Perfusion Imaging in a Pediatric Stroke Patient Population Using Pulsed Arterial Spin Labeling- Initial Experience

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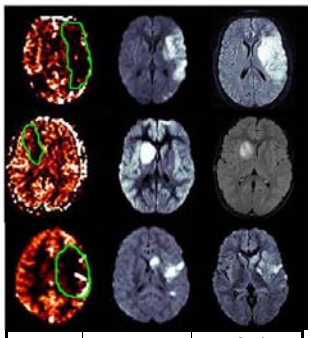
Introduction Perfusion/diffusion mismatch has been shown to be a criterion for patient selection when considering thrombolytic therapy in adult strokes. To date, there is no standard protocol for stroke management in pediatric patients. Arterial spin labeling (ASL) perfusion MRI offers a promising means to assess hemodynamic deficits in pediatric stroke patients because it is entirely noninvasive and provides improved perfusion image quality compared to adult scans (1). The purpose of this study was to assess the feasibility of quantitative measurement of regional cerebral blood flow (rCBF) in a clinical setting in a select cohort of pediatric patients with arterial ischemic stroke (AIS).



	DWI (cc)	Perfusion (cc)
stk04	176.8	327.4
stk11	21.6	53.4
stk22	10.2	57.8

Fig. 1. Perfusion, diffusion and FLAIR images in three AIS children showing hypoperfusion (lesion volumes are shown in green and below in same order figures appear).

Methods Since its inception (2/28/03-8/19/05), approximately 160 patients have been recruited for the Stroke Registry Database at The Children's Hospital of Philadelphia, of which 59 had AIS. Of 45 patients who had acute MR imaging, we selected 5 patients (2 female, age 6-15 years, mean age: 11.2 years) with M1 segment MCA stenosis on MRA. MRI was obtained on Siemens whole-body 1.5T (Vision, Sonata, or Avanto) or 3T (Trio) systems. Written informed consent was obtained from parents or guardians of all participating children. An identical pulsed ASL (PASL) sequence was added to clinically indicated MRI scans (including diffusion, T1, T2, FLAIR and MRA). A delay time between 1 and 1.5s was applied between the saturation and excitation pulses to reduce transit artifacts. Imaging parameters were: FOV 64x64 matrix, TR/TE=3000/19ms, slice thickness= 8 mm, 2 mm gap for 1.5 T; 5 mm, 1mm gap for 3 T. Eight (1.5T) or 16 (3.0T) 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 EPI image series were pair-wise subtracted and then averaged to form the mean ASL perfusion images. CBF images were obtained using the PASL perfusion model (1). Motion corrected image series were used for CBF calculation on patients manifesting head movements. Relative perfusion deficits were then determined by two methods: 1) ROI of the diffusion weighted image overlaid on the PASL image. The image intensity was then compared between the affected and unaffected hemispheres. 2) Vascular territory analysis, calculating rCBF in the leptomeningeal MCA territory using SPM2 (2). A percent difference of $\geq$20% was assumed to demonstrate a perfusional difference between affected and unaffected hemispheres (3).

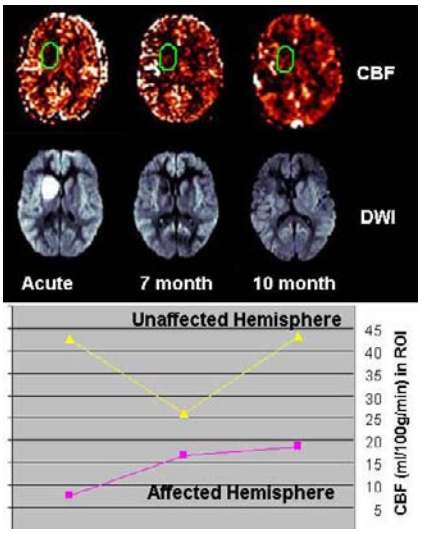


Fig 2. Longitudinal perfusion, diffusion imaging in a child with M1 stenosis and AIS. (CBF time course in DWI ROI, green circle, shown below).

Results Patients were scanned at variable times (range: 6-125 hours) after symptom onset, depending on presentation to the hospital. Accordingly, variable perfusion patterns were observed in affected regions. Three patients imaged at 6.25, 29.6, and 114.5 hours showed relative hypoperfusion in the affected vascular territory upon acute imaging and perfusion/diffusion mismatch (Fig. 1 and 3). One patient showed hyperperfusion upon first imaging at 125 hours. One patient showed no relative difference in CBF between the cerebral hemispheres on acute imaging due to the size of infarct (small subcortical). Additionally, reperfusion was observed in the two patients with one or more follow up scans (Fig. 2). Both patients had complete recovery and remained asymptomatic following their acute hospital recuperation.

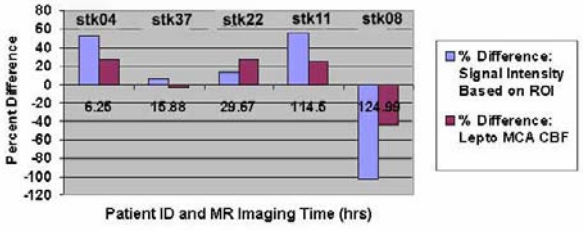


Fig. 3. Percent difference between affected and unaffected hemispheres. Negative values indicate hyperperfusion.

Discussion ASL is a useful tool in imaging adult cerebrovascular disease (3, 4) and may be even more important in the pediatric population given the noninvasive nature of the imaging technique. This preliminary study demonstrated detectable perfusion deficits in pediatric strokes using PASL at acute and subacute stages. Longitudinal ASL scans may provide a means to track evolutions in CBF in pediatric patients with vasculopathy, where there is evidence that these patients may compensate for their perfusional deficits.

References (1) Wang J et al. *J. Magn. Reson. Imaging* **18**:404-413. (2) Tatu, et al. *Neurology* **50**: 1699-1708. (3) Detre J et al. *Neurology* **50**: 633-641. (4) Chalela JA et al. *Stroke* **31**: 680-687.