**Introduction**

Up to 30% of patients undergoing elective EVAR have pre-existent chronic renal insufficiency (CRI).\(^1\) This particular group is at risk for developing contrast-induced nephropathy (CIN). The incidence of CIN rises with 5-8% annually.\(^2\) CIN is associated with extended hospital stay and increased use of medical resources.\(^3\) Techniques using intra-operative ultrasound enables vascular surgeons to reduce the amount of iodinated contrast or eliminate this completely. For example Intravascular ultrasound (IVUS) as well as contrast-enhanced ultrasound (CEUS), with micro bubbles, have been shown feasible for endovascular repair of Abdominal Aortic Aneurysm (AAA) in patients with contra-indications for contrast agents.\(^4\)–\(^7\) Using intra-operative doppler-ultrasound contrast agents can be completely abolished during EVAR-procedures. This report describes three cases in which duplex-assisted EVAR (D-EVAR) was employed. An application for approval of this study was not required by the local ethics committee.

**Cases**

All three procedures were performed in the operating room under spinal anaesthesia. After preparing and draping the abdomen and groins, a short segment of the common femoral artery (CFA) was exposed. A purse string stitch was placed on the CFA on both sides. An uncalcified segment of the artery was punctured and an 11 cm long 7Fr Brite Tip introducer sheath (Cordis, Cordis Congregation, City of Florida, Florida, USA) was inserted. 2500U Heparin was given intravenously to all patients. Using conventional fluoroscopy, a Terumo angled 180 cm 0,035 guide wire (Terumo Europe N.V. Leuven, Belgium) via a straight 5F angiographic Catheter (Cordis) was introduced passing through the iliac artery. Depending on which renal artery orifice was located most distally, the guide wire was positioned as a marker in the first centimetres of the renal artery. A Lunderquist extra stiff guide wire was positioned and the main endograft device was positioned over the Lunderquist wire and deployed infrarenal...
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i.e. exclude any remaining perfusion of the aneurysm sac. SonoVue (Bracco Diagnostics Inc, Monroe Township, New Jersey, USA) 5 ml solution was mixed with 45 ml sodium chloride 0,9% (Baxter) solution. This combined volume was injected intravenously at a rate of 200 mL/hour. Bilateral iliac device components were insonated by pulsed doppler to detect a significant increase of flow velocities, which may indicate a stenosis. Finally, the CFA and both wounds in the groin were closed on a conventional way.

Case Report 1

A 80 year old male with a prior medical history of hypertension, prostatectomy and CRI with estimated glomerular filtration rate (eGFR) of 47 mL/min/1.73 m² and creatinine 128 µmol/l was seen for routine follow-up with a growing AAA of 5.5 cm. Body mass index (BMI) of the patient was 29 kg/m². The AAA was EVAR suitable. Diameter of the infrarenal aneurysm was 27 mm, neck length 24 mm, 53° angulation of the neck, 27° angulation of the iliac arteries. Procedure duration was 162 minutes (min.), with a fluoroscopy time of 25 minutes. Postoperative course was uneventful and the patient was discharged from hospital after four days. One year postoperative CT-scan showed no endoleak, diameter reduction from 55 mm to 49 mm (Fig. 4). Eighteen months postoperative CEUS showed no endoleak, stable diameter of 49 mm and unchanged renal function (eGFR 47 mL/min/1.73 m²).
Case Report 2
A 76 year old male with prior medical history of contrast allergy, CRI (eGFR 59 mL/min/1.73 m² and creatinine 104 µmol/l) and a BMI of 34 kg/m². During routine follow-up, ultrasound imaging showed increase of AAA to 6.2 cm. The AAA was EVAR suitable. Diameter of the infrarenal aneurysm was 24 mm, neck length 30 mm, 50° angulation of the neck, 35° angulation of the iliac arteries. Total procedural time was 150 min. with 20 min. of fluoroscopy time. Postoperative course was uneventful and the patient was discharged from hospital after four days. Eighteen months postoperative CEUS showed no endoleak, diameter reduction from 62 mm to 52 mm and unchanged renal function (eGFR 65 mL/min/1.73 m²).

Case Report 3
A 76 year old male with CRI (eGFR 47 mL/min/1.73 m² and creatinine 143 µmol/l) showed during routine follow-up on ultrasound imaging an increase in diameter of AAA up to 5.9 cm.

BMI of the patient was 24.2 kg/m² and the aneurysm was EVAR suitable. Diameter of the infrarenal aneurysm was 23 mm, neck length 28 mm, 25° angulation of the neck, 55° angulation of the iliac arteries. Total procedural time was 140 min. with 16 min of fluoroscopy time. Postoperative course was uneventful and the patient was discharged from hospital after 4 days. Twelve months postoperative CEUS showed no endoleak, diameter reduction from 59 mm to 54 mm and unchanged renal function (eGFR 50 mL/min/1.73 m²).

Discussion
Patients with AAA have an incidence of up to 30% of CRI.¹¹ CRI is defined as impaired glomerular filtration rate (eGFR <60 mL/min/1.73 m²) or elevated urine albumin excretion.⁸ Patients with CRI have increased risk for developing CIN, which may affect over 50% in those with eGFR <30 mL/min/1.73 m². In a recent overview the average dose of iodinated contrast administered during EVAR procedure ranged from 89–223 ml.⁹ Utilizing D-EVAR contrast administration can be abolished completely, avoiding any risk for CIN. In addition, potential complications such as cardiac decompensation, which may be caused by preventive hydration, can be averted. With higher resolution of contemporary multislice CT-scanners, preoperative sizing for AAA is possible without administration of contrast.

Reported entities that have been utilized to avoid iodinated contrast during EVAR are (IVUS) and the use of carbon dioxide as radio-opaque agent at angiography.²,⁴,⁵ However, these techniques are not widely used and available. Moreover, both techniques lack the diagnostic sensitivity to detect endoleaks. Doppler-ultrasound in pulsed mode enables the additional assessment of in-stent flow characteristics. This may be useful in detecting iliac limb stenosis and endograft kinking during the procedure. In contrast it has been recognized that in IVUS, limb stenosis and endograft kinking cannot be visualized.⁴,⁶ However, in anatomically easy cases, IVUS can visualize the endograft morphology and inner condition.

Our approach utilized four available ultrasound modalities of current high-end duplex scanners: B-mode and colour-mode imaging, ultrasound-contrast enhanced assessment and pulsed doppler velocity measurements. We believe that this is the first report on the use of comprehensive integration of duplex modalities during intra-operative imaging at EVAR.

CEUS is a recognized diagnostic tool for follow-up after EVAR.¹⁰ Sensitivity of CEUS is 97% and specificity 93%.¹⁰ Intra-operative use of CEUS-assisted EVAR identified more endoleaks compared to EVAR with angiography.¹⁰ Early and sensitive detection of endoleak might improve long-term results of EVAR and prevent re-interventions.

Drawbacks of D-EVAR include bowel gas, the most common cause of failure of duplex imaging in visualizing anatomic structures.¹¹ An advantage of spinal anaesthesia might be maximum muscle relaxation, possible improving duplex visibility. Our patients were successfully examined pre-procedural visualizing the external iliac artery and IIA. Moreover, visualization of the renal artery was performed solely with preoperative

Fig. 4 Preoperative CT-scan and CT-scan 1 year postoperative, showing regression of the aneurysm (55 mm to 49 mm).
ultrasound, possible significant renal artery orifice stenosis may complicate cannulation. Challenges for duplex imaging also include patients with marked obesity and complex vascular anatomy. In the period from 1 September 2012 to 1 September 2013 a total of 35 conventional EVAR procedures were performed in our medical centre. In this period in three patients an elective (D-EVAR) was performed without complications. No problems visualizing the arterial anatomy were encountered in our three patients of whom one had a BMI as high as 34 kg/m². In addition, as the authors have reported earlier in duplex-guided percutaneous transluminal angioplasty (PTA) in iliac arterial occlusive disease. We did not find any problems visualizing the aorta-iliac anatomy in patient with BMI ranging from 15.4–35.3 kg/m² (Mean: 25.3). We would recommend against using D-EVAR in patient with infrarenal necks shorter than 10–15 mm or and significantly angulation >70°. The authors appreciate the possibility of performing contrast-free EVAR with IVUS and CO2 guided interventions.

Conclusion

Duplex-assisted EVAR is a safe and effective approach of treating selected patients with chronic renal insufficiency or contrast allergy who require endovascular AAA repair. Duplex-assisted EVAR in our view has a place in the armamentarium of vascular surgeons involved with EVAR.

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References


