

Multi-spectral MRI shows unorganized thrombus one year after endovascular abdominal aortic aneurysm repair.

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Introduction

To prevent often lethal aneurysm rupture, an aortic aneurysm can be excluded from blood flow by endovascular placement of an endoprosthesis (EVAR). The blood in the aortic lumen which is excluded from the circulation during this procedure remains in the aneurysm sac and forms a thrombus which is expected to progressively organize in time. After successful EVAR the aneurysm sac is completely excluded from the circulation and the aneurysm shrinks. In a substantial number of patients this exclusion is not complete and subsequently, blood leaks into the aneurysm sac (endoleak). Endoleak hampers aneurysm shrinkage. However, even in the absence of endoleak a substantial number of aneurysms remain the same size or grow (endotension) for unknown reasons. Whether such aneurysms were adequately treated to prevent rupture still remains unclear. Therefore it is important to further investigate this phenomenon. Different causes have been proposed like graft porosity, fibrinolysis or inflammatory reactions (1). Apparently, more parameters are needed to evaluate treatment success. The acquisition of longitudinal information about the thrombus organization process after EVAR may provide more insight into this phenomenon. The usual CTA based follow-up does not provide such data. It has already been shown that MRI can be used to visualize thrombus organization (2-5). Unorganized thrombus has a high and very high signal intensity (SI) on T1-w and T2-w imaging respectively (2). Organized thrombus has a low SI on both T1- and T2-w imaging (2). In this work we show the use of multispectral MRI to study thrombus organization after EVAR in a longitudinal patient study.

Methods

Patients planned for endovascular abdominal aortic aneurysm repair (EVAR) were asked on the outpatient clinic for vascular surgery to participate in this MRI-based follow-up study. Patients were imaged at 1.5 T at multiple points in time before and after EVAR: pre-operatively, 1 day post-operatively, 6 months and 1 year after EVAR. This study was approved by the medical ethics committee of our institution. The results obtained in the first 7 patients who have completed the total follow-up period are reported here, resulting in 28 MR datasets. The patients also underwent CT angiography exams post-operatively and yearly after EVAR, which is part of our routine follow-up schedule. Of five patients CTA- follow-up 2 years after EVAR already became available. For analysis of endoleak as well as for monitoring of thrombus organization, transverse pre-contrast T2-weighted turbo spin echo and pre- and postcontrast T1-weighted spin echo images were acquired. The non-luminal aneurysm sac was manually segmented. Dedicated in-house developed software (Thrombix) was used for analysis of aneurysm sac composition. To be able to compare intensities across images a region of interest was drawn in a region of homogeneous fat close to the aneurysm sac on the middle slice of the dataset. The mean of this ROI was calculated in the different images to provide a reference pixel value across the three images. Fat was used as a reference because it has an intermediate gray value on the three different images. To classify the intra-aneurysmal voxels into the categories endoleak, unorganized thrombus and organized thrombus (Table 1) slider bars were used to manually set thresholds relative to the intensity of fat in the corresponding image. (6). The classification was interactively visualized by a color overlay on the MRI datasets. After classification, volumes of endoleak, organized and unorganized thrombus were calculated.

Results

In all patients and at all points in time after EVAR a substantial volume of the nonluminal aneurysm sac consisted of unorganized thrombus (Figure 2). In two patients the unorganized thrombus volume increased between post-operative imaging and 6 months after EVAR. Between 6 months and 1 year after EVAR in 1 patient the unorganized thrombus volume % increased, in the others unorganized thrombus volume % decreased or stabilized. In all patients a substantial volume of 4 – 38 volume % of unorganized thrombus remained 1 year after EVAR. The group of patients presented here is too small to correlate aneurysm size changes to unorganized thrombus volume and endoleak volume. 1 Patient had a growing aneurysm, 4 patients had a stable aneurysm and 2 patients had a shrinking aneurysm. 5 Patients had voxels classified in the endoleak category after 1 year, 3 patients less than 6 volume % (endoleak not visible on CTA, 1 shrinking and 2 stable aneurysms), 2 patients had 12 and 15 volume % endoleak voxels, (endoleak also visible on CTA, 1 shrinking and 1 growing aneurysm).

Discussion

One year after EVAR considerable amounts of unorganized thrombus may be seen in the non-luminal aneurysm sac. This is an unexpected result, as we expected the signal intensity of thrombus to be low on T1w and T2w images, as is seen in the brain several months after hemorrhage, when complete breakdown and resorption of the fluid and protein within the clot have occurred (7). Maybe the location of the thrombus next to the vessel wall plays a role, potentially exposing the thrombus to the cellular constituents of blood. Alternatively, edema may be present as a consequence of fibrinolysis or an inflammatory process. Further investigations in a larger population are currently taking place.

(1) Risberg B et al. J EVT 2001; (2) Castrucci M et al. Radiology 1995; (3) Engellau L et al. EJVES 1998 (4) Pitton MB et al. Circulation 2002; (5) Bartels LW et al. ISMRM 2002 268. (6) Cornelissen SA ISMRM 2006 no. 2181 (7) Neuroradiology, The requisites, Grossman et al, Mosby 2003, p.209

Category	T1w-SE	T2W-TSE	T1w-SE Gd
endoleak	low SI	low/high SI	high SI
unorganized thrombus	low/high SI	high SI	low SI
organized thrombus	low SI	low SI	low SI

Table 1 colors used to identify pixels classified to corresponding category. SI given relative to manually set thresholds.

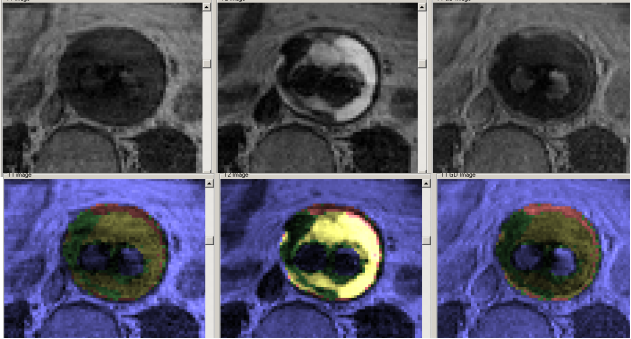


Figure 1 Manually segmented aneurysm sac in which the pixels are classified by multispectral MR-image analysis as explained in Table 1. Each pixel is colored according to the category it is assigned to, from left to right, T1-w, T2-w and postcontrast T1-w image.

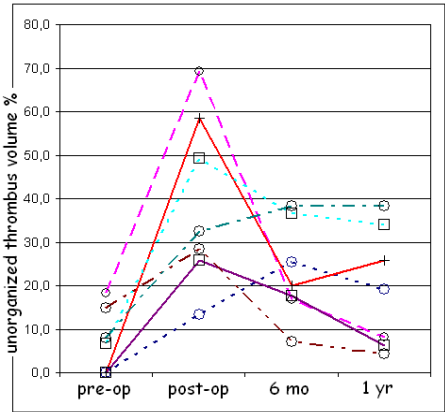


Figure 2 Change of unorganized thrombus volume in time (in volume % relative to nonluminal aneurysm sac volume), each line is 1 patient, + represents growing, circle is stable and square is shrinking aneurysm.