Non-Contrast-Enhanced MR Identification of Deep Vein Thrombosis: A Feasibility Study

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Introduction: Pulmonary embolism is the third most common cause of death in United States hospitals, with at least 650 000 cases occurring annually,[1] and is the first or second most frequent cause of unexpected deaths in many age groups. The common sources of embolism emanate from pelvic vein thrombosis or lower extremity deep vein thrombosis (DVT). Pulmonary embolism is present in 60-80% of patients with DVT, even though more than half of patients are asymptomatic.

The clinical gold standard for identifying DVT is compression ultrasound: the detection sensitivity and specificity in symptomatic patients are high (both > 90%), but markedly reduced in asymptomatic patients (sensitivity < 40% with a positive predictive value of about 25%).[2] Clinically, routine ultrasound is used, but since the smaller calf veins are difficult to visualize, imaging is typically limited to the thighs and knees. Our hypothesis is that calf DVT is both clinically relevant and important, and so we are investigating high-resolution non-contrast-enhanced thrombus MR imaging from the thighs to the calves.

Methods: We adapted a direct thrombus imaging sequence[3,4] to include a velocity-suppression bipolar gradient. All images were acquired on a 3.0 T scanner (Signa VH/*i*; GE Healthcare, Waukesha, WI) with a 4-channel torso phased-array coil and the following parameters: 3D coronal, 40 cm FOV, 15° flip angle, ±62.5 kHz receiver bandwidth, 9.2 ms TR, in-plane matrix size of 320×320 (reconstructed to 512×512), 120 slices (thigh region) or 90 slices (calf/knee region), 2.0 mm slice thickness (interpolated to 1.0 mm), velocity suppression (v_{ENC}) of 20 cm/s, TE of 5.4/2.0 ms with/without velocity suppression, and one signal average. This produced overall scan times of approximately 6:00 and 4:30 for the thigh and calf/knee regions, respectively.

The institutional review board approved the study protocol to scan the lower extremities of patients with known thigh or knee DVT (all of which were confirmed via ultrasound). Each and every subject gave written informed consent before MR imaging. Following each exam, certified body radiologists interpreted the MR thrombus images for determination of the presence of clots.

Results: Figure 1 is from a patient with known DVT in the right popliteal vein. The ultrasound popliteal image is shown in Figure 1a, and the calf MR thrombus scans with/without velocity suppression appear in Figures 1b/1c. The right calf peroneal vein DVT is more conspicuous without velocity suppression (Figure 1c). Note that the effective (acquired) voxel size is $1.25\times1.25\times2.0$ mm^3, although interpolated voxels are $0.78\times0.78\times1.0$ mm^3. All patients tolerated the exams very well.

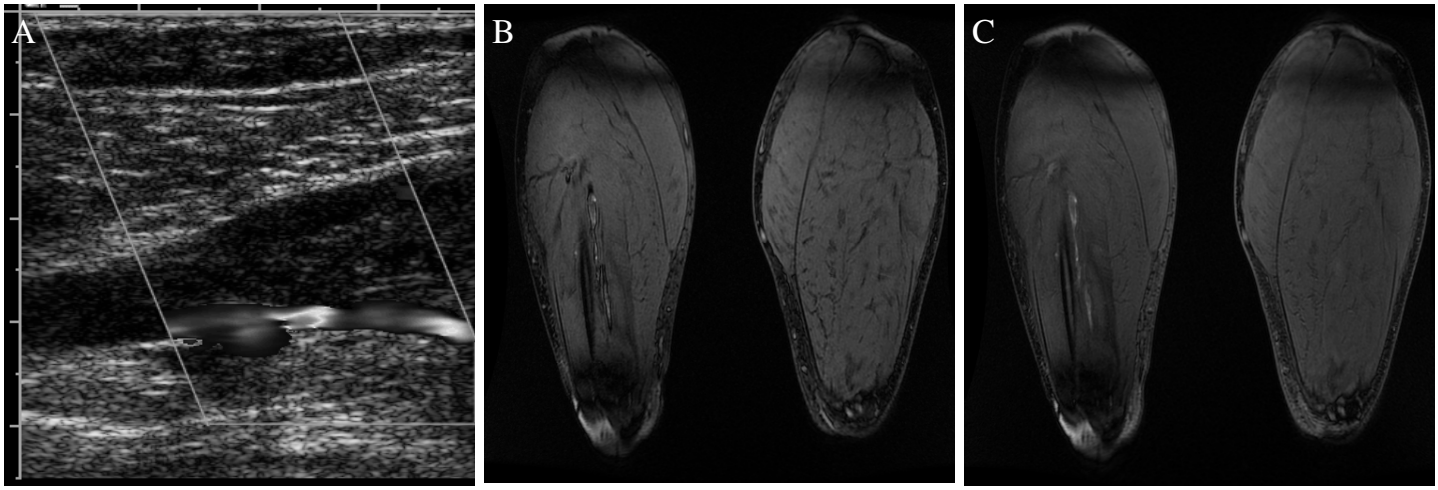

Figure 1: (A) Ultrasound image of the right popliteal vein. (B) MR thrombus image with velocity suppression. (C) MR thrombus image without velocity suppression. Note the improved conspicuity of the DVT in the right peroneal vein in (C) compared to (B). However, the lack of flow suppression suggests that perhaps some of the observed DVT extent in (C) is actually flowing blood.

Discussion: The visualization of calf DVT using MR imaging shows great promise and potential. The next step is to examine the ultrasound and MR thrombus images of the thigh, and statistically compare the length and extent of the thrombi between these two modalities. This will allow us to validate the accuracy and efficacy of the MR scanning techniques with/without velocity-suppression. Concurrently, we will provide descriptive analysis (*e.g.*, DVT conspicuity and uniformity, image artifacts) in the calves, after which a more comprehensive clinical study/correlation of patients with pulmonary embolism and calf DVT can be undertaken.

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