-acute (mod TBI occurs within 3 days 3 weeks)
    - Chronic (mod TBI occurs more than 3 weeks following injury)

## Common Neuroimaging Pathology (cont.)

- Contusion
  - Bleeding due to capillary damage (small blood vessels)
- Micro-bleeding
  - Bleeding in the area near or around a blood vessel)
- Edema (swelling)
  - Fluid accumulation
- Expanded ventricles

### Common Neuroimaging Pathology (cont.)

- Midline shift /subfalcine (falx cerebri) herniation
- Encephalomalacia
  - Softening of brain tissue
- •Hemosiderin & ferritin
  - Iron by product left over from the presence of blood
  - Believed to be result of axonal shearing





A

Β

С





Cortical White Matter Gray Matter

Subcortical

Ventricles Hippocampus Amygdala Thalamus Caudate Putamen Globus Pallidus Brain Stem Mamillary Bodies Corpus Callosum Fornix







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А

B

С

Subcortical Ventricles Hippocampus Amygdala Thalamus Caudate Putamen Globus Pallidus Brain Stem Mamillary Bodies Corpus Callosum Fornix











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Cortical White Matter **Gray Matter** Subcortical Ventricles Hippocampus Amygdala Thalamus Caudate Putamen Globus Pallidus **Brain Stem** Mamillary Bodies Corpus Callosum Fornix

В

A









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