Evaluation of thrombus organization as a new parameter for follow-up after endovascular abdominal aortic aneurysm repair

S. A. Cornelissen[1], M. J. Van der Laan[2], K. L. Vincken[1], C. J. Bakker[1], H. J. Verhagen[3], W. P. Mali[4], F. L. Moll[3], L. W. Bartels[1]

[1]Image Sciences Institute, University Medical Center, Utrecht, Netherlands, [2]Surgery, Hilversum General Hospital, Hilversum, Netherlands, [3]Vascular Surgery, University Medical Center, Utrecht, Netherlands, [4]Radiology, University Medical Center, Utrecht, Netherlands

Introduction

Endovascular aortic aneurysm repair (EVAR) requires regular postoperative imaging to evaluate treatment success. After successful EVAR, the aneurysm sac shrinks. A widely accepted cause of non-shrinkage of the aneurysm sac is an endoleak. A considerable group of patients, however, experience non-shrinkage of the aneurysm sac without a detectable endoleak. Whether such aneurysms were adequately treated still remains unclear. Apparently, in these patients more parameters are needed to evaluate treatment success. Recent studies have shown that MRI is a promising technique not only for enhancing the characterization of endoleaks(1), but also for visualizing aneurysm sac contents (2-5). Unlike CT, which is the mostly used modality for follow-up imaging after EVAR, MRI allows the monitoring of thrombus organization during follow-up, by using its excellent soft tissue contrast. Figure 1 illustrates the appearance of aneurysm sac contents on different MRI-images. Clearly, hyperintense voxels are visible on the T2w-image, possibly caused by intermittent endoleak, in which fresh blood intermittently leaks into the aneurysm sac, keeping the thrombus wet or by fibrinolysis, keeping the thrombus wet by enzymatic breakdown of thrombus contents.(6) Although the cause of these hyperintense voxels is still unknown, and the significance of these hyperintense volumes is still unclear, the change of these hyperintensities in time may prove to be an important parameter in the follow-up of these patients. For this reason we developed a way to quantitatively measure these hyperintense volumes.

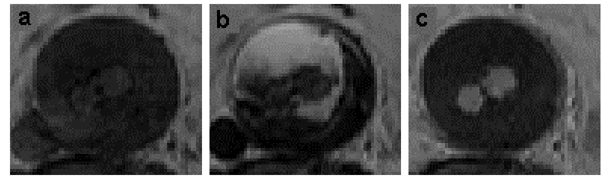

Figure 1 *Illustration of appearance of unorganized thrombus using a) T1w-, b) T2w- and c) T1w-image postcontrast. In b) areas with high signal intensity are clearly visible in areas which have low signal intensity in a) and c)*

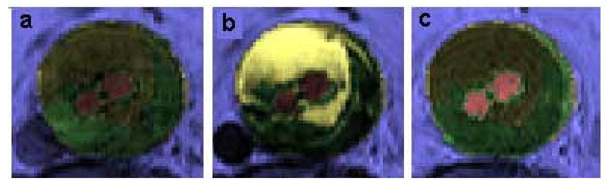

Figure 2 *Manually segmented aneurysm sac in which the pixels are classified by multispectral MR-image analysis as explained in Table 1. Each pixel is colored according to the category it is assigned to: a) T1w- b) T2w- and c) T1w-image postcontrast*

Patients and methods

17 patients, all participating in a CTA-based follow-up scheme were evaluated with both spiral CTA and MRI. All MRI scans were performed on a Philips Intera 1.5-T scanner (Philips Medical Systems, Best, The Netherlands). Fifteen patients had an Ancure graft (Guidant, Menlo Park, CA, USA) and the other two had an Excluder (W.L. Gore, Flagstaff, AZ, USA). One patient was scanned twice. For visualization of the thrombus we acquired pre- and post-contrast transverse T1-weighted spin echo and T2-weighted turbo spin echo images. All aneurysms were manually segmented on the postcontrast T1w-images.

A reference circle was drawn in a homogeneous region of abdominal fat. The mean of this ROI was calculated in the different images to provide the pixel values of fat across the three images. Fat was chosen as a reference because it has an intermediate gray value in all three images. The intra-aneurysmal pixels were then classified by manually setting thresholds relative to the intensity of fat in the corresponding image. Pixels were classified into three categories (lumen/endoleak, unorganized thrombus (long T2) and organized thrombus), the classification scheme with the corresponding colors is given in Table 1. This classification was visualized by a color overlay, as shown in Figure 2. This process was conducted twice by two observers independently after a consensus meeting.

Category	T1w-SE	T2W-TSE	T1w-SE Gd
lumen/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
undefined (fat)	high SI	low/high SI	high SI

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

Results & Discussion

The interobserver-variability of this multispectral pixel classification is shown in Figure 3. In 8 patients at least 10 % of the intra-aneurysmal volume was classified as unorganized thrombus. Pixel classification problems can arise if the patient has moved between the acquisition of the different images. The need for registering the images as well as automatic pixel classification (by using machine learning techniques, e.g. kNN) are currently being evaluated. The value of MRI and MRA for the follow-up of patients after EVAR with respect to measurement of aneurysm size, endoleak and thrombus organization is a subject which will be investigated in a longitudinal patient study which is currently set up in our institution.

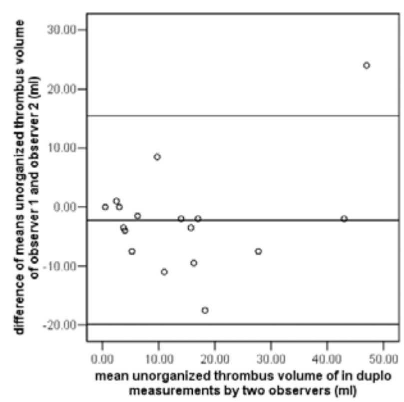

Figure 3: Bland-Altman plot of interobserver variability of volume classified as unorganized thrombus (horizontal lines represent mean +/- 2 · s.d.)

References

(1) van der Laan MJ et al. Eur J Vasc Endovasc Surg 2005; Sep. 30 [epub ahead of print]
(2) Castrucci M et al. Radiology 1995; 197(1):135-139.
(3) Engellau L et al. Eur J Vasc Endovasc Surg 1998; 15(3):212-219.
(4) Pitton MB et al. Circulation 2002; 105(16):1995-1999.
(5) Bartels LW ISMRM 2002 p.268.
(6) Risberg B et al. J Endovasc Ther 2001; 8(5):447-453.