Novel Use of Contrast-enhanced Ultrasound in the Pretreatment Planning Prior to Endovascular Repair of Endoleak after Endovascular Aortic Aneurysm Repair in a Patient with Chronic Renal Insufficiency: A Case Report and Literature Review

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Abstract

Endoleaks are a common complication in patients who have undergone endovascular stent-graft repair of abdominal aortic aneurysms. The management of these complications depends on the type of endoleak seen at follow-up imaging, with embolization being generally accepted treatment option for Type 2 endoleaks in certain clinical scenarios. Endovascular endoleak embolization can be arduous, time-consuming, and require large amounts of iodinated contrast during the angiographic procedure. This article describes a novel use of contrast-enhanced ultrasound as a clinical problem-solving tool in the preprocedural planning of patient undergoing an endoleak embolization.

Keywords: Contrast-enhanced, embolization, endoleak, ultrasound

INTRODUCTION

Endovascular aortic aneurysm repair (EVAR) has become a safe and viable alternative to open surgical repair for abdominal aortic aneurysm since first being described in 1991.[1] Endoleaks, defined as perfusion of the aneurysm sac after endovascular stent graft placement, are the most common complication following EVAR and are divided into five types based on the origin of leak by the Society for Vascular Surgery and American Association for Vascular Surgery.[2] Type 2 endoleaks are the most common type following EVAR and result from the aneurysm sac being supplied by patent branch vessels, often the IMA or lumbar arteries, which reconstitute through retrograde filling by arterial anastomotic collateral pathways.[3] Treating all Type 2 endoleaks is controversial, as the natural history suggests that the majority will decrease in size or remain stable due to slow flow and/or spontaneous thrombosis.[4-6] However, treatment is generally warranted for Type 2 endoleaks associated with aneurysm sac

expansion >5 mm or endoleaks persisting longer than 6 months on follow up imaging.[7-9] Other authors have also suggested consideration for treatment of Type 2 endoleaks in the setting of a large nidus, multiple (>3) feeding vessels or large (>4 mm) feeding vessel(s), or when high flow velocities within the sac are seen on postoperative follow up imaging.[10-13]

The treatment of Type 2 endoleaks consists of embolization of feeding vessels and endoleak nidus, which can be achieved in a variety of ways. The transarterial approach consists of endovascular access of the nidus within the aneurysm sac through arterial collaterals. This method of treatment usually involves microcatheterization of anastomotic arterial collaterals

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recannalizing the inflow vessel supplying the nidus, most often the inferior mesenteric artery (IMA) or lumbar arteries. Once the nidus is accessed, the nidus and feeding vessel(s) are occluded using microcoils and/or liquid embolic agents.[14,15] The transarterial approach can be difficult due to anastomotic variability, vessel size, and tortuosity of the arterial collateral pathways or may not be feasible in the setting of stenosis or occlusion of the mesenteric or iliac arteries. If endovascular routes cannot be safely obtained, access into the nidus may be achieved by percutaneous fashion through direct puncture of the aneurysm sac through a translumbar, transabdominal, or transcaval approach.[6,16,17] Once percutaneous access into the nidus is established, angiography and embolization of the nidus and the feeding vessels can be performed with coils and/or liquid embolic agents. Both transarterial and direct sac puncture methods have been shown to be effective in the treatment of Type 2 endoleaks.[14]

Although computed tomography angiogram (CTA) is most commonly for the detection of endoleaks, contrast-enhanced ultrasound (CEUS) is increasingly being used to assess for EVAR complications in patients unable to undergo CTA. Benefits of CEUS include lack of radiation to the patient in contrast to that which is incurred with multiphase CTA or angiography. CEUS is noninvasive, inexpensive, and as there is no radiation penalty, the sac can be imaged continuously instead of at only certain time points. Breath holds are not required during CEUS. In addition, patients can be re-dosed during CEUS to further interrogate a suspicious area – the contrast bubbles from the initial contrast injection can be manually burst using the ultrasound, allowing for immediate administration of a second contrast dose. This is a major difference to CTA, where contrast will diffuse into the sac in the presence of endoleak and may need hours or days to clear, before the scan could be repeated. Contrast agents in CEUS remain intravascular and byproducts are exhaled through the pulmonary system, and so they are not renally excreted.[18-20] Patients can, therefore, be given more than one dose and do not require renal function evaluation before or after an exam. The allergy profile of ultrasound contrast is lower than that of CT/angiography dye. Both major and minor reactions are exceedingly rare.[20-22]

While the detection and surveillance of endoleaks is well documented and validated, there is a paucity of information in the current body of literature pertaining to CEUS use in planning the treatment of Type 2 endoleaks undergoing embolization. In this report, we present an example of how CEUS was used in the diagnosis, classification, and pretreatment planning of a patient who underwent transarterial embolization for a Type 2 endoleak.

Case Report

Our patient is a 72-year-old male with chronic renal insufficiency secondary to autosomal dominant polycystic kidney disease (PCKD) who had a 5.5 cm abdominal aortic aneurysm diagnosed 3 years prior to current presentation. Due to PCKD, open aortic aneurysm repair was deferred and the patient underwent EVAR at that time, as well as placement of Aptus EndoAnchors owing to a Type 1 endoleak (perfusion of the excluded aneurysm sac via incomplete seal at the graft anchor) noted intraoperatively, which resolved after deployment of the EndoAnchors.

The patient underwent routine postoperative surveillance with duplex ultrasound. Ten months later, follow-up duplex ultrasound showed a new endoleak at the anterior aspect of the sac [Figure 1a] which was confirmed with CTA with pooling of contrast during the arterial phase of imaging at the anterior aspect of the aneurysm sac [Figure 1b]. Given the location of the endoleak, it was thought that the IMA was the likely feeding vessel, but, as the aneurysm sac had not increased in size, the vascular surgeon elected to proceed with clinical monitoring and imaging surveillance.

The patient was then lost to follow-up, returning to the vascular surgeon after a delay of 16 months. The patient underwent repeat imaging with CTA [Figure 2a] and duplex US [Figure 2b] which showed the aneurysm sac had increased in size, now measuring 6.3 cm, with persistent endoleak that had changed morphology. The follow-up CTA showed faint pooling of contrast along the anterior margin of the aneurysm sac and a new, larger collection of contrast along the posterior margin of the aneurysm sac. The follow-up duplex US demonstrated a linear endoleak nidus which spanned from the anterior margin to the posterior margin of the aneurysm sac Due to the proximity of the endoleak in relation to the left iliac limb gate, it was unable to be determined if this was a Type 2 or Type 3 endoleak (persistent perfusion of the aneurysm sac via a mechanical defect involving the graft material or graft component junction).

The patient was referred to interventional radiology for conventional angiography and embolization of the endoleak. As the patient had chronic renal insufficiency, it was requested to reduce the amount of contrast administered at the time of angiography to help preserve renal function. CEUS was performed immediately prior to the procedure to help characterize the endoleak. Additional imaging was deemed
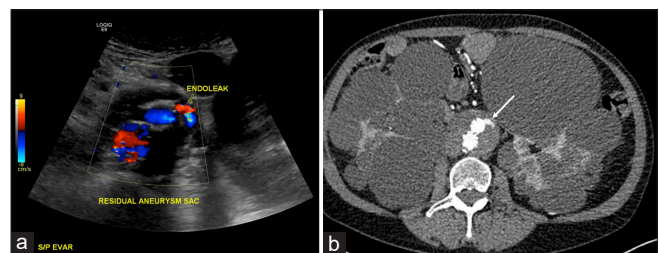

Figure 1: Initial endoleak diagnosis after endovascular aortic aneurysm repair. Axial Color Doppler US (a) and axial arterial phase computed tomography angiogram (b) showing endoleak at the anterior margin of the aneurysm sac (arrow), near the IMA origin, suggesting Type 2 endoleak. Polycystic kidney disease also seen

warranted as the diagnosis of a Type 3 endoleak would have required referral back to vascular surgery for re-lining of the stent. Additionally, localization of arterial inflow would help to reduce the amount of contrast used during multi-vessel angiographic interrogation.

The previously obtained CTA and vascular Doppler ultrasound images were reviewed that showed the potential locations/origins of the endoleak. The contrast ultrasound was performed at the patient's bedside, with an abdominal imager, interventionalist, and sonographer present. Grayscale ultrasound images were obtained of the aortic aneurysm sac to obtain an optimal imaging window, to look for leak visible on Doppler, and to identify the IMA.

Through an intravenous access, 1.5 mL of Lumason sulfur hexafluoride lipid-Type 1 microspheres (Bracco Diagnostics Inc., Monroe Township NJ, USA) was injected, followed by a 5 mL sterile saline flush. Imaging was performed through the aneurysm sac, to verify that a leak was present [Figure 2c]. Once a leak was identified, the specific location within the sac was evaluated in real time to evaluate for the potential inflow vessel. For example, a leak from a lumbar artery source would be located in the posterior sac, whereas a leak from the IMA would be located in the anterior sac. Timing of the appearance of the endoleak in conjunction with contrast in the aortic graft is also vital to determine type of endoleak. Initial images confirmed the leak presence which had delayed appearance compared to arrival of contrast opacification of the endograft limb. This delayed opacification suggests perfusion via pelvic or mesenteric anastomotic collateral vessels, confirming

a diagnosis of a Type 2 endoleak and ruling out a Type 3 endoleak, which would have more immediate opacification of the endoleak in relation to the endograft. Therefore, the contrast was burst using power Doppler and a second dose of 1.5 mL of Lumason followed by a saline flush were administered to better identify the inflow vessel. Specific attention at the suspected inflow was performed, and contrast was seen arising from the right side of the graft posteriorly, also confirming delayed timing of the appearance of the leak. Sagittal imaging was also utilized to confirm a posterior inflow vessel [Figure 2d] a right lumbar artery.

Since the arterial inflow was identified to be arising from the right lumbar arteries on the CEUS, right femoral access was used, as the internal iliac vessels are difficult to select via contralateral access due to the cranial position of the iliac flow divider of the stent. The right internal iliac angiography demonstrated an arterial collateral pathway arising from the right iliolumbar artery, which reconstituted the right L3 lumbar artery that supplied the arterial nidus of the endoleak [Figure 3a]. A coaxial microcatheter system was used to select the arterial inflow of the right L3 lumbar artery, and superselective angiography confirmed supply to the nidus and also identified the left L3 lumbar artery as the outflow vessel [Figure 3b]. The microcatheter system was used to select and embolize the outflow vessel, nidus, and inflow vessel with postembolization angiography demonstrating stasis through the nidus and treated vessels [Figure 3c]. The entire procedure used only 63 mL of intravenous contrast.
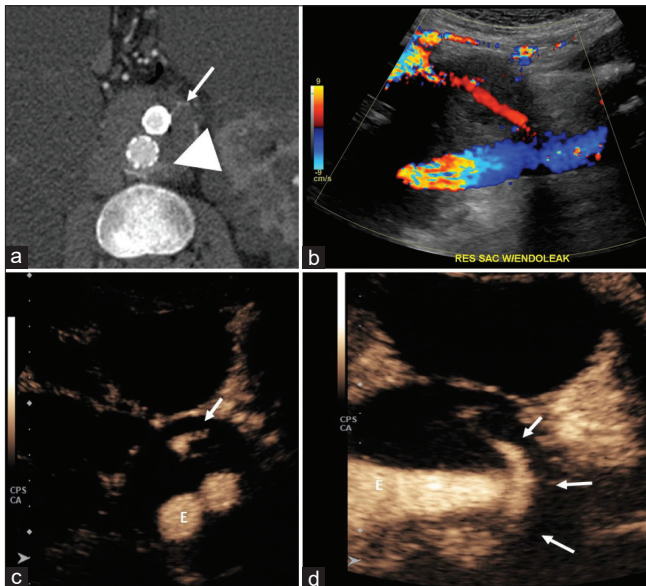
DISCUSSION

CEUS has been shown to adequately detect and evaluate Type 2 endoleaks with high reported rates of sensitivity and specificity.[23-27] This case report describes the use of CEUS as an effective imaging modality, not only for diagnosis of an endoleak, but also for the planning of endoleak embolization. This is primarily due to the dynamic nature of real-time scanning and decreased associated risks. In contrast to multiphasic CTA, CEUS allow for greater, real-time examination of the nidus and inflow vessel. This is in contradistinction with CTA arterial

Figure 2: Follow-up endoleak imaging. Axial arterial phase computed tomography angiogram (a) showing endoleak anteriorly (arrow) and posteriorly (arrowhead). Sagittal color Doppler US (b) showing endoleak spanning anteroposterior dimension of the sac. Preoperative axial contrast enhanced ultrasound (c) showing a delayed endoleak (arrow), appearing 11 s after endograft (E) opacification. Sagittal contrast-enhanced ultrasound (d) demonstrating inflow from right lumbar artery (arrows)
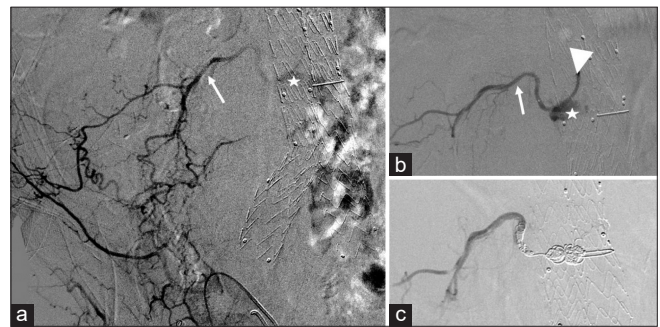

Figure 3: Angiographic procedure. (a) Right internal iliac arteriogram showing endoleak nidus (star) with right L3 lumbar artery inflow (arrow). (b) Selective right L3 lumbar arteriogram showing inflow, nidus, and left L3 lumbar artery outflow (arrowhead). (c) Postembolization angiography demonstrating endoleak occlusion

phase images acquired at a single time interval, which may not always definitively show the nidus and inflow. Performing and interpreting CEUS in patients with suspected endoleak requires thorough knowledge of postoperative anatomy and pathophysiology. Once the endoleak is identified, the type of endoleak can be assessed based on the location and timing of the opacification of the endoleak in relation to the opacification of the endograft [Table 1]. Delayed opacification of the endoleak in relation to the opacification of the endograft suggests a Type 2 endoleak, as the time delay of contrast opacification is related to the transit of the contrast bolus through retrograde perfusion of the aneurysm sac via the anastomotic collateral pathway. Rapid or immediate opacification of the endoleak would more likely suggest a Type 1 or Type 3 endoleak, which results in antegrade filling of the aneurysm sac via a mechanical defect of the endograft. The location of the endoleak helps to determine source of persistent aneurysm sac perfusion. Rapid appearance of the endoleak near the proximal or distal anchor of the graft would be indicative of a Type 1 endoleak and rapid appearance of the endoleak near the iliac limb gate or central portion of the graft would indicate a Type 3 endoleak. Delayed opacification of the endoleak starting in the periphery of the excluded aneurysm sac at a posterior location suggests a lumbar artery as a source of Type 2 endoleak, whereas delayed opacification of the excluded aneurysm sac at an anterior location would suggest the IMA as the potential source of Type 2 endoleak.

In this particular case, the information obtained from the preoperative CEUS was valuable in the planning of the subsequent embolization in several ways. CEUS performed the same day as the procedure allowed for collaborative discussion between the abdominal imager and interventionalist regarding specific technical and clinical concerns which helped to create a more targeted, clinically focused examination. The preoperative CEUS was able to confirm diagnosis of a Type 2 endoleak, establishing the need for angiography and embolization. It also aided in the preoperative determination of the laterality of the inflow, allowing for the appropriate choice of initial arterial access. As multiple arterial access punctures increase the risk of procedural complications, determining the laterality of access with CEUS helped to decrease the potential risk within the procedure. Additionally, the information obtained from the preoperative CEUS helped to preoperatively identify and localize the inflow vessel, which led to a reduction in the overall required iodinated contrast volume. Flush aortography

and multi-vessel angiographic interrogation are used to assess potential inflow vessels at the time of angiography, which often leads to larger volumes of iodinated contrast. At our institution, for the past 5 years, the average iodinated contrast dose for angiography for evaluation of endoleak is 94 mL and has ranged up to 234 mL. The use of CEUS in this particular case eliminated the need for multi-vessel interrogation and the entire procedure was able to be performed with 63 mL of iodinated contrast, a 33% reduction of iodinated contrast compared to the average. Reducing the iodinated contrast volume during angiography helped to mitigate the potential nephrotoxic effects of iodinated contrast in this patient with chronic renal insufficiency.

CEUS does have several pitfalls and limitations in the evaluation of endoleaks. One pitfall is a reported inability of CEUS to accurately assess the aneurysm sac size.[26] However, many practices rely on grayscale ultrasound surveillance in detecting changes in aneurysm size to decrease life-time radiation and preserve renal function. Another reported pitfall is that CEUS is unable to detect stent graft migration, which would require additional imaging modalities to diagnose.[24,27] General limitations of ultrasound also apply to CEUS, including limitations secondary to large patient body habitus, overlying bowel gas, and scanner/interpreter inexperience. In addition, only the image planes acquired during the exam are available for review, unlike CTA. CEUS may also have limitations in the assessment of complex Type 2 endoleaks, which can have multiple inflow vessels. In our experience, CEUS may show more than one endoleak inflow and it is currently not clear how to identify which is the major inflow for enlarging the sac. The analysis of arrival time of the leak and relative flow velocity (contrast puddling vs. jet of contrast) may be useful in this particular setting but has not been studied to the authors' knowledge.

CEUS has a potential role not only in the diagnosis of endoleaks after endovascular repair of abdominal aortic aneurysms, but may also be beneficial in the planning of endovascular treatment of endoleaks. It can allow for appropriate choice of laterality of arterial access and reduction of intra-procedural iodinated contrast. This case demonstrates the clinical utility of CEUS in the preoperative assessment and planning of endoleak embolization.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient has given his

Table 1: Imaging characteristics of endoleaks on contrast-enhanced ultrasound by type			
Endoleak type	Timing of endoleak enhancement relative to endograft	Direction of endoleak enhancement within aneurysm sac	Location of endoleak
Type 1	Rapid	Central to peripheral	Proximal or distal endograft anchor(s)
Type 2	Delayed	Peripheral to central	Posterior - Lumbar artery
			Anterior - IMA
Type 3	Rapid	Central to peripheral	Near iliac limb gate or graft material

IMA: Inferior mesenteric artery

consent for his images and other clinical information to be reported in the journal. The patient understands that his name and initials will not be published and due efforts will be made to conceal the identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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