Clinical assessment of brain perfusion in newborn infants with arterial spin labeling perfusion MRI

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INTRODUCTION.

Many approaches have been applied to evaluate brain perfusion in neonates: brain ultrasound, near-infrared spectroscopy, and positron emission tomography (PET). However perfusion weighted imaging (PWI) MRI has been shown to enable in vivo direct measurements of brain perfusion in different brain regions. Recent advances have lead to the development of non-contrast agent based Arterial Spin Labeling (ASL) PWI. ASL-PWI relies upon the magnetic labeling of incoming blood flow to provide a change in contrast on the order of 1-2% that is proportional to the amount of perfusion present. This technique has been applied to study brain perfusion of older children [1-2], but only very limited data exists in neonates [3] because of the technical and clinical challenges to obtain sufficient signal-to-noise ratio (SNR) with spatial resolution sufficient to resolve cortical gray matter and white matter and basal ganglia in neonates.

Our study assesses brain perfusion patterns of normal term newborn infants using an ASL-PWI MRI sequence, and compares regional cerebral blood flow measurements to data previously described [3-5].

PATIENTS AND METHODS.

Four term newborn infants with normal brain MRI underwent a complete MRI study, including conventional anatomical imaging and ASL-PWI MRI. Infants were not sedated, but were wrapped in a specialized restraining pillow. IRB approval and parental consent were obtained.

All images were acquired on a 3T Siemens MAGNETOM Trio, a TIM System (Siemens HealthCare, Erlangen, Germany). We used a proximal inversion with a control for off-resonance effects (PICORE) sequence [6] for ASL-PWI MR measurements including QUIPSS II with thin-slice TI1 periodic saturation (Q2TIPS) using FOCI pulses [6]. Eighteen slices were acquired with a slice thickness of 6 mm. The ASL parameters were TI1 = 700 ms (time between inversion recovery pulse for labeling the blood and periodic saturation pulse), TI1s = 1400 ms (time between inversion recovery pulse for labeling the blood and end of the saturation pulse on the labeling plane), and TI2 = 1500 ms (time between inversion recovery pulse for labeling the blood and beginning of the imaging data acquisition by an EPI sequence), and, TE (echo time) / TR (repetition time) = 13/2400 ms, FOV (field of view) = 192 mm, 64 x 64 matrix echo planar imaging (EPI) readout, giving an image resolution of 3 x 3 x 6 mm. Quantification was done inline on the scanner using a separate M0 scan (λ=1.2, α=0.95, T1a=1500 ms). 3D PACE was used for real-time prospective motion correction.

RESULTS.

Perfusion was higher in the gray matter (GM) (42.3 ± 8.8 mL/100g/min) and in the basal ganglia (BG) (25.3 ± 6.6 mL/100g/min) compared to the white matter (WM) (1.7 ± 1.2 mL/100g/min). These trends are in general accordance with values previously described in the literature and measured in neonates by other approaches: either with PET (GM > WM) [3] or with PWI-MRI obtained with injection of gadolinium (GM > BG > WM) [4], or with values measured with ASL-PWI in older children (GM > WM) [5]. This is in opposition with previous values obtained in neonates with a different ASL-PWI sequence [1] that described values in GM nearly equivalent to WM, and much lower than in BG. This difference may be explained by less contamination from cerebrospinal fluid (CSF) in the measurements of GM using this ASL-PWI sequence, because of improved differentiation between grey matter, white matter and basal ganglia.

Figure 1 shows perfusion maps obtained with this ASL-PWI MRI sequence. **Figure 2** shows the average perfusion values for GM, WM, and BG.

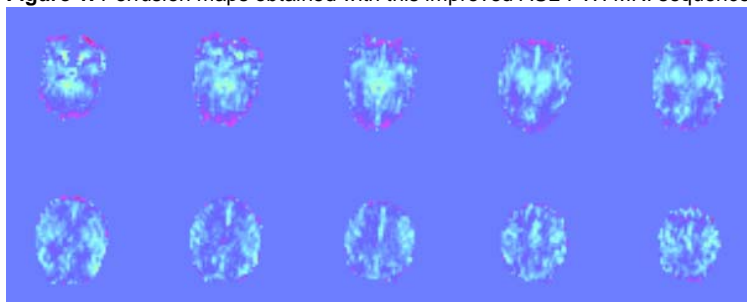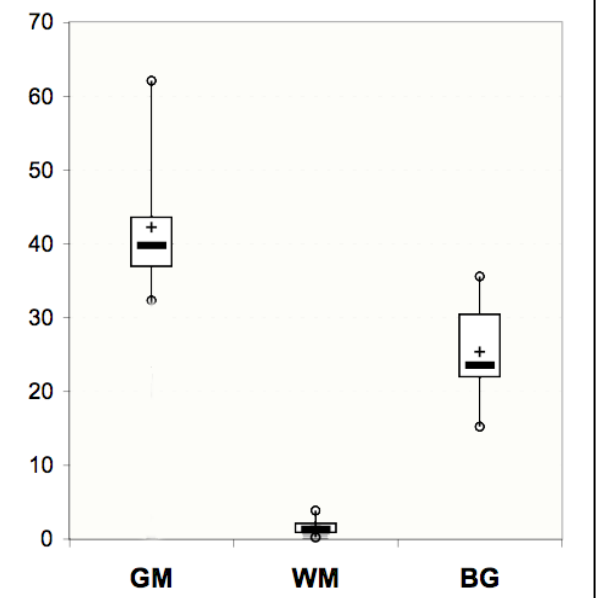**Figure 1.** Perfusion maps obtained with this improved ASL-PWI MRI sequence.

Figure 2. Box and whisker plot of the measured perfusion values (mean, minimum, and maximum, in [mL/100g/min]) for grey matter (GM), white matter (WM), and basal ganglia (BG).

DISCUSSION.

This study demonstrates that this ASL-PWI MRI sequence enabled the acquisition of regional cerebral blood flow perfusion maps of increased spatial resolution in term newborn infants, with adequate differentiation of gray matter, white matter, and basal ganglia. It permitted more accurate measurements of absolute brain perfusion in different regions of interest, with less contamination of the CSF, which occurs with partial voluming in lower resolution images. This improved image acquisition provides data to study brain perfusion in newborn infants, and was facilitated by the use of a 3T scanner that offer an increase in SNR compared to imaging at 1.5T, and the use of PICORE Q2TIPS sequence that bring a better saturation profile [6].

In conclusion, this sequence may improve measurements of brain perfusion in term newborn infants using ASL-PWI MRI. This will permit systematic prospective studies of brain perfusion in newborn infants, and assess for abnormalities of brain perfusion in newborn infants, such as in hypoxic-ischemic encephalopathy.

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