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Contrast-enhanced ultrasonography versus computed tomographic angiography in the monitoring of patients after endovascular repair of abdominal aortic aneurysm – preliminary experience

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Abstract

BACKGROUND: Computed tomographic angiography (CTA) is routinely used in the monitoring of patients after endovascular repair of abdominal aortic aneurysm.
The aim of the study was to determine if contrast-enhanced ultrasonography (CEUS) provides equivalent results to CTA in detection of endo-leaks in patients after abdominal aortic stent-graft placement.

MATERIAL AND METHODS: In a group of 7 patients (6 men and 1 woman; aged 71±7 years) after repair procedure, 16 CTA and 16 CEUS follow-up examinations were performed. Second-generation contrast agent (Sonovue) and low-mechanical index technique were used for ultrasonography imaging.
RESULTS: Computed tomographic angiography showed seven cases of type I, five cases of type II, and no endo-leaks in four examinations. In 15 out of 16 studies, the results of CEUS were consistent with the results of CTA. In one discrepant study, type II endo-leak was detected with CEUS while CTA was negative.
CONCLUSIONS: Contrast-enhanced ultrasonography and CTA examinations in patients after endovascular repair of abdominal aortic aneurysm provide comparable results. CEUS may be considered an alternative technique to CTA.
Key words: ultrasonography, contrast agent, aorta, aneurysm

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Introduction

Computed tomographic angiography (CTA) is the modality of choice in the follow-up of patients after endovascular repair of abdominal aortic aneurysm (AAA) [1]. It provides high-resolution information about the morphology of the aneurysm and the surrounding structures. CTA is highly effective in detecting endo-leaks, which are the most frequent complications of the procedure [2]. How-

ever, CTA exposes patients to ionizing radiation and the risk of complications associated with administration of iodinated contrast media. Non-invasive contrast-enhanced ultrasonography (CEUS) can be preferred over CTA if it provides comparable diagnostic information.

The purpose of the study was to determine whether CEUS is equivalent to CTA in the detection of endo-leaks in patients with abdominal aortic aneurysms treated with stent-graft placement.

Materials and methods

The study was approved by the institutional review board, and informed consent was given by each patient. The examined group included seven consecutive patients after aorto-bi-iliac stent-graft placement. One of them was a woman and six were men; the mean age was 71 ± 7 years, and the age range was 56–78 years. In the follow-up, further endovascular interventions were required in two patients. The first CTA examination was performed about ten days after the repair procedure. In cases of endo-leak detection, further CTAs in the first year were executed after 3, 6, and 12 months. If endo-leak was not observed in the initial study, follow-up CTA examinations were performed after 6 and 12 months and once a year thereafter. Independent comparative CEUS examinations were performed less than two days before or after CTA examinations.

Computed tomographic angiography

Three-phase helical CT of the abdomen was performed using a commercially available scanner Aquilion 16 (Toshiba, Japan) equipped with 16 rows of detectors. The following scanning parameters were used: a gantry rotation speed of 0.4 sec per rotation, detector row configuration of 16 × 1 mm, and helical pitch 23 (pitch factor 1.4375). Images were reconstructed with a 1 mm slice thickness at 0.8 mm intervals. The scanning region of interest ranged from the diaphragmatic domes to the trochanter minor plane. Non-ionic contrast material was administered through an antecubital vein at a dose of 1.5 ml/kg, concentration of 400 mg/ml, and infusion rate of 4 ml/sec. Post-contrast images were acquired in the arterial phase (20–40 sec delay after injection) and the venous phase (60–70 sec delay after injection). The images were processed by dedicated software at an independent workstation to enable multiplanar, volume-rendering, and maximum-intensity projection reconstructions.

Contrast-enhanced ultrasonography

Before CEUS, patients underwent B-mode, colour Doppler, and power Doppler examinations for the preliminary evaluation of the aneurysm. A convex transducer of 1.8–5.2 MHz frequency (Siemens Elegra, Siemens, Erlangen, Germany) was used for the study. Examinations were performed by two radiologists who had three and five years of experience with contrast-enhanced US. A second-generation contrast agent (Sonovue, Bracco, Italy) was used for the study. The agent was administered into an antecubital vein at a dose of 2.4 ml followed by 10 ml saline solution. The study was performed with low-mechanical index (MI = 0.1) technique and manufacturer-delivered software-EnsembleTM Contrast Imaging (Siemens, Erlangen, Germany). The aorta was examined for five minutes after the injection from the diaphragm to below the iliac limb attachment sites. The structures were evaluated in the axial and longitudinal planes. The entire examination was tape recorded to allow later analysis, which was performed separately by another radiologist. Discrepant findings were resolved by consensus.

The following aspects during the computed tomography and ultrasonography examinations were assessed: the presence of an endo-leak, the type of endo-leak, and other pathologies related to the procedure. Endo-leaks were classified into the following five types:

I — due to inadequate proximal or distal anchoring;
II — due to the presence of retrograde collateral flow;
III — due to the prosthetic defects;
IV — due to the graft porosity;
V — due to endotension [3].

Results

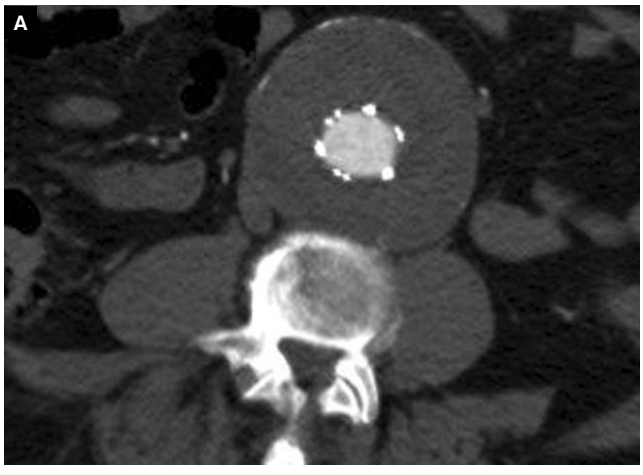
In the studied group, 16 CTA and 16 CEUS examinations were performed (Table 1). None of the patients reported any adverse effects relating to the US contrast media injection.

Aneurysm diameter was 64.6 ± 11.5 mm on CT and 61.3 ± ± 12.3 mm in US examinations (difference not significant, paired t-test, t = 0.76)

CTA identified seven cases of type I and five cases of type II endo-leaks. In four examinations, no endo-leaks were detected. CEUS studies showed seven cases of type I, six cases of type II, and no endo-leaks in three examinations (Figures 1 and 2). Type I endo-leaks appeared synchronously to the graft enhancement (they started to be seen 15–27 seconds after contrast media ad-

Table 1. The number of computed tomographic angiography (CTA) and contrast-enhanced ultrasonography (CEUS) examinations performed in the examined group of patients

Patient	Number of CTA examinations	Number of CEUS examinations
1	4	4
2	3	3
3	1	1
4	3	3
5	2	2
6	1	1
7	2	2
Total	16	16



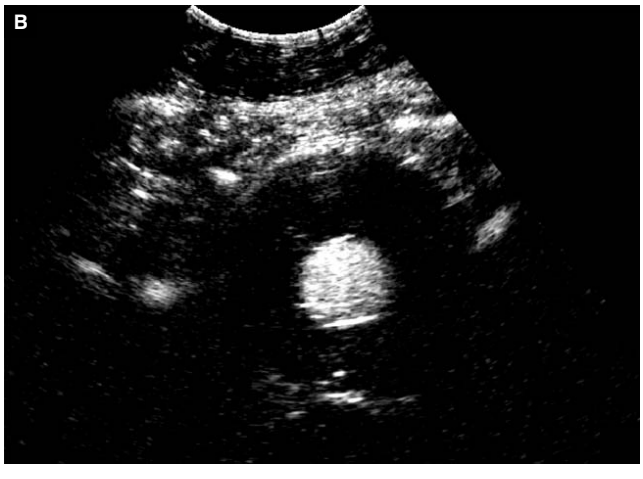
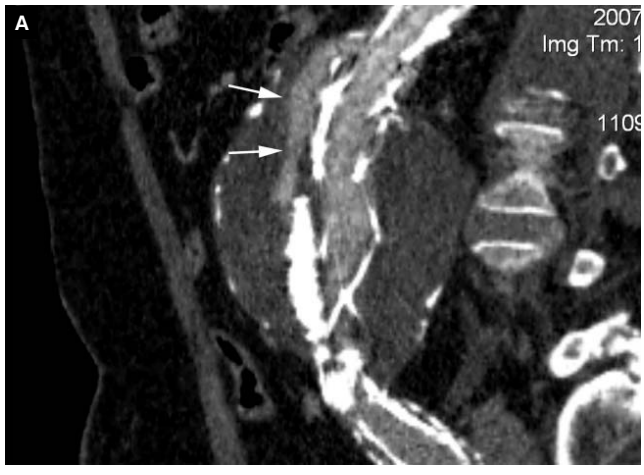


Figure 1. Abdominal aortic aneurysm after endovascular repair visualized by CTA (**A**) and CEUS (**B**). Axial plane demonstrating no endo-leak or other pathologies related to the procedure.



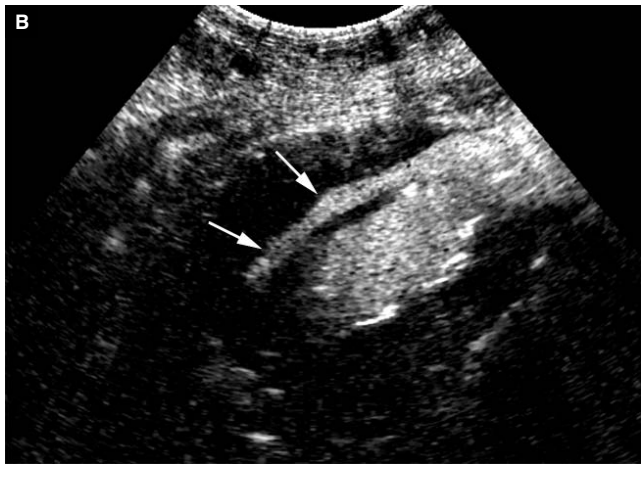


Figure 2. Abdominal aortic aneurysm after endovascular repair visualized by CTA (**A**) and CEUS (**B**). Sagittal plane demonstrating type I endo-leak (white arrows).

ministration), while type II endo-leaks were detected later (they started to be seen 35–76 seconds after contrast media administration). Neither CTA nor CEUS identified other types of endoleaks (type III, IV, or V). No other pathologies relating to the endovascular procedure were detected with computed tomography or ultrasonography.

The results of 15 out of 16 (94%) CEUS examinations were in accordance with the results of CTA. In one patient, CTA and CEUS findings were discrepant. In the late phase of CEUS examination (after 76 seconds) in the aneurysmal sac, a linear structure suggesting an endo-leak from the lumbar artery was identified (Figure 3), while CTA was negative.

Discussion

Our preliminary study shows that CEUS and CTA examinations provide equivalent results. The findings of CTA and CEUS were discrepant only in one patient. Type II endo-leak was detected with CEUS but was not found with CTA. Failure to detect this endo-leak with the CTA was probably the result of the slow-flow (the endo-leak started to be visible 76 seconds after the contrast injection) and haemodynamic status of the patient.

Figure 3. Abdominal aortic aneurysm after endovascular repair visualized by CEUS. Axial plane demonstrating type II endo-leak (white arrow), not detected with CTA.

Our results are in accordance with the results of other investigators. Recently, Carrafiello et al. showed that CEUS can diag-

nose more endo-leaks than CTA [3]. As in our case, they were slow-flow type II endo-leaks. In addition, Henao et al. demonstrated that CTA failed to recognize three type II endo-leaks that were identified by CEUS, whereas no additional endo-leaks seen on CTA were missed by CEUS [4]. This was possibly because they used continuous infusion technique. Sonovue is of low solubility, innocuous, and isotonic with human plasma. It does not contain any proteinaceous material and is devoid of allergic potential [5]. These features allow administration of more contrast in case of insufficient first dose.

Second-generation ultrasound contrast agents available today are not toxic because they consist of stabilized microbubbles of sulphur hexafluoride gas which are eliminated through the respiratory system [5]. These microbubbles can generate non-linear signals at low acoustic power. This enables longer enhancement and reduction in blooming artefacts, which have had the effect of decreasing the utility of the first-generation contrast agent. Because the microbubble diameters range in size from 1 to 10 micrometres they are not filtered by the lungs and circulate in the arterial flow after intravenous injection [5, 6]. These properties make US contrast agents specific for the blood pool and excellent for vasculature imaging. They are successfully used not only in large vessel pathology imaging, but also in the evaluation microvasculature of focal lesions or heart perfusion [7, 8].

CTA is considered the gold standard for monitoring patients after the endovascular repair of abdominal aortic aneurysms. The current protocol of CTA studies for endo-leak detection requires three-phase examination resulting in high radiation dose and risk of complications relating to iodinated contrast agent administration, particularly high in older patients with cardio-vascular disease [1, 9, 10].

The study has some limitations. Our results are preliminary and are based on a small sample. Furthermore, not all types of endoleaks were observed. We detected only type I and II endo-leaks, while types III, IV, and V were not present. Additional studies are essential to estimate the sensitivity and specificity of this technique in the detection of different endo-leaks with higher precision. We also reported a relatively high proportion of patients with type I endo-leak. This situation was the result of the incorrect classification of patients and technical problems (too short stent) during two endovascular procedures. The disadvantage of the study is the lack of digital subtraction angiography results for comparison, but additional ionizing radiation exposure and iodinated contrast media administration for DSA was not acceptable solely for research purposes. Thus, our study can be considered a non-inferiority trial. Other limitations associated with CEUS technique are typical for general ultrasound imaging, such as obesity, bowel gas interference, or patient incompliance.

The use of contrast-enhanced ultrasonography is recommended in the monitoring of patients after endovascular repair of the abdominal aortic aneurysm, as our study supports previous observations that CEUS is not worse than CTA in the diagnosis of endo-leaks.

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