

Proper and Timely Detection of Seal Failure After EVAR

Using detailed imaging analysis and dedicated software to identify subtle changes in endograft geometry within the aortic neck prior to late failure.

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With the EVAR 1 trial follow-up approaching 20 years, it has become evident that the short-term benefits of endovascular aneurysm repair (EVAR) over open repair are counterbalanced by seal failure and complications at longer-term follow-up. The main concern is secondary aneurysm sac rupture as a result of endoleak, which makes lifelong surveillance mandatory.¹

The aorta in which the endograft is deployed is not a static environment. Hemodynamic forces continuously act on the endograft, forcing it downward, thereby challenging passive (oversizing) and active (hooks) antimigration measures. As the years pass, these hooks may slowly lose their grip, allowing downward displacement. Reduction of radial force caused by adaptive enlargement of the aortic neck could be one of the contributing factors.²

Surveillance with CTA is commonly recommended at 1 month and at 1 year after the index procedure, followed by annual color Doppler ultrasound surveillance if significant aneurysm growth and endoleaks are absent.³⁻⁶ Despite superior sensitivity for detecting endoleaks, the use of CTA for routine surveillance is limited by the use of nephrotoxic contrast, radiation exposure, and high costs.⁷ However, the highly detailed CTA images contain a massive amount of valuable information in addition to the sensitive detection of aneurysm growth and endoleak. Detailed analysis of these scans with dedicated software allows detection of subtle changes of the endograft configuration in the infrarenal aortic neck, even before actual complications such as type I endoleak or significant migration arise.⁸

THE GEOMETRIC APPROACH

Both displacement of the endograft and distal effacement of the aortic neck result in the loss of apposition of the graft fabric to the aortic wall. Sufficient circumferential apposition is essential for good seal. Therefore, progressive reduction of apposition could predict later type Ia endoleak. Vascular image analysis prototype software (Endovascular Diagnostics B.V.) was developed and validated to assess the contact surface area and shortest length of apposition of the endograft fabric within the aortic neck. The software also calculates the endograft geometry within the aortic neck, including the renal artery-to-fabric distances over the curve of the aorta, proximal graft diameter, and tilt.^{9,10}

Figure 1 shows how the apposition can slowly disappear, while type Ia endoleak and significant aneurysm growth are not yet detected on standard CTA reports. At 17-month follow-up, significant loss of apposition can be observed, which was the result of combined endograft migration and distal neck effacement. A 28-mm-diameter Talent endograft (Medtronic) was used, which oversized the 27-mm neck by only 4% and may have caused the migration. Loss of apposition at the distal site of the neck often remains undetected on regular CT assessment but is also clearly visualized with the software. Despite seemingly successful deployment of the endograft in this straight, uncomplicated neck, neck apposition decreased from 71% at 1 month to 43% at 17 months. If these scans would have been assessed with the software, intensified surveillance would have been advised.

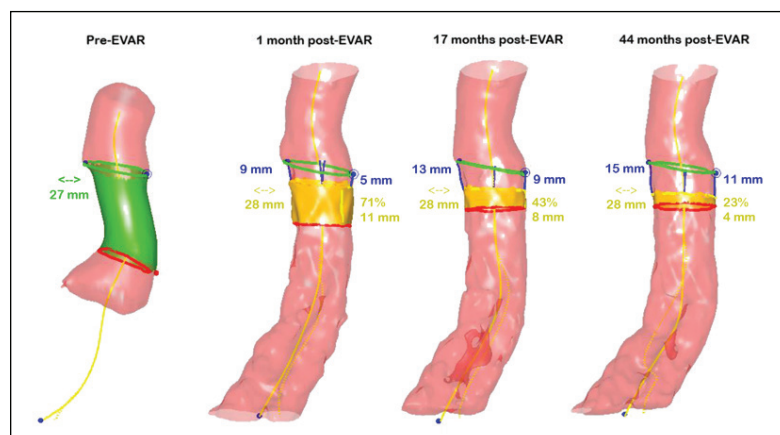


Figure 1. Example of endograft geometry over 44 months of EVAR follow-up in a patient treated for endograft migration at 4-year follow-up. Green denotes the pre-EVAR infrarenal neck surface, and the post-EVAR apposition surface is shown in yellow. The blue dots mark the left and right renal artery orifices. Full dilation of the 28-mm main body was observed at 1 month, and apposition decreased continuously from 71% (11 mm) to 22% (4 mm) as a result of stent migration and distal effacement. The aneurysm grew slightly from 59 mm to 62 mm.

DEPLOYMENT ACCURACY AND PREDICTION OF SEAL FAILURE

With the previously described software, endograft deployment accuracy relative to the renal arteries was assessed in a series of 81 elective EVAR patients, followed by a comparative study of the endograft geometry in patients with and without late seal failure.^{8,11}

In the first study by Schuurmann et al of 81 elective EVAR patients, the top of the endograft fabric was deployed at an average of 1.4 mm below the lowest renal artery orifice.⁸ In one-third of patients, the implanted endografts were positioned partially proximal to the lowest renal artery orifice, which did not result in occlusion of the arteries. In 26% of patients, the endograft was deployed at more than 3 mm below the lowest renal artery, which means that a large portion of the aortic neck was not used for seal. At the contralateral side, 4 to 14 mm of aortic neck was not covered. This unused area of the aortic neck could be utilized when the top of the graft is tilted during deployment, which is possible, for example, with the Excluder conformable abdominal aortic aneurysm endoprosthesis (Gore & Associates).

In the second study by Schuurmann et al, the endograft geometry in patients with a late (> 1 year) type Ia endoleak or migration (> 10 mm) was compared to a control group without complications with similar duration of CT follow-up (19 months [range, 14–38 months]).¹¹ The late CT scan, which was the most recent CTA before diagnosis of the endoleak or migration in the complication groups, and a late (> 1 year) CT

scan in the control group were compared to the CTA at 1-month follow-up. There were no significant differences between groups in the part of the aortic neck covered by the endograft and the minimum length of seal on the CT scan at 1 month after the index procedure. On the most recent CT scan before diagnosis of the endoleak or migration, significant differences were observed in patients with seal failure compared to those without complications. On the late CT scan, endografts in patients with seal failure were displaced more, had less contact with the aortic wall, and were more expanded compared to the controls. In the complication group, the aortic neck coverage on the late CT scan was significantly reduced compared to the 1-month CT scan, whereas the apposition had increased in the control group as a result of aneurysm shrinkage.

Interestingly, most grafts, including the controls, were displaced by a few millimeters, but the displacement was significantly larger in the complication group. The majority of endografts that were implanted in the complication group expanded (almost) to their original size, whereas in the control group, the expansion was still at 90% (range, 83%–97%) of the original graft diameter after > 1-year follow-up.⁸

CONCLUSION

There is great need for accurate surveillance of patients who undergo EVAR, as long-term complications may arise at any time during follow-up and may be missed with standard surveillance methods. The results of these studies suggest that a type Ia endoleak does not occur instantly, but is preceded by slow, subtle displacement and expansion of the endograft in most patients.^{8,9} These subtle changes are often missed on regular CT surveillance but can be quantified and clearly visualized with the dedicated software. By comparing the CT scan at 1 month with a later CT scan, these subtle changes can be detected, allowing for tailor-made surveillance or even prophylactic reintervention. Patients with relatively low deployment of the endograft during the index procedure may be at increased risk for later failure, as there is less remaining margin for displacement without consequence for an effective seal.

Future studies should identify the relevant cutoffs for each variable for accurate prediction of late failure. Meanwhile, the vascular image analysis prototype software is being further developed to make it available for clinical use. ■

1. Patel R, Sweeting MJ, Powell JT, Greenhalgh RM. Endovascular versus open repair of abdominal aortic aneurysm in 15-years' follow-up of the UK endovascular aneurysm repair trial 1 (EVAR trial 1): a randomised controlled trial. *Lancet*. 2016;388:2366-2374.
2. Savlovskis J, Krievins D, de Vries JP, et al. Aortic neck enlargement after endovascular aneurysm repair using balloon-expandable versus self-expanding endografts. *J Vasc Surg*. 2015;62:541-549.
3. Moll FL, Powell JT, Fraedrich G, et al. Management of abdominal aortic aneurysms clinical practice guidelines of the European Society for Vascular Surgery. *Eur J Vasc Endovasc Surg*. 2011;41(suppl 1):S1-S58.
4. Chaikof EL, Brewster DC, Dalman RL, et al. The care of patients with an abdominal aortic aneurysm: the Society for Vascular Surgery practice guidelines. *J Vasc Surg*. 2009;50(4 suppl):S2-S49.
5. Sternbergh WC 3rd, Greenberg RK, Chuter TAM, Tonnessen BH. Redefining postoperative surveillance after endovascular aneurysm repair: recommendations based on 5-year follow-up in the US Zenith multicenter trial. *J Vasc Surg*. 2008;48:278-285.
6. Chaer RA, Gushchin A, Rhee R, et al. Duplex ultrasound as the sole long-term surveillance method post-endovascular aneurysm repair: a safe alternative for stable aneurysms. *J Vasc Surg*. 2009;49:845-849.
7. AbuRahma AF, Welch CA, Mullins BB, Dyer B. Computed tomography versus color duplex ultrasound for surveillance of abdominal aortic stent-grafts. *J Endovasc Ther*. 2005;12:568-573.
8. Schuurmann RCL, van Noort K, Overeem SP, et al. Determination of endograft apposition, position, and expansion in the aortic neck predicts type Ia endoleak and migration after endovascular aneurysm repair. *J Endovasc Ther*. 2018;25:366-375.
9. Van Noort K, Schuurmann RC, Slump CH, et al. A new method for precise determination of endograft position and apposition in the aortic neck after endovascular aortic aneurysm repair. *J Cardiovasc Surg (Torino)*. 2016;57:737-746.
10. Schuurmann RCL, Overeem SP, van Noort K, et al. Validation of a new methodology to determine 3-dimensional endograft apposition, position, and expansion in the aortic neck after endovascular aneurysm repair. *J Endovasc Ther*. 2018;25:358-365.
11. Schuurmann RCL, Overeem SP, Ouriel K, et al. A semiautomated method for measuring the 3-dimensional fabric to renal artery distances to determine endograft position after endovascular aneurysm repair. *J Endovasc Ther*. 2017;24:698-706.

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Disclosures: Cofounder of Endovascular Diagnostics B.V.

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Disclosures: None.

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