

Animal ASL Imaging

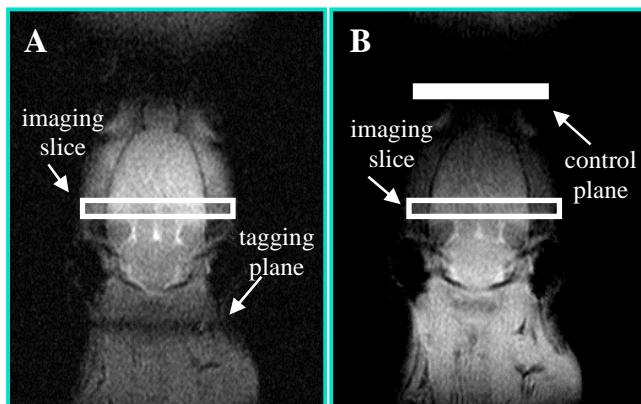
Ke Fang, Research Officer

Howard Florey Institute, Animal MRI Facility

Introduction

Regional cerebral blood flow (CBF) is an important parameter to assess the function of brain and was observed over a century ago. Several modern functional neuroimaging methods such as positron emission tomography (PET), magnetic resonance imaging (MRI) and optical imaging spectroscopy (OIS) have been used to get the CBF maps. Arterial spin labeling (ASL) MRI uses arterial water as an endogenous contrast agent to get the perfusion information and is a completely non-invasive in vivo method. ASL allows an unlimited number of repeat measurements to be made with a time resolution that is limited only by the signal-to-noise ratio (SNR) required to ensure good precision for the cerebral blood flow values is obtained. Consequently, ASL (in combination with other MR methods) is an excellent tool for assessing evolving tissue status and viability in animal models.

In our lab, we have developed continuous ASL MRI. The following figure demonstrates how the ASL image works. The magnetization of arterial water in the major arteries feeding the brain is inverted continuously at the level of the neck (labeling plane) by using flow-induced adiabatic fast passage (AFP). The inverted arterial water is transported through the arterial circulatory system in the brain, where it exchanges completely with brain tissue water, under the assumption that water is a freely diffusible tracer. Moreover, assuming that CBF remains constant, a new steady-state value of the tissue longitudinal magnetization is developed, and is directly related to CBF. This magnetization is interrogated and read at the end of the application of AFP, using Gradient Echo fast imaging methods. The ASL signal is the tissue CBF and is calculated from the voxel-by-voxel difference between image pairs acquired alternately with and without AFP pulses every few seconds. Control tagging is used for removing the MT effect of tagging pulse. What is MT?



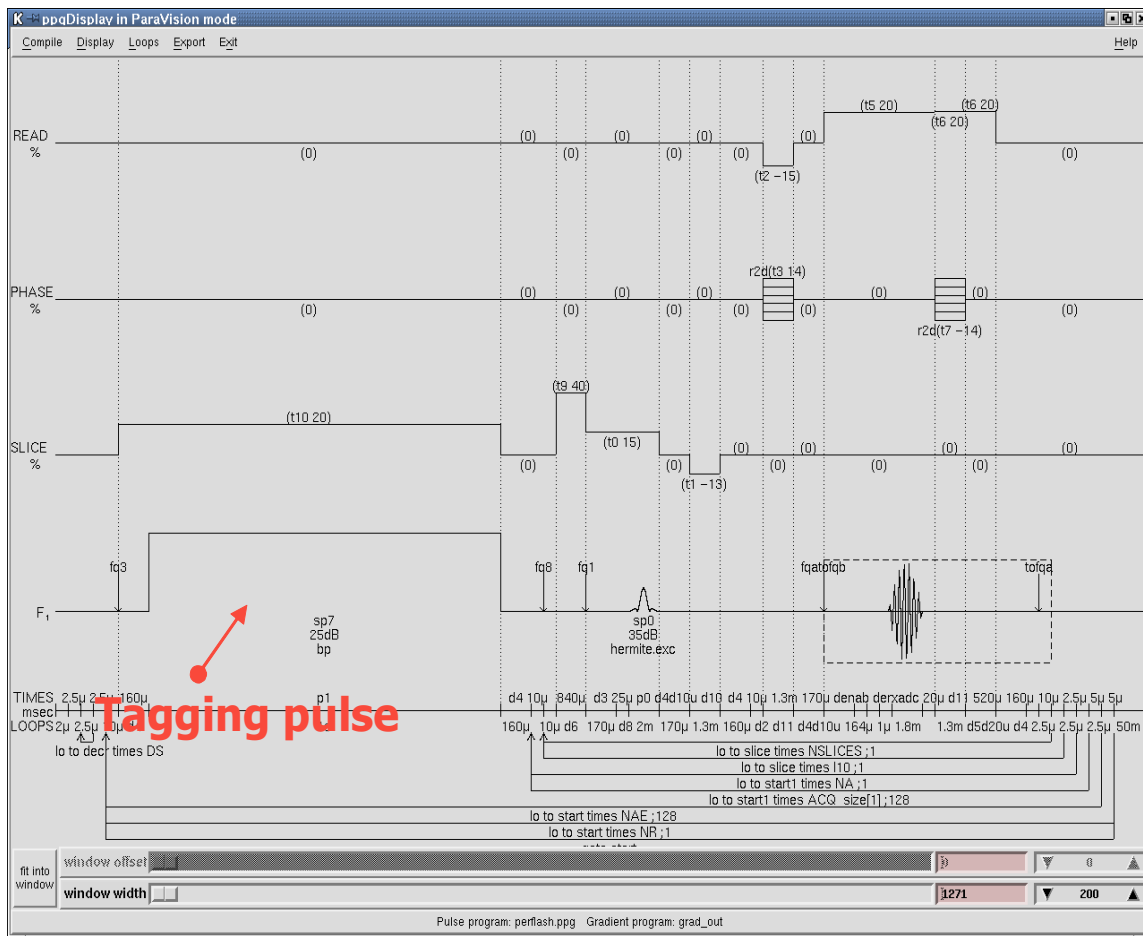
ASL image

The following formulation was used to define the ASL:

$$ASL = \frac{\lambda * (M_{control} - M_{tagging})}{T1 * (M_{tagging} - (2\alpha - 1) * M_{control})}$$

where $M_{tagging}$, $M_{control}$ are voxel intensities (magnetisation) of images acquired with and without labeling, respectively, λ is the blood brain partition coefficient, $T1$ is the longitudinal relaxation time of the tissue, and α is the tagging efficiency, which determines the relative value of the arterial magnetisation reaching the brain.

Sequences used in our 4.7 scanner:

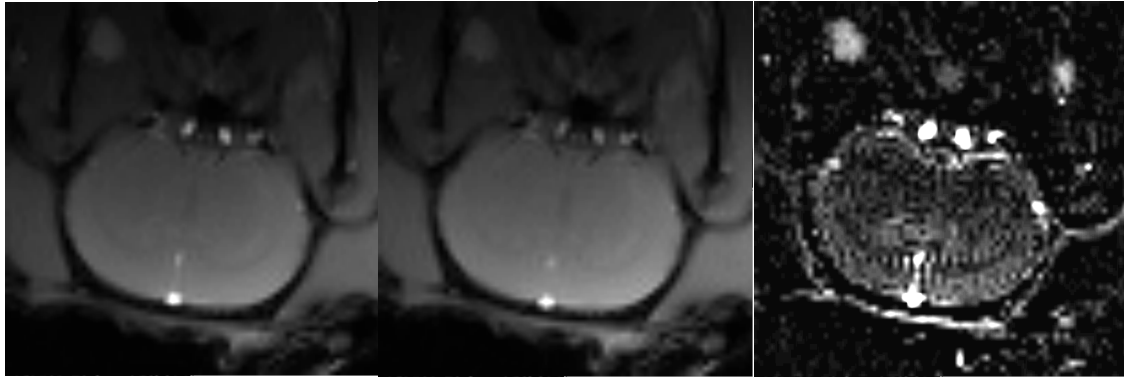


Parameters: GE sequence : single slice thickness 2mm, FOV 4cm*4cm, Matrix 128*128
 TR=10ms , TE = 5.3 ms. Tagging pulse: BP pulse, 1ms, power 25 dB. Offset position -
 2cm to the image plane, Average 128, post delay time 300ms total scanning time 6
 minutes

Material:

Rats were used for optimizing the parameters in MT sequences. And surface coil and volume coil were used using gradient S116.

Results:



Tagging image

Control image

Perfusion image

A typical rat was scanned using ASL. Hyperintensity CBF signal can be seen in the cortex. Low signal was revealed in white matter. Muscle shows the dark since no cerebral blood can go through the muscles.

Conclusion:

ASL imaging is established in the Howard Florey Institute aMRI facility. Proposed next step is to get the T1 map of the brain to obtain the absolute CBF values.