ASL Outside the Brain

David C. Alsop
Department of Radiology, Beth Israel Deaconess Medical Center and
Harvard Medical School, Boston MA USA
dalsop@bidmc.harvard.edu

Introduction and Objectives
Though Arterial Spin Labeling (ASL) has been most widely applied to perfusion imaging of the brain, the technique shows great promise for applications in other organs. After attending this lecture, you should be able to describe what other tissues have been imaged with ASL, list some of the challenges in ASL applied outside the brain, and give examples of how ASL can be used in research studies and clinical evaluation.

Current Experience with ASL Outside the Brain
ASL perfusion imaging has been reported in kidney, lung, myocardium, muscle, spleen, placenta, pancreas, retina, and tumors in various locations. Kidney studies readily demonstrate high flow and sharp contrast between the higher flow kidney cortex and the medulla. The high flow signal and relatively low motion have allowed successful application of ASL to characterize renal masses, renal insufficiency and renal transplants. Because of concerns regarding contrast administration to patients with renal insufficiency, renal ASL may serve an important clinical role for this population.

Imaging of lung and myocardium are appealing cardiovascular applications of ASL. Lung ASL has been more successful, with reports of single and multi-slice acquisitions. Clinical applications have been less widespread, perhaps because of technical challenges. Despite initial promise and continued interest, myocardial perfusion measurement with ASL is still largely under development. Hopefully newer developments in labeling and image acquisition may make this important application a more robust tool in the near future.

Studies of muscle perfusion with ASL have highlighted the very low level of perfusion at rest but the ability to readily quantify perfusion during and after exercise.

Challenges of ASL Outside the Brain
It is a common phenomenon in MRI that new techniques are developed first in the brain and ASL is no exception. The brain moves very little, has high resting flow, and has more uniform magnetic field and a simpler vascular supply than many other regions of the body. Motion artifacts, image degradation by nonuniform fields, low baseline flow and complex vascular geometry and supply are all major challenges of nonbrain ASL.

Respiratory motion remains a significant challenge for ASL in the abdomen and thorax. Strategies including background suppression, single-shot imaging, respiratory triggering and automated registration have been evaluated for renal perfusion. In the thorax, the difficulty of separating the
proximal vessels from the distal tissue can be a major challenge. The ventricles may be included
within the desired imaging volume, for example, causing inefficiency of labeling and very bright
vascular and ventricular artifacts on the perfusion images. Complex flow geometry can also be
challenging for imaging of the liver, where arterial flow is a small fraction of the total flow to the
liver.

Low baseline flow, as in muscle and many other tissues, further complicates ASL. Small lesions
with high flow in a low flow tissue may have long transit delays that can reduce the sensitivity of
the perfusion images. Metastatic lesions may present such challenges, though our studies of high
flow renal metastases have been quite successful (de Bazelaire et al 2005, 2008).

Summary
ASL is a promising technique for use outside the brain with many potentially important
applications. Though ASL in some organs is becoming routine, other regions may require further
development and evaluation before perfusion can be robustly measured.

References
Artz NS, Sadowski EA, Wentland AL, Djamali A, Grist TM, Seo S, Fain SB. Reproducibility of
renal perfusion MR imaging in native and transplanted kidneys using non-contrast arterial spin

de Bazelaire C, Alsop DC, George D, Pedrosa I, Wang Y, Michaelson MD, Rofsky NM.
Magnetic resonance imaging-measured blood flow change after antiangiogenic therapy with
PTK787/ZK 222584 correlates with clinical outcome in metastatic renal cell carcinoma.

De Bazelaire C, Rofsky NM, Duhamel G, Michaelson MD, George D, Alsop DC.
Arterial spin labeling blood flow magnetic resonance imaging for the characterization of

Frank LR, Wong EC, Haseler LJ et al. Dynamic imaging of perfusion in human skeletal muscle

Gardener AG, Francis ST. Multislice Perfusion of the Kidneys Using Parallel Imaging: Image
Acquisition and Analysis Strategies

Gowland PA, Francis S, Duncan KR, Freeman AJ, Issa B, Moore RJ, Bowtell RW, Baker PN,
Johnson IR, Worthington BS

Hirshberg B, Qiu M, Cali AMG, Sherwin R, Constable T, Calle RA, Tal MG. Pancreatic perfusion
of healthy individuals and type 1 diabetic patients as assessed by magnetic resonance perfusion

Lipson DA, Roberts DA, Hansen-Flaschen J, Gentile TR, Jones G, Thompson A, Dimitrov IE,
Palevsky HI, Leigh JS, Schnall M, Rizi RR. Pulmonary ventilation and perfusion scanning using
hyperfuearized helium-3 MRI and arterial spin tagging in healthy normal subjects and in
pulmonary embolism and orthotopic lung transplant patients.

Mai VM, Berr SS. MR perfusion imaging of pulmonary parenchyma using pulsed arterial spin

Maleki N, Dai W, Alsop DC. Blood flow quantification of the human retina with MRI
NMR in Biomed 24:104-111 (2011)


