Pediatric Perfusion Imaging Using Pulsed Arterial Spin Labeling

J. Wang[1], D. J. Licht[2], C. Liu[1], G. Jahng[3], J. Haselgrove[2], J. Detre[1]

[1]University of Pennsylvania, Philadelphia, PA, United States, [2]Children's Hospital of Philadelphia, Philadelphia, PA, United States, [3]University of California San Francisco, San Francisco, CA, United States

Abstract Arterial spin labeling (ASL) perfusion MRI is ideally suited for pediatric imaging because it is entirely noninvasive and provides improved ASL effects due to increased cerebral blood flow (CBF) in child population. In this study, we compared pulsed ASL (PASL) perfusion imaging in neurologically normal children and healthy adults. In this cohort, the child results showed 70% increase in the ASL signal and 30% increase in absolute CBF compared to adult data. A significant linear decrease in the ASL signal with age was observed. Applications of PASL also demonstrated its feasibility in diagnosis of pediatric cerebrovascular disease.

Introduction Parenchymal perfusion is an important physiological parameter that may contribute to the diagnosis, prognosis, and management of childhood brain disorders. To date, both normative and disease data on pediatric brain perfusion remain sparse due to the ethical and technical difficulties in applying existing approaches that rely on radioisotopes and contrast agents. ASL methods provide an alternative and completely noninvasive approach to image CBF utilizing magnetically labeled arterial blood water as an endogenous tracer. While the widespread application of ASL has been hampered by the relatively small fractional perfusion signal, pediatric ASL is expected to provide improved signal-to-noise ratio (SNR) due to the increased blood flow in children (1). These factors make pediatric ASL a potentially appealing tool given the unique and reciprocal benefits in terms of safety and image quality. The purposes of the present study are: 1) to test the feasibility of quantitative pediatric perfusion imaging using a PASL technique at 1.5T; 2) to compare PASL perfusion images in neurologically normal children and healty adults.

Methods MRI scanning was carried out on a 1.5T Siemens Vision scanner at the Children's Hospital of Philadelphia, using the standard birdcage head coil. Perfusion scans were obtained from 5 healthy adults (1 female, 27-40yrs) and from 7 children who received MRI scans but were neurologically normal (1 female, 1mo-10yrs). Three children diagnosed with neurological diseases (periventricular leukomalacia, external benign hydrocephalus and stroke respectively) were also studied. Written informed consent was obtained from parents of participating children and from adult volunteers. The PASL sequence consisted of interleaved selective/global inversion recovery acquisitions with a saturation pulse placed 0.8s after the HS inversion pulse (3). A delay time, *w*, was applied between the saturation and excitation pulses. Steady state perfusion imaging with 80 acquisitions was performed at three delays respectively on each adult and child (*w*=0.1, 0.4 and 0.7s). Imaging parameters were: FOV=20-24cm, 64x64 matrix, TR/TE=3000/29ms, slice thickness=8mm (2mm gap), inversion band thickness=10cm. 7 slices were acquired sequentially from inferior to superior using a gradient echo EPI sequence. An M_0 image was acquired after the perfusion scans. The raw image series at each delay were pair-wise subtracted and then averaged to form the mean ASL perfusion images. A T1 image was calculated using the M_0 image and the mean raw PASL intensity. Data acquired at *w*=0.7s were used for CBF quantification and comparison. CBF images were obtained using the PASL perfusion model (3). The ASL signals at three delays in the bottom slice were also fitted to estimate the transit time.

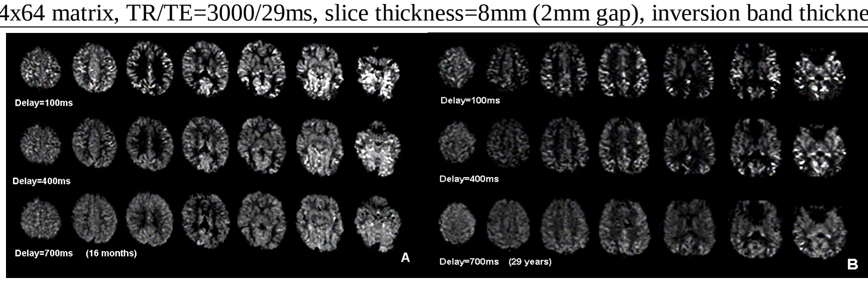

Fig. 1 Representative sets of ASL perfusion images in child (A) and adult (B) acquired at different delays, images are normalized with the background noise level.

Results The mean T1 and M_0 of brain are significantly higher in child than adult (T1=885.3±29.7 and 988.1±59.0ms, M0=948.2± 40.1 and 1174.7 ±120.8 in adult and child group respectively), consistent with previous finding of higher water content in pediatric brain (2). As displayed in Fig. 1, child images provide improved delineation of cortical and subcortical gray matter structures. The ratio of the whole brain SNR of ASL signal acquired in child and adult is 1.72:1 while the ratio of calculated whole brain CBF is 1.27:1. The increase in ASL signal is greater than the increase in CBF because T1 and M_0 are higher in child. A negative linear relationship between ASL signal SNR and age is observed (Fig. 2). Transit time estimated from the ASL signal series in the bottom slice does not show difference between the two age groups. Applications of PASL in the three neurologically abnormal children show deficits in perfusion images compatible with clinical diagnosis. Figure 3 displays CBF and diffusion weighted images (DWI) of pediatric stroke (6yrs male), showing deficits in left middle cerebral artery territory.

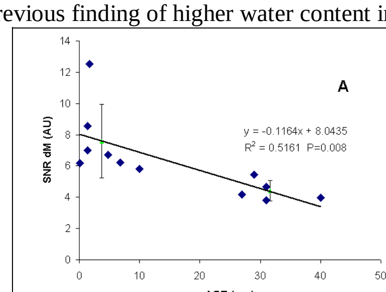

Fig. 2. ASL SNR versus age.

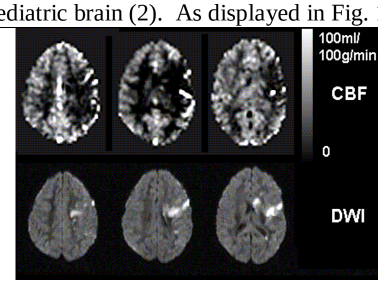

Fig. 3. CBF and DWI of pediatric stroke

Discussion Pediatric ASL is a very promising approach given the improvements in image quality and safety. Since ASL data are obtained using pair-wise subtraction of control and labeled images on a very short time scale of only a few seconds, bulk motion effects are reduced as compared to dynamic susceptibility contrast approaches. Further efforts will be needed to improve the accuracy of CBF quantification with specific ASL perfusion model for child population.

References (1) Chiron C et al. *J Nucl Med* **33**: 696-703; 1992. (2) Dobbing J & Sands J *Arch Dis Child*. **48**: 757-67; 1973. (3). Wang J et al. *MRM* **48**: 242-254; 2002.