Developing an arterial spin labeling technique for measuring cerebral blood flow in pediatrics: Comparison with Computed Tomography Perfusion

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Introduction: Measuring cerebral blood flow (CBF) in critically ill neonates could potentially help identify those at risk of developing brain injury since major causes of neonatal brain injury, such as cerebral hemorrhage, are associated with abnormalities in blood flow. Arterial spin labeling (ASL) techniques are well suited for neonates as they are non-invasive, and absolute CBF can be measured, which is important for serial studies[1]. The goals of this project were to develop, in an animal model, an ASL technique on a 3 T neonatal MR unit, and to validate the CBF measurements by comparison with perfusion computed tomography (pCT)[2].

***Methods*:** Arterial spin labeling images were acquired using a flow sensitive alternating inversion recovery (FAIR)[3] sequence with inversion times (TI) of 1200 ms and 2000ms. Experiments were conducted on a custom-designed 3 T MR unit. A multi-slice, segmented gradient echo-planar imaging (EPI) sequence was used to collect the CBF images (4 slices, TE = 12 ms, TR = 3000 and 3800 ms/segment, 2 × 2 mm^2 pixel size, 5 mm slice thickness). To determine T_1, EPI images were acquired with twenty-five inversion times ranging between 50 to 4700 ms. Higher resolution (1mm x 1mm x 5mm) T_1 maps were collected for anatomical reference using the TOMROP[4] Look-Locker sequence. To quantify CBF, the transit time was characterized by collecting perfusion-weighted images (i.e., ΔM_B (t)/M_0) at nine inversion times. Perfusion CT images were collected on a Discovery™ LS PET/CT scanner (General Electric Medical Systems) at 120 kVp/150 mA with 4 slices at 0.23 × 0.23 mm^2 pixel size and 5 mm slice thickness.

***Results*:** Multiple TI data were collected on six piglets (age 34 ± 25.6 hrs, weight 1.63± 0.22 kg). An average vascular time of 630 ms was determined by fitting the signal equation for pulsed ASL to the data (see Fig. 1). To date, corresponding ASL and pCT CBF data have been collected on three piglets (age 22 ± 12.5 hrs, weight 1.76 ± 0.28 kg). Average CBF values from the two techniques are given in Table 1. CBF maps for one slice are shown in Figure 2 along with the corresponding T_1 map.

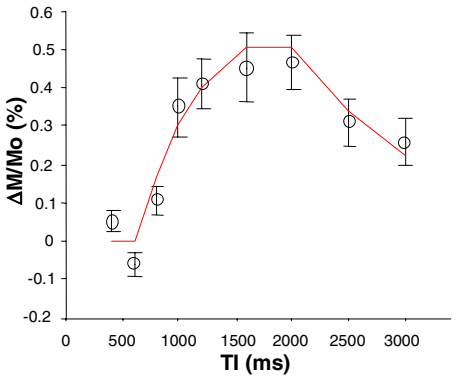

Fig. 1 Global $\Delta M/M_0$ signal plotted as a function of TI.

Table 1 Average CBF from pCT and ASL

Global CBF ml/100g/min	pCT	ASL (TI = 1.2 s)	ASL (TI = 2 s)
	80.3 ± 18.2	81.7 ± 21.5	56.8 ± 5.90

***Discussion*:** In this study we compared ASL CBF images to those acquired with a previously validated pCT technique[2]. Of the two TI values chosen, the average CBF for the shorter TI agreed with CBF from pCT; whereas, the longer TI was associated with substantially lower CBF. However, both the pCT and ASL (TI = 1.2 s) images have noticeable vascular artifacts (see Fig 2) that caused an overestimation of global CBF. With ASL, it is well known that vascular artifacts can be reduced by increasing the TI to allow sufficient time for all of the labeled water to reach the tissue[5]. This is evident by comparing the images in Fig. 2c and d. In the future, we plan to segment the pCT images to eliminate vascular pixels. It is useful to validate ASL with pCT because of the high spatial resolution of CT, which allows regional CBF patterns to be well delineated, and its insensitivity to transit time errors. However, pCT is not suitable for neonates due to use of ionizing radiation. On the other hand, ASL is more appropriate for imaging in this fragile age group because it is safe and completely non-invasive.

References

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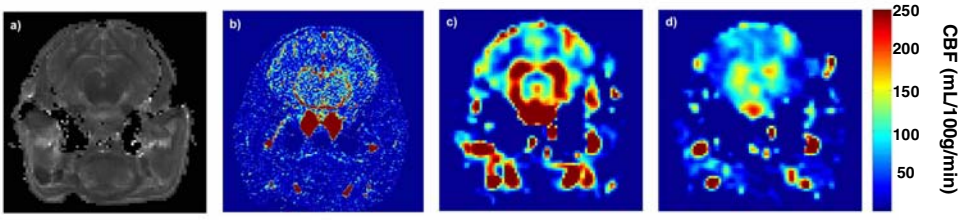

Figure 2. Representative CT perfusion map (b) with corresponding ASL perfusion maps at inversion times of 1200 ms (c) and 2000 ms (d). The corresponding anatomical T1 map is shown for reference (a).