Neuroimaging Teaching Files

Department of Neurology
Brain Imaging Workshop

Objectives

• Identify different radiologic modalities used in diagnosis and management of neurological disorders (K5, K7, S8)
• Correlate anatomic structures with function based on different radiological modalities (K1)
• Review common neuroradiological findings of common neurological disorders (K3, K5, S8)
Imaging Modalities

- **Structural Imaging**
  - CT
  - MRI
  - MRS
  - Conventional Angiography

- **Functional Imaging**
  - fMRI
  - PET
  - SPECT
<table>
<thead>
<tr>
<th></th>
<th>MRI-(T_1)</th>
<th>MRI-(T_2)</th>
<th>XRAY-CT(_2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense bone</td>
<td>Dark</td>
<td>Dark</td>
<td>Bright</td>
</tr>
<tr>
<td>Air</td>
<td>Dark</td>
<td>Dark</td>
<td>Dark</td>
</tr>
<tr>
<td>Fat</td>
<td>Bright</td>
<td>Bright</td>
<td>Bright</td>
</tr>
<tr>
<td>Water</td>
<td>Dark</td>
<td>Bright</td>
<td>Dark</td>
</tr>
<tr>
<td>Brain</td>
<td>(^3)“anatomic”</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
</tbody>
</table>

1. Bright means high signal intensity, dark means low, and intermediate means intermediate.
2. Bright means high density/high attenuation of x-rays, dark means low.
3. Gray matter appears grey, white matter white.
Vascular Disease
Cerebral Arterial Circle (Willis) - Vessels Dissected Out
Inferior View

- Anterior cerebral artery
- Anterior cerebral artery
- Ophthalmic artery
- Internal carotid artery
- Middle cerebral artery
- Posterior communicating artery
- Posterior cerebral artery
- Superior cerebellar artery
- Basilar artery
- Vertebral artery
- Distal medial striate artery (recurrent artery of Heubner)
- Anterolateral central (lenticulostriate) arteries
L anterior cerebral A
R anterior cerebral A
L middle cerebral A
V = lenticulostriate branches of MCA
eophthalmic A
ICA
posterior communicating A
internal carotid artery: no branches
external carotid artery: branches in neck
common carotid artery
v = perforators off the top of the basilar
Axial section through the putamen with vascular territories demonstrated

- ACA
- MCA
- Choroidal artery
- Posterior communicating artery (PCOM)
- Perforating branches of PCA
- PCA
Axial section through the inferior corpus callosum with vascular territories demonstrated

- ACA
- MCA
- Choroidal arteries
- PCA
Coronal section through the head of caudate and anterior limit of amygdala with vascular territories demonstrated

- ACA
- MCA
- Choroidal arteries
- PCA
Coronal section through posterior limb of hippocampus with vascular territories demonstrated

- ACA
- MCA
- Choroidal artery
- PCA
- Posterior communicating artery (PCOM)
- Internal carotid artery
Coronal section through intraventricular foramen with vascular territories demonstrated

- ACA
- MCA
- Choroidal artery
- PCA
- Superior cerebellar artery
- Anterior-inferior cerebellar artery
- Posterior-inferior cerebellar artery
- Posterior spinal artery
Sagittal section through pulvinar with vascular territories demonstrated

- ACA
- MCA
- Choroidal artery
- Perforating branches of PCA
- PCA
- Superior cerebellar artery
- Anterior-inferior cerebellar artery
- Posterior-inferior cerebellar artery
A 64 year old woman with atrial fibrillation and sudden onset of aphasia and right hemiplegia.
2 Magnetic resonance angiography (a), diffusion-weighted imaging (b) and perfusion-weighted imaging (c) performed in a patient 2.5 hours after onset of aphasia and right hemiparesis. Occlusion of the left middle cerebral artery trunk (arrow) is seen, with a small diffusion abnormality and a large perfusion abnormality indicative of a large ischaemic penumbra (tissue potentially salvageable with thrombolysis).
Hypertensive Encephalopathy

A 57 year old man with poorly controlled hypertension who presents with confusion, headaches, nausea and vomiting. On examination has markedly impaired attention and concentration with hyperreflexia. An astute medical student notes difficulty with identifying visual objects as well.
A 52 year old woman with sudden onset of the “worst headache of her life”. She collapses at home and in the ED is noted to be comatose and has marked neck stiffness
<table>
<thead>
<tr>
<th>Clinical phase</th>
<th>Time</th>
<th>Component</th>
<th>Hgb state</th>
<th>T&lt;sub&gt;1&lt;/sub&gt;WI</th>
<th>T&lt;sub&gt;2&lt;/sub&gt;WI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperacute</td>
<td>Immediate</td>
<td>Intracellular</td>
<td>Oxy-hemoglobin</td>
<td>Iso-to-hypointense</td>
<td>↑</td>
</tr>
<tr>
<td>Acute</td>
<td>5 hrs</td>
<td>Intracellular</td>
<td>Deoxy-Hgb</td>
<td>Iso-to slight ↓</td>
<td>Very ↓</td>
</tr>
<tr>
<td></td>
<td>1-5 days</td>
<td>Extracellular</td>
<td>Deoxy-Hbg</td>
<td>Very ↑</td>
<td></td>
</tr>
<tr>
<td>Subacute</td>
<td>&gt;5 days</td>
<td>Intracellular</td>
<td>Met-Hemoglobin</td>
<td>Very ↑</td>
<td>Very ↓</td>
</tr>
<tr>
<td>Early</td>
<td></td>
<td>Extracellular</td>
<td>Met-Hemoglobin</td>
<td>Very ↑</td>
<td></td>
</tr>
<tr>
<td>Late</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chronic</td>
<td>&gt; 15 days</td>
<td>Extracellular</td>
<td>Hemichrome</td>
<td>→</td>
<td>Slight ↑</td>
</tr>
<tr>
<td>Center</td>
<td></td>
<td>Intercellular</td>
<td>Hemosiderin</td>
<td>Very ↓</td>
<td>Very ↓</td>
</tr>
<tr>
<td>Rim</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

↑ Hyperintense    ↓ Hypointense → Isotense
A 23 year old man with new onset seizures. Neurological examination is normal.
Cavernous angioma

A 16 year old with new onset seizures. There is a family history of spontaneous intracerebral hemorrhage.
Neoplasms
A 69 year old with 3 month history of progressive confusion with difficulty with reading, writing and right/left discrimination.
CNS Lymphoma

A 35 year old man with AIDS who has headaches.
Metastatic brain tumor

A 68 year old man with headaches and left sided weakness. On examination has left upper and lower extremity weakness with left homonymous hemianopia.
Meningioma

A 44 year old with headaches, loss of olfaction and memory loss.
Congenital Abnormalities
Agenesis of Corpus Callosum

A 10 year old with developmental delay, congenital blindness and seizures.
Cortical Migration Abnormalities

An infant with prematurity of birth, developmental delay and seizures
Bilateral Periventricular Nodular Heterotopia

A 9 year old with refractory seizures
A 20 year old with bilateral arm numbness and weakness with urinary incontinence.
Infections of the Nervous System
Acute Bacterial Meningitis

History: 54 y.o. man with severe headache
Subdural Empyema

A 77 year old man with meningitis who has recurrence of headaches and seizures after 5 days of therapy
Cryptococcal infection

A 33 year old man with AIDS and severe headaches for 2 weeks and mild confusion.
A 41 year old with AIDS who has headaches and mild tremors.
A 14 year old with seizures, encephalopathy and left homonymous hemianopia.
Herpes Simplex Encephalitis

A 36 year old with 3 day history of confusion, memory loss and seizures.
A 79 year old with headaches, progressive weakness and encephalopathy.
A 32 year old with poor memory, weakness and inability to comprehend.
Chronic Meningitis

A 36 year old with 3 week history of progressive gait disorder, weakness and multiple cranial neuropathies.
A 12 year old immigrant from South Asia with chronic cough and headaches. Examination shows bilateral sixth nerve paralysis.
Demyelinating Diseases
Multiple Sclerosis

A 36 year old woman with intermittent weakness and numbness.
Multiple Sclerosis
This 44y/o RHF awoke with left hemibody numbness without tingling, weakness, ataxia, visual or mental status change. She later had progression of her symptoms when she noticed her right hand was stiff and clumsy. She coincidentally began listing to the right when walking. She denied any recent colds/flu-like illness or history of multiple sclerosis. She denied symptoms of Lhermitte's or Uhthoff's phenomena. Symptoms resolved within one month.
Trauma
A 23 year old man is brought to ED after a MVA with decerebrate posturing of the right.
Epilepsy
A 25 year old with weekly episodes of brief episodes of staring with confusion, followed by sleepiness and irritability.
SPECT IN TLE
MRS in TLE
Memory in TLE- Controls
Innovation in Imaging

Figure 4. The uncinate fasciculi (blue arrows) and cingulate fasciculi (pink arrows) are displayed in this coronal tensor map, with strong out-of-plane diffusion displayed on the tensor map (red/orange color).

Figure 7. Three-dimensional tractography of a normal subject showing the anterior (yellow) and posterior (blue) part of the corpus callosum as well as the left and right (red and green) cortico-spinal tract. The tracts pass through an axial section of the lateral ventricles.

Figure 5. Two-dimensional tractography of a normal subject showing the supracallosal portion of the cingulum bundle. Points seeded within the small region of the anterior cingulate gyrus.

Diffusion Tensor Imaging
Conclusions
## Tissue Densities on CT/MRI

<table>
<thead>
<tr>
<th></th>
<th>CT</th>
<th>T1</th>
<th>T2</th>
<th>FLAIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Dark</td>
<td>Dark</td>
<td>Bright</td>
<td>Dark</td>
</tr>
<tr>
<td>Fat</td>
<td>Very Dark</td>
<td>Bright</td>
<td>Bright</td>
<td>Bright</td>
</tr>
<tr>
<td>Air</td>
<td>Darkest</td>
<td>Dark</td>
<td>Dark</td>
<td>Dark</td>
</tr>
<tr>
<td>Calcium</td>
<td>Whitest</td>
<td>Dark</td>
<td>Dark</td>
<td>Dark</td>
</tr>
<tr>
<td>Brain - Gray Matter</td>
<td>White (brain window)</td>
<td>Gray</td>
<td>Gray</td>
<td>Gray (Light)</td>
</tr>
<tr>
<td>Brain - White Matter</td>
<td>Gray (brain window)</td>
<td>Bright</td>
<td>Dark</td>
<td>Gray (Dark)</td>
</tr>
</tbody>
</table>
## Evolution of MRI Blood Density

<table>
<thead>
<tr>
<th>Time</th>
<th>Products</th>
<th>T1</th>
<th>T2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-24 hours</td>
<td>OxyHb</td>
<td>↓ or Unchanged</td>
<td>↑</td>
</tr>
<tr>
<td>1-5 days</td>
<td>DeoxyHb</td>
<td>↓ or Unchanged</td>
<td>↓↓</td>
</tr>
<tr>
<td>3-7 days</td>
<td>Intracellular metHb</td>
<td>↑</td>
<td>↓↓</td>
</tr>
<tr>
<td>1 week - months</td>
<td>Extracellular metHb</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>1-2 week - years</td>
<td>Hemosiderin</td>
<td>Unchanged or ↓</td>
<td>↓↓</td>
</tr>
</tbody>
</table>
References:

Terminologies

CT    Computed Tomography
MRI   Magnetic Resonant Imaging
MRS   Magnetic Resonant Spectrometry
PET   Positron Emission Tomography
SPECT Single Photon Emission Computed Tomography
FLAIR Fluid Attenuation Inversion Recovery
DWI   Diffusion weighted Imaging
ADC   Apparent Diffusion Coefficient
DTT   Diffusion Tensor Tomography