Evaluation of Magnetic Resonance Imaging Phase Data of Projection and 2-D FLASH Acquisition for the Estimation of the Arterial Input Function

Jennifer L Moroz, Stefan A Reinsberg, Piotr Kozlowski
Dept of Physics & Astronomy, University of British Columbia, Vancouver, BC

Motivation

- The **arterial input function** (AIF) describes the plasma concentration of contrast agent in a vessel over time[1]
- AIF required to model dynamic contrast enhanced (DCE) MRI data
  - Incorrect AIF affects model parameters
- DCE MRI non-invasively studies tumor vasculature

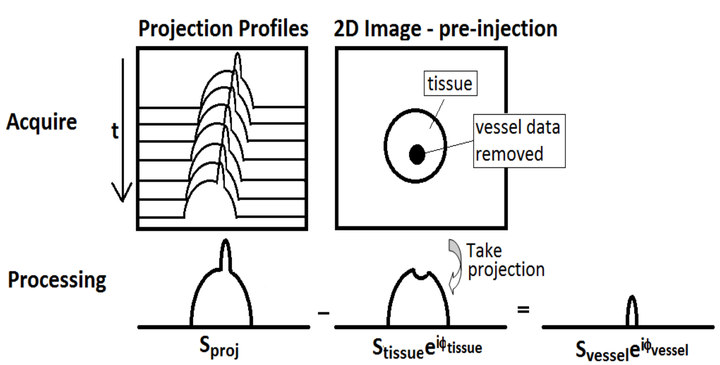
Introduction:

- AIF requires
  - High spatial resolution – minimize partial-volume effects
  - **High temporal resolution** – resolve rapid pass of agent through vessels[2,3]
- AIF traditionally derived from changes in the blood signal magnitude, however:
  - Magnitude does not vary linearly with concentration
  - Image acquisition is time consuming
- Analysis of MRI signal phase is advantageous[3]
  - Phase is expected to have an improved SNR
  - Phase varies linearly with the concentration
  - Phase is not affected by T_2^* relaxation
- Population averaged AIF is often used
  - Does not accurately describe the concentration at time of examination[4]
- Projection profiles are acquired rapidly
  - 256 profiles collected in time required for one image
- **Hypothesis: Projection-based approach using MRI phase data can significantly improve the quality of the AIF**

Projection-Based Approach:

- Our method involves
  - One 2-D image pre-injection
  - Series of projections before, during and after contrast injection

Protocol:



Solve for ϕ

$$\phi_{contrast} = \phi_{vessel} - \phi_{reference}$$

Results: Calibrating Concentration-Phase Relationship

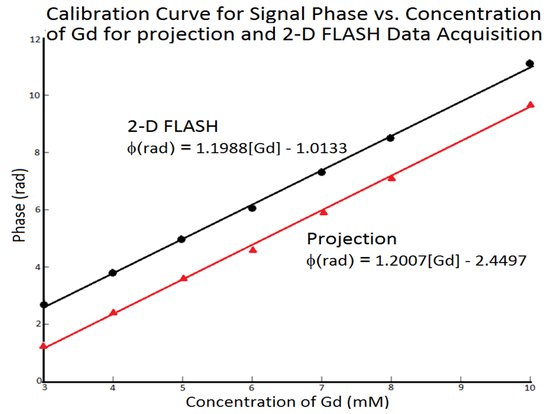


Figure 1: Phase and concentration vary linearly, providing a calibration factor of (1.20 ± 0.01) rad/mM for a TE of 5.399 ms.
The results imply that a series of projections may be used to generate an AIF with high temporal resolution.

Results: Low vs. High Temporal Resolution AIF's:

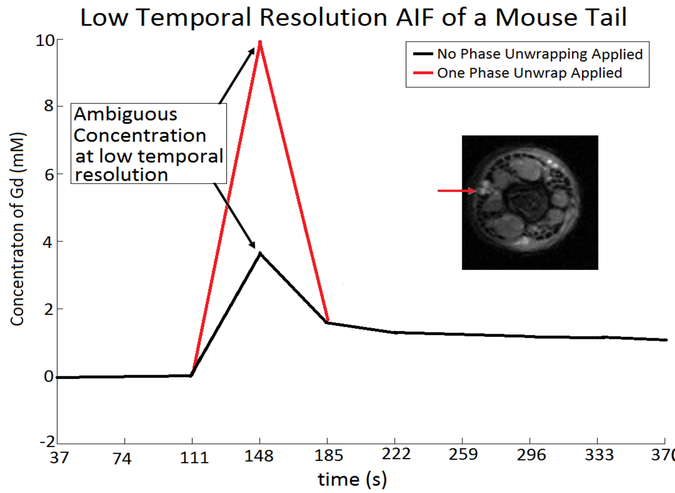


Figure 2: Data was acquired through a series of 2-D FLASH acquisitions. The MRI image shows location of vessel used to derive AIF. The fourth data point may suffer from phase wrapping ($\phi > 2\pi$), but it is unclear at this temporal resolution.

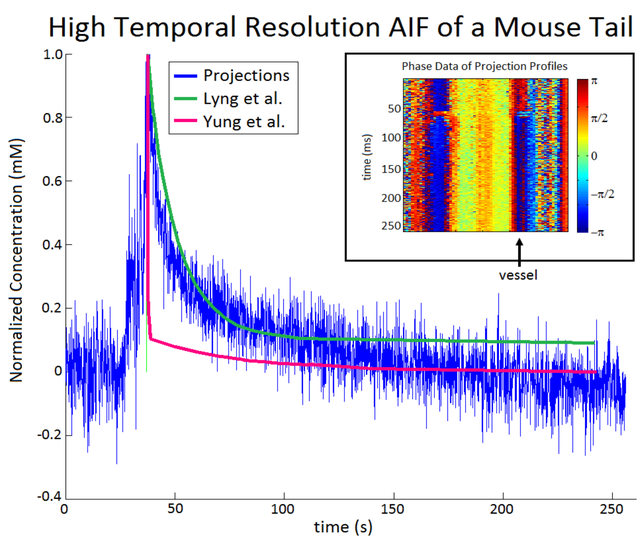
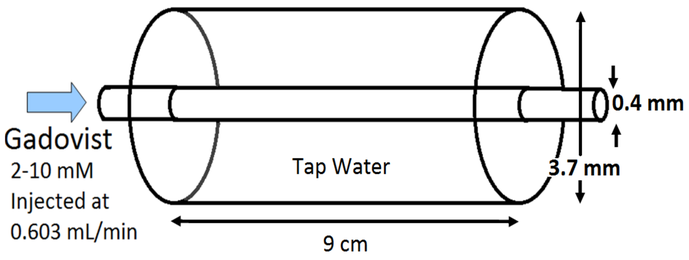


Figure 3: With a higher resolution, the shape of the curve is known with greater confidence. Insert shows the vessel AIF was constructed from. Published AIFs are Lyng et al. (Left ventricle, temporal resolution = 25.6 s)[5] and Yung et al. (Abdominal aorta, temporal resolution = 15.6 s)[6].

Methods:

Phantom:



MRI Data:

- Acquired on a 7.0 T Bruker MRI system
  - In-house built surface coil used for signal collection
- Calibration Curve
  - 1-D and 2-D FLASH acquisitions
  - TE/TR = 5.399 ms / 150 ms, 10 slices, 2x2 cm² FOV, 256x1 and 256x256 matrix sizes respectively
- Projection Data
  - No phase encoding
  - Time resolution of projections is 0.1 ms
  - TE/TR = 3.92 ms / 100 ms, 1x1 cm² FOV, 256x1 and 256x256 matrix sizes respectively
- Phase obtained from FID
- Data unwrapped ($\pm 2\pi$ radians) at discontinuities

Results:

Phantom:

- Analysis on 2-10 mM gadovist solutions
- The calibration factor converting phase into concentration of gadovist is (0.222 ± 0.002) rad/(mM*ms)

Mouse tail:

- High temporal resolution clearly showed shape of AIF

Conclusions and Future:

- Vessel phase data is recoverable in projections
- Projections significantly increase temporal resolution
- Plans to interleave with DCE acquisition

Acknowledgements:

This project was made possible by funding from NSERC and the Canadian Cancer Society
JLM is grateful for scholarship from NSERC

***References*:**

1. McIntyre D.J.O et al., *NRM Biomed*, 2004; **17** : 132-143.
2. Conturo T.E. et al., *J Mag Reson Imag*; 2005; **22**: 697-703.
3. Egbert J.W. et al., *Mag Reson Med*, 2010; **64** : 358-368.
4. Yankeelov and Gore, *Med Imaging Rev*, 2009; **3**: 91-107.
5. Lyng et al., *Mag Reson Med,* 1998; **40**: 89-98.
6. Yung et al., *Int Soc Mag Reson Med,* 2009; p. 2283