Time-Resolved MR Angiography for Evaluation of Peripheral Congenital Vascular Lesions in Young Children

G. S. Sandhu[1,2], D. P. Hsu[1], J. Tamburro[3], M. A. Griswold[1], and V. Gulani[1,2]

[1]Radiology, University Hospitals of Cleveland, Case Western Reserve University, Cleveland, Ohio, United States, [2]Case Center for Imaging Research, Case Western Reserve University, Cleveland, Ohio, United States, [3]Dermatology, University Hospitals of Cleveland, Case Western Reserve University, Cleveland, Ohio, United States

Introduction: Pediatric congenital vascular lesions can be classified into broad categories on the basis of endothelial characteristics: namely, hemangiomas and arterio-venous malformations (1). Accurate classification of a vascular lesion enables one to plan the optimal protocol for its management. Here we investigate the role played by time-resolved MR angiography (trMRA) to define the type of vascular lesion in young children (whose small vasculature, fast hemodynamics, and need for anesthesia pose particularly high demands on the imaging) and evaluate the efficacy of time-resolved images to identify arterial supply (feeders) and venous drainage (drainers) of the vascular lesions.

Methods: In this IRB compliant retrospective study, image analysis of 6 children (mean age 2.8 yrs, range 5 months-7.1 yrs, M/F 2/4) who had trMRA for evaluation of a congenital peripheral vascular lesion at our institution between July 1st, 2008 and October 21, 2009 and in whose MRA exam report a vascular lesion was stated was performed. Time resolved imaging with stochastic trajectories (TWIST) was used for trMRA acquisition. Data were acquired at 3 T (Magnetom Verio, Siemens) and 0.10 mMol/Kg of Gadopentetate Dimeglumine (Magnevist; Bayer Healthcare Pharmaceuticals Inc. Wayne, NJ, USA) was injected. The fraction of fully sampled k-space for each frame in the central region and sampling fraction of the peripheral region were 0.14 and 0.33-0.5, respectively. Parallel imaging (GRAPPA, R=3), partial Fourier acquisition (6/8 in phase and slice direction) and temporal interpolation (factor 2-3) were used to accelerate the frame rate. The temporal and spatial resolution ranged from 1.1 s /frame to 1.6 s /frame and $0.9\times0.7\times0.9$ mm^3 to $1.4\times1.2\times1.6$ mm^3, respectively. Acquisition parameters varied between individual patients depending upon the imaging region. Two patients had an ultrasound (US) exam prior to the MR exam. One patient underwent digital subtraction angiography (DSA) at our institution for embolization of the vascular lesion. The suspected diagnosis of the lesion prior the exam was compared with the diagnosis reached after analysis of MR images. The time-resolved image set of each patient was analyzed to identify the number of feeders and drainers of the lesion. The total and average number of feeders and drainers in each lesion was calculated. For the one patient who underwent DSA, the number of feeders and drainers from trMRA and DSA was compared.

Results: The US exam was inconclusive in both patients who underwent sonography. Out of the total 7 vascular lesions identified, the suspected diagnosis was stated as hemangioma for 4, AVM/venous malformation for 1 and no suspected diagnosis was stated for the remaining 2. One child was being evaluated for PHACE Syndrome (Posterior fossa, Hemangioma, Arterial lesions, Cardiac abnormalities, Eye abnormalities), which predisposes them the head/neck vascular abnormalities and the results were negative. Following trMRA, 6 lesions were diagnosed as AVMs and 1 as hemangioma. The final diagnosis was concordant with the suspected diagnosis in 1 (14.2%) lesion, changed from hemangioma to AVM in 3 (42.8%), from AVM/ venous malformation to AVM in 1 (14.2%) and from no suspected diagnosis to AVM in the remaining 2 (28.4%) lesions. A total of 16 feeders and 13 drainers were identified. The average (range) number of feeders and drainers is 2.3 (1-4) and 1.9 (1-2), respectively. In the patient who had DSA, the number of feeders and drainers from trMRA and DSA is 3 and 3, and 6 and 5, respectively (Figure 1).

Age [months]	Location of vascular lesion	Resolution of trMRA		Number of	
		Spatial [mm]	Temporal [s]	Feeders	Drainers
15	left breast region	1.4×1.1×1.5	1.3	3	3
10	right scalp region	1.4×1.4×1.5	1.1	2	2
5	left back region	1.3×1.1×1.1	1.5	1	2
85	left thigh	1.5×1.3×1.6	1.4	4	2
61	left hand	0.9×0.9×1.0	1.6	2	2
22	Penis	1.4×1.2×1.5	1.1	3	1
22	Left posterior chest wall	1.4×1.2×1.5	1.1	1	1

Table 1: Location of the lesion, spatial and temporal resolution of trMRA, and number of feeders supplying to the lesion and drainers arising from those lesions.

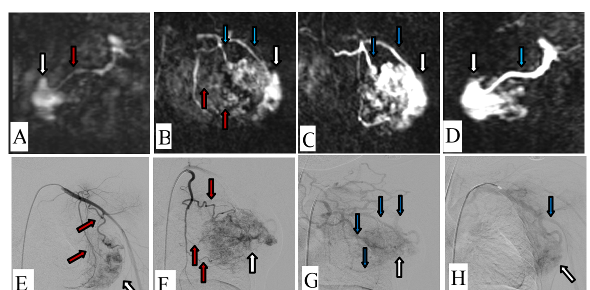

Figure 1: MIPs (A-D) and CA images (E-F) of the patient showing feeders (red arrows), drainers (blue arrows) and the lesion blush (white arrows).

Discussion: The results demonstrate that trMRA played a significant role in reaching the diagnosis in 6 (84%) out of 7 lesions investigated in this study. Time-resolved images enable one to delineate the arterial supply and venous drainage of a vascular lesion even in very young children (Figure 2). The size, location and adjacent anatomy of the lesion can be characterized from the structural MR images that can be acquired in the same setting. The number of feeding arteries and draining veins identified from trMRA is lower than those identified from DSA, primarily due to lower spatial resolution and the inability to acquire trMRA images following selective arterial injections which provide more accurate delineation of vascular connections of the lesion. However, this procedure requires general anesthesia, has a small but defined complication rate, is more costly and is difficult to repeat time and again (2). trMRA is non-invasive and can be performed in free-breathing children under mild sedation, and is a safe alternative to DSA for the diagnosis and follow-up of vascular lesions. Injection of a test bolus, which is often a significant proportion of the total contrast dose in children, is also not required for trMRA, lowering the Gadolinium dose for the exam and allowing for a larger bolus during the actual angiogram. Contrast doses as small as 1.1 cc were employed in this study. MRA in very young children is particularly challenging due to the inability of these patients to provide breath holds, very fast hemodynamics and small vasculature. The high spatial and temporal resolution requirements mean that the exam has to be highly accelerated with parallel imaging and with view sharing. However, there are trade-offs with trMRA: primarily SNR in case of GRAPPA, and temporal blurring in case of view sharing. The settings used here are the best heuristic trade-offs between spatial resolution, temporal resolution, SNR and the temporal footprint based on initial clinical experience, but a formal optimization of these parameters remains to be performed.

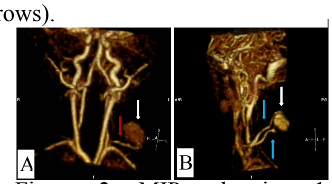

Figure 2: MIPs showing 1 feeder (red arrow), 2 drainers (blue arrows) and nidus (white arrows) of lesion in back of a 5 month old child.

References: 1. Mulliken JB, et al. Plast Reconstr Surg. 1982; 69 (3):412-22. 2. Burger IM, et al. Stroke 2006; 37: 2535-2539.

Acknowledgments: This work was partially supported by Siemens Medical Solutions. VG is also supported in part by NIH/NCRR 1KL2RR024990.