MRI-Guided Sclerotherapy of Veno-lymphatic Vascular Malformations: Evaluation of Procedure Safety and Long-term Efficacy

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Introduction & Purpose: Slow-flow (venous-lymphatic) malformations are congenital vascular anomalies that are present at birth but usually manifest during later years of childhood or adulthood. Percutaneous sclerotherapy under x-ray fluoroscopy is the current standard management and is frequently complicated with skin ulceration, scarring, and incomplete treatment. Lewin et al [1] introduced the concept of using MRI for guiding sclerotherapy on low-field interventional scanners. The current widespread shift to higher field interventions provides an opportunity to exploit the fast scan times and the improved image resolution and SNR to revive this approach and to further it for targeting large, complex, and deep malformations aiming at full therapeutic results. The aims of this study are to: (1) test the feasibility of performing sclerotherapy procedures within the high-field interventional MRI environment; (2) examine the ability of intra-procedural MRI guidance and monitoring to reduce peri-procedural complications; and (3) explore the long-term efficacy of MRI-controlled sclerotherapy procedures.

Patients & Methods: 46 MRI-guided percutaneous sclerotherapy procedures were performed on 13 consecutive (4 male & 9 female) patients with low-flow vascular malformations (age = 3.6 – 46.4 y, median = 9.6 y). All procedures were exclusively performed within an interventional MRI suite on a wide (70cm), short (125 cm) bore 1.5T MRI scanner (Siemens Espree, Germany). An in-room monitor and trackball were used for real-time needle guidance, injection monitoring and bedside scanner operation. A 22g MR compatible needle (E-Z-Em, Westbury, NY) was inserted into the targeted part of the malformation under MR fluoroscopic guidance. A new method for triorthogonal image plane MR guidance [2] was used to interactively monitor the needle on continuously updated sets of true-FISP images (TR/TE, 4.35/2.18; FA, 60°; NSA, 3; TA, 3.11 s/ slice). The three orthogonal planes could be acquired relative to needle axis, relative to the target lesion itself, or in any three arbitrary planes. Reconstruction and display program was modified to simultaneously project updates of the 3 planes. 0.6% diluted gadolinium was mixed with 5% Ethanolamine Oleate (Ethamolin®, QOL Medical, USA) (0.15ml: 1.0ml vol.) and injected under real-time monitoring using a triorthogonal FLASH sequence (TR/TE, 2484/5.4). Injection endpoints were tailored for individual lesions based on lesion size and adequacy of filling under real-time monitoring. Patients were observed overnight for pain, edema, skin ulcers, compartment syndrome, signs of hemolysis, and pulmonary embolism. Follow-up durations ranged between 3.1 and 36.1 months (median = 11.9 months). Lesion volumes were quantified on pre- and post-treatment TSE T2WI-FS using the ellipsoid formula.

Results: Treated lesions consisted of 5 head and neck, 1 upper extremity, 1 pelvic, and 6 lower extremity malformations. 9 lesions were treatment-naïve and 4 lesions were previously treated (2 surgically, and 2 with prior x-ray guided sclerotherapy). Initial needle insertion and subsequent repositioning within the malformations were feasible in all cases. Adequate visualization of sclerosing agent was persistently achieved and could be interactively monitored on 3 orthogonal planes. The total volume of sclerosing material injected per procedure ranged between 2ml and 28ml (median = 11ml). 10 of 13 malformations were completely filled with the sclerosing material on the first treatment session. 3 of these required re-treatment (with 1-5 additional procedures) due to recurrent components on follow-up MRI. The remaining 3 malformations in this series were extensive lesions (1 neck, 1 hemiface, and 1 pelvic) that were approached in a staged manner and required 5, 18, and 4 procedures, respectively. The procedures were tolerated by all patients. Patients predominantly reported localized tenderness rather than pain. Noticeable local edema and bruising were a standard finding that lasted 1- 2 weeks following procedures. A prophylactic tracheotomy was offered to one patient to guard the airway during repeated parapharyngeal and pharyngeal mucosal space injections. This patient developed a 3mm self healing skin ulcer during one of the treatments. 4 patients reported temporary dark urine for one or two voids following the procedures without overt signs of hemolysis. No other complications were encountered. The mean ± SD lesion volume was 60.2 ± 90.1ml (median = 24.4ml) on pre-treatment and 26.4 ± 44.3ml (median = 8.1ml) on post-treatment scans.

Discussion & Conclusion: This study demonstrates the feasibility of treating slow-flow vascular malformations exclusively within a high-field interventional MRI suite. In addition to avoiding the repeated radiation exposures in this predominantly younger population, the technique also holds a great deal of promise in terms of procedure safety and efficacy of treatment. Safety stems off the ability to interactively monitor the sclerosing agent distribution in 3 simultaneous planes and thereby prevent extravasation toward the skin and other critical structures. The flexibility of independently aligning the 3 planes of guidance/monitoring also allows continuous monitoring of sizeable draining veins as desired. Treatment efficacy is related to the ability to reposition / re-inject the various compartments of the malformation during the same session as well as to the ability to selectively target deeper or complex areas to eliminate potential niduses of recurrence.

References: [1] Lewin JS, et al. Radiology. 1999;211(2):566-70.   [2] Derakhshan JJ, et al. Proc ISMRM 15: 487 (2007).
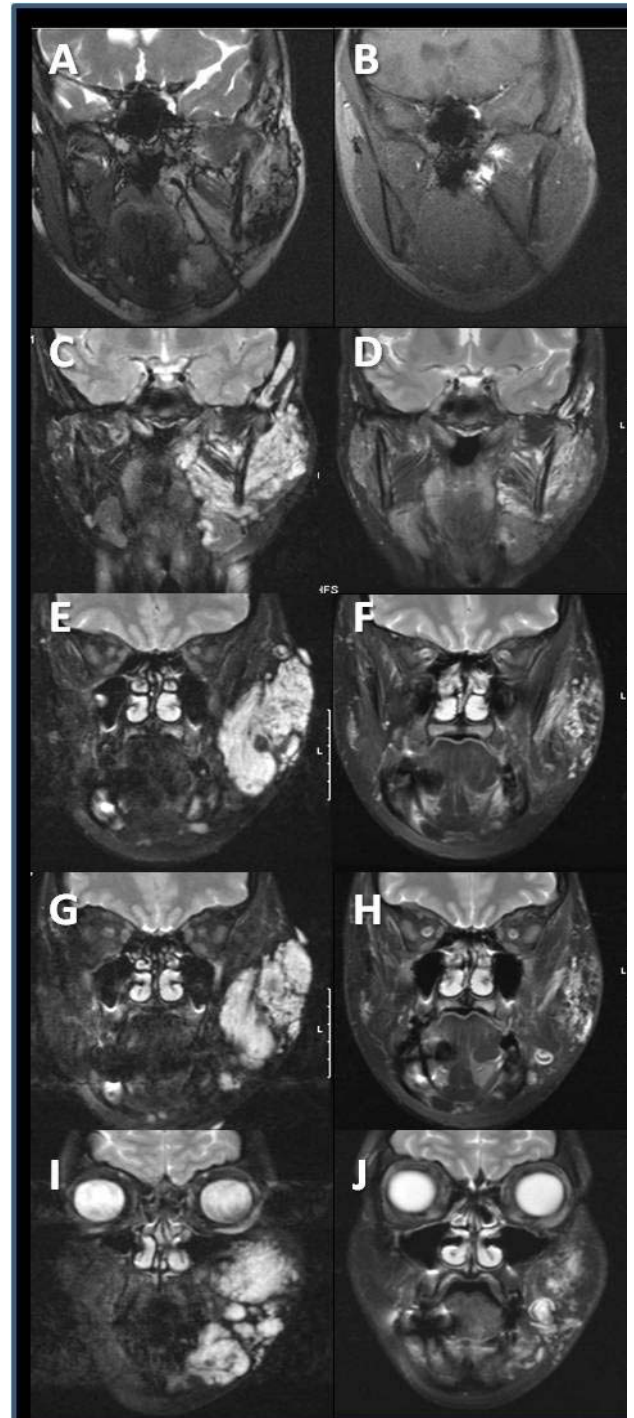
Fig. 1. Coronal images of an extensive venous malformation of the left hemiface. A: True-FISP image demonstrating the needle tip within the pharyngeal mucosal space; B: monitoring of injection distribution on FLASH imaging; C, E, G, I: pre-treatment T2WI-FS showing the initial extent of the malformation; D, F, H, J: corresponding images showing the overall response to 16 treatment sessions over a period of 8 months.