Stroke, Cerebrovascular Imaging, and Anatomy

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AGENDA

Diagnosis

Diagnostics

Presentation

Observation*

Provisional diagnosis

Care requirements

Predictive

Diagnostic Testing: Reasoning

- Allows prompt diagnostic information
- Correlates/confirms physical presentation (functional location)
- To rule in/out pathology or disease process
- Guides care, practice, conversation

Common stroke diagnostic imaging includes: CT, MRI (and their variants), digital subtraction angiography (DSA), PET, SPECT

- We have come a long way......The 1st DSA included injections of petroleum, quicklime and mercury
DIAGNOSTIC TESTS
Considerations prior to determining test:
- Need to determine:
  - the pre-test probability of the disease—how likely the patient has something
  - if the test will change the decision to treat
  - what test provides the best information with the least harm
  - cost
  - skill set of the reader/quality of the image
- 50% of all acquired personal radiation exposure comes from diagnostic imaging

DIAGNOSTIC TIMING
Mr. S. is a 72 yr. old male admitted for ER via ambulance after collapsing on the street. On his way to ER he loses his airway. Upon arrival, his pupils are large, the (L) unreactive. During your assessment his (R) pupil 'blows'. His BP is 280/124. He is urgently treated with Mannitol/3% prior to his DI.
- The decision to treat without a DI is based upon:
  - High probability he has high ICP
  - The medication benefit outweighs the risk
- A CT is ordered because:
  - CT is sensitive to rapid neurological deterioration
  - The result will change the decision to treat and type of treatment required

DI = diagnostic image
**QUESTION**

Plain CT of head is always ordered first on a potential stroke patient because:

A. Most institutions have a CT and can administer timely TPA
B. CTs always show areas of ischemic infarction
C. CTs rule out/in non-ischemic causes of stroke
D. CTs allow clear visualization of the whole brain
<table>
<thead>
<tr>
<th>Diagnostic Test</th>
<th>Good for</th>
<th>Not great for</th>
<th>Benefits or limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT: plain</td>
<td>acute blood, trauma, edema, acute stroke evaluation</td>
<td>parenchymal definition, limited ability in early ischemia</td>
<td>B: available, rapid, cheap, tolerated, can be used to determine treatment options, high reliability L: poor visualization of bone and soft tissues</td>
</tr>
<tr>
<td>CTA/MRA</td>
<td>vascular imaging</td>
<td>MRI parenchymal, previous infarction, micro-hemorrhage (GRE), worsening of neurology (ICP)</td>
<td>Can be used to guide treatment</td>
</tr>
<tr>
<td>MRI</td>
<td>parenchymal, previous infarction, micro-hemorrhage (GRE), worsening of neurology (ICP)</td>
<td>acute blood (can be confusing)</td>
<td>B: can determine age of hemorrhage L: less tolerated, less available, may exclude some patients (pacemaker)</td>
</tr>
<tr>
<td>Diffusion-weighted image (DWI)</td>
<td>ischemic changes visual within minutes of stroke onset (can separate out acute and chronic stroke)</td>
<td>can be falsely positive</td>
<td>&gt;90% reliability L: may be positive in non-stroke (migraines, seizures, acute MS, TIA)</td>
</tr>
<tr>
<td>Cerebral angiography</td>
<td>vascular requiring finite image can be used singularly or in conjunction with other treatments ( clot retrieval, embozilation)</td>
<td></td>
<td>L: small risk of stroke, side effects, invasive, inconvenient for patient</td>
</tr>
</tbody>
</table>

**TEST TYPE**

- Axial CT:plain
- Axial MRI:plain (T2)
CAT SCAN (CT): 3D X-RAYS

Overall principles:
- X-rays are absorbed by different degrees by different tissues.
- The ‘colour’ of the tissue produced is the result of attenuation (rate at which the x-ray passes through the tissue or how much the radiation is absorbed).
- Produces a 3D image.

CT language = ‘density’ ‘dens’ — — “See—tee” (CT)
- ‘hypodensity’, ‘hyperdensity’

Limitations:
- Beam hardening: when high density tissue abuts low density tissue in a small space (post fossa).
- Volume averaging: pictures produced include a variety of tissues with different densities (early stroke).

CT DENSITY

CT density chart showing levels of low and high attenuation, with labels for various tissues like Air, Bone, Gray matter, White matter, CSF, Fat, Edema, Isodense, and Whitish.

Bone is bright white: takes longer to ‘shoot through’
Air is very black: very quick to shoot through.
CSF: is black—like shooting through chicken broth.
CT Variation

CT plain
Good for looking at 'stuff'
Great for blood, deterioration

CT with contrast: iodine-based
Good for abscess, compromised BBB

CTA (with contrast): great for blood vessels

CTA

Spot Sign

The presence of contrast enhancement within ICH, visible on CTA. Suggests active, dynamic hemorrhage. Is a predictor of ICH growth and poorer outcomes.
STROKE AND CT
- Stroke involves both gray and white matter
- Deprived of blood, cells will take on water (cytotoxic edema)
- Gray matter takes on water faster (more metabolically active)
- Water influx into cells begins at 6 hours
- Leads to loss of gray-white differentiation
- A 1% increase in water content will reveal hypodensity
- 60% of infarcts are seen within 3-6 hours (all seen within 24)

CT LIMITATIONS
- Volume averaging: tissues of different densities look the same
- Beam hardening: stuff is jammed in together
**MRI: RADIO WAVES**

Bursts of radio waves (magnet) are sent to the head.

- Radio waves disrupt Hydrogen (protons) ion
- Protons re-align and relax: T2 produces variations in relaxation and re-alignment (time)
- Hydrogen (protons) move towards the magnet position
- Once radio waves stop proton relax

**MRI COLOURS**

<table>
<thead>
<tr>
<th>MR I</th>
<th>Bright White</th>
<th>White</th>
<th>Gray</th>
<th>Black</th>
<th>Very Black</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Bone</td>
<td>Fat</td>
<td>Light white</td>
<td>Water</td>
<td>Air</td>
</tr>
<tr>
<td></td>
<td>Gadolinium</td>
<td>Orbit</td>
<td>white matter</td>
<td>Fluid (edema)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blood (with</td>
<td>(with</td>
<td>Dark: Light</td>
<td>Calcium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>contrast only)</td>
<td>light</td>
<td>gray matter</td>
<td>eyes, globe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blood vessels</td>
<td></td>
<td></td>
<td>dense bone,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Calcium</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>dense bone,</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>calcium</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>flow</td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td>CSF</td>
<td>Water</td>
<td>Light gray</td>
<td>Blood vessels</td>
<td>Air</td>
</tr>
<tr>
<td></td>
<td>Water, Fat</td>
<td>Fluid</td>
<td>matter</td>
<td>dense bone,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fluid</td>
<td>New blood</td>
<td></td>
<td>calcium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Most lesion</td>
<td></td>
<td></td>
<td>dense bone,</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>calcium</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>flow</td>
<td></td>
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</table>
**COMMON TYPES OF MRI**

- T1 CSF is ‘black’, white matter is white
- T2 CSF is white and white matter is black

Produces picture of intensity (not density)

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**MRI: DWI (DIFFUSION WEIGHTED IMAGE)**

- Is the most sensitive sequence
- Image is the result of the loss of Brownian motion of water (water that can move freely has no signal)
- Swollen tissue (cytotoxic edema) has restricted-no movement = signal
- Can be positive within minutes of stroke
- Produces a high intensity signal for 7 days, then settles
- Maximizes bw 7-30 days (positive in early stages, the fades)
- Can be positive for MS and migraine

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**FLUID ATTENUATION INVERSION RECOVERY: FLAIR**
ANATOMY

- Managing a patient with vascular disease requires an understanding of where that vessel goes and areas that vessel supplies
- Allows predictability, care, and knowing when patient's are running into trouble
- Remember that:
  - BV variations are common and frequently non-pathological
  - Significant anastomosis exist
  - Presentation is related to functional disturbance, not always to the cause of the disturbance

**Cerebral Vascular Territories**

- Anterior cerebral artery (ACA)
- Middle cerebral artery (MCA)
- Posterior cerebral artery (PCA)
- Basilar artery
- Aortic arch
- ICA
- MCA
- ACA

![Cerebral Vascular Territories Diagram](image)
1. Clyde is 2 days post clipping of an asymptomatic p.comm aneurysm. On rounds, the student nurse informs you that the patient has a ‘blown’ pupil on the same side.

2. Susan is admitted for a right parietal AVM resection. She is experiencing changes in proprioception, agnosia and agraphia.

3. Rahmin has been diagnosed with a thalamic hemorrhagic stroke. He has difficulty keeping awake and is experiencing allodynia.

4. Michael is admitted with a PCA ischemic stroke. He is suffering from significant nausea, is disoriented to place and year.

Which one of the above vignette(s) is correct:
A. One of them
B. Two of them
C. Three of them
D. All of them
E. None of them

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CASE PRESENTATION

- Carol is a healthy 42 yr. old female that was at the shopping mall with her husband and children. Carol had a 15 minute neck massage at a pop-up massage place. Shortly after, Carol experienced a bad headache and dizziness. By the time she met her husband, Carol was a bit off-balance and nauseated. When not better 5 hours later, they went to the hospital, thinking Carol had a bad virus.

- In ER, Carol’s BP was 182/97. Neurologically, Carol was found to have 6th nerve palsy, a small pupil and facial weakness on the right, ataxia, dysdiadochokinesia left upper extremity, and difficulty with word articulation (NIHSS 10).
CASE PRESENTATION

Mary is a 78 year old female driving in CDN tire parking lot. Was noted to be hitting parked cars. Stopped car. Police/ambulance were called. Upon arrival Mary when she was found to be densely hemiplegic on left side. Speech normal. No past history.

Transferred to stroke center at 14:40. NIHSS on arrival 13, right lateral gaze. BP 220/124.

CT plain at 1450-normal
MCA supplies the greatest territory and is the most often occluded.

? Why the left MCA more?

Mary: treated with TPA, off to radiology.

DSA

Thrombectomy wire

Post thrombectomy DSA

Post stroke CT
CASE PRESENTATION

- Clyde is a 52 yr. old janitor with a known history of HTN. He is found with mild hemiplegia with hemianaesthesia and broca’s aphasia. EMS is called. Clyde loses consciousness and requires airway support upon transfer to ER.
- On admission to ER his BP is 268/128, HR 110. GCS 6 (eyes 1, verbal 1, motor 4 (withdraws))

QUESTION

What statement is true regarding thalamic hemorrhage?

1. Left-sided hemorrhage is more common than right
2. Hallucinations, agitation and dementia can occur
3. Hemianaesthesia is the most common presentation
4. A significant percentage of patients have Type I or II diabetes

QUESTION

What statement is true regarding thalamic hemorrhage

1. Left-sided hemorrhage is more common than right (equal distribution)
2. Hallucinations, agitation and dementia can occur
3. Hemianaesthesia is the most common presentation (motor weakness)
4. A significant percentage of patients have Type I or II diabetes (approx. 10%)

- 4 thalamic stroke variations exist-symptoms location dependent (anterior-posterior), can also ‘mimic’ cortical function
CASE PRESENTATION

Brittany is a 24 yr. receptionist at a dental. On Monday she doesn't show up for work. Her colleagues try to reach her, but to no avail. At 10:00 pm after continuing to be unsuccessful, her colleague goes to her apartment where her superintendent opens the door. Her history includes Type I DM. Brittany is on the floor unconscious. EMS is called. Her pulse is thready. Both pupils are large. She is provided airway support and transported to ER. GCS on arrival 4 (extension to pain).

BRAIN EDEMA