Arterial Spin Labeling Applications of Ischemic Stroke

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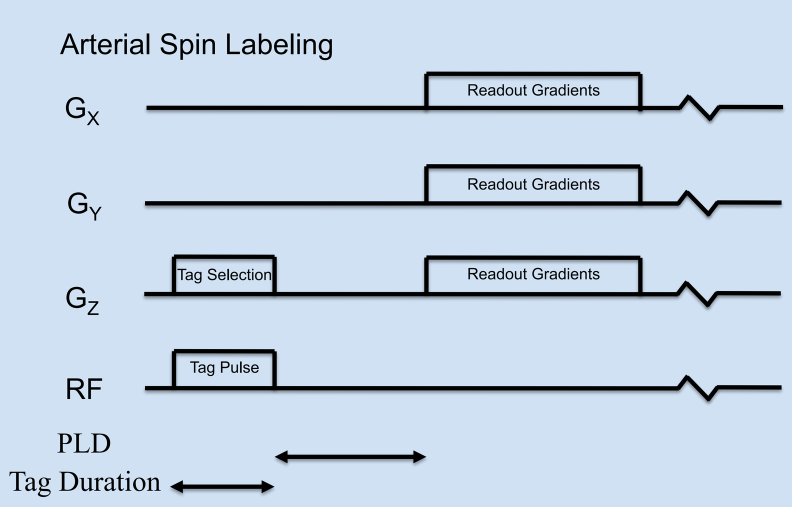
Introduction

- Ischemic stroke is a reduction of cerebral blood flow (CBF) to a region of brain tissue
- Arterial spin labeling (ASL) is a magnetic resonance (MR) imaging technique designed to measure CBF
- ASL derives its estimates from the difference of images with a tagging pulse on and off
- CBF measurements can also be obtained with bolus passage imaging, however these method requires contrast agent injection
- ASL has been explored to a great extent already for stroke imaging [1,2]
- We have recently obtained this ASL technology in Calgary, and it is greatly desired when MR imaging ischemic stroke
- ASL is a sophisticated method that can very extensively with implementation [3-5]
- On the rest of this poster you will find some initial experiments performed with ASL

Image Acquisition

- Imaging was performed on a 3T MR Scanner (Discovery 750, GE Healthcare)
- A pseudo-continuous (pc-) ASL sequence was used, an example timing diagram is shown below



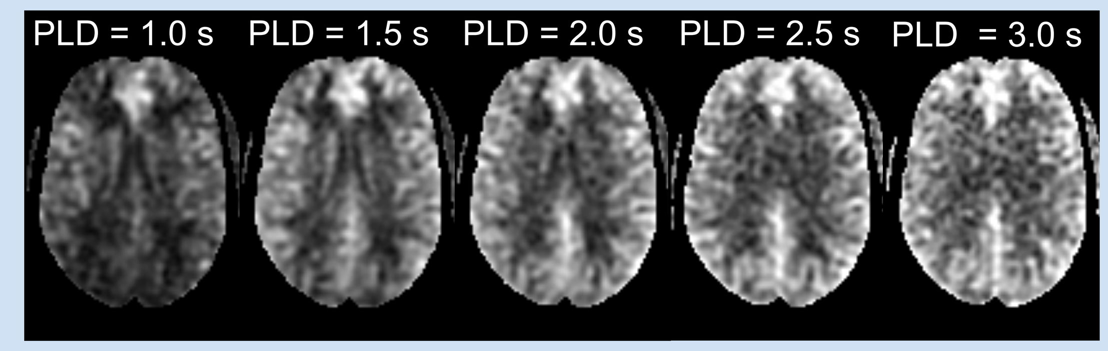
- The equation used for CBF quantification was,

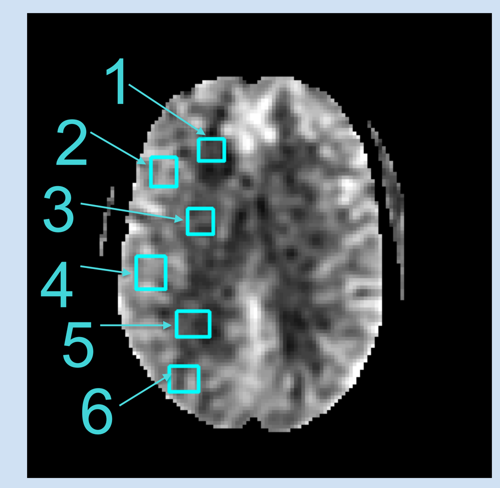
$$CBF = 6000\frac{\lambda\left(1-e^{-\frac{ST}{T_{1T}}}\right)e^{\frac{PLD}{T_{1B}}}}{2T_{1B}(s)\left(1-e^{-\frac{LT}{T_1}}\right)\varepsilon\cdot NEX}\left(\frac{\Delta M}{SF\cdot PD_{REF}}\right)$$

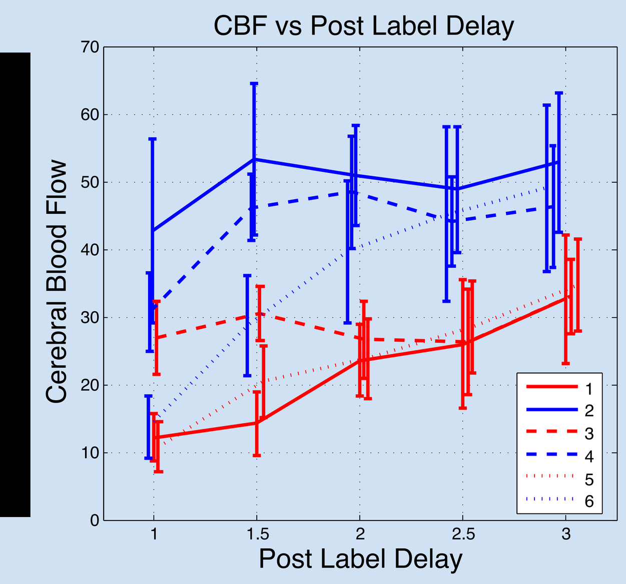
where T_1 is 1.6 s (@ 3T), λ is the partial coefficient set to 0.9, ε is the efficiency and is set to 0.80x0.75, ΔM is the difference of tag and no tag images; PD_{REF} is the reference proton density images; NEX is the number of excitation; and SF was a scaling factor of 45.

Varying Post Labeling Delay Time

- As indicated in the timing diagram, the delay between when the tag pulses are applied and the images are collected can be varyed
- We adjusted the PLD form 1.0 s to 3.0 s at 0.5 s intervals and collected images at each delay time
- A fixed labeling duration of 1.0 s was used
- This experiment was repeated for 5 healthy subjects ranging from 22 – 33 years
- Region of interest measurements were taken from each of the subjects and plotted with respect to PLD
- We found that CBF measures matched closely to what is expected with a PLD time of 2.5 s, *e.g.*, the grey and white matter had CBF values of ~ 60 ml 100 g^{-1} min^{-1} and 22 ml 100 g^{-1} min^{-1}

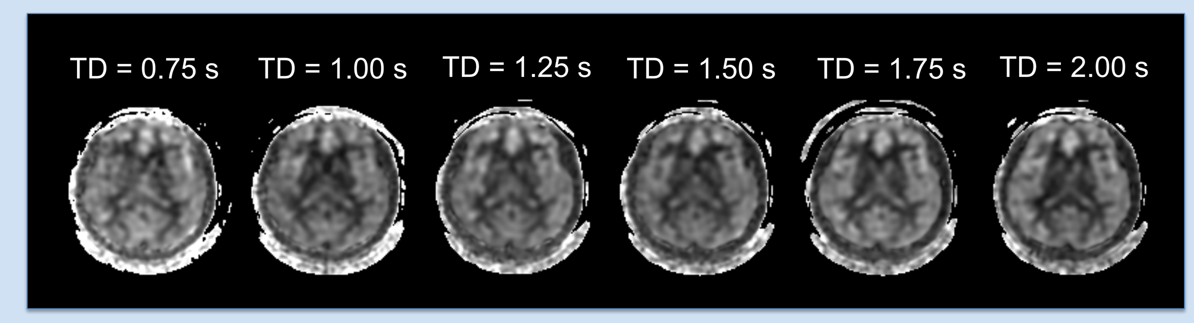


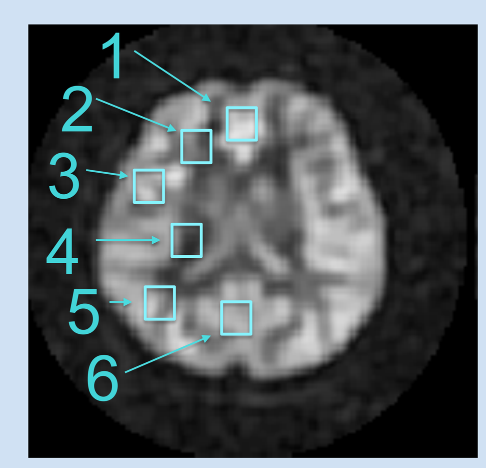


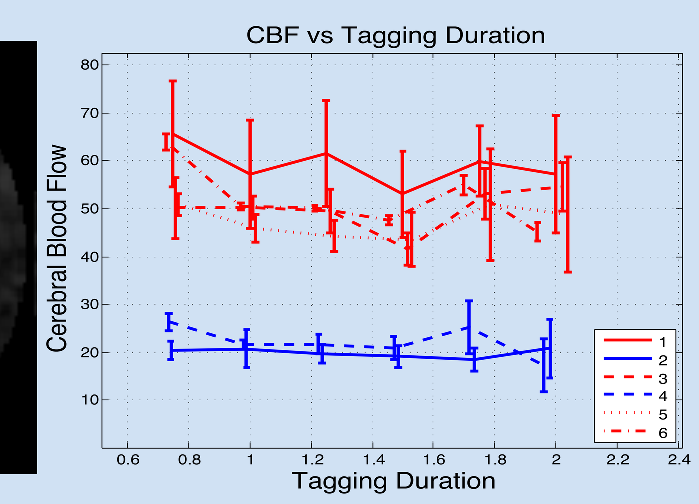


Varying Tagging Duration

- the time that the tagging pulse is applied can be adjusted (As indicated in the timing diagram)
- The tagging delay was swept from 0.75 s to 2.0 s at increments of 0.25 s, the PLD time was fixed to 2.5 s
- Again measurements were taken and plotted with respect to tagging duration
- We found that the tagging duration did not as greatly effect on the CBF measurement as did the post labeling delay time
- Using the CBF quantification algorithm there was a minor decrease in CBF with in gray matter with respect to tagging duration



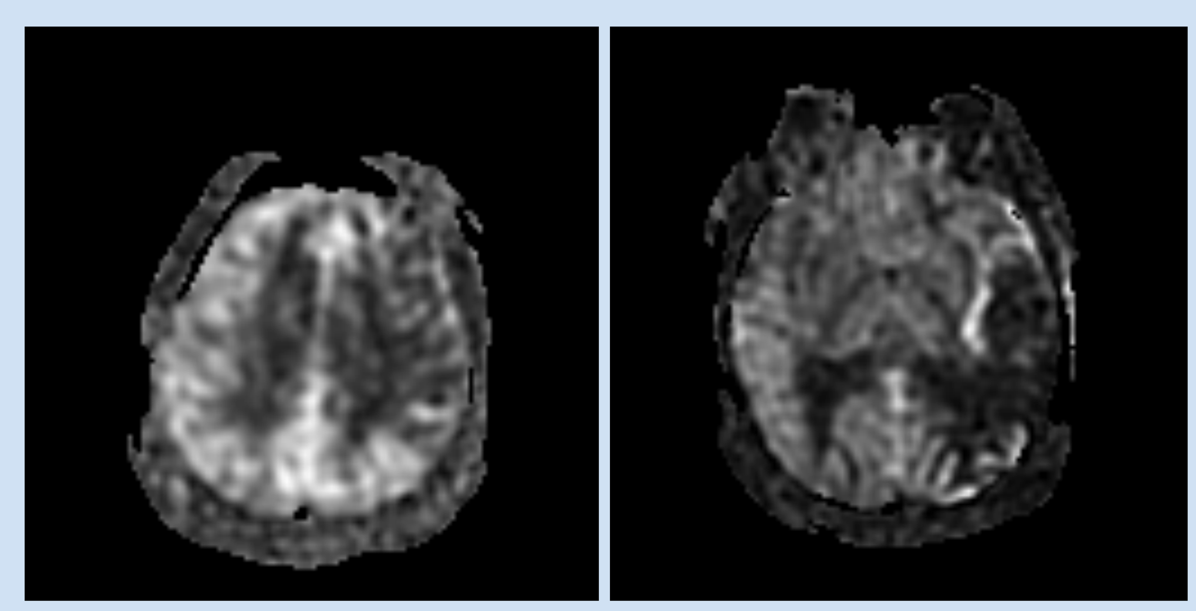




Stroke Imaging

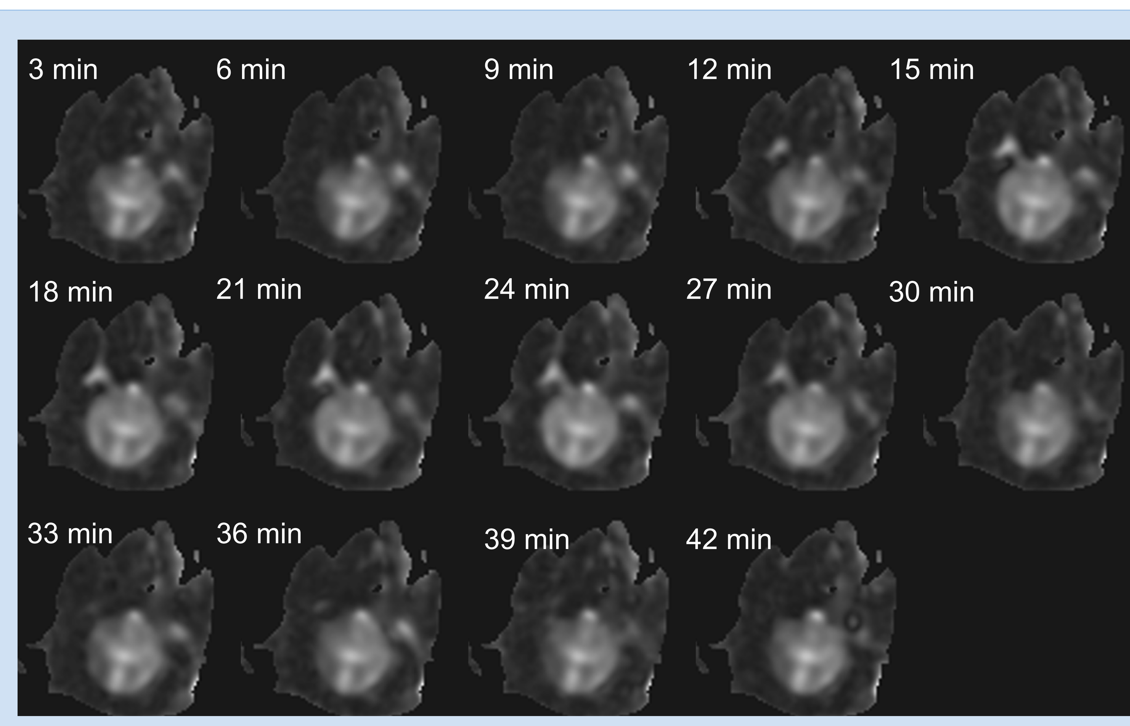
- There have been two ischemic stroke patients imaged with ASL at our institute
- Example ASL CBF maps are shown in to the right
- As reported [1], CBF measurement are very low in the ischemic tissue region
- Measurements of CBF in ischemic gray and white mater were taken

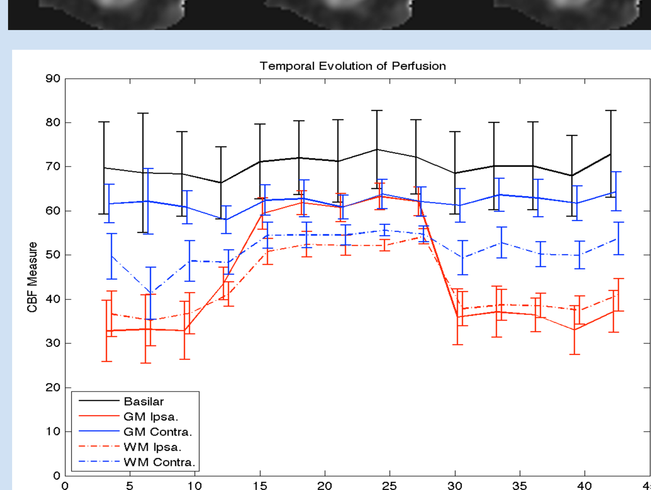
	WM	GM
Subject 1 (Left)	10 ml / 100 g / min	26 ml / 100 g /min
Subject 2 (Right)	6 ml / 100 g / min	8 ml / 100 g / min

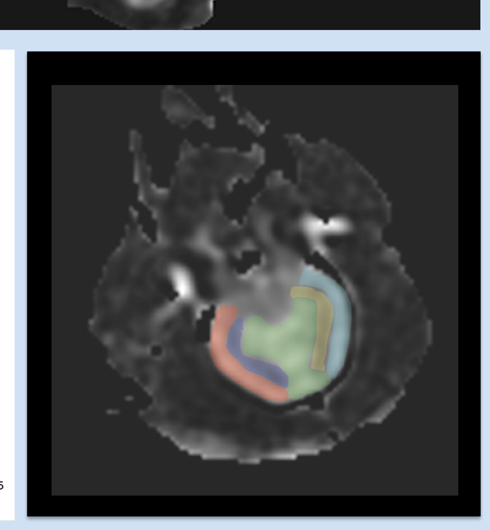


Interventional

- Using a canine model a transient measurement of perfusion was obtained
- An endovascular angioplasty balloon was navigated to the right common carotid artery
- 3 min repetitive ASL imaging was performed while the right carotid artery of a canine was occluded with the balloon
- The balloon was inflated at 10 minute mark and deflated at twenty five minute mark
- Vascular territories were selected as shown in Figure, and measurements were taken the occlusion time course
- Low perfusion was observed when the balloon was deflated as the tagging could not be performed properly with the endovasulcar devices in the carotid
- With the balloon inflated the perfusion was high due to collateral filling







Discussion

- The canine experiment demonstrates that ASL will not be effective with implants such as stents in the neck
- Be careful with the evidence shown here, although 2.5 s PLD times may appear desirable, an older population may have slower flow, and lower perfusion
- Increasing the Tagging Duration increases energy deposition
- A fundamental concern with ASL is that it can only obtain accurate estimates in tissues with delay times less than 4 s, ischemic stroke may have tissue delay times as long as 12 s, so perfusion is ischemic tissues will be underestimated

REFERENCES

[1] Chalela, *et al.*, Stroke, 2000
[2] Zaharchuk, *et al.*, Stroke, 2012
[3] Detre, *et al.*, MRM, 1992
[4] Dai, *et al.*, MRM, 2010
[5] Okell, *et al.*, Proc. of ISMRM, 2012

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Lake Minnewanka, Alberta. Photo by JN Draper