Imaging of The Stroke Patient

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Acute Stroke

• Approximately 795,000 strokes each year in the US.
• Fourth leading cause of death
• 1.9 million brain cells die each minute without treatment.
• IV rtPA approved to 4.5 hours after symptoms onset.
• Neuroprotection.

Stroke

• Acute ischemia constitutes about 80% of all strokes.
• Old days. Imaging was used primarily to exclude hemorrhage and other mimics of stroke
• National Institute for Neurological Diseases and Stroke Trial.
• Concept of salvageable brain tissue
• Imaging should be targeted toward assessment of the four Ps - parenchyma, pipes, perfusion and penumbra.
Penumbra

- Core is irreversible infarcted tissue.
- Surrounding salvageable tissue - penumbra
- Without early recanalization, the infarction expands to include the penumbra.
- Irreversible cell death occurs when blood flow decreases to less than 10 mL/100 g/min.

Acute Stroke

- The clock is ticking
- IV r tPA approved to 4.5 hours after symptom onset.
- Medical trials for wake up stroke.
- History
- Alberta Stroke Program Early CT Score (ASPECTS)
- Emergent large vessel occlusion (ELVO)

“Time is Brain”

- Success of acute stroke interventions depends on:
  - Patient selection
  - Symptom onset to treatment
Acute Stroke - Clinical Evaluation

- Neurological Exam - National Institutes of Health Stroke Scale
- Time of symptom onset.
  - 4.5 hrs IV tPA
  - < 6 hrs - IV rtPA in selected patients with MCA occlusion not candidates for IV rtPA.
  - tPA inclusion/exclusion

NIH Stroke Scale

0 - No stroke
1-4 minor stroke
5-15 moderate stroke
16-20 moderate to severe
21-42 severe stroke

Tissue Plasminogen Activator

- Exclusion
  - Hemorrhage on initial CT
  - Recent heart attack
  - Serious head trauma within the last 3 months
  - Bleeding from the stomach or urinary track within the last 21 days.
  - Major surgery within previous 14 days
  - Bleeding disorders
  - Use of blood thinners
  - Pregnancy
  - Uncontrolled high blood pressure.
Acute Stroke - Imaging

Stroke Algorithm

Noncontrast CT
- R/O hemorrhage
- Stroke volume

MRI
- DWI core?
- Timing
- R/O hemorrhage

CTA
- LVO?
- Collaterals?

MR Perfusion
- LVO?
- Perfusion mismatch

Important Detail

• Differentiate stroke from stroke mimics.

Window and level settings

Detection of early acute ischemic stroke on unenhanced CT images maybe improved by using variable window and center level settings.
CT signs of ACUTE stroke:

- Hypoattenuation
- Loss of gray white matter differentiation
- Sulcal effacement and mass effect
- Dense vessel sign

Case 1

- What CT acute stroke finding shown
  - insular ribbon sign
  - loss of gray white matter differentiation
  - dense vessel sign
  - hemorrhagic conversion

Case 1

What changed?

- What CT acute stroke finding shown
  - insular ribbon sign
  - loss of gray white matter differentiation
  - dense vessel sign
  - hemorrhagic conversion
Loss of Gray White Matter Differentiation

• #1. Basal Ganglia Sign
• #2. Insular Ribbon Sign

Quantitation of Ischemic Involvement

• Alberta Stroke Program Early CT Score (ASPECTS)
• Proposed 2001
• 10 point topographic scoring scale
• Involvement of more than 1/3 of the MCA territory was a criteria for the exclusion of patients because of a potential increase in the risk for hemorrhage.
• Poor interobserver correlation because of the variability in the level of axial CT images.

Alberta Stroke Program Early CT Score

• Aspects Score? 9
Alberta Stroke Program Early CT Score

- Aspects Score?

Which of the following most likely makes patient ineligible for IV tPA?

- No findings on head CT
- Stroke onset 4 hours
- ASPECTS score of 2
- Positive basal ganglia sign on CT

Acute Stroke - Imaging

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- MRI
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Diffusion Imaging

- Brownian motion
- In acute stroke, there is a homeostasis problem. Results in excess intracellular water with an overall decreased rate of water molecular diffusion within the affected tissue
- The motion of water molecules is restricted.
- Restricted diffusion (decreased apparent diffusion coefficient ADC) in humans in stroke seen as early as 30 mins.
- Reduced ADC: 30 mins to 5 days.
- Mildly hyperintense signal with pseudo normal ADC values at 1-4 weeks
- Variable ADC signal from several weeks to months.

MRI: Diffusion Weighted Imaging

MRI: Diffusion Imaging
MRI: FLAIR

- DWI-FLAIR mismatch (within 6 hours)
- DWI-FLAIR mismatch (≤ 24 hours)

SWI

- DWI-FLAIR mismatch (≤ 24 hours)

Acute Stroke - Imaging

Stroke Algorithm

- Noncontrast CT
  - R/O hemorrhage
  - Stroke volume
- MRI
  - DWI core?
  - Timing?
  - R/O hemorrhage
- CTA
  - LVO?
  - Collaterals?
- MR Perfusion
  - LVO?
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MRA or CTA: Large Vessel Occlusion

Salvageable Brain

Perfusion Imaging

- Dynamic susceptibility contrast enhanced MRI
- Dynamic contrast enhanced MRI
- Arterial spin labeled perfusion
- CT perfusion
Perfusion Parameters

- Tissue viability (cerebral blood flow)
  - Nmt: 50-60 ml/100g/min
  - At risk: 12-20 ml/100g/min
  - Infarct: <10-12 ml/100g/min
- Time sensitive
  - TTP: Time to peak (sec)
  - Tmax: Time to max (sec)
  - MTT: Mean transit time (sec)
  - Cerebral blood volume (ml/100g)

Abnormal MRI Perfusion

MRI Perfusion: Diffusion Mismatch
MRI Perfusion: Diffusion Mismatch

- Target Mismatch Profile:
  - PWI-DWI greater than or equal to 1.2
  - DWI: <70 cc
  - PWI > DWI by greater than or equal 10-15 cc

- Malignant Profile:
  - DWI > 70 - 100 cc
  - PWI > 100 cc

Case

- Based on the images, IA therapy is a consideration?

CTA

- Intraarterial thrombolysis maybe more efficacious than IV therapy in patients with an acute stroke and a significant thrombus burden.

- What do the carotids look like?

- Correlation between the location of intravascular occlusion on CTA's and clinical outcome.
Multiphasic CTA

- Phase 1: Arterial phase acquisition, vertex to arch
- Phase 2: 8 second delay, peak venous acquisition, vertex to skull base
- Phase 3: Second delay, delayed venous acquisition vertex to skull base
- 3D MIP recons

CTA Collaterals Scoring

CTA Collaterals
CT Perfusion
Widely Available
Measures:
Cerebral blood volume
Cerebral blood flow
Mean transit time
Time to peak enhancement

2006 Chart

[Diagram showing flowchart for stroke treatment decisions]