Thrombus-MRI: Characterization of a Venous Stagnation Thrombus Model by MRI and Histology

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Introduction

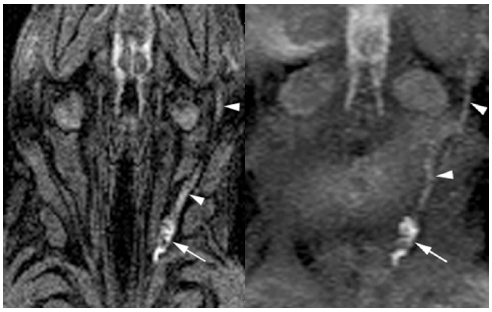
Several T1-weighted techniques aimed to demonstrate the high signal intensity of blood degeneration products of thrombus have been suggested, however the effect of thrombus organization on MR thrombus display remains to be determined. The purpose of this study is to develop a stagnation thrombus model in rabbits and characterize thrombus of different ages with magnetic resonance (MR) imaging techniques and histology.

Methods

Venous stagnation thrombi were induced in the external jugular veins of rabbits using a minimally invasive radiological technique producing artificial vessel embolic occlusion and hypercoagulability. Twenty-five animals subdivided into 5 groups of 5 animals each were examined by 1.5 T MR imaging 1, 3, 5, 7 or 9 days after thrombus induction using a T1-weighted magnetization-prepared rapid gradient-echo sequence (MP-RAGE; TR 10.4 msec, TE 4.0 msec, FA 15°) and a fast low-angle shot sequence (TR 54 msec, TE 18 msec, FA 15°) (1). Thrombus length was measured on T1-weighted images. Thrombus conspicuity, signal intensity, and heterogeneity were described on T2* weighed images using visual scales. Radiographic venography and histology served as reference methods.

Results

Thrombi were successfully induced in all animals. The overall thrombus length decreased from 43+-9 (day 1 after induction) to 23+-3.5 mm (day 9). On 3D-reconstructions of the T1-weighted images the visible portion of the true thrombus length was 0.16±0.3 (day 1), 0.24±0.3 (day 3), 0.38±0.5 (day 5), 0.06±0.1 (day 7) and 0.00 (day 9), see figures. Sixteen of 25 thrombi were detectable with the T2*-weighted technique. The overall thrombus signal intensity decreased with thrombus age from day 1 to day 9.



MR-RAGE T1-weighted sequence of a five day-old thrombus. A 2D-source image (left) and a 3D-maximum intensity projection image (right) are shown. The thrombus is visible as a hyperintense structure within the external jugular vein (arrow heads). The site of the embolic occlusion is also shown (arrow).

Conclusions

The thrombus model closely resembles human venous stagnation thrombus of different organizational stages. With both T1- and T2*-weighted techniques thrombi were only partially displayed. T1-weighted techniques are more effective, but strongly depended on thrombus age. Our data suggest that thrombus imaging may be insufficient for detecting thrombi, but may have a potential for characterizing thrombus organizational stage.

Reference

1) Moody AR, Pollock JG, O'Connor AR, Bagnall M. Lower-limb deep venous thrombosis: direct MR imaging of the thrombus. Radiology 1998; 209:349-55.