Non-Contrast MR Angiography

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Nephrogenic Systemic Fibrosis:  
*Game-changer for CE-MRA*

- NSF can be prevented with simple precautions, but damage is already done…
- The “go to” imaging test for patients with impaired renal function is now viewed by many clinicians as hazardous
- Decreased referrals for renal and peripheral MRA
  - hard to recapture patients
- Substantial additional cost for POS eGFR testing equipment
Up to 50% Reduction in Contrast Agent Dose For 3T MRA

Total of 20cc GdDTPA (dual bolus, 3 stations)

Use of Higher Relaxivity Contrast Agent Allows Decreased Dosage

Whole body MR MRA/MRV with Ferumoxytol (Equilibrium Phase)

Total Acquisition Time:
5 minutes 45 seconds
for 8 stations

*Note lack of renal parenchymal enhancement
How About Not Using Any Contrast Agent for MRA?

Potential contrast mechanisms for unenhanced MRA:

- Gated Subtraction (subtraction of images acquired at different phases of the cardiac cycle)
- Spin-Labeling (subtraction of image sets prepared by different RF pulses)
- Time-Of-Flight (TOF) effects
- Phase-Contrast
- Flow-independent mechanisms
Time of Flight Non-Contrast MRA

Good for Intracranial Vessels……Bad for Vessels in Body
bSSFP: Improve Background Suppression Using an Inversion Pulse time-SLIP, native trueFISP

Native trueFISP MRA with Navigator Gating

X. Bi, PhD Siemens Medical Solutions
Renal Transplant

CE-MRA

NC-MRA
Gated Subtractive MRA

- Fresh Blood Imaging (FBI): TurboSE readout (1)
- Flow-sensitive Dephasing (FSD): bSSFP readout (2)

Fresh Blood Imaging

- Uses 3D Half-Fourier fast SE for data acquisition
- Use cine PC to determine ECG delay for maximum and minimum flow velocity
- Subtraction shows arteries while eliminating background tissues
- Scan time only a few minutes
- Sensitivity/specificity for >50% stenosis 94%/94%

Ideal Methodology for Unenhanced MRA

- Fast
- Easy to use
- Insensitive to:
  - Patient motion
  - Heart rate
  - Flow patterns
- Robust imaging of pelvis arteries
Quiescent Interval Single Shot (QISS) MRA: Multi-station Acquisition Method
PATIENT JR
87 YEAR OLD MALE
ACHING LEGS
ATRIAL FIBRILLATION

QISS MRA

CE-MRA
Patient KW
66 year old male
Bilateral claudication

QISS MRA

CE-MRA
Patient NC
88 year old male with claudication, diabetes and atrial fibrillation
ZERO DOSE (QISS) MRA STRATEGY

Sensitivity 93.9%
Specificity 90.6%

Sensitivity 96.4%
Specificity 89.3%

Sensitivity 96.5%
Specificity 95.8%

Sensitivity 95.8%
Specificity 92.4%

NPV 96.7%
PPV 89.8%
Arterial Spin Labeling:
20 Second “STAR” Non-Contrast Carotid MRA

Koktzoglou, Edelman ENH
Arterial Spin-Labeled MRA (ASL)

- Contrast predicated on differential vascular signal created by preparatory RF pulses

Non-Contrast MRA of the Hands Using FSD
Patient 3

Severe disease

CE-MRA

Non-contrast MRA
Direct Thrombus Imaging


- All clots > 8 hours appeared bright with water-excite MP-RAGE sequence
- Sens/spec within each of the venous segments ranged from 91% to 100%; same below knee (101 patients)
Steady State Free Precession (SSFP)-Based MR Venography

Cantwell CP et al. JVIR 2006; 17:1763–1769

<table>
<thead>
<tr>
<th>Venous Segment</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
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<tbody>
<tr>
<td>Iliac</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Femoral</td>
<td>100</td>
<td>98</td>
</tr>
<tr>
<td>Popliteal</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Tibial, peroneal, and soleus veins</td>
<td>68</td>
<td>94</td>
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<tr>
<td>Overall</td>
<td>87</td>
<td>98</td>
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Flow-Independent MRA:  
**STARFIRE**
Non-Contrast Evaluation of Acute DVT

Water-excite MP-RAGE  STARFIRE  Dbl dose Gd-3DMRA delayed - arterial
Pitfalls of Non-Contrast MRA

- Stenosis exaggeration from accelerating or turbulent flow with bSSFP and turboSE readouts
- Sensitivity of bSSFP sequences to B0 inhomogeneity
- Mistiming of delays for peak and minimal flow velocities with FBI/native SPACE
- ECG mis-triggering
- Stair-step artifact with 2D acquisitions
Conclusions

- NSF has changed landscape for MR angiography
- Contrast-enhanced MRA can be safely performed and NSF entirely avoided if proper screening procedures are undertaken and appropriate contrast agents are used (but remains disruptive to workflow)
- Newer non-contrast MRA techniques may permit screening for vascular disease with high negative predictive value, thereby eliminating need for contrast agents in many if not most cases
- Only limited clinical validation has been published: lack of technique uniformity across vendors
- With proper validation, will likely reduce or eliminate need for contrast agents in many MRA applications, thereby reducing cost and morbidity
Acknowledgments

• Ioannis Koktzoglou, Ph.D.  NorthShore
• Philip Hodnett, M.D. NorthShore/NMH
• John Sheehan, M.D. NorthShore
• Debiao Li, Ph.D.  NMH
• Xiaoming Bi, Ph.D.  Siemens Healthcare
• Christopher Glielmi, Ph.D.  Siemens Healthcare