Advanced Imaging: What is it and What does it mean?

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Welcome to the ER
Please lay down on the table to enter

Disclosure
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What CT Tells Us

- Is there hemorrhage?
- Are there other causes of symptoms?
- Is there visible infarct?
- Does not tell us if the patient is having an acute stroke

What are we looking at?

- Old or subacute ischemic tissue - hypodensity or dark
  - Indicates irreversible ischemic brain damage.
- Acute blood - hyperdense or bright
  - Can be seen immediately
- A subarachnoid bleed - diffuse hyperdensity

Left is Right and Right is Left
Early signs of ischemia may be seen within the first 6 hours but pronounced hypodensity does not occur till 12 to 24 hours post infarct.
An MCA occlusion will cause hypoperfusion of the most distal branches first. These small vessels are known as lenticulostriate branches. This region is very sensitive to ischemia as these branches are end arteries without collateral flow.
**Pathophysiology**

Failure of the ion pump during ischemia causes cytotoxic edema leading to sulcal effacement and hypodensity.

**Hyperdense Sign**

Hyperdense vessel is seen when a thrombus is located in an intracranial vessel showing a high attenuation causing it to look bright white.

Hyperdense MCA sign has a high specificity indicating clot in the M1 branch but has poor sensitivity occurring only 38% of the time on CT.

*An MCA “dot” sign is seen as a dot in the Sylvian fissure and indicates thrombosis in the M2 or M3 MCA branch.*

**CT scan demonstrates**

- lentiform nucleus obscuration (long white arrow)
- caudate nucleus (arrowhead)
- loss of insular ribbon (short white arrow)
- sulci effacement of MCA territory (black arrows).
These early ischemic changes occur in the first 2 to 3 hours and **DO NOT** exclude the administration of IV rt-PA.

The Radiologist reads the scan as Normal

AND the patient is still having symptoms

Treat with IV tPA if patient is within the 3-4.5 hour window

Bhatia et al. (2010)

Rates of acute recanalization with IV rt-PA
- 4.4% in distal intracerebral artery
- 32.3% in M1-MCA
- 30.8% in M2-MCA

Further acute interventional endovascular therapy may be warranted to achieve optimal clinical outcomes

CT Angiogram and CT Perfusion

- CTA – confirms the location of the thrombus
- CTP – indicates the viability of the cerebral parenchyma

CTA and CTP

- Requires injection of contrast
  - Contrast allergy
  - Renal function
- Visualize and reconstruct in 3 dimensional display
- Detect large vessel thrombi and vascular stenosis
- Determine if further therapy is warranted
• **Penumbra** - an area peripheral to one of ischemia where metabolism is active but blood flow is diminished

• **Salvageable tissue**

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**Primary Indicators**

**Cerebral Blood Volume (CBV)**
- If CBV is preserved there will likely be salvageable tissue.
- Patients’ BP can elevate and vessels dilate to attempt to preserve the amount of volume to cerebral tissue.
- Normal range 4-5 mL/100 g/min

**Cerebral Blood Flow (CBF)**
- Amount of blood flow to the brain tissue.
- Normal range 50-60 mL/100 g/min

**Mean Transit Time (MTT)**
- Represents the period of time the contrast is in the cerebral artery to the cerebral vein.
- MTT is increased because the flow is very slow and contrast dye remains in the vessels longer.
- MTT = CBV/CBF x 60. Normal 5 seconds
Pathology of Tissue

<table>
<thead>
<tr>
<th>Condition</th>
<th>MTT</th>
<th>CBF</th>
<th>CBV</th>
</tr>
</thead>
<tbody>
<tr>
<td>No ischemia</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>Tissue viable</td>
<td>Increased</td>
<td>Moderately Reduced</td>
<td>Normal or Hyperemia</td>
</tr>
<tr>
<td>Tissue at Risk</td>
<td>Increased</td>
<td>Markedly reduced</td>
<td>Moderately reduced</td>
</tr>
<tr>
<td>Tissue irreversible</td>
<td>Increased</td>
<td>Severely reduced</td>
<td>Severely reduced</td>
</tr>
</tbody>
</table>

CT Perfusion Data Analysis

Alberta Stroke Program Early CT Score (ASPECT)

- 10 point quantitative topographic CT scan score to assess early ischemic changes of the MCA region
- Assessed at 2 standardized regions
  - Ganglionic Level where the thalamus, basal ganglia and caudate are visible
  - Supraganglionic level which includes the corona radiata and centrum semiovale

10 Regions of MCA

- M1, M2, M3, M4, M5, M6
- Caudate nucleus (C)
- Lentiform nucleus (L)
- Internal capsule (IC)
- Insular cortex (I)

For each area involved in ischemia depicted at unenhanced CT, one point is subtracted from the total score of 10.
**ASPECT score**

Normal ASPECT score is 10
Deduct 1 point for each area involved.

A score of 7 or less
Correlates with poor functional outcome and hemorrhage.

*Limitation – Only scores the MCA

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**What about MRI?**

Conventional MRI plays a relatively minor role in evaluating acute cerebral ischemia, however since the development of **diffusion-weighted MRI**, it has become the most sensitive tool for detecting early ischemia.

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**Infarct on MRI**

Unenhanced CT images in a 56-year-old man with right hemiparesis (a at a lower level than b) demonstrate involvement of the M1 region, insular cortex (i), and lentiform nucleus (l). Thus, three points are subtracted from the 10-point ASPECTS, and the final score is seven points. C = caudate nucleus, IC = internal capsule.

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**Hyperintensity vs. Hyperdensity**

MRI DWI: Diffusion Weighted Image
Non-Contrast CT
MR angiography or MRA provides information on the status of the blood vessels including detection of a high-grade stenosis or thrombotic occlusion.

A low- or high-intensity vessel sign on an MR T2-weighted gradient echo may indicate a thrombus similar to a hyperdense vessel sign on CT.

**MRA**

**Normal MRA head**

**Right MCA occlusion**

**DWI vs. PWI**

- Diffusion Weighted Image or DWI
  - Lesions on a DWI are considered irreversibly damaged tissue

- Perfusion weighted image or PWI
  - Lesions on a PWI shows hypoperfused or hypoxic tissue

**Mismatch**

The volume difference between the DWI and PWI is referred to as a PWI/DWI mismatch. The mismatched tissue is considered to be the penumbra.

**Mismatch**
When the area on the DWI and PWI are the same size, this is indicative of irreversible infarcted tissue and treatment would not be recommended.

The purpose of ADC mapping is to differentiate T2-signal (T2 shine through) effect or artifact from true ischemic lesions.

The Debate Continues.
### CT MRI Comparison

<table>
<thead>
<tr>
<th></th>
<th>CT</th>
<th>MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scan Time</td>
<td>5-10 minutes</td>
<td>20-30 minutes</td>
</tr>
<tr>
<td>Availability</td>
<td>Widely available</td>
<td>Limited availability</td>
</tr>
<tr>
<td>Screening</td>
<td>None</td>
<td>Required</td>
</tr>
<tr>
<td>Contraindications</td>
<td>Renal insufficiency</td>
<td>Claustrophobia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Some pace-makers and metal</td>
</tr>
<tr>
<td>Cost</td>
<td>Less expensive</td>
<td>More expensive</td>
</tr>
<tr>
<td>Motion Intensive patient monitoring</td>
<td>Not as sensitive</td>
<td>Very sensitive to patient motion</td>
</tr>
<tr>
<td>Intensive patient monitoring</td>
<td>Feasible</td>
<td>Difficult</td>
</tr>
<tr>
<td>Radiation exposure</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Identification of early ischemia</td>
<td>Poor</td>
<td>High</td>
</tr>
<tr>
<td>Recognition of mismatch</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Visualize Posterior fossa and brain stem</td>
<td>Poor</td>
<td>Good</td>
</tr>
</tbody>
</table>

### Beyond Diagnostic Imaging

- **Cerebral Arteries**

![Cerebral Arteries Image]

- **Treatment Options**

  - IV rt-PA within 3 – 4.5 hours of onset
  - IA rt-PA (off label use) within 6 hours
  - Mechanical clot retrieval within 8 hours
    - MERCI retriever
    - Penumbra retrieval system

- **Recanalization of Rt MCA using IA t-PA**

![Recanalization Image]

- **Case: MERCI Retrieval (L MCA)**

![Case Image]
Thank you!!

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