Computed Tomography versus Magnetic Resonance Imaging of Endoleaks after EVAR

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Aim. The aim of study was to compare the sensitivity of MRI and CTA for endoleak detection and classification after EVAR.

Patients & Methods. Twenty-eight patients, between 2 days and 65 months after EVAR, were evaluated with both CT and MRI. Twenty-five patients had an Ancure graft and the other three had an Excluder. The MRI protocol for endoleak evaluation included: a T1-weighted spin echo, a high-resolution 3D CE-MRA, and a post-contrast T1-weighted spin echo. In total 40 ml Gadolinium was administered. The CT protocol consisted of a blank survey followed by a spiral CT angiography (CTA) using 140 ml of Ultravist. An experienced, blinded observer evaluated all CTs and MRIs.

Results. Using MRI and MRA techniques significantly more endoleaks (23/35) were detected than with CTA (11/35) (p = 0.01, Chi-Square). CT could not determine the type of endoleak in 3 of the 11 endoleaks detected and was uncertain in one. MRI was uncertain about the type in 14 of the 23 endoleaks detected. All endoleaks visible on CT were visible by MRI as well.

Conclusions. MRI techniques are more sensitive for the detection of endoleak after endovascular AAA repair than CT.

Keywords: MRI; CTA; AAA; Endovascular; Endoleak; Imaging; Complications.

Background

An important drawback of endovascular aneurysm repair (EVAR) is the need for a post-operative surveillance program. An intensive imaging schedule to detect early or late complications, such as sac size increase, endoleak or graft migration is required for the rest of the patients life.1–4

Death from aneurysm rupture after EVAR is the ultimate proof of treatment failure. As the postoperative rupture risk is extremely low, it will take many years and large numbers of patients before the hard endpoint of rupture risk can be used as a representative outcome measure.5–8 This long-term data is not yet available. The evaluation of short term treatment success has to rely on secondary and softer endpoints like endoleak or aneurysm sac size change.

Endoleak is a frequent problem after EVAR. Computed Tomography Angiography (CTA)-based studies show that up to 20% of patients have an initial endoleak,9 many of which are type II. It has been demonstrated that all type I endoleaks create systemic pressure inside the aneurysm sac.10–12 The risk of rupture appears to be increased in these patients.7,11,13 Type II endoleaks can create high intra-sac pressures too.10,11,14 Therefore some authors advise a more aggressive approach towards type II endoleaks than was previously thought necessary.7,11,13,15 Still, many patients present with a shrinking aneurysm sac, despite the presence of an endoleak. Whether these patients need to be treated remains controversial.7,15–17 However, in the presence of a new or a previously undetected endoleak, some aneurysms can show secondary growth after initial shrinkage.18 In our opinion many cases of endotension, aneurysm sac enlargement without a detectable endoleak, could be attributed to a missed endoleak.19–21

Magnetic resonance imaging (MRI) techniques have been shown to be very sensitive for depicting small endoleaks.22–24 Because of the high sensitivity to Gadolinium-based T1-shortening contrast agent, the intrinsic three dimensionality and excellent soft tissue contrast, MRI and magnetic resonance angiography (MRA) techniques theoretically are well suited for endoleak detection after EVAR.
Our current follow-up imaging program consists of CT scanning and abdominal x-ray. The CT data are used for volume measurements, evaluation of endoleaks, graft patency and graft migration. The plain abdominal radiograph is used for the evaluation of stent-graft integrity. In the present study we focus on the detection and classification of endoleaks.

The aim of this study was to compare the sensitivity of CT and MRI for the detection of endoleak. We hypothesized that MRI is more sensitive for detection of endoleaks than Computed Tomography (CT).

Patients & Methods

Patients

In the period between March 2001 and March 2003, 28 patients randomly selected from our EVAR follow-up program were included in the study. This group consisted of 26 males and 2 females with a mean age of 75 years (range 58–87 years). These patients were scanned using CTA and with our MRI protocol. Three patients had an Excluder endograft (Gore, Flagstaff, AZ, USA) and 25 had an Ancure endograft (EVT, Menlo Park CA, USA). There were 5 patients who were evaluated twice with a 6 month or 1 year interval and 1 patient was scanned three times with 6 months intervals in between. This resulted in 35 MRI data sets and 35 CTA data sets. Institutional review board approval was obtained and all included patients signed an informed consent form. Patients were between 2 days and 65 month (mean 30 months) after EVAR at the time of imaging.

Design

Patients underwent MRI as well as CT evaluation. The MRI was added to our standard CT surveillance protocol. For practical reasons the 2 examinations could not take place on the same day. The time between the CT and the MRI exam was minimized and was not allowed to exceed one month.

Scans from both imaging modalities were evaluated for the presence of endoleaks and for the determination of the type of endoleak. Endoleak was scored as present, not present, or uncertain. Classification of the endoleaks was performed as proposed by White et al., type I, II, III, IV or unknown (meaning the exact site of inflow could not be identified). The MRI images were evaluated by an experienced observer blinded to the results of the CT.

Clinical data acquisition techniques

Computed tomography angiography: CT scans were performed on a spiral CT scanner (AV-EP, Philips Medical Systems, Best, The Netherlands). The table speed used was 5 mm/sec with a reconstruction index of 2 mm. One non-contrast-enhanced scan and one with an intravenous infusion of 140 ml Ultravist (Berlex, Montville, NJ, USA) at 3 ml/sec with a 30 second delay between the start of the injection and the start of the scan were acquired at 120 kV and 250 mA with a matrix size of 250. In our standard CT protocol, delayed series (2 scans with a 2 minute and a 4 minute interval after the CTA) were performed if an endoleak was suspected, i.e. in case of a growing or stable nonluminal volume of the aneurysm sac based upon previous assessments.

Magnetic resonance imaging and angiography: MRI scans were performed on a clinical 1.5-T scanner (Gyroscan Intera NT, Philips Medical Systems, Best, The Netherlands). A quadrature wrap-around synergy body coil was used as a receive coil. The following scans from our MRI-protocol for surveillance after EVAR were used for this study:

1. a transverse T1-weighted spin echo: TR/TE/\(\alpha\) = 580 ms/14 ms/90\(^\circ\), slice thickness 6.0 mm, FOV 270 x 385 mm\(^2\), acquisition matrix 179 x 256. 30 slices. Total acquisition time: 2.30 min.
2. a coronal 3D CE-MRA: TR/TE/\(\alpha\) = 8.5 ms/2.1 ms/45\(^\circ\), slice thickness 3.0 mm, FOV 360 x 450 mm\(^2\), Matrix 154 x 512. 25 slices. Total acquisition time: 28 s with breath hold technique and 20 ml of contrast agent at 2.0 ml/s.
3. repeated post-contrast T1-weighted spin echo (as pre-contrast).

A comparison of pre- and post-contrast T1-weighted scans was used for endoleak detection and classification. The high-resolution 3D CE-MRA scan was used for additional information for endoleak classification. For the CE-MRA scan, 20 ml of Gd-DTPA (Magnevist, Schering, Berlin, Germany) was administered intravenously at a rate of at 2.0 ml/s, followed by a saline chaser bolus (20 ml) injected at 1.5 ml/s.

Image analysis

Adequate evaluation of the post-operative analysis of both CTA images and MRI images involves extensive image post-processing. For endoleak detection alone, only limited image post-processing is necessary. All scans were loaded on to the graphical
workstation (Philips EasyVision workstation, release 4, Philips Medical Systems, Best The Netherlands).

An Endoleak on CT was defined by a contrast deposit or enhancement inside the aneurysm sac, outside the graft. An Endoleak on MRI/MRA was defined as increased signal intensity inside the aneurysm sac outside the graft on the post-contrast T1-weighted SE scan, which was not present on the T1-weighted SE before contrast enhancement (Fig. 1).

**Statistical analysis**

For statistical analysis of the comparison between CTA and MRI the Chi-square test was used. A $p$-value of less than 0.05 was considered significant.

**Results**

Using MRI, an endoleak was detected in 23 of 35 (66%) evaluations. Using CT, in 11 of 35 scans an endoleak was detected (31%) ($p < 0.005$, Chi-Square). All endoleaks detected on CT were visible on MRI. The main difference in endoleak detection between CT and MRI was the higher sensitivity of MRI for type II endoleaks (Table 1).

In 13 cases, delayed post-contrast CT series were performed. These scans did not reveal an additional endoleak. MRI evaluation revealed endoleaks in 4 of these 13 cases (Fig. 2).

Based upon the MRI data 14 of the 23 detected endoleaks were classified as having an unknown origin (61%). Using the CT data 5 of the 11 detected endoleaks were classified as having an unknown origin (45%) ($p = 0.183$, Chi-Square test).

| Table 1. A summary of the results of endoleak detection and classification |
|--------------------------------|---------|---------|---------|---------|-------------------|
|                             | No-endoleak | Type I | Type II | Type III | Type IV | Endoleak of unknown origin | Total |
| MRI/MRA                     | 12 (34%)    | 2       | 6       | 1        | 0       | 14                           | 35    |
| CTA                         | 24 (69%)    | 2       | 3       | 1        | 0       | 5                            | 35    |

This study shows that MRI techniques are more sensitive in detecting endoleaks than CT. Furthermore, the MRI protocol was more conclusive at identifying the site of inflow of endoleaks. For several of the endoleaks detected by MRI, but not by CT, the origin was hard to trace. Although the absolute number of classified endoleaks by MRI was higher than by CTA, the percentage of classified endoleaks was lower, due to the high number of unclassified endoleaks detected by MRI.

It must be noted that the current study only included Ancure and Excluder endografts. All nitinol stents are MR compatible. All fully supported endografts show some amount of signal loss due to RF caging. For most endografts MRI and MRA based follow-up is an option. When considering the diagnostic interpretation of the imaging results, artifacts caused by the metallic stents should be considered, since these artifacts can mimic stenosis or occlusion of the endograft. A more sensitive follow-up can help to identify small and concealed endoleaks in patients with a non-shrinking aneurysm sac or late aneurysm sac enlargement. More exact information of the patent vessels involved in a type II endoleak will facilitate decision making and re-intervention (Fig. 2).

Discussion

**Fig. 1.** A slice of a T1-weighted pre-contrast enhancement scan and the corresponding slice of the T1-weighted post-contrast enhancement scan demonstrating an endoleak. L; denotes the graft lumen. E; denotes the endoleak.
For reasons of radiation dose reduction, only in patients who had aneurysm sac enlargement at previous evaluations were delayed CTA series acquired at our institution. This may theoretically have resulted in an underestimation of the number of endoleaks in the CT scans. However, the delayed series that performed (13 cases), did not result in the detection of additional endoleaks, whereas in 4 of these cases an endoleak was found on MRI. In clinical practice only selected patients should be subjected to delayed CT imaging, as the cumulated exposure of the patient to ionizing radiation would be high. The use of dynamic MRA techniques may obviate the need for such delayed CT scans.

It is customary to compare new diagnostic tests with the current clinical gold standard. However, for MRI scans, there are very unlikely to be false positive results. In the comparison of the T1-weighted scans (scan 1 and 3), pre- and post-contrast enhancement, contrast enhancement in scan 3 (post CE scan), not seen on scan 1 (pre CE scan), can only result from contrast agent, for that is the only difference between the two scans (Fig. 1).

Measurements of aneurysm sac pressure probably will become available in the near future but the exact added value of these measurements remains to be determined. The presence of an endoleak gives only limited information about short term treatment success or outcome. In order to obtain complete insight in aneurysm sac exclusion, the combined data of endoleak and its classification (type I, II, III or IV), aneurysm sac size change over time and perhaps intra sac pressure readings will be needed. Time resolved MRA seems a good candidate to combine the advantages of MRI over CT and time resolved over static imaging. The implementation of SENSE (parallel imaging) and ultra fast gradient systems into modern MRI scanners have made fast dynamic scanning in 3D (also: 4D scanning) possible. Time-resolved 3D MRA datasets are constructed of sequential 3D volumes containing information about the contrast dynamics. Our recent experiences with this technique indicate, as Lookstein et al. also has demonstrated, that time resolved imaging might offer some additional advantages over static imaging techniques. We are currently investigating the additional clinical value of such techniques.

This study demonstrates that the MRI protocol we used was significantly more sensitive for endoleak detection than CT. Perhaps the most important conclusion that can be drawn from this study is that there are many more endoleaks than previously assumed. Many cases of endotension are likely to be caused by a small endoleak not detected by CT. An MRI protocol for EVAR follow-up including time resolved MRA is currently under investigation.

References
Computed Tomography versus MRI for Endoleak Detection after EVAR


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