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
Coronal
Axial
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

<table>
<thead>
<tr>
<th>Tissue</th>
<th>T1 – Weighted</th>
<th>T2 – Weighted</th>
<th>X-RAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray Matter</td>
<td>Gray</td>
<td>Light gray</td>
<td>Shades of gray</td>
</tr>
<tr>
<td>White Matter</td>
<td>White</td>
<td>Dark gray</td>
<td>Shades of gray</td>
</tr>
<tr>
<td>CSF or water</td>
<td>Black</td>
<td>White</td>
<td>Shades of gray</td>
</tr>
<tr>
<td>Fat</td>
<td>White</td>
<td>Black</td>
<td>Shades of gray</td>
</tr>
<tr>
<td>Air</td>
<td>Black</td>
<td>Black</td>
<td>Black</td>
</tr>
<tr>
<td>Bone or Calcification</td>
<td>Black</td>
<td>Black</td>
<td>White</td>
</tr>
<tr>
<td>Edema</td>
<td>Gray</td>
<td>White</td>
<td>Shades of gray</td>
</tr>
</tbody>
</table>
T1-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

Hematomas (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
References


References
