MR-GUIDED SCLEROTHERAPY OF LOW-FLOW VASCULAR MALFORMATIONS: VISUALIZATION AND NEEDLE GUIDANCE USING CONTRAST-PREPARED SSFP (CP-SSFP)

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BACKGROUND Venous malformations (VMs) and lymphatic malformations (LMs) are congenital lesions that affect both children and adults.[1] T_2-weighted fat suppressed turbo spin echo imaging (T_2W TSE) is the gold standard technique for diagnostic visualization of VMs and LMs, these lesions are typically treated percutaneously using ultrasound (US) and fluoroscopic guidance. However, certain lesions cannot be treated using these modalities. Typically these include lesions that are deep within the body, that lie beneath scars, or are located in bone. Additionally, many patients require multiple treatments with repeated exposure to ionizing radiation. Real-time MR-guided intervention serves as a safer alternative, with better visualization of surrounding critical soft tissue structures. However, conventional real-time sequences are limited; they are either slow, with blurry, distorted edges (HASTE)[2] or with inferior malformation delineation because of poor T_2-weighting (SSFP)[3].

PURPOSE To clinically deploy a new technique specifically designed for the visualization of VMs and LMs during real-time image guidance during intervention: Contrast-Prepared SSFP (CP-SSFP).

METHODS ***Sequence design:*** CP-SSFP uses variable flip angle SSFP to establish T_2 contrast (derived from TIDE[4]) with the addition of modified spectrally selective SSFP (S5FP)[5] and a new inversion recovery scheme for robust fat suppression.[6] High/low T_2 weighting and fat suppression is customizable by high/low flip angles (HFA/LFA) in the SSFP train, respectively. ***Patient testing:*** Seven patients took part in the study. To compare the malformation visualization, patients were scanned by HASTE, SSFP and CP-SSFP; TSE was used as the reference of lesion detection. The scans were performed either as part of a diagnostic scan or during an intervention, both with IRB approval. To evaluate the sequence's performance in patients, numerical metrics, CNR efficiency (CNR of VMs vs. muscle divided by the square root of acquisition time) and image sharpness (the reciprocal of mean edge width of malformations),[7] were used. Additionally, MR-guided percutaneous needle placement procedures were carried out using this pulse sequence on swine (N=3) and on VM patients (N=2).

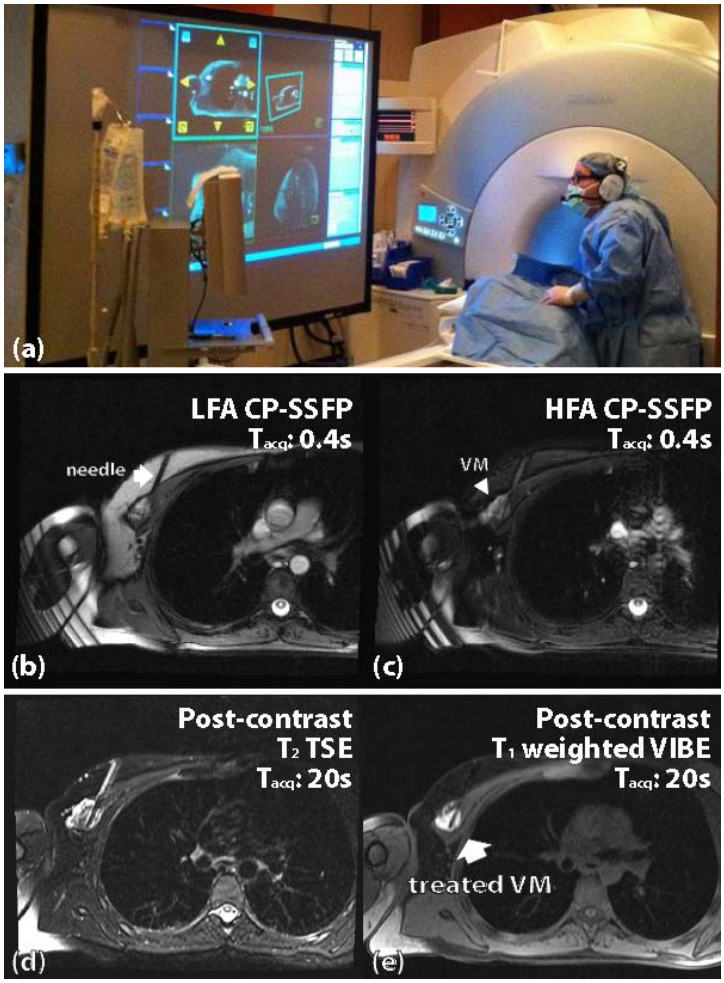

Fig 1. (a) Image depicting scanner suite layout as used during a VM embolization procedure. This 33 y.o. woman had a lesion in the right lateral chest wall adjacent to axilla and was referred for MR guidance due to a failure to locate the lesion using US. (b) LFA and (c) HFA CP-SSFP images of real-time needle guidance are shown. Specifically, HFA CP-SSFP clearly characterizes the VM (arrowhead). LFA CP-SSFP permits superior needle and soft tissue delineation (shown by the arrow). Post-contrast T_2 TSE (d) and post-contrast T_1 weighted volumetric interpolated breath-hold (VIBE) (e) demonstrate that the treated malformation was successfully filled with gadolinium doped sclerosant (3% sodium tetradecyl sulfate).

RESULTS Using TSE as the reference sequence, 9 VMs were detected. The malformation detection rates are 9/9 (HASTE), 4/9 (SSFP) and 9/9 (CP-SSFP), respectively. CNR efficiency: 27±8(HASTE), -1±7(SSFP), 37±4(CP-SSFP). Image sharpness: 0.09±0.03(HASTE), 0.3±0.04(SSFP), 0.3±0.04(CP-SSFP). Imaging time per slice: 1-2s(HASTE), 0.3-0.6s(SSFP), 0.3-0.7s(CP-SSFP). A successful MR guided VM embolization is presented in Fig 1.

CONCLUSION CP-SSFP is able to characterize malformations while monitoring needle insertion. CP-SSFP shows superior CNR efficiency to SSFP ($p<0.05$, ANOVA) and higher image sharpness than HASTE ($p<0.05$). CP-SSFP demonstrates T_2 contrast similar to the "gold standard" TSE, but with the speed comparable to SSFP.

REFERENCES

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