

SYLLABUS OUTLINE

Specialty area:
Technical developments

Title of session:
How MRI Became the Gold Standard

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Highlights:

- Diffusion-weighted MR imaging is the gold standard for the diagnosis of acute cerebral ischemia.
- The role of perfusion-weighted MR and penumbra imaging is still being debated.
- Emerging stroke MR imaging modalities include sodium imaging and intravascular incoherent motion imaging.

Talk Title:
Brain MRI in stroke

Target Audience:
This presentation targets all scientists and clinicians who have an interest for stroke imaging.

Purpose:
The purpose of this presentation is to review how MRI became the gold standard for stroke imaging, and how new MRI modalities for stroke have developed and matured over time.

Discussion:

The development and generalization of treatment modalities for hyperacute stroke has made stroke a treatable emergency. The addition of magnetic resonance imaging (MRI) to acute stroke patient work-up has increased our knowledge of acute stroke pathophysiology and brought a tool to study how to best select patients for acute revascularization therapy. A typical stroke MR work-up includes several components, including diffusion-weighted imaging (DWI), FLAIR, MR-angiography (MRA) and potentially perfusion imaging.

DWI is used to determine how much brain tissue is injured. In conjunction with FLAIR, it can be used to determine the age of an infarct. DWI is more accurate than CT in localizing ischemic lesions shortly after stroke onset. Admission CT does indeed localize lesions correctly in only 53% of patients. On the other hand, conventional MRI correctly identifies acute cerebral ischemia in 71% to 80% of cases. With the addition of DWI, this percentage increases to 94%. DWI can easily distinguish between new and old ischemic brain injuries, as they respectively show hypo- and hypersignal on ADC maps. In 77% to 100% of patients with multiple cerebral infarcts, DWI not only delineates early ischemic

brain injury better than conventional MR, but also successfully identifies the acute lesion responsible for the clinical deficit.

In the same vein, MRI is extremely sensitive at detecting intracerebral hemorrhage, and can also help determine the age of an intracranial hematoma. T1- and T2-weighted MR sequences can estimate the age of an intracranial hemorrhage. T2*-gradient echo (GRE) and more recently susceptibility-weighted imaging (SWI) sequences are highly sensitive to the susceptibility effects of paramagnetic and superparamagnetic breakdown products of hemoglobin. Echo-planar T2*-weighted imaging can be performed with a very low acquisition time (seconds), which represents a significant advantage in patients with acute intracranial hemorrhage who are unable to cooperate.

MRA can demonstrate the site of major cerebral artery occlusion and also the degree of collateral circulation. MR angiography techniques used for vascular imaging can be broadly categorized into contrast enhanced and non-contrasted time of flight (TOF) and phase contrast techniques. Contrast-enhanced MRA is the most frequently used MRA technique for imaging the extracranial carotid arteries, while TOF MRA is the standard for intracranial arteries.

Perfusion imaging in conjunction with DWI gives information that bears on how much tissue is injured (DWI) and how much tissue is functionally inactive but still viable (ischemic on PWI but still normal on DWI, the so-called "mismatch"). Different MRI techniques are available for cerebral perfusion measurements in routine clinical practice, but a contrast-enhanced dynamic susceptibility T2* weighted technique remains the most common method. Arterial spin labeling (ASL) technique is an additional technique that does not require the use of a contrast agent but rather utilizes the spins of endogenous water protons as a tracer.

In addition to the conventional sequences described above, new emerging modalities are being developed with exciting perspectives for stroke, including intravascular incoherent motion (IVIM) imaging, oxygen extraction fraction, cerebrovascular reactivity imaging, blood-brain barrier permeability imaging, pH imaging, and many others.

A number of important questions remain, but current knowledge of natural history of stroke using MRI has provided a framework for comparing new therapeutic interventions. One critical issue that remains to be answered is whether patient treatment can be tailored not to a fixed time window but to the physiological state of the ischemic tissue as defined by MRI.

Conclusion:

MRI is the reference standard modality for stroke. It provides insight into acute stroke pathophysiology and can potentially serve as a tool for management decisions in stroke patients.

References:

- 1) Jauch EC, Saver JL, Adams HP Jr, Bruno A, Connors JJ, Demaerschalk BM, Khatri P, McMullan PW Jr, Qureshi AI, Rosenfield K, Scott PA, Summers DR, Wang DZ, Wintermark M, Yonas H; American Heart Association Stroke Council; Council on Cardiovascular Nursing; Council on Peripheral Vascular Disease; Council on Clinical Cardiology. Guidelines for the early management of patients with acute ischemic stroke:

a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2013 Mar;44(3):870-947. doi: 10.1161/STR.0b013e318284056a. Epub 2013 Jan 31.

2) Wintermark M, Sanelli PC, Albers GW, Bello J, Derdeyn C, Hetts SW, Johnson MH, Kidwell C, Lev MH, Liebeskind DS, Rowley H, Schaefer PW, Sunshine JL, Zaharchuk G, Meltzer CC. Imaging Recommendations for Acute Stroke and Transient Ischemic Attack Patients: A Joint Statement by the American Society of Neuroradiology, the American College of Radiology, and the Society of NeuroInterventional Surgery. *AJNR Am J Neuroradiol*. 2013 Nov;34(11):E117-27. doi: 10.3174/ajnr.A3690. Epub 2013 Aug 1.

3) Saver JL, Jovin TG, Smith WS, Albers GW; STAIR VIII Consortium; STAIR VIII writing committee members. Stroke treatment academic industry roundtable: research priorities in the assessment of neurothrombectomy devices. *Stroke*. 2013 Dec;44(12):3596-601. doi: 10.1161/STROKEAHA.113.002769. Epub 2013 Nov 5.