Endovascular treatment of abdominal aortic aneurysms

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Abstract

The management of abdominal aortic aneurysms has been revolutionized by the development of endovascular stent grafts. The deployment of these devices requires precise clinical and endovascular skills. This review aims to provide an overview of the essential aspects of an endovascular repair of an abdominal aortic aneurysm (EVAR), from initial presentation and assessment for the procedure through to follow-up and long-term outcomes. Consideration is also given to the newer devices, e.g. fenestrated and branched stent grafts, which have further expanded the numbers of patients who are suitable for treatment by EVAR. Abdominal aortic aneurysm etiology, screening and open repair is dealt with in the previous article.

Keywords Aneurysm; aortic; endoleak; stent graft

Introduction

The National Vascular Registry Annual Report for 2016 from the Vascular Society of Great Britain and Ireland captured data from 4198 infra-renal AAA repairs in 2015, of which 69% were endovascular; this is an increase from 54% in 2009.[1] The principle of AAA repair is to exclude the sac of the aneurysm from the high pressure circulation, while maintaining blood flow through a normal calibre conduit. In endovascular repairs, the stent graft acts as the conduit. To keep the aneurysmal segment excluded from the systemic circulation, the stent graft creates a blood-tight proximal and distal seals. The proximal seal (also known as the proximal landing zone) is located at the neck of the aneurysm (Figure 1) in a normal, non-aneurysmal component of the aorta, superior to the aneurysmal segment. The distal seal or landing zone is in a normal, non-aneurysmal artery or arteries that lie inferior to the aneurysmal segment. For example, in infra-renal aneurysm repairs, the proximal seal is in the infra-renal neck of the aneurysm, and the distal seal is usually in the common iliac arteries. If the common iliac arteries are aneurysmal the distal landing zone can be extended into the external iliac arteries. For more complex repairs, e.g. aneurysms of the visceral aorta, the proximal seal may be in the thoracic aorta and the distal seal in the infra-renal aorta.

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Endovascular stent grafts

Endovascular stent grafts have a number of important design features:

- Stent grafts are packaged as modular components with various sizes of main-body and limbs (Figure 2). Depending on the patient's anatomy, the appropriate size of each modular component is selected to create a customised device.
- The metal stent is a self-expanding frame made of nitinol. When deployed, the stent opens up and at the same time it unfolds the covering impermeable graft fabric (Figure 2). Once open, the stent generates the necessary radial forces to prevent slippage from the sealing zones and the impermeable fabric creates the conduit.
- Each stent graft component is enclosed in a low profile (meaning a small diameter), hydrophilic delivery system to enable smooth passage through the iliac arteries to the aorta.
- Some stent graft designs have barbs on a proximal, bare (no fabric) stent. These barbs penetrate into the aorta wall above the sealing zone and provide extra fixation (Figure 3).

Indications and contraindications for the endovascular repair of aneurysms

Not all patients will be suitable for an endograft, and certain criteria have to be met to ensure safe deployment and long-term stability of the stent graft itself. These include:

Size of access vessels

Although modern stent devices are increasingly low profile, the diameter of the common femoral and iliac vessels through which the stent device is introduced in to the AAA must be large enough to accommodate the chosen stent.

Tortuosity and calcification of access vessels

Excessively tortuous iliac arteries will resist the passage of the delivery system. Similarly, rigid, heavily calcified iliac arteries, and/or arteries containing mural thrombus will also prevent stent graft passage, particularly if the calcification/thrombus is circumferential. As well as impeding stent passage, heavy calcification may also put the arteries at risk of damage by the delivery system, including the creation of a dissection flap or vessel rupture.

Length of proximal sealing zone

Sufficient radial force has to be generated by the stent graft with the wall of the aorta to secure the graft's position for the duration of the patient's life. Short sealing zones within the neck of the AAA will compromise generation of these radial forces and increase the risk of slippage of the stent graft; however, some modern stent devices can now be deployed with a proximal sealing zone as short as 10 mm.

Shape of sealing zone

A conical aneurysmal neck will not make full contact with the stent graft. Again this will compromise the degree of radial force generated. Similar to the access vessels, protruding calcified

Please cite this article in press as: Thomas M, Wyatt M, Endovascular treatment of abdominal aortic aneurysms, Surgery (2018), https://doi.org/10.1016/j.mpsur.2018.03.014

Figure 1 Three-dimensional CT reconstruction of an abdominal aortic aneurysm, showing the infra-renal neck which will provide the proximal sealing zone.

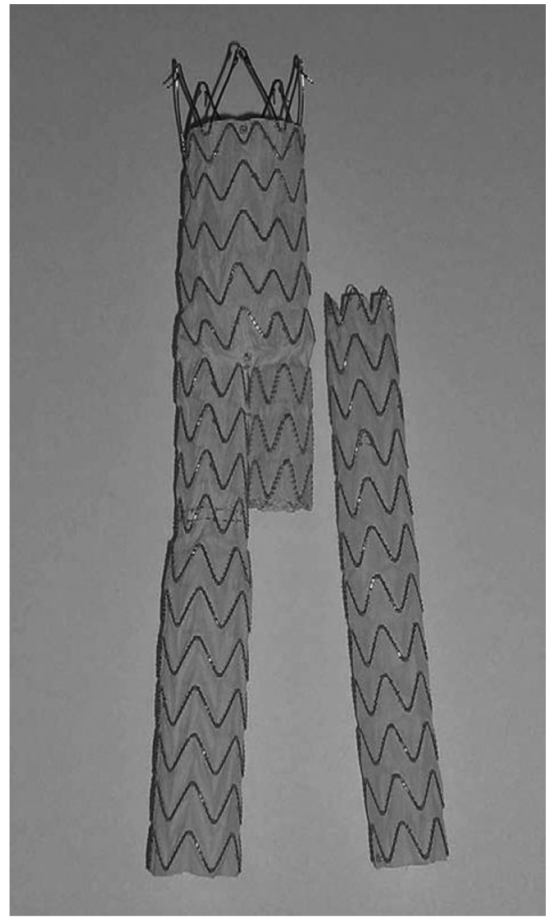

Figure 2 The modular components of a bifurcated aortic stent graft showing a main body (left) and stent graft limb (right).

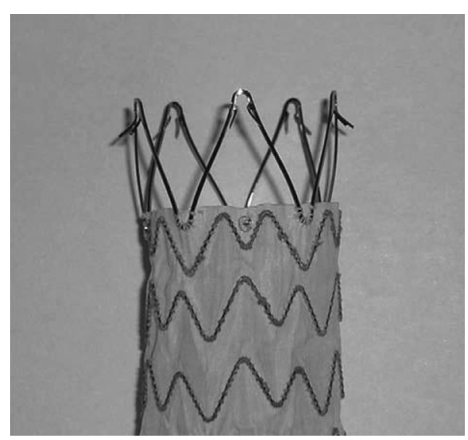

Figure 3 Bare metal suprarenal fixation of a stent graft; the barbs allow improved wall anchorage.

plaques and extensive mural thrombus within the neck of the aneurysm will impact on the quality of the sealing zone. Angulation of the neck of the aneurysm can also create difficulties achieving a proximal seal, with most stents designed for a neck angle of $<60^{o}$.

Preoperative assessment and insertion of the stent graft

Prior to insertion of a stent graft, the anatomy of the AAA must be carefully assessed, and selection of stent graft and the stenting procedure must be carefully planned. Patients should undergo a multislice CT angiogram of the aorta, which can be used to create multiple-plane reconstructions. Looking at the scans of the patient's AAA in several planes enables accurate calculation of the precise size of the device to be deployed and will also determine if the patient's aortic morphology is suitable for EVAR (as discussed above). Insertion of the stent graft can be done under

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