EVALUATION OF A NOVEL NON-CONTRAST-ENHANCED MRI IMAGING TECHNIQUE FOR DIAGNOSIS AND CHARACTERISATION OF DEEP VENOUS THROMBOSIS (DVT).

David Bowden[1], Andrew N Priest[1], Claire Smith[1], Ilse Joubert[1], Sally Hunter[1], Martin John Graves[1], Trevor Baglin[2], and David J Lomas[1]

[1]*Radiology, Cambridge University Hospitals NHS Foundation Trust, Cambridge, Cambs, United Kingdom,* [2]*Haematology, Cambridge University Hospitals NHS Foundation Trust, Cambridge, Cambs, United Kingdom*

Target Audience: Radiologists, Physicians and Scientists with an interest in thromboembolism

Purpose: To define multiple MRI features of acute onset lower limb deep venous thrombosis in a thrombosis naïve population as a baseline for the study of lower limb DVT evolution.

Introduction: Deep venous thrombosis (DVT) is a serious condition with a high morbidity and mortality. At present duplex ultrasonography (US) of the peripheral veins is the diagnostic gold standard, but with significant limitations. Non-contrast MR venography (NCE-MRV) has been shown in some studies to be superior to US for the diagnosis of DVT in the thigh. In addition a Direct Thrombus Imaging (MR-DTI)[1] technique has shown promise in determining the age of a thrombus and whether it is new or residual[2]. Previous studies have used in isolation contrast enhanced and non-contrast enhanced MRV, DTI and balanced SSFP techniques. The aim of this work is to report the initial baseline results using a novel multi-parametric MR technique compared with reference ultrasound (US) to define the MR features of acute onset lower limb deep vein thrombosis in a DVT naive population as a baseline for longitudinal study of its evolution.

Methods: Patients with ultrasound-proven above knee DVT and no previous history of venous thrombosis were recruited from the hospital thrombosis clinic. Same day compression US and MR was then performed using a clinical US system (Aplio, Toshiba Medical) with 5 and 7.5MHz transducers and a 1.5T MRI system (DV450, GE Healthcare) using a 12-channel phased array coil. *MR Direct Thrombus Imaging* (MR-DTI)[1] was acquired in axial orientation with the following parameters: TI 340 ms, TE 6.3 ms, TR 12.2 ms, flip angle 25°, matrix 320×288×96, FoV 40×40 cm^2, slice thickness 2 mm, ASSET factor 2, 2 shots per k-space plane, 320 ms delay after each shot. *R2* mapping* was performed using a multi-echo gradient echo sequence (oblique coronal orientation, 6 echoes with TE 2.38–18.38 ms, TR 21.9 ms, flip angle 60°, ASSET factor 2, matrix 320×288, FoV 40×40 cm^2, slice thickness 2.4 mm). *Non-contrast-enhanced MR Venography* was acquired using Acceleration-Dependent Vascular Anatomy for Non-Contrast-Enhanced MRV (ADVANCE-MRV)[3] using dual flow-preparation modules, which combined flow sensitisation using effective first gradient moments of 1.2, 0.6, 0.3 and 0.15 μTs2/m. This technique is based on a previously published flow-dependent angiography method.[4] The readout was a 3D balanced-SSFP (oblique coronal orientation, flip angle 65°, TE 1.7 ms, TR 3.7 ms, ASSET factor 2, acquisition matrix 288×288×20, FoV 40×40 cm2, slice thickness 2.4 mm). US and MRI images were assessed independently for thrombus extent, signal characteristics and consistency supero-inferiorly (SI) and axially. The extent data was compared and the appearance of the thrombus evaluated on the different MR sequences: DTI, R2* map, NCE-MRV.

Results: 8 patients (6M:2F ages 19-78yrs) were examined 2-9 days after the onset of symptoms, with complete concordance between US and all three MRI techniques for thrombus extent. On MR-DTI and R2* imaging increased thrombus signal was present along the whole of the supero-inferior (SI) extent along with axial heterogeneity across the thrombi (low signal centre) in all DTI cases and in 6 of 8 R2* cases. On NCE-MRV imaging thrombi possessed low signal over their whole SI extent but there was heterogeneity axially (increased signal centre) in 6 of 8 cases. (Fig.1.)

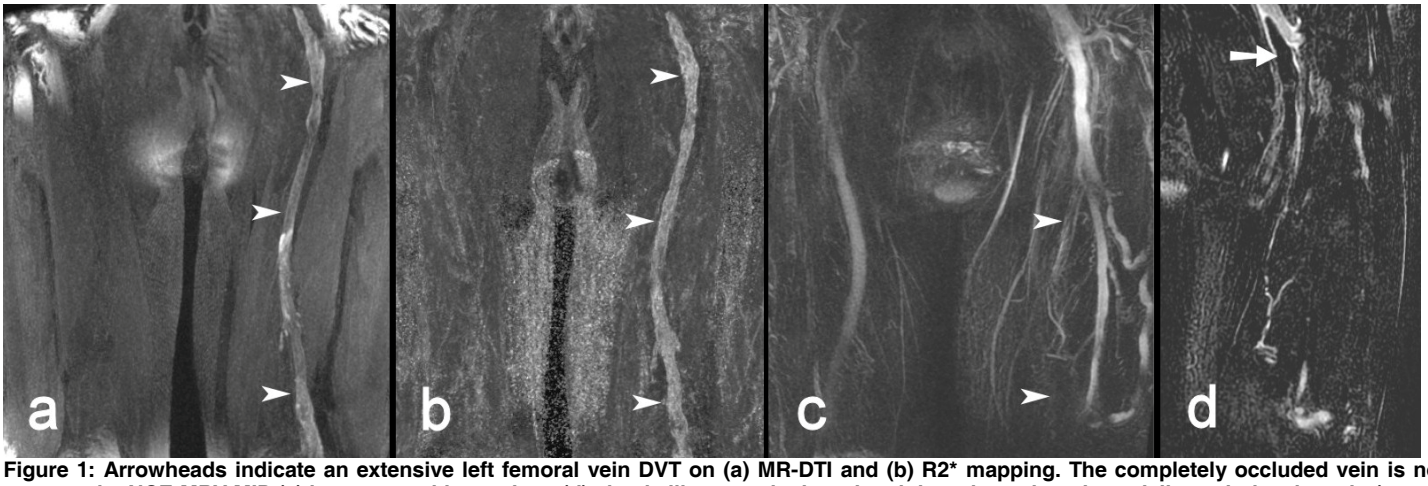

Figure 1: Arrowheads indicate an extensive left femoral vein DVT on (a) MR-DTI and (b) R2* mapping. The completely occluded vein is not seen on the NCE-MRV MIP (c) but source thin sections (d) clearly illustrate the low signal thrombus where it partially occludes the vein (arrow)

Discussion: NCE-MRV, MR-DTI and R2* imaging of acute lower limb venous thrombosis provides concordant accurate identification of thrombus extent. The dominant signal change was present along the whole SI extent of thrombus although the majority of thrombi were heterogeneous axially reflecting the natural evolution of thrombus. Further studies will evaluate extent and signal changes at 3 and 6 month time points.

Conclusion: Multi-parametric MRI using MR-DTI, R2* mapping and NCE-MRV accurately defines the supero-inferior extent of acute lower limb DVT and in the majority of cases demonstrates axial heterogeneity consistent with thrombus evolution.

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