



# How to "Watch the Sac" after Endovascular Aortic Repair

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## Introduction

Since its first introduction in clinical practice in 1991, the endovascular repair of the abdominal aortic aneurysm (AAA) has been widely performed and is reported to be an effective alternative to conventional open surgery, especially for patients with medical comorbidities.<sup>1-3</sup>

The number of patients considered suitable for the endovascular repair of either thoracic or abdominal aortic aneurysm is on the increase currently,<sup>4</sup> and this is mainly due to the availability of a newer generation of devices with fewer complications and better applicability. On the other hand, patients are increasingly requesting this procedure as they and also physicians find the minimally invasive nature of the treatment attractive.

Endovascular aneurysm repair (EVAR) is based upon the hypothesis that the exclusion of the AAA sac from arterial pressure will prevent AAA rupture.<sup>5</sup> EVAR is, therefore, deemed successful when the device permanently excludes the aneurysm sac from arterial pressure. Endoleaks refer to the persistent perfusion of the aneurysm sac after EVAR and affect 15% to 21% of patients.<sup>6-12</sup>

The rise in the number of patients treated by endovascular teams and the resultant experience have led to periprocedural complications and primary anchorage problems with type 1 endoleaks becoming more and more infrequent. Types 1 and 3 endoleaks both give rise to a persistent blood flow into the aneurysm sac at high pressure, causing rapid aneurysm expansion and potential rupture. Type 4 endoleaks are mainly due to the porosity of the graft material in stent-grafts and nowadays are rare with the current devices. Type 2 endoleaks are usually low-pressure leaks into the aneurysmal sac secondary to retrograde filling by branching vessels like the lumbar arteries in abdominal aneurysms and most often have a benign course, with only a few of them requiring secondary intervention. Zarins et al. estimated the incidence of Type 2 endoleaks following

EVAR at 10% to 20%.<sup>13</sup>

Although endoleaks are the major concern in endovascular treatment, there are other potential complications such as graft migration, graft fracture or fatigue, endograft stenosis, and kinking, which may become troublesome.

Because a favorable clinical outcome depends on the reliable detection of such complications, the choice of the right imaging method for follow-up is crucial. However, published data for different methods vary greatly in terms of detection rates.<sup>14-19</sup> Follow-up examinations are advised by the European Collaborating Group on Stent-Graft Techniques for Abdominal Aortic Aneurysm Repair (EUROSTAR) at 1, 3, 6, 12, 18, and 24 months and yearly thereafter. Different follow-up protocols are used by different endovascular teams or hospitals, but all of them agree on the crucial role of this surveillance.

What imaging mode should be chosen in the immediate, mid-term and long-term follow-up of patients with an endoprosthesis? Multislice CT scan, magnetic resonance imaging (MRI), duplex ultrasonography (US), sac pressure measurement, and even plain radiography are used for this purpose.

## CT scan

In many centers, CT scan is the imaging modality of choice for surveillance, and currently the follow-up protocol recommended by most manufacturers is based upon it. The combination of speed, reproducibility, and spatial and contrast resolution have made this the preferred method of imaging follow-up, despite the associated radiation dose and the potential for nephrotoxicity.<sup>20</sup>

The clinical performance of CT angiography in aneurysm imaging is well established, with documented utility in both the thoracic and abdominal aortas. The high-resolution data sets allow the reconstruction of thin transverse sections,

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multiplanar reformatted images, and three-dimensional volumes, all of which can be used to generate highly accurate aneurysm size and volume measurements. Moreover, CT angiography is able to depict endoleaks with a higher sensitivity than is conventional angiography.<sup>21,22</sup> It has been shown that volume measurement is more sensitive than diameter to detect any changes which may need secondary intervention.<sup>23,24</sup>

Helical CT angiography has been widely used in both pre- and post-aortic stent-grafting and has been confirmed to be the preferred modality when compared to conventional angiography. The recent development of multislice CT (MSCT) has further enhanced the applications of CT angiography for aortic stent-grafting. One of the advantages of MSCT angiography over conventional angiography is that the 3D reconstructions, based on the volumetric CT data, provide additional information during the follow-up of aortic stent-grafting. While endovascular repair has been increasingly used in clinical practice, the use of 3D MSCT imaging in endovascular repair continues to play an important role.<sup>25</sup>

The standard protocol is a triphasic CT, including pre-contrast, arterial, and delayed phases. Endoleaks have variable flow rates; they may, therefore, be detected in different phases of CT scanning. Despite this, Cat scan is known to have its own limitations in the detection of some types of endoleaks as highlighted by the phenomenon of endotension and by the difficulty to visualize type 2 endoleaks with a slow flow. The recommended protocol for long-term follow-up is yearly Cat scan, but what deserves attention is how many Cat scans are needed after an EVAR procedure in young or middle-aged patients given the cumulative radiation dose, cost, patients' comfort, and dye nephrotoxicity. That is why some investigators believe that a shrinking sac and no evidence of endoleaks one year after EVAR will have negligible risk of late problems and that any problems that do occur can be picked up by the ultrasound determination of the sac size, history taking, and physical examinations alone.

This hypothesis is supported by the fact that the newer generation of endoprostheses has much fewer complications than do the older ones.

### ***Magnetic Resonance Imaging***

Gadolinium-enhanced MR angiography is capable of detecting endoleaks, but its performance is dependent on the composition of the stent-graft. Nitinol stents are generally MR-compatible, and stainless steel stents cause extensive artifact that renders the study non-diagnostic. In several studies<sup>26-29</sup> on patients with predominantly nitinol stents, MR angiography was at least as sensitive as CT angiography and in some cases demonstrated endoleaks that were not

detected at CT angiography.<sup>30</sup>

MRI does not have the drawback of radiation exposure and is associated with a lower risk of nephrotoxicity. Consequently, it can be considered a viable alternative to MSCT for the follow-up of patients after EVAR with nitinol stent-grafts.

### ***Duplex ultrasonography***

Ultrasonography (US) is frequently used as a screening tool for the detection of AAA by radiologists or vascular surgeons. There are many reports in the literature which show the efficacy of US for the surveillance of patients with endoprosthesis.<sup>31,32</sup>

There are two sets of complications following endovascular aortic repair: 1) mechanical problems such as graft collapse or kinking and limb occlusion, which can often be detected in routine clinical visits and examinations and sometimes even via plain radiography and 2) endoleaks which can be detected sonographically by an expert and in selected cases.

Although the sensitivity of ultrasound for endoleak identification is highly variable, it can measure the sac size with reasonable accuracy.<sup>33-35</sup> The measurements of the aneurysm size obtained with US correlate well with those obtained with CT.<sup>36</sup> A meta-analysis studying the detection rate of endoleaks reported a sensitivity of 69% for US in 2005.<sup>37</sup> Nevertheless, advances in technology and the accumulated experiences over the recent years have resulted in much higher rates of sensitivity.

US is an inexpensive, safe, and portable mode of imaging; be that as it may, its main disadvantage is the fact that it is operator-dependent, which renders many findings subjective. Another drawback is that US is less useful in some obese patients. In addition, the scanning protocols vary greatly from one institution to another. In spite of these shortcomings, US seems to play an important role in surveillance protocols, not least for young non-obese patients with new endoprostheses and evidence of sac shrinkage in early Cat scans.

### ***Sac Pressure Monitoring***

As was mentioned earlier, the "Achilles heel" of the endovascular therapy of AAA is the endoleak, which can beget aneurysm growth and potential risk of rupture. On the other hand, sometimes the sac pressure rises without evident endoleaks; this phenomenon is called "endotension". Whether or not this is due to missed endoleaks or revascularization of the aneurysmal sac or other mechanisms is not yet clear.<sup>38,39</sup> but it is important inasmuch as it can put the patient at risk of rupture. Therefore, pressure measurement can be utilized to monitor the sac and predict the complications or need for re-intervention.

The primary attempts to measure the pressure were



comprised of the direct puncture of the aneurismal sac with a needle<sup>40,41</sup> or the insertion of a catheter with a tip sensor during or after EVAR.<sup>42</sup> The newer technique is the use of wireless pressure sensors, which enables us to measure the sac pressure via a less invasive technique. There are two types of the sensor: ultrasound-based and radiofrequency-based. The main drawbacks of this monitoring are its inaccuracy and cost. In many centers, it is still an experimental tool; in general, however, it can be considered an adjunctive tool and holds promise for the future.

### Radiography

Plain radiography remains a valuable technique for the follow-up of EVAR patients in spite of the availability of multiple sophisticated imaging modalities. Radiographs are still considered by some to be superior to CT scans for demonstrating the conformation of thoracic stent-grafts<sup>43</sup> and are important for detecting kinks in abdominal stent-grafts.<sup>44</sup> Nonetheless, improvements in multislice CT, along with advances in other imaging tools, may require a reevaluation of the added clinical value of radiographs.

### Conclusion

EVAR has gained acceptance as an efficient and minimally invasive therapeutic option for patients with aortic aneurysms, but the main problem is the need for life-time surveillance, which is crucial to detect the major complication of endoprotheses, namely endoleaks.

CT angiography is still the gold standard for follow-up, but MR imaging and contrast-enhanced ultrasonography are adjunctive. Defining a rigid protocol for all patients does not seem to be justified and it should be individualized according to the patient's age and compliance, cost, type of the stent-graft, anatomy of the aneurysm, and the results of previous imaging.

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