Update on New Imaging Techniques for Cerebral Ischemia and Stroke

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Goals of Stroke Imaging

- Detection/Differentiation of ischemia / infarction
  - Hemorrhage vs bland infarction/ ischemia
  - Infarction vs other diseases

- Large vessel vs small vessel occlusion

- Penumbra assessment: ?? aggressive Rx
  - Infarct CORE: MR Diffusion, CT CBV
  - “Penumbra”: (MTT – CBV) ; (Perfusion Tmax – Diffusion)

Stroke Imaging and Therapies

- CT
  - Non Contrast CT
  - CT perfusion
  - CT Angiography

- MR
  - Diffusion / DTI : Most sensitive for infarction
  - Perfusion
  - MRA, MR Venography
  - Arterial Spin Label Imaging : Equal to DCS perfusion
  - Susceptibility Weighted Imaging : useful for Ca++, Heme

- Image Guided Thrombolysis
  - IV/IA TPA
  - Embolectomy ( MERCI, Penumbra, Solitaire)
  - Ultrasound thrombolysis

CT Findings in Acute Stroke

- Early
  - Perfusion deficit
  - Hyperdense MCA 34%
  - Hypodense tissue
    - “Insular ribbon”
    - Basal ganglia hypodensity
  - Mass effect
    - sulcal effacement

von Kummer et al.
Radiology 1997;205:327-333
MR Diffusion/ Perfusion Mismatch
CT based CBV/ hypodensity

- “Penumbra” assessment
  MTT – CBV = tissue at risk
- Reflects collateral status
- May determine futile cases
- “Favorable” penumbra:
  - Infarct core < 30% of perfusion deficit
  - Infarct core < 90 ml (1/3 MCA)

66 yr old with acute hemiparesis, mild aphasia
Non contrast CT at admission

Minimal abnormality—maybe low density in Left putamen.. ??

CT Perfusion

Mean Transit time

3 parameters:
- Regional Cerebral Blood Volume (rCBV)
- Mean Transit Time (MTT)
- Regional Cerebral Blood Flow (rCBF = rCBV / MTT)

Complete Collateral Flow

proximal M1 occlusion TIMI 0, with great collateral flow via ACA
70 year old with new onset aphasia, R HP, occult ca, DVT

**Does Imaging Select those who would benefit from aggressive recanalization?**

- Kidwell et al. NEJM 2013 “MR RESCUE”
  - Randomized, standard care vs Embolectomy within 8 hours of AIS, 22 sites, 116 patients
  - Favorable penumbral pattern = a predicted infarct core of < 90 ml and a proportion of predicted infarct tissue within the at-risk region of 70% or less
  - Penumbra and Merci devices; recanalization rate 67% (< standard care w penumbra??)

- “A favorable penumbral pattern on neuroimaging did not identify patients who would differentially benefit from endovascular therapy for acute ischemic stroke, nor was embolectomy shown to be superior to standard care”
74 year old with expressive aphasia AMS upon waking scanned within 1.5 hours with CT (9:30am) and MR (11am) before angio and thrombolysis.

MR Perfusion / Diffusion
**MR Perfusion**

SPGR T1 or T2* EPI technique obtained during bolus injection of gadolinium
Uses: Acute stroke, perfusion deficit?
Vascular assessment of tumors

- **peak**
- **TTP**
- **rCBV**
- **rMTT**
- **rCBF**

**Arterial Spin Labeling**

- Blood is labeled in neck and imaged in the brain following a short delay
- Labeled protons decays with the blood T1 time, which is on the order of 1 to 2 seconds
- Flow that arrives late, ie through collateral pathways, may be incorrectly interpreted as absence of flow, but slow and increased flow is visible without contrast injection

**High Resolution Spiral CASL**

TR: 5 sec
FOV: 24 cm
pts: 4096
arms: 4
thick: 6 mm
skip: 3 mm
label: 2.5 s / 1 s
loc: 2 cm
amp: 0.038 G
pairs: 8
scan time: 5:30

**The Value of Arterial Spin-Labeled Perfusion Imaging in Acute Ischemic Stroke**

by Danny J.J. Wang, Jeffry R. Alger, Joe X. Qiao, Qing Hao, Samuel Hou, Rana Fiaz, Matthias Gunther, Whitney B. Pope, Jeffrey L. Saver, Noriko Salamon, David S. Liebeskind, Stroke
Volume 43(4):1018-1024
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ASL and DSC- PWI provided largely consistent results in delineating hypoperfusion lesions in AIS

Hyperemic lesions appeared more conspicuous on ASL CBF than on DSC PWI maps
Representative AIS cases showing hypoperfused lesions in baseline scans.


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Representative AIS cases showing hyperperfused lesions on baseline scans.


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Chronic Headaches, initially thought SIH
But OP 40+. SSS meningioma found on ASL
A 64-year-old man presenting with complex partial seizure

ASL shows increased signal in left transverse sinus

### Susceptibility Weighted Imaging

- Increased conspicuity of blood products, calcification
- Gradient Echo (MPGR)
- 3D velocity encoded Gradient Echo

### Spin Echo, FSE sensitive to T2

GRE, EPI sensitive to T2*

Difference = loss of signal due to susceptibility (eg magnetic gradients induced by air/bone/calcium, heme etc)
A 64-year-old man presenting with aphasia and right hemiplegia of sudden onset 3 hours before MRI.

Susceptibility Weighted Imaging (SWI) detects disruption of magnetic field:

- Reduced oxygen
- Within venous capillaries = Low signal on SWI

SWI detects:
- Calcification
- Hemorrhage
- Air
- Emboli
- DeoxyHgb
- Amyloid

42 year old male with interstitial lung disease, acute respiratory failure (+ rhinovirus) requiring ventilation persistent neurological deficit. Thrombocytopenia on heparin.

SWI in PRES:
A 43-year-old woman developed an acute severe left hemiplegia. Detection of heme in Stroke prior to CT.

**Take Home Points**

- Non Contrast CT: first line pre-IV TPA
- CTA: Large vs small vessel occlusion
  - Triage to Neuro Interventional
- CT and MR Perfusion: should not delay IV TPA
  - MR diffusion most sensitive for acute stroke
- Perfusion / Diffusion mismatch:
  - Reflects status of collateral flow
  - CT and MR perfusion demonstrates tissue at risk, but embolectomy not better than standard medical therapy (Kidwell)
- MR ASL: non invasive quantitative measure of CBF
  - Acute ischemic infarction: low CBF
  - Dural AVF, brain tumors: elevation of CBF
  - Seizure, TIA: may have elevated CBF