ASL: Single Subject & Group Analysis, Including Live Demo

Michael A. Chappell
michael.chappell@eng.ox.ac.uk
Institute of Biomedical Engineering & FMRIB Centre, University of Oxford.

Highlights:

- A guide to perfusion quantification from ASL data.
- A introduction to tracer kinetics applied to ASL perfusion.
- An overview of more advanced quantification topics in ASL.

Target audience: clinicians and basic scientists interested in quantifying perfusion from ASL data and/or using it within group studies.

Objectives: Outline the basic principles behind the analysis of ASL data focusing on perfusion quantification. Illustrate how single subject and group analysis can be achieved using the widely available FMRIB Software Library (www.fmrib.ox.ac.uk/fsl). Provide an introduction to more advanced issues in ASL quantification.

Purpose: ASL provides a non-invasive way to image cerebral perfusion and it is possible to quantify perfusion in absolute units (ml/100g/min), making it highly suited to clinical applications. Quantified perfusion images can also be used within large group studies with a wider range of possible study designs than BOLD fMRI.

Methods: The first step in any ASL analysis is subtraction of the pairs of tag-control images to give a perfusion image. To transform this into absolute CBF it is necessary to apply tracer kinetics. This summarises the system as an arterial input function (AIF) – describing the arrival of the tracer in the imaging region, and a residue function – describing what happens to the tracer once it has arrived. For perfusion quantification using ASL both AIF and residue functions are defined both by the physiology and also the way the ASL label was created[1]. The resulting model can then be inverted and applied to the data to give an estimate of perfusion. A separate estimate of the magnetization of arterial blood, which might be derived either directly from the data or a separate calibration scan, then permits values in standard units to be calculated. Perfusion images from individuals can then be used within larger group studies either following a classic general linear model or permutation testing approach.

Discussion: More advanced quantitative analyses with ASL are also possible, especially where data has been acquired at a range of delays post labelling. This includes the going beyond perfusion, for example the quantification of changes in vascular transit times[2], as well as for correction of confounding effects such as signal from large arteries[3] and the effects of partial voluming of grey and white matter within the voxel volume.

Conclusion: Sequences for ASL acquisition are becoming increasingly accessible. However, the accompanying methods for perfusion quantification are often missing or mysterious. Software tools are now available that make ASL perfusion quantification relatively straightforward for research use.

References:

1. Buxton R, *et al.* A general kinetic model for quantitative perfusion imaging with arterial spin labeling. *Magn Reson Med*. 1998;40(3):383–396.
2. MacIntosh BJ, *et al*. Assessment of arterial arrival times derived from multiple inversion time pulsed arterial spin labeling MRI. *Magn Reson Med*. 2010;63(3):641–647.
3. Chappell MA, *et al*. Separation of Macrovascular Signal in Multi-inversion Time Arterial Spin Labelling MRI. *Magn Reson Med*. 2010;63(5):1357–1365.