Sub-minute Arterial Spin Labelling at 3.0T

E. A. Moore[1], F. G. Hoogenraad[2], X. Golay[3,4], E. T. Petersen[3], M. Versluis[2], J. M. den Harder[2], A. Moerland[2]

[1]MR Clinical Science, Philips Medical Systems UK, Reigate, United Kingdom, [2]Philips Medical Systems, Best, Netherlands, [3]National Neuroscience Institute, Singapore, Singapore, [4]Singapore Bioimaging Consortium, Singapore, Singapore

Background

Arterial spin labelling (ASL) is a technique which offers the possibility of absolute quantification of cerebral perfusion. However the SNR is very low, requiring multiple signal averages and thus the studies are time-consuming to acquire. In addition the technique is highly sensitive to motion. This limits its application in a clinical setting, particularly in patients with stroke who may be confused and unable to cooperate with instructions to remain still. Many clinicians prefer to rely on the more reliable Gd-bolus method, which can be acquired within 90-120 seconds, however this has the disadvantages of being invasive and expensive.

3.0T scanners offer the potential advantages of both increased SNR and longer T_1 of arterial blood, which means the label survives longer, however B_1 inhomogeneity is a well-known disadvantage of 3.0T transmit coils. Recently Golay et al [1] introduced a new sequence (PULSAR) which combines the 2nd EPI-STAR labelling method [2] with WET [3] pre-saturation of the imaging volume. Both these elements are relatively insensitive to B_1 inhomogeneity, and the resulting PULSAR images have high SNR in scan times of 3-5mins [1]. We investigated whether this increased SNR could be traded for a reduced scan time, to acquire qualitative ASL images in less than 1 minute.

Methods

5 healthy volunteers were scanned using a 3.0T Achieva system (Philips Medical Systems, Best, The Netherlands) equipped with 40mT/m gradients and a 6-channel head coil. The PULSAR[1] ASL technique (fig 1) was used with an adiabatic inversion slab 150mm thick centered on the carotid bifurcation and covering all the cerebral arteries. Following a transit delay of 1000ms or 1200ms, single-shot FFE-EPI images were acquired with the following parameters: field of view 230mm, matrix 64x64, 12 slices, slice thickness 4.5mm, slice gap 1mm, TE 10.5ms, TR 4000ms, SENSE factor 3.0. 6 pairs of label-control images were acquired taking a total of 48s; an extra 8 seconds was necessary for preparation phases, giving a total scan time of 56s. Data were processed using a dedicated software package (Universal Flow Observation, UFO, courtesy E.T.P.); from each pair of label-control images the subtraction images were calculated and then averaged to provide a qualitative image of ΔM. No motion correction was used in this processing software.

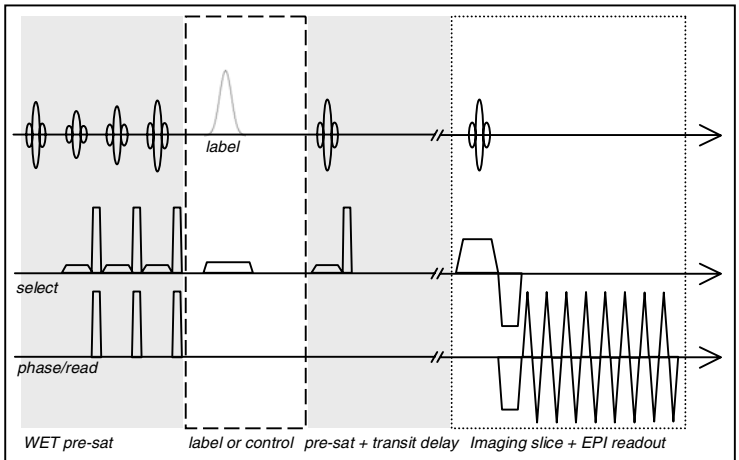

Fig 1: schematic pulse sequence

Results

Perfusion images were successfully obtained in all 5 subjects (fig 2). No motion was detected in any of the studies. In the qualitative ΔM images, grey matter SNR was measured and ranged from 7 to 13.

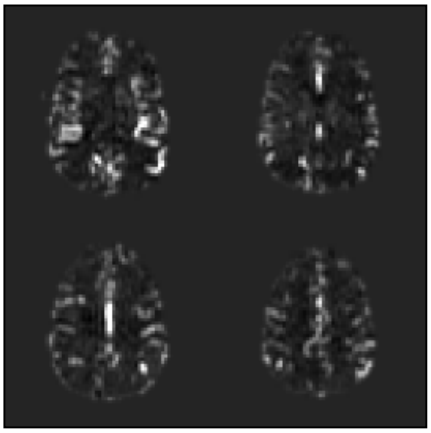
Fig 2: Qualitative perfusion images

Discussion

The EPI-STAR labelling scheme is similar to TILT but is less sensitive to B_1 inhomogeneity. It is also controlled for magnetization transfer effects so multi-slice imaging is possible. The label/control pulses are applied with the body coil, which allows us to invert spins over a long section of the carotid and vertebral arteries. Provided we limit ourselves to a qualitative technique we can ignore the leading and trailing edges of the bolus and focus on simply labelling the maximum number of arterial spins to maximise the SNR. The WET pre-labelling saturation provides excellent suppression of the static brain parenchyma; it is also insensitive to B_1 inhomogeneity and provides suppression over a wide range of T_1s. This efficient pre-saturation greatly increases the sensitivity of the subtraction images to the effect of the arterial spin labelling. The combination of these two features allows us to exploit the additional SNR at 3.0T, and the sequence is sufficiently robust to allow a good visualization of perfusion with only a small number of signal averages. The combination of whole brain coverage with a short scan time provides clinicians with a realistic alternative to Gd-bolus techniques for investigating perfusion in conditions such as stroke and dementia.

References

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[3] Ogg R.J. et al, J Mag Res B 1994 104:1-10