Endovascular repair of abdominal aortic aneurysms

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Introduction

Endovascular aneurysm repair (EVAR) for abdominal aortic aneurysms (AAAs) represents an advancement in patient care, and is an alternative to open surgical repair. It has significantly reduced the perioperative mortality rate, and is currently the most common treatment approach for AAAs. EVAR is performed through image-guided placement of stent-graft (SG) components that are folded and compressed within a delivery sheath and are delivered through the lumen of an access vessel. On reaching the target site, the SG is expanded, and it contacts the aortic wall proximally and the iliac vessels distally to eliminate AAA sac pressurization by preventing aortic blood flow **(Figure 1.2)**. With the increase in the use of EVAR, the incidences of ruptured AAA and associated morbidity and mortality have reduced, and these reductions are likely due to the ability to offer EVAR to patients who would not otherwise be candidates for open surgical repair[1)].

Indications for AAA Repair

The abdominal aorta is considered to have an aneurysm when a localized dilation is identified and the diameter of the dilated region is over 50% greater than the normal aortic diameter[2)]. AAA repair is indicated when the aneurysm diameter reaches 5.5 cm, the aneurysm grows by more than 0.5 cm within a 6-month period, or the aneurysm is symptomatic (e.g., back pain), which might indicate impending rupture.

Pre-operative Imaging and Planning

Pre-operative planning involves risk assessment and careful quantitative and qualitative evaluation of the anatomic suitability of the AAA for successful EVAR. The specific criteria recommended for a specific device are provided in the instructions for use that are published and packaged with each device. Contrast-enhanced computed tomography (CECT) imaging with three-dimensional (3D) volumetric reformation is usually necessary to determine the feasibility of EVAR, and select the size and configuration of SG components **(Figure 3)**. CTA with 3D reconstruction allows measurements that are perpendicular to the true axis of the aorta. 3D length measurements are considered more accurate than 2D measurements and can improve graft sizing, particularly in patients with tortuous vessels[3)].

The definitions of important aortic measurements are as follows:

Aortic neck diameter: The aortic neck diameter is determined at the inferior-most renal artery. The required SG diameter is based on the aortic neck diameter. Over-sizing the SG by 15–20% over the measured aortic neck diameter will provide sufficient radial force to prevent device migration.

Aortic neck length: The aortic neck length is the distance between the inferior-most renal artery and the beginning of the aneurysm. The aortic neck length should be at least 10–15 mm to allow an adequate proximal landing zone for SG fixation. Ideally, the proximal neck should be normal in appearance, without significant thrombus or calcification.

Aortic neck angulation: The aortic neck angulation is the angle formed between points connecting the inferior-most renal artery, the beginning of the aneurysm, and the aortic bifurcation. Ideally, the aortic neck angle should be less than 60°. Severe angulation is generally considered to be a contraindication for EVAR; however, the ability to place a device is ultimately determined by the conformability of the specific device type and its delivery characteristics.

Iliac artery and access vessel morphology: The iliac arteries should have a minimal amount of calcification and tortuosity, and no significant stenosis or mural thrombus. The common iliac artery (CIA) is the preferred distal attachment site, but the external iliac artery (EIA) can also be used. When the EIA is used for distal fixation (e.g., a CIA aneurysm), the origin of the internal iliac artery (IIA) is covered by the SG. While an attempt at the IIA should be made to maintain pelvic perfusion, IIA embolization may be required before SG placement to prevent back-bleeding into the aneurysm sac. The SG is typically delivered through the common femoral artery (CFA), usually by direct surgical cut-down. The size of the delivery system varies depending on the device diameter.

Other measurements that are important for sizing the SG include the distance from the aortic neck to the iliac bifurcation, distance from the inferior-most renal artery to the aortic bifurcation, and maximal AAA sac diameter.

Contraindications

The contraindications for EVAR are generally associated with clinical factors and anatomic criteria related to the placement of any of the available SGs. Poor anatomic pre-procedural patient selection is associated with a high risk for complications and compromised long-term outcomes[4,5]. Adverse anatomic features include suprarenal or juxtarenal AAA, small caliber vessels, circumferential aortic calcification, and extensive tortuosity. Many next-generation devices are being developed to treat suprarenal and juxtarenal AAAs.

Procedure

The chosen device and its components should be kept ready before the start of the procedure, and additional device components, several types of guidewires, and sheaths should be immediately available to manage any technical issues that might arise. Under regional or general anesthesia, bilateral femoral access usually requires arterial exposure via cut-down skin incisions with creation of an open arteriotomy for device insertion. Intravenous heparin is routinely administered, typically using a weight-based heparin dose of 80–100 units/kg. The goals are to achieve adequate anticoagulation quickly and to maintain a steady anticoagulation concentration until cross-clamp removal.

Once landmarks for positioning the device are identified with angiography, the main device is advanced to the optimal location. With parallax-corrected angiography images at the inferior-most renal artery level, the proximal end of the SG body is positioned and then deployed appropriately at the level of the contralateral gate. A guidewire is selectively cannulated in a retrograde manner via the contralateral side into the opening of the contralateral gate. Gate cannulation is confirmed by rotation of the catheter freely within the main body of the graft. If gate cannulation is problematic and difficult to achieve with the usual technique, an alternative antegrade or cross over cannulation technique may be used. Once the contralateral guidewire is positioned within the SG, the deployment of the SG is completed, and then, the contralateral and ipsilateral iliac artery graft limbs are deployed. After placement of all device components, a large compliant balloon is introduced and is used to distend the attachment sites and the SG junctions.

Completion angiography is performed to evaluate patency and the presence of endoleak. If the completion angiography demonstrates narrowing or kinking of the graft limbs and any compromise of essential arteries, adjunctive angioplasty with or without stent placement is necessary.

Postoperative Surveillance

Failure of aortic SGs is well documented and can lead to continued aneurysm expansion and potential rupture; therefore, lifelong imaging surveillance after EVAR is critical. The principle concerns are endoleak, aneurysm sac enlargement, migration of the stents, and separation of the device components. CECTA is the most widely used post EVAR surveillance modality. However, repeated administration of intravenous contrast medium may contribute to a progressive decline in renal function that is observed following EVAR[6]. The guidelines for the management of AAAs presented by the Society for Vascular Surgery advocate CTA at 1 and 12 months in the first year after EVAR[7]. Imaging at 6 months is no longer routinely recommended unless an endoleak or other device-related abnormality is identified at the imaging study performed 1 month after EVAR[8].

Following successful SG repair, the aneurysm sac will eventually thrombose, and in most cases, the sac progressively shrinks. A systematic review identified four trials that included 1532 patients who were considered suitable candidates for endovascular or open repair of non-ruptured AAAs larger than 5.0 cm in diameter[9]. The 30-day all-cause mortality was significantly lower with EVAR (1.6 vs. 4.8%). The short-term survival advantage of EVAR appears to be much greater when EVAR is limited to patients at highest risk for open surgery.

In a long-term survival evaluation of 22,830 matched pairs of patients who underwent elective repair with an open or endovascular technique[10], there was a significantly lower rate of perioperative mortality with EVAR (1.2 vs. 4.8%), and a more pronounced benefit was seen with increasing age. However, the overall mortality at 3–4 years following repair was nearly identical between both groups of patients. It has not been definitively established whether EVAR is superior to open surgical repair over the long-term, even among patients at highest risk for surgery. Although a 3% reduction in aneurysm-related mortality persisted throughout the follow-up period in the EVAR trial 1[11], the initial reduction in all-cause mortality was lost within 1–2 years, with equivalent overall survival in both treatment groups. Moreover, according to the outcomes of 15-years' follow-up of the EVAR trial 1 published in 2016[13], aneurysm-related mortality increased beyond 8 years after the procedure probably due to aneurysm sac rupture.

Summary

EVAR represents a widely available alternative to open surgical repair. However, the precise role of EVAR continues to be defined. Guidelines from major medical and surgical societies emphasize an individualized approach when choosing between open and endovascular repair, taking into account the patient's age, risk factors for perioperative morbidity and mortality, and anatomic factors[7,12].

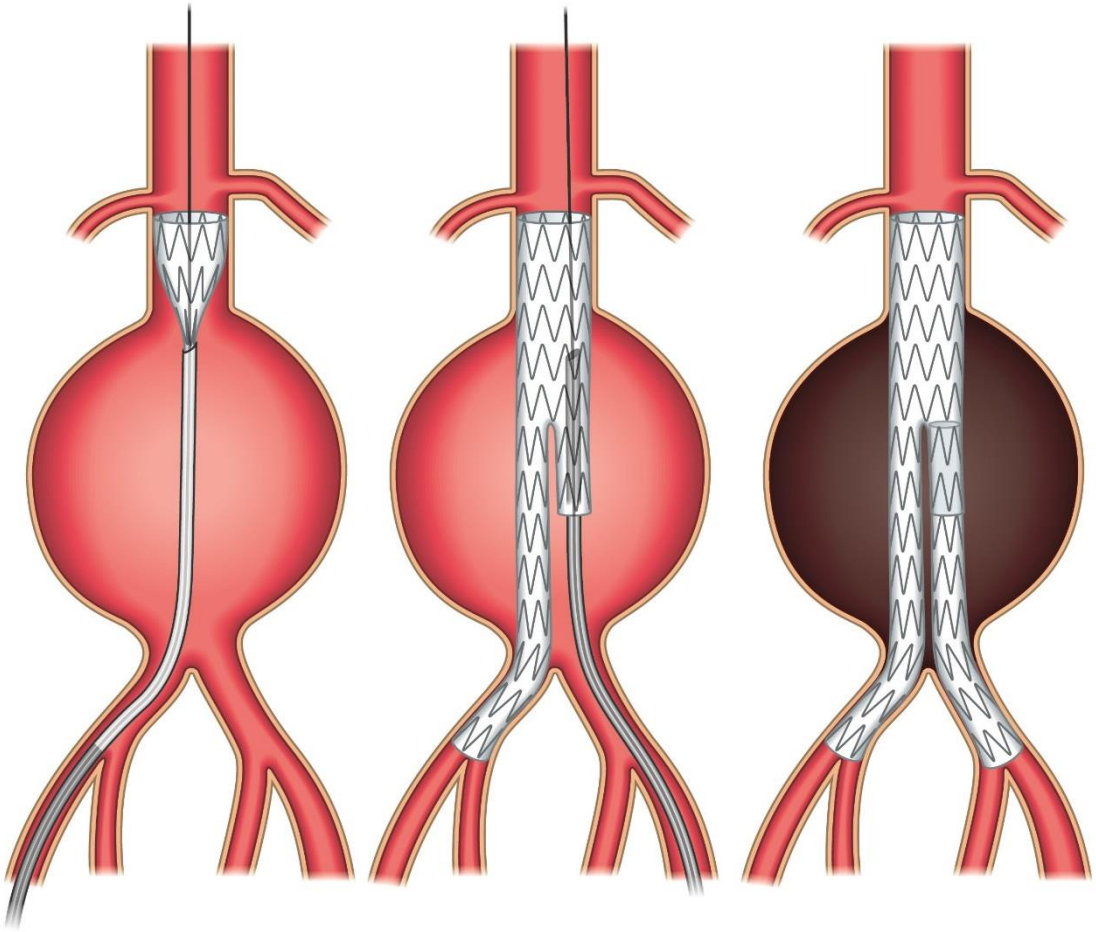

Figure1

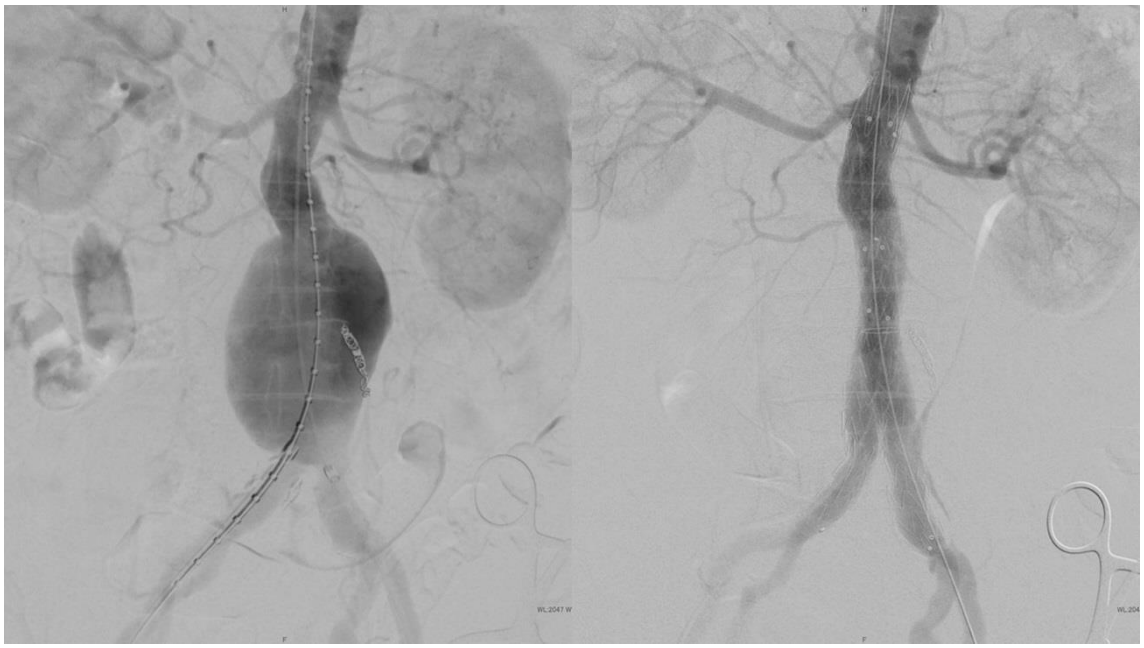

Figure2

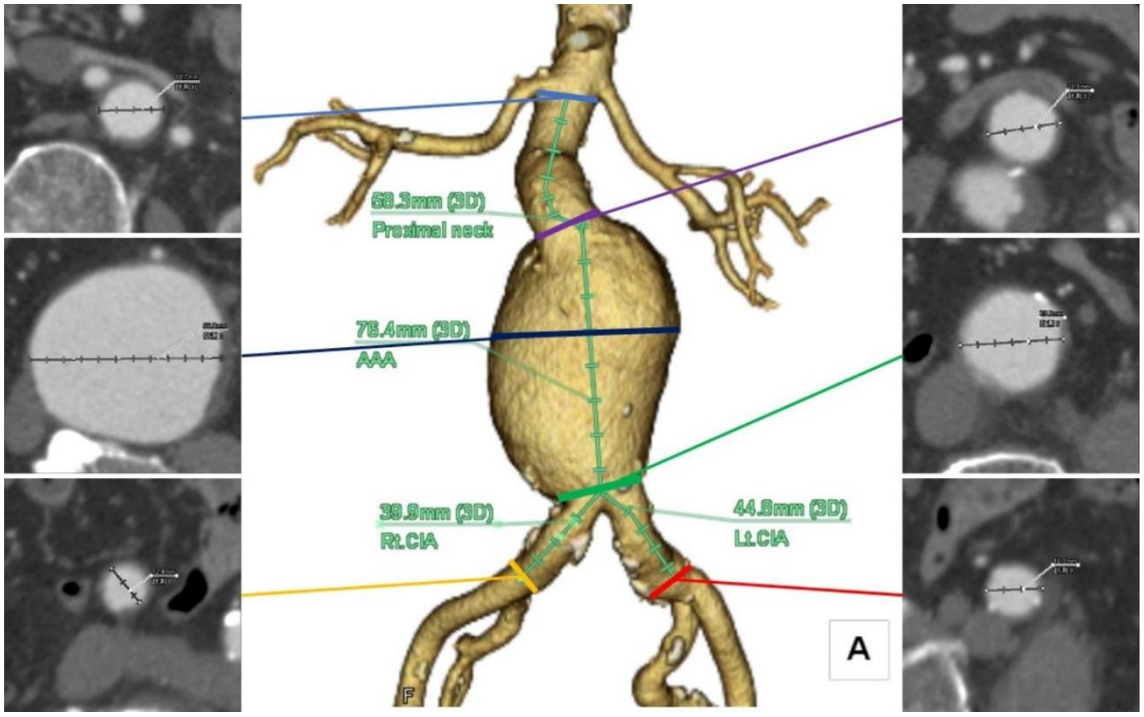

Figure3

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