Case Report: Clinical Validation of Arterial Spin Labeling

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Introduction

Arterial spin labeling (ASL) magnetic resonance imaging methods are perfusion-based imaging techniques; they provide quantitative measures of capillary blood flow rCBF (regional cerebral blood flow), in units of ml/100 g/min. Like positron emission tomography and certain other imaging methods, ASL measures can be either absolute (measuring overall flow), or relative (measuring changes in flow). However, ASL does not require injection of radioactive tracers or contrast agent, since it depends on the endogenous tracer of the spin-tagged blood. This allows it to be used in many clinical populations, and to be used repeatedly over shorter periods of time without any side effects observed with other exogenous tracer based methods. The basis of ASL is to use an appropriate RF pulse to tag all the blood in a particular location with a particular magnetization, i.e. an inversion (hence spin labeling). As the blood perfuses from the tagging location into the rest of the brain, the tagged blood changes the magnetization characteristics of the area, and thus can be measured [1]. ASL has been used successfully to measure blood flow in cardiovascular disorders and brain tumors [2–6]. Areas of high perfusion around a tumor, for example, can indicate where the growth is occurring most rapidly [7]. ASL can identify signs of stenosis which can be very difficult to otherwise identify non-invasively in the clinic [8]. These

disorders which stem from structural changes closely involved with the cardiovascular system are obvious candidates for a study using ASL. Here we would like to demonstrate how ASL can be useful in clinical settings. The following protocol (referred to as "FBIRN-ASL protocol") was used: FAIR QUIPSSII as pulsed ASL method, TI2 = 1600 ms, TI1 = 600 ms; TR = 4 s, TE = 12 ms; flip angle 90 degrees; 24 slices, 4 mm thick, 1 mm gap. P >> A phase encoding; 220 mm FOV, base resolution 64, phase partial Fourier 6/8, ascending slice order, AC–PC aligned. Fat saturation was turned on; the coil combine mode was sum of squares. The bandwidth was 2368 Hz/Px, echo spacing 0.49. We collected 105 measurements, which included an M0 reference scan. All studies were conducted using the 12-channel Siemens product Head Matrix coil. 3D PACE was used for real-time prospective motion correction.

Case 1

The subject is a 47-year-old male, who has been schizophrenic for 31 years, currently on antipsychotics and sleep aids. He had a self-report of a head injury at age 3 requiring both stitches and surgery, and another concussion with hospitalization in his teens. His schizophrenic symptoms are stable on his current medications. The head injury is not the current cause for treatment. The subject received T1- and T2-weighted anatomic scans, and an ASL scan using the FBIRN settings. The MRIs were reviewed by a radiologist to determine whether the internal brain damage required any current attention, and it was determined that it did not. The rCBF measures from the entire brain, from gray matter and from areas near the damage were measured for comparison both in their means and their variability. The T1 and T2-weighted images clearly showed areas of damage in the frontal lobes, with multiple fluid filled cysts, and dilation of the posterior sulci. There was no dilatation of the left frontal horn of the ventricles, which frequently is associated with atrophy, so general atrophy was not noted. The ASL images showed the expected distortion from the frontal cysts.

The rCBF measures both globally and from the entire grey matter of the subject were in general quite low, 45–47 ml/100 g/min (as compared to 58 ml/100 g/min for similarly aged healthy males, using a 1.5T multi-slice CASL method, in Parkes et al. (2004).) Areas near the cysts showed a higher variability in rCBF than did the overall grey matter measures.
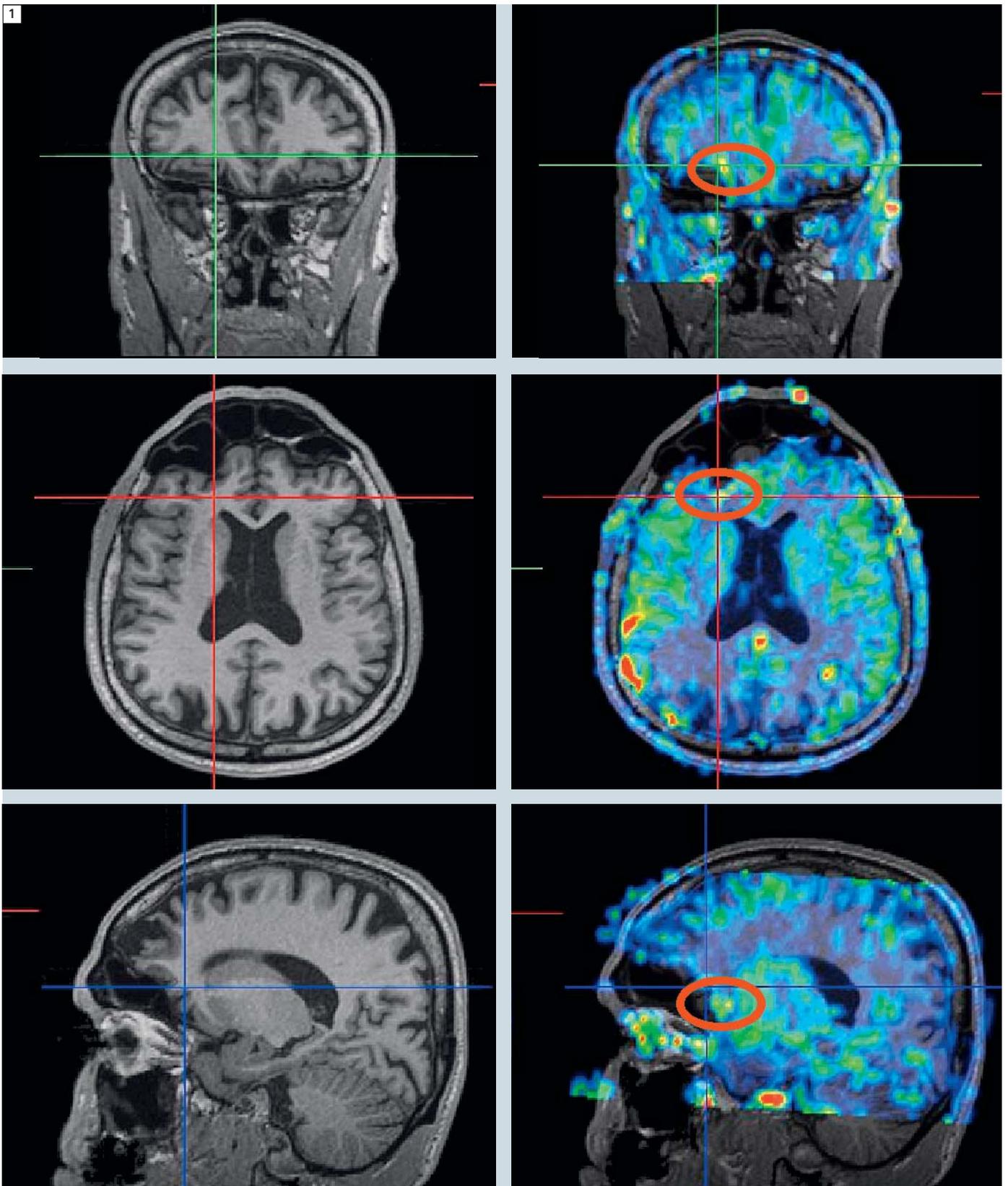
1 rCBF measurement around the area of brain damage. Left row is the anatomical scan and the right row shows the ASL rCBF measurement fused to the anatomical scan. The rCBF of the area around the brain damage is found to be higher.
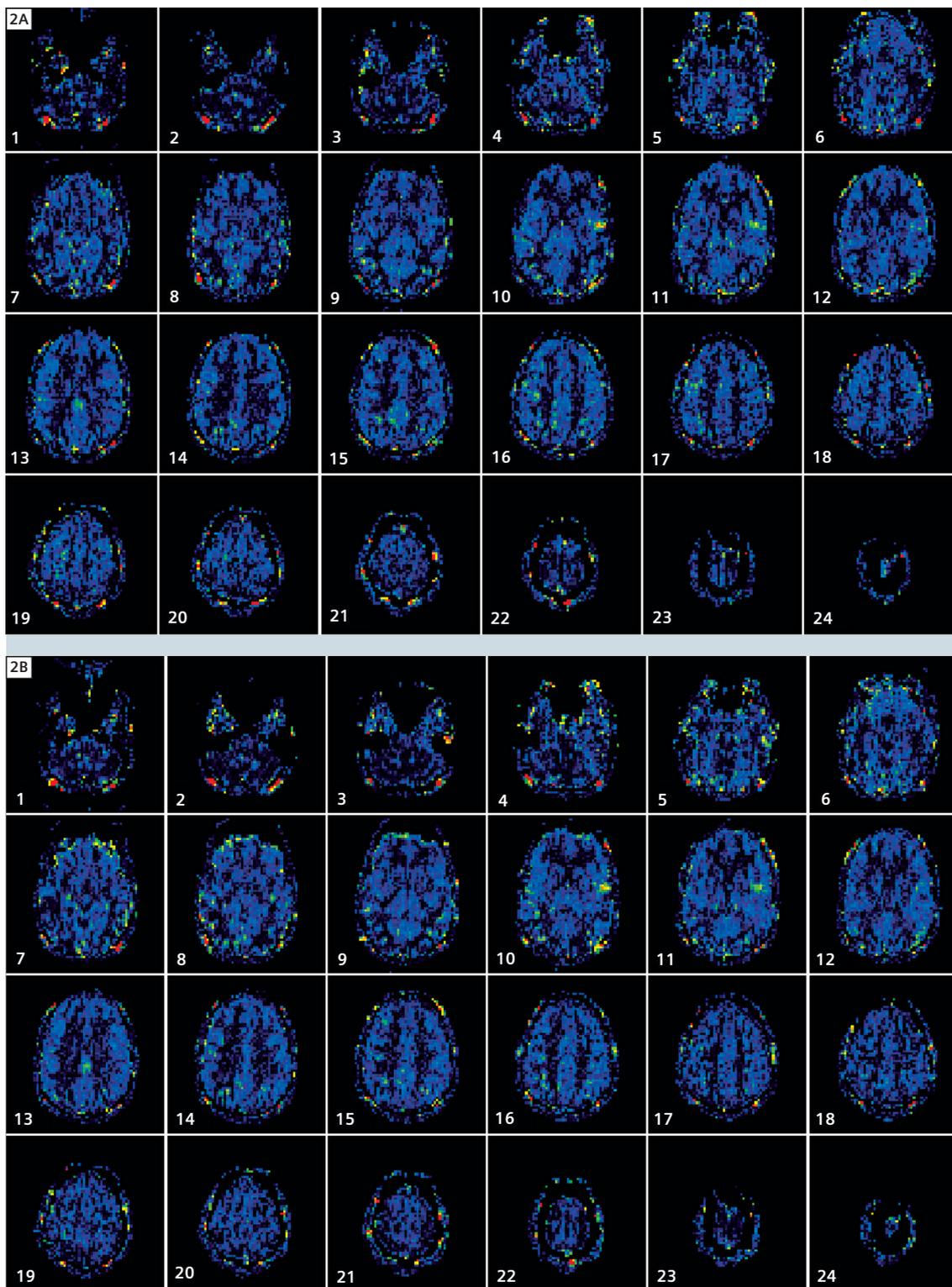
2A, B Representative images from the experiment. **(2A)** rCBF images when eyes open and **(2B)** when closed.
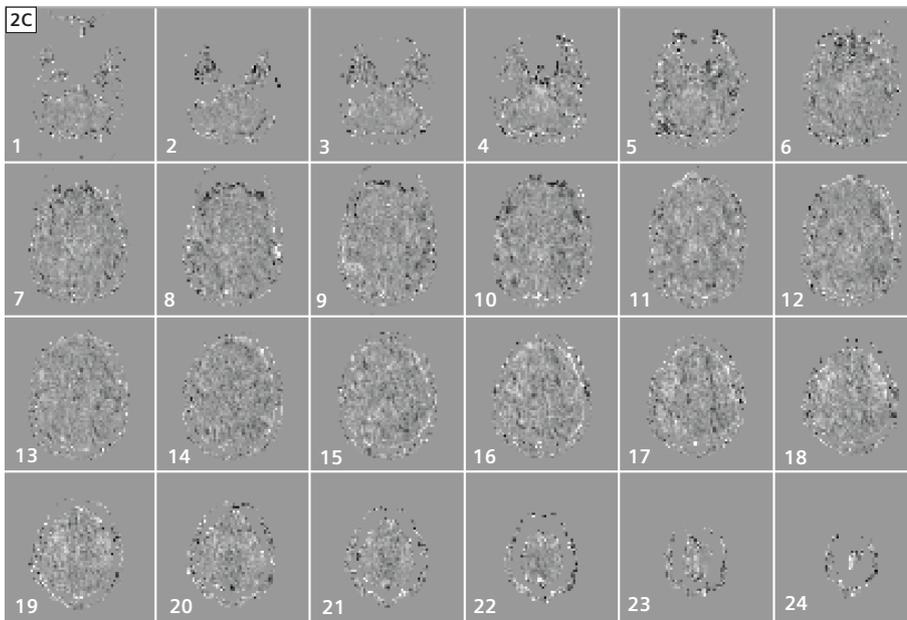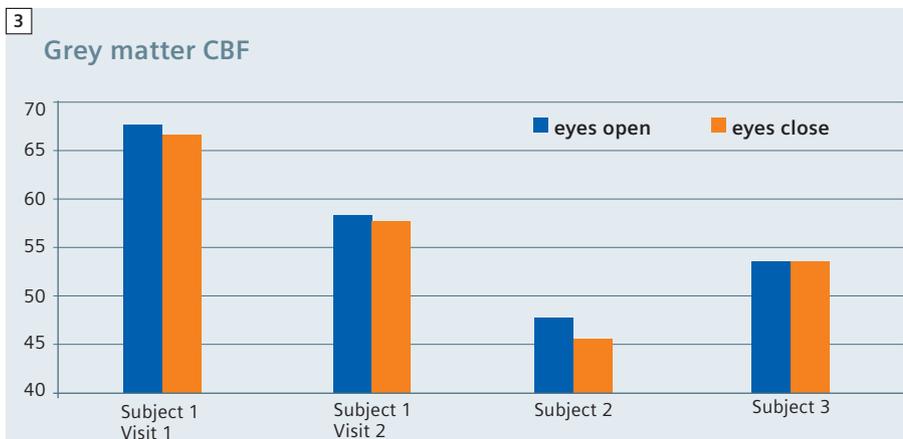
2C Difference images between eyes closed and eyes open.

Case 2

Three healthy subjects (ages 22 to 62) were scanned twice each in the FBIRN-ASL setting, once with eyes open and once with eyes closed. One subject was scanned twice in each condition. No motion correction was included during the scan.

Various rCBF measures were summarized from the rCBF images in each condition. The difference image (rCBF with eyes open – rCBF with eyes closed) was calculated for each subject. Head movement over the 105 image volumes was also measured in the two conditions. Overall, ASL flow within the grey matter mask increases very slightly with the eyes open. In three of the four cases, head movement was greater when the subject's eyes were closed.

Grey matter CBF

Legend: ■ eyes open ■ eyes close

X-axis: Subject 1 Visit 1, Subject 1 Visit 2, Subject 2, Subject 3

3 Grey matter rCBF [ml/100 g/min]. There is a consistent decrease in grey matter CBF when the eyes are closed.

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