Update on
Myocardial Perfusion
using ASL

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Arterial Spin Labeling

Tag Arterial Blood with inversion pulse

Wait for delivery of tagged blood (1-2 RR)

Image myocardium + tagged blood

“Control”

Image myocardium

“Tagged”

ASL Signal (<1%)
Special Features

- ASL signal is directly proportional to tissue blood flow (ml-blood/g-tissue/min)
- Endogenous tag, no contrast agent needed
- Non-invasive, no injections, repeatable indefinitely
- Extensively applied to brain

![Vascular Territory Mapping](image)
First-Pass Imaging

47% – Unresolved artifacts (e.g. dark rim)
   – Difficulties with quantification
11% – Requires T1 shortening contrast agents

~2-3 pixels across the myocardium

2010 CMR Questionnaire:
Biggest current limitation?
Myocardial ASL Scan

\[ MBF = \frac{C - T}{2B \times RR \times e^{-RR/T_1}} \]

Buxton, et al. MRM 1998
Experimental Setup

GE Signa 3.0T EXCITE
8-channel cardiac coil
Mid Short-Axis Slice
SENSE R=1 reconstruction
6 breath-holds
Assessment of Myocardial Blood Flow (MBF) in Humans Using Arterial Spin Labeling (ASL): Feasibility and Noise Analysis

Zungho Zun, Eric C. Wong, and Krishna S. Nayak

- Healthy Volunteers, ~3 cm³ septal ROIs.
- Measured MBF range at rest was $0.70 - 2.14$ ml/g/min (matches PET literature: $0.73 - 2.43$ ml/g/min).
- Measured ASL signal decreased as tag was distanced from the imaging slice, indicating that ASL is indeed measuring inflow.
- Measured MBF increased with mild stress: 30% with passive leg elevation, and 29% with isometric handgrip exercise.
Assessment of Myocardial Blood Flow (MBF) in Humans Using Arterial Spin Labeling (ASL): Feasibility and Noise Analysis

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- Physiological Noise Statistics

  Includes metabolic fluctuation, respiratory/cardiac motion, and other unknown variations

- $\sigma_{MBF,P} \approx 0.05$ to $0.43$ ml/g/min

- Physiological noise is, on average, 3.4 times larger than thermal noise ($\sigma_{MBF,P} / \sigma_{MBF,T} = 3.4$).
Adenosine Stress Perfusion using ASL
Rest vs. Stress

- Added ASL to a CMR protocol for patients getting adenosine stress first-pass perfusion at LLU.

<table>
<thead>
<tr>
<th>Time</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 min</td>
<td>Resting ASL scan</td>
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<tr>
<td>3 min</td>
<td>Resting ASL scan</td>
</tr>
<tr>
<td>2 min</td>
<td>Wait</td>
</tr>
<tr>
<td>3 min</td>
<td>Stress ASL scan</td>
</tr>
<tr>
<td>1 min</td>
<td>Stress First-Pass scan</td>
</tr>
</tbody>
</table>

- 11 datasets (and counting...)

#P209
Seven “Normals”

- normal first-pass perfusion, and normal angio (if it was performed)
Single vessel disease

- Anecdotal evidence at this point (N=2)... MBF reserve maps seem consistent with angio.

#P209
Reducing Physiological Noise
High blood pool signal may interfere with MBF measurements in adjacent myocardium because of partial voluming and k-space truncation.
Tagging the Proximal Aorta

Inversion profiles

ASL difference images

Blood pool signal decreased by 91%
Summary

• ASL-based MBF measurements (1) match range of published literature values, (2) are inflow dependent and (3) increase (30%) with mild stress (4) increase significantly (4x) with adenosine.

• Additional patient data is needed to determine whether ASL methods can identify CAD.

• Our technical development efforts target the reduction of physiological noise
  - LV blood pool suppression
  - Shortening or eliminating breath-holds
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