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.

Keywords Aneurysm; aortic; endoleak; stent-graft

Diagnosis of aortic aneurysmal disease

An aneurysm is defined as a permanent localized (i.e. focal) dilation of an artery, having at least a 50% increase diameter compared with the expected normal diameter measurement. The estimated incidence of abdominal aortic aneurysm (AAA) is 5% in men over 65 years old. Any part of the aorta may become aneurysmal. Once the aneurysm develops, the risk of rupture increases with increasing diameter size.

NHS Abdominal Aortic Aneurysm Screening Programme (NAAASP)

Prior to establishment of the NHS AAA Screening Program (NAAASP),[1] AAAs were usually detected through clinical suspicion, or as an incidental finding whilst investigating the cause of other symptoms or when the patient presented emergently with a rupture. Given that the mortality rate for a ruptured AAA is greater than 50% for patients who reach hospital, and that the UK mortality rate for elective repairs is 2.4%, the benefits of the AAA screening programme are self-evident. The NAAASP invites men in their 65th year to present for an abdominal ultrasound scan. Those patients who are found to have an aneurysm are offered surveillance scans at intervals based on the rate of growth of the aneurysm. For example, a patient with a 4.5 cm aneurysm can expect to have a scan every 3–6 months depending on the rate of growth of the aneurysm between each surveillance scan.

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It is estimated that the screening programme will prevent 1900 deaths per year.

Treatment

An audit by the Vascular Society of Great Britain and Ireland showed that of the 21,266 infra-renal AAA repairs carried out between 2008 and 2013, 59% were repaired with an endovascular stent-graft, and the remaining 40.4% were open repairs.[2] The principle of both methods is to re-establish laminar blood flow through a normal calibre conduit. In endovascular repairs, the stent-graft acts as the conduit and excludes the aneurysmal segment of aorta. To keep the aneurysmal segment excluded from the systemic circulation, the stent-graft creates a watertight proximal and distal seal. The proximal seal at the neck of the aneurysm (Figure 1) is in a normal, non-aneurysmal component of the aorta cephalad to the aneurysmal segment. The distal seal is a normal, non-aneurysmal artery or arteries that is/are caudal 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.

The multiple functions of the stent-graft (establishing a watertight, normal calibre conduit that is deployed using endovascular techniques and which will remain fixed in place in the presence of systolic blood pressures) are feasible because of 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 customized 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 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. Certain criteria have to be met to ensure safe deployment and long-term stability of the stent-graft. These include;

- *7 mm external iliac arteries*. As mentioned above, the stent-graft is packaged in a low profile, hydrophilic delivery system. Iliac arteries that are smaller than 7 mm will

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

not accommodate the delivery apparatus and will therefore inhibit passage of the stent-graft into the aorta.

- *Flexible, smooth iliac arteries*. Excessively tortuous iliac arteries will resist the passage of the delivery system. Similarly, rigid, calcified, iliac arteries or vessels littered with obstructing plaques will also prevent stent-graft passage and may put the arteries at risk of damage by the delivery system.
- *15 mm 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. Proximal sealing zones less than 15 mm in length will compromise generation of these radial forces and increase the risk of slippage of the stent-graft.
- *A straight 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. For the same reason, anything in the aneurysm neck that interferes with direct contact between the graft and the aorta such protruding calcified plaques and extensive mural thrombus will also impact on the quality of the sealing zone.

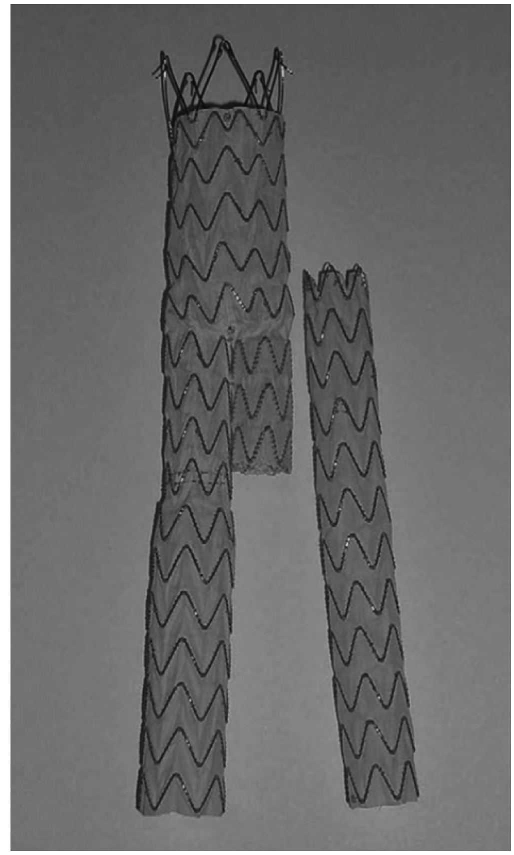

Figure 2 The modular components of a bifurcated aortic stent-graft showing a main-body (left) and stent-graft limb (right).

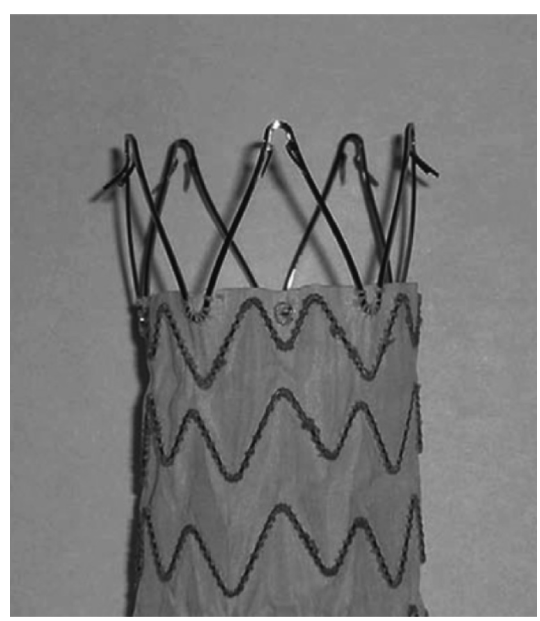

Figure 3 Bare metal suprarenal fixation of a stent-graft; the barbs allow improved wall anchorage.

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