Evidence for contrast-enhanced ultrasound in fenestrated EVAR surveillance

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Endovascular aneurysm repair (EVAR) has been reported as an effective alternative to open surgical repair.\textsuperscript{1,2} Since its first introduction into clinical practice in the early 1990s, endovascular stent-grafting has progressed rapidly, following an improved understanding of the strengths and limitations of various devices and treated patient populations.\textsuperscript{3-6} Endovascular technology has evolved to produce fenestrated stent-grafts which are designed to deal with patients with short-necked and juxtarenal aneurysms.\textsuperscript{7-18} Fenestrated stent-grafts have concerns similar to those that apply to conventional endovascular repair, i.e., structural durability, endoleak, renal dysfunction, and migration. Moreover, there is the potential loss of the target vessel resulting from the fenestrated technique. Two published systematic reviews confirm the potential lower perioperative mortality of the fenestrated technique in comparison with open repair, based on short to midterm data.\textsuperscript{19, 20} Fenestrated stent-grafts have become commercially available and provide an alternative to open surgery, especially in patients who are unfit for open repair or standard endovascular repair.

Although fenestrated repair of abdominal aortic aneurysms (AAA) has been shown to reduce perioperative mortality compared to open repair, it is associated with a higher rate of subsequent re-intervention.\textsuperscript{19} Thus, postoperative surveillance is considered mandatory to identify graft-related complications such as visceral vessel stenosis and to direct re-intervention and avoid later morbidity and mortality.\textsuperscript{21, 22} Imaging techniques play an important role in the detection of any abnormalities associated with fenestrated endovascular repair. Helical computed tomographic angiography (CTA) is the routine technique used to assess the patency of the fenestration vessels and target vessel stents in relation to the arterial branches.\textsuperscript{20}

The diagnostic value of CTA in EVAR has been enhanced with development of multislice CT technology and use of a series of 2-dimensional (2D) or 3D reconstructed visualizations
which are generated to improve the understanding of stent-grafts in relation to the aortic branches.\textsuperscript{23-29} CTA is currently the gold standard for EVAR surveillance, however, it is associated with radiation exposure. This raises increasing concerns about the cumulative radiation dose of CTA, since patients treated with EVAR including fenestrated repair undergo regular surveillance imaging (serial CT scans) to monitor the integrity of the endovascular repair and to enable secondary intervention to prevent rupture should CT imaging reveal a problem. It has been reported that the cumulative dose from a series of CT scans following EVAR could be as high as 205 mSv over five years.\textsuperscript{30} This equates to a lifetime attributable risk of cancer of 0.60\% (1 in 170). In addition, CTA contributes to the decline in renal function after EVAR due to contrast-induced nephropathy.\textsuperscript{31} Therefore, duplex ultrasound, an alternative to CTA in the follow-up of EVAR, has been investigated as the potential method of imaging modality.

In the current issue of the \textit{JEVT}, Perini et al\textsuperscript{32} evaluated the accuracy of contrast-enhanced ultrasound (CEUS) as an effective alternative to CTA in the endoleak detection, aneurysm sac diameter measurement and target vessel patency during follow-up after fenestrated EVAR. The authors studied 62 patients (mean age 72 years) who underwent fenestrated EVAR with a maximum of 3 fenestrations. Both CEUS and CTA examinations were performed in all patients for comparative analysis. Maximum aneurysm sac diameters were measured with both imaging modalities. Detection of endoleaks was evaluated and differences in endoleak detection were assessed between the two modalities. Target vessel patency following fenestrated EVAR was analyzed, and the agreement between two modalities was compared. The authors demonstrated the good to excellent agreement between the two modalities in the follow-up performance based on the first postoperative images. The mean difference in aneurysm sac diameter was $-1.13 \pm 3.19$ mm (95\% CI $-0.34$ to $-1.92$), with CTA measurements tending to be slightly larger. Both CEUS and CTA
showed the same diagnostic accuracy with excellent agreement in the endoleak detection. A complete agreement was reached between CEUS and CTA in the assessment of fenestrated vessels, with 144 (98.6%) vessel being patent, 1 having significant stenosis and another being thrombosed. The study by Perini et al therefore concluded that CEUS is as accurate as CTA in monitoring endoleaks, aneurysm sac diameters, and target vessel patency in patients treated with fenestrated stent grafts. CEUS is not recommended as the sole imaging modality for fenestrated EVAR surveillance, however, it could be used as an effective alternative to CTA due to its advantage of reducing lifetime exposure to ionizing radiation associated with the CTA scans.

There are three observations from Perini’s study that bear discussions. First, the authors have validated CEUS in this study as an accurate modality for early follow-up of fenestrated EVAR. Color duplex ultrasound scanning has been considered a potentially attractive alternative to CTA in the follow-up of patients after standard EVAR, as it is less expensive and does not involve ionizing radiation or potentially nephrotoxic contrast. Several studies have reported excellent results with color duplex ultrasound compared to CTA, while others have concluded that CTA is still the technique for surveillance after EVAR. Several authors have pointed out the usefulness of CEUS because it seems to allow better identification and characterization of endoleaks. In a study using CEUS, Napoli et al. were able to differentiate a low-flow endoleak from endotension, which had been diagnosed on the basis of triple-phase contrast-enhanced CTA. Similarly, Henao et al. confirmed the efficacy of CEUS to detect endoleaks compared to CTA, as their results demonstrated that CEUS detected all of the nine endoleaks, while CTA failed to recognize three type II endoleaks observed by CEUS. CEUS may be used as a primary modality for the detection of endoleaks and characterization of the dynamic flow of endoleaks. Perini et al. in their recent study consisting of 395 patients who underwent both standard and fenestrated EVAR showed
the same efficacy by CEUS and CTA in post-EVAR follow-up. According to authors’ experience, CEUS has been recommended to replace the 6-month and 24-month CTA examinations in the standard EVAR surveillance.

The second comment is related to some of the CEUS limitations which prevent it from being used as the sole imaging modality for fenestrated EVAR surveillance. In addition to the well documented operator dependency of ultrasound examinations and patient factors (e.g., large body mass index, bowel gas), the authors noted that CEUS has limitations in the reliable detection of other complications such as stent fracture, limb kinking, stent graft migration or component separation. In contrast, CTA provides superior information related to stent graft structure and integrity, and its diagnostic applications are augmented by 3D reconstructions which have been reported to provide valuable information for the assessment of stent graft migration, as well as its relationship with aortic branches.\textsuperscript{23-29,46} Despite the advantages of CTA in the identification of stent graft details, the deleterious effect on renal function, radiation exposure, and significant cost of this surveillance procedure are considered problematic. As the authors recommended, 4-view abdominal radiographs should always be performed at the same time as ultrasound,\textsuperscript{47} and their findings should be interpreted together. This significantly reduces the radiation dose as plain radiography produces radiation dose of less than 1 mSv, thus the radiation-induced risk of malignancy is negligible.

The third comment is related to the clinical applicability of these findings to patients treated with fenestrated stent-grafts. The authors highlighted the potential value of using CEUS as an alternative to CTA in the follow-up of fenestrated stent-grafts, however, their data was based on a single center experience and was restricted to the observation of the first postoperative investigation. Furthermore, the limited number of patients and the number of abnormalities in their first follow-up series represents another limitation of the study. The
authors indicated that further studies are necessary to better define the role of CEUS in surveillance of fenestrated EVAR. Many clinical centers initially undertook surveillance protocols from those outlines in the randomised controlled trials or early registries, which used contrast-enhanced CT as the gold standard of surveillance. However, excessive dependence on CT is expensive and exposes the patients to nephrotoxic intravenous contrast and ionizing radiation. Increasing the proportional use of non-nephrotoxic imaging modalities after EVAR has been advocated as an alternative approach to reduce surveillance-related morbidity. Sternbergh et al recommended a revised EVAR surveillance regimen according to their multicenter data from the US Zenith endovascular AAA trials. On the basis of these data and 5-year follow-up outcomes, they proposed a modified surveillance protocol to alter the intensity and frequency of postoperative imaging follow-up. In patients without early endoleaks, the 6-month surveillance is eliminated, and the yearly aortic ultrasound examination is recommended for long-term surveillance of more than 1 year. There is increasing evidence of a trend from using conventional CT follow-up to ultrasound monitoring, so there is a need for a contemporary evaluation of surveillance after EVAR. A recent survey which was administered to 41 clinical centers experienced in EVAR in the UK has shown there is significant heterogeneity in national practice for postoperative surveillance after EVAR. Intensive use of CT was observed in some centers and this may lead to cumulative renal injury due to repeated administration of contrast agents and radiation exposure. The heterogeneity seen in this survey reflects the ongoing uncertainty about the surveillance protocol following EVAR. More evidence is needed to establish a consensus towards an optimal surveillance protocol that is clinically and economically effective.

In summary, Perini and colleagues have successfully shown the accuracy of CEUS in the surveillance of fenestrated stent-grafts. However, since the current study is based on a small number of patients and the first postoperative imaging session only, large-scale multicenter
studies are needed before generalizing conclusions regarding the use of CEUS in routine surveillance of fenestrated EVAR patients.
References


