MR Guided Percutaneous Embolization of Low-Flow Vascular Malformations: Initial Experience Using a Hybrid MR/X-Ray Fluoroscopy System

C. R. Weiss[1], A. J. Flammang[2], W. Gilson[2], D. L. Kraitchman[1], S. E. Mitchell[1], F. K. Wacker[3], and J. S. Lewin[1]

[1]Radiology and Radiologic Science, Johns Hopkins University School of Medicine, Baltimore, Maryland, United States, [2]Center for Applied Medical Imaging, Siemens Corporate Research, Baltimore, Maryland, United States, [3]Department of Diagnostic and Interventional Radiology, Hannover Medical School, Hannover, Germany

Background/Objective:

Low-flow Vascular Malformations (VM's), namely the Venous and Lymphatic malformations, are congenital, non-malignant, lesions which affect both children and adults. Because these lesions can be found anywhere in the body, and grow proportionally over time patients can present with a myriad of symptoms and signs, including pain, cosmetic disfigurement, functional impairment and bleeding.(*1*) Currently, these low-flow VM's are treated surgically or, more commonly, by the interventional radiologist using ultrasound and X-Ray fluoroscopically guided percutaneous sclerotherapy.(*2*) However, this combination of imaging modalities has significant limitations. It is difficult to use ultrasound to identify and access deep lesions, lesions in bone, or lesions that lie deep to previously treated, now scarred, lesions. Furthermore, patients with VM's typically require multiple treatment sessions and therefore repeated exposures to ionizing radiation. MR imaging provides a solution to both of these problems. Low-flow VM's are easily identified on T2 weighted, fat-saturated imaging, at any depth, regardless of overlying scar tissue, and the multiplanar capabilities of MR allow for accurate, real-time needle targeting with simultaneous visualization of surrounding critical structures. Furthermore, MR can be used to identify draining veins when needed, and to assess immediate post procedural changes both within and surrounding the treated lesions, all without the use of ionizing radiation. Early work has demonstrated both the feasibility and efficacy of MR guided percutaneous sclerotherapy of low-flow head and neck VM's on an open 0.2 T system.(*3*) In this abstract we present our initial experience treating low-flow VM's using a hybrid short bore 1.5T MRI/X-Ray "Miyabi" suite.

Materials and Methods:

This study was performed with the approval of our Institutional Review Board. **Patient Selection:** Between September 7, 2010 and November 3, 2010 five patients either venous or lymphatic malformations were enrolled in this study. Each patient had already undergone at least one percutaneous VM embolization using standard ultrasound and fluoroscopic guidance, and were referred for MR guidance due to either an actual or predicted inability to find the lesion using ultrasound. **Equipment/General Workflow:** All MR guided interventions were performed in a hybrid 1.5 T MRI (MAGNETOM Espree, Siemens)/X-Ray angiography (Axiom Artis dFA, Siemens) "Miyabi" suite. Lesions were accessed using either 20 or 22 Gauge MR-compatible needles ranging between 10 cm and 15 cm in length (MReye, Cook). One lesion was targeted using a 22 Gauge, 5 cm long MR compatible needle (InVivo). After a planning MR, all lesions were punctured using real-time MR imaging. Once access to the lesions had been confirmed by fluid return, patients with lymphatic malformations were then treated in the MR scanner with Doxycyclene (10 mg/cc) through the access needle. Patients with venous malformations were first injected through the access needle with gadopentate dimeglumine (Bayer) at 0.002 mmol/cc under MR to assess for draining veins, and then were transferred to the in-room X-ray angiographic system using the Miyabi table where a hand injection of ioxilan 350 (Guerbet) was used to confirm MR findings. These patients were then treated on the angiographic table using 100% (anhydrous) ethanol under fluoroscopic control. After treatment, all patients were reimaged with the initial planning sequences. **MR Imaging:** Coil utilization differed slightly from patient to patient. For the most part, the access granted from a simple linearly polarized circular coil (loop coil) was desirable, despite greater signal available from a traditional anterior body array assembly. In our case, the loop coil was 19 cm in diameter. In each instance, the patient was placed on top of the Spine Matrix, which consists of 24 freely selectable elements. The typical combination and resulting channel count was 6 elements of the Spine Matrix combined with 1 element on top of the patient for a total of 7 RF channels used. Patient positioning (head/feet first/supine/prone) was based on lesion location and preferred approach path with respect to the magnet environment. The imaging protocol was standardized and consisted of the following for each case: 1) 3 plane gradient echo localizer; 2) Axial, Sagittal, and Coronal T2 with Fat Saturation (SPAIR, 3mm with no interslice gap); 3) Interactive Real Time TrueFISP imaging (BEAT IRTTT) parallel 4mm slices (465 ms per slice); 4) Half Fourier Single Shot Turbo SE (HASTE with fat saturation, 5 parallel 4mm slices, 700 – 800 ms per slice); 5) Dynamic "thick slab" Fast Low Angle Shot (FLASH with subtraction, temporal resolution <2 frames/s) for evaluation of contrast in the lesion and draining veins [Technique #5 was optional and performed on venous malformation patients only]; 6) Axial, Sagittal, and Coronal T2 with Fat Saturation (SPAIR 3mm with no interslice gap).

Results:

The results of our experience are summarized in **Table 1**, and an example of a successful MR guided venous malformation embolization is seen in **Figure 1**. Five patients were treated (ages 8-56 years) with a total of seven targeted lesions (three venous and four lymphatic malformations). We successfully targeted and treated six of the eight lesions. Of the three successfully treated patients, two have had a complete therapeutic response, and one is scheduled for clinical follow-up.

Table 1

Patient #	Age	Sex	Lesion Type	# of Lesions Targeted	Lesion location(s)	X-Ray Flouro	Treatment Agent	Total Procedure Time	Technical Success	Imaging Success	Therapeutic Success
1	54	F	VM	1	Left breast/chest wall	No	none	2H 30 min	No - small & mobile	NA	NA
2	18	F	VM	1	Left shoulder (subcuteneous)	No	none	3H	No - small & mobile	NA	NA
3	20	F	VM	1	Right lower back (near Psoas)	Yes	ETOH 3cc	2H 20 min	Yes	Yes	Yes - no pain
4	56	M	LM	2	Right acetabulum and Right Fascia Lata	No	DOXY 7 cc	3H 10 min	Yes	Pending	Yes - no pain
5	8	M	LM	2	Peri-vesicular	No	DOXY 6 cc	3h	Yes	Pending	Pending

Discussion and Conclusion:

This preliminary data demonstrates that low-flow VM's can be safely and effectively accessed and treated using a short bore 1.5 T MR system. The treatment of lymphatic malformations can be already safely performed with no X-ray imaging due to the relatively benign nature of the administered therapeutic (doxycycline). However, the treatment of venous malformations demonstrates the utility of using an MR/angiographic hybrid system; namely the added safety of angiographic evaluation before the administration of a highly caustic therapeutic (absolute alcohol). Our goal is to improve our MR imaging protocol so that we can eventually eliminate the use of X-ray altogether for all types of VM's, regardless of therapeutic or venous outflow. Already, we have learned that although there are advantages to using TrueFISP based real time sequences, namely faster frame rate and higher signal to noise, the image contrast produced by this technique could be described as a relationship of T2/T1. Because of this and the fact that the lesions targeted are often best visualized using a traditional T2 weighted techniques, HASTE imaging was prescribed to offer further detail during guidance. At this point, no truly interactive multi-slice HASTE scheme was available. Our next steps will involve the further development of this HASTE sequence as well as of a FLASH sequence for assessment of lesion flow/outflow.

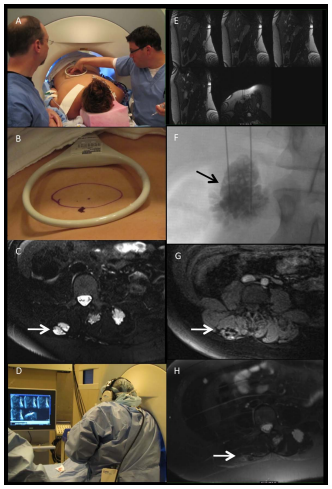

Figure 1: Example of a venous malformation embolization procedure in a 20 y.o. woman with Blue Rubber Bleb Nevus Syndrome and multiple venous malformations. Her current symptoms are right back/flank pain. *Where applicable, targeted right flank VM is marked with an arrow.* **(A)** Planning stage, patient is prone, feet first in the 1.5 T Espree. **(B)** 19 cm loop coil is placed on the patient's circled "area of greatest pain". **(C)** Planning MR, Axial T2 SPAIR with fat saturation. **(D)** Procedural set-up for real time needle placement. **(E)** Sagittal and Axial real-time TrueFISP for needle placement into selected VM. **(F)** After Miyabi transfer to Artis angiographic system, ioxilan injection confirms needle position, and further demonstrates the multiloculated nature of the VM. **(G)** 10 min after treatment Axial T1 VIBE demonstrates areas of thrombosis (dark areas) within the treated VM. **(H)** 6 week follow-up Axial T2 TSE with fat saturation demonstrates resolution of the treated VM.

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