STAIR VIII

STIR: Clinical Translation of Advanced Imaging Techniques for Stroke

March 9, 2013

Ona Wu, PhD
Associate Professor of Radiology, Harvard Medical School
Director of Clinical Computational Neuroimaging,
Athinoula A Martinos Center for Biomedical Imaging
Department of Radiology, Massachusetts General Hospital

On behalf of STIR Advanced Imaging Subcommittee

Speaker Disclosures: Partly funded by NIH/NINDS R01NS059775, R01NS063925, P50NS051343, R01NS051412, and U01NS069208. Inventor of “Delay-compensated calculation of tissue blood flow,” US Patent 7,512,435, which has been licensed to General Electric, Siemens, Imaging Biometrics & Olea Medical.
<table>
<thead>
<tr>
<th>Subcommittee Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeffrey Alger</td>
</tr>
<tr>
<td>E Akyuz</td>
</tr>
<tr>
<td>Roland Bammer</td>
</tr>
<tr>
<td>Charles Bisordi</td>
</tr>
<tr>
<td>Mark Bouts</td>
</tr>
<tr>
<td>Mark Bowman</td>
</tr>
<tr>
<td>Trevor Carpenter</td>
</tr>
<tr>
<td>William Copen</td>
</tr>
<tr>
<td>Brian Frake</td>
</tr>
<tr>
<td>Keith Heberlein</td>
</tr>
<tr>
<td>Joseph Helpern</td>
</tr>
</tbody>
</table>
Overview

- Why are clinical translation of advanced imaging techniques important?
- Examples of promising advanced techniques
- Practical study design considerations for translation of advanced techniques from research to clinical settings
- Challenges to doing these studies now
- Priorities for meeting these challenges
  - ISMRM, ISMRM Perfusion Workshop, ISC
Why?

- Move beyond “penumbral” patterns
- May improve understanding of pathophysiology
- Less invasive methods – increase repeatability of assessments
- Improve accuracy of measurements
  - Motion compensated techniques critical for agitated/non-compliant subjects
What are some the new techniques?

- Arterial spin labeling (ASL) for non-invasive cerebral blood flow measurements
- MR-based Oxygen Extraction Fraction (OEF)
- pH-weighted MRI
- Diffusion-kurtosis imaging
- Diffusion tractography
- Whole-brain CTP
- Dual-energy CT
- Motion compensation
Arterial Spin Labeling: Non-invasive, repeat measures
MR-based Oxygen Extraction Fraction

T2' Measured from qT2 & qT2* Geisler, Stroke 2006

Asymmetric Spin Echo

Multi-echo Gradient & Spin Echo

Oxygen Challenge

Dani, Ann Neurol 2010

Wu, ISC P32, 2013

An, Stroke, 2009
Fig 2. Gray matter CVR map overlaid on anatomic T1-weighted images for a representative patient (patient 24). Top row is before bypass, and bottom row is after bypass surgery. CVR units are %ΔBOLD MR signal intensity per mm Hg ΔPetCO₂. Images demonstrate decreased, and in fact paradoxical (negative), CVR in the left MCA territory cortex and deep gray matter before bypass and marked improvement postbypass surgery.

Mandell DM, AJNR, 2011
Patient 62 hrs post-onset

TTP > pHw > DWI

Courtesy of P van Zijl, Kennedy Krieger Center
Diffusion Kurtosis Imaging

Diffusion Tractography

Acute

4 months

O Wu (MGH)
Dual Energy CT

Contrast extravasation

ICH

Whole Brain CTP

Courtesy of M Parsons, University of Newcastle
Motion Insensitivity: Academic-Industry Collaboration

- No motion correction (2:14 min)
- Real-time motion correction (10:00 min)

H Bhat (Siemens)/O Wu (MGH)
Bench-to-Bedside Translation

- ASL: Developed in 1992
- Became available as product only recently
- Still not used widely clinically or in stroke research trials
- How to translate into practical clinical use

Williams DS, PNAS 1992
Practical Study Design

- Single platform vs multiple platforms
- Single center or multi-center
- Focus on specialized centers (e.g. 3T or whole-brain CTP scanners available) or emphasize generalizability
Practical Study Design

- Standardization of data acquisition needed
  - Type of labeling for ASL, e.g. PCASL
  - Number of directions for DTI
  - Number of shells for DKI
  - Repetition time for DSC

- Standardization of post-processing algorithms

- Patient population
  - At-risk of stroke, acute, chronic
Criteria for Evaluation

- “Validation” of quantitative values?
- Equivalency of information with existing methods?
- Complementary information?
- Patient neurological outcome and/or lesion growth?
- Accurately reflects symptomatic ischemia?
- Prognosis of secondary events?
- Affect clinical decision making?
Challenges

- Limited support for developing advanced imaging
- Criticism regarding feasibility in acute setting

Need a mechanism to:
- Translate and test advanced imaging across sites
- Encourage advanced imaging in acute setting
- Standardized minimal imaging screening for trials
- Share and pool imaging prospectively
Priority 1: Stroke Trial Imaging Network

- Infrastructure to facilitate Neuroimaging Studies
- Capabilities of sites
  - Ability to do CT, CTA, MR in acute studies
  - How many stroke patients
- Scanner types (1.5 T, 3T, dual-energy CT)
  - Manufacturer, Software Version
- Easy lookup table to find potential sites for new trials or studies involving new technologies for rapid deployment
Priority 2: Imaging Harmonization

- Standardized minimal basic imaging protocol (< 15 min) to screen acute patient – Common Data Elements
  - To be eligible for grant funding (e.g. clinical trials) must agree to CDE
  - Additional advanced imaging sequences can be optionally added

- Standardized IRB-approved Imaging Protocol funded by world-wide government agencies to acquire data sets
  - To test utility of “standard” imaging protocol optimized for stroke
  - Additional scans can be added
Priority 2: Imaging Harmonization

- Promote adding data to cloud-based imaging repository (STIR/VISTA)
- Advocate public-private collaborations to promote standardization/distribution/translation of advanced imaging technologies