Short-necked / Juxtarenal Aneurysms – Fenestrated Stent Grafts (FSGs) and Chimney Grafts (CGs)

These aneurysms are so named because the aneurysmal dilatation begins less than 1.5 cm from the lowest renal artery. These aneurysms account for about 15% of all AAAs. Indications for treatment include transverse diameter of more than 5.5 cm, development of symptoms (regardless of diameter) or development of complications related to the aneurysm, for example, distal lower limb or visceral vessel emboli. Conventional EVAR stent grafts require at least a 1.5 cm neck length (distance from the renal arteries to aneurysm sac) to allow for adequate sealing of the proximal portion of the stent graft device. Deploying such a stent graft with <1.5 cm neck length may result in either metod coverage of the renal arteries or a leak around the seal zone into the aneurismal sac (otherwise known as an endoleak). The availability of stent grafts with openings for the renal vessels (fenestrations) has negated the issue of short necks (Fig 1). These fenestrated stent grafts are custom-made to the individual patient anatomy based on high-definition fine-sliced CT scans of the aneurysm. Once deployed, the fenestrations are optimised in line with the renal artery orifices and additional short covered stents (Atrium V12, Atrium Cere) will be introduced from the main stent graft body through the fenestrations, into the renal arteries to provide a tight seal (Fig 1). Due to its bespoke nature (a 6-week manufacturing period is needed), FSGs are unsuitable for use in emergency circumstances, such as ruptured/leaking aneurysms. Moreover, the use of such stent grafts requires specialised training and good fluoroscopic imaging techniques. Fenestrated stent grafts are also not widely available in some countries (e.g. USA, China). As a result, surgeons in these countries have developed the Chimney Graft (CG) technique for juxtarenal AAAs. The CG technique utilises off the shelf conventional stent grafts and covered stents and as such, can be used in emergency situations. Essentially, covered stents are first deployed in the renal arteries and out into the aorta in an upward direction (like a chimney) into the descending aorta, following which a conventional stent graft, introduced from the femoral arteries in a retrograde fashion, is deployed in line with the covered stents. While FSGs have reported good outcomes with low patency rates and low mortality rates at up to 2 years follow up, short coverage lengths are limited due to it being a relatively new technique”. Certainly, the use of these devices and techniques have extended the scope of effective treatment for juxtarenal AAAs.

Table 1: Conventional Anatomical Criteria for successful EVAR

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck length</td>
<td>≥ 1.5 cm</td>
</tr>
<tr>
<td>Angles between</td>
<td>≤ 60 degrees</td>
</tr>
<tr>
<td>Iliac arteries</td>
<td>≥ 8mm</td>
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For EVAR to be performed successfully, certain conventional anatomical criteria have to be fulfilled (Table 1). However, with advances in stent graft design and with increasing operator experience with EVAR, complex aneurysms that by criteria were previously unsuitable for endovascular repair are now being treated with EVAR. Some of these include thoracic aortic aneurysms and dissection, thoracoabdominal aneurysms that involve one or all of the celiac, superior mesenteric and renal arteries, short-necked juxta/para renal aneurysms and common iliac, external or internal iliac artery aneurysms. Much of this “new frontier” in endovascular repair of aortic and iliac aneurysms can be attributed to improved stent graft design and better fluoroscopic imaging modalities.

Thoracoabdominal aneurysms – Brachial Stent Graft, FSGs and CGs

Thoracoabdominal aneurysms (TAAs) involve both thoracic and abdominal aortic segments. As such, visceral branches from the aorta are frequently involved in the aneurysm sac. TAAs have been treated conventionally by open repair, which involves exposure of the thoracic and abdominal cavities, or, extensive dissection in the retroperitoneal plane. As such, morbidity and mortality from such surgery is significantly higher than compared to endovascular repair. As with FSGs for juxtarenal aneurysms, additional fenestrations or scallops can be custom-made to accommodate the visceral, superior mesenteric arteries and renal arteries (Fig 2). As the number of fenestrations increases, a more advanced skill set is required for the operator to be successful in deploying these grafts. Also, more fluoroscopy time and contrast may be needed. The chimney graft technique as described above, may also be used to treat TAAs. With more chimney branches, the likelihood of an endoleak around the proximal seal zone also increases. Some TAAs may be related to an extent that there is a significant gap distance between the main stent graft and visceral vessel orifices. For such cases, custom made stent grafts with side branch protrusions (instead of fenestrations) can be used (Fig 2). The concept is that the side branches will provide a bridge to reduce the distance from the main stent graft body to the visceral orifices, providing a better seal and minimising endoleaks. Through the branches are inserted covered stents into the visceral arteries. Moreover, these branched devices can be made with pre-loaded angiographic catheters and wires for easier cannulation of the visceral.
Thoracic Aortic Dissections (Type B) and Aneurysms –
Hybrid Debranching Surgery, Chimney Grafts

The management of Type B aortic dissections has been controversial due to the unpredictable nature of the dissections. The majority of Type B dissections remain stable and are managed medically. Indications for surgical treatment include development of a significant secondary branch vessel with evidence of ischaemia, extension of dissection to involve aortic branch vessels or development of a significant aortic pseudoaneurysm. Prior to the development of endovascular treatment, surgery was the only option for the treatment of thoracic aortic dissections. However, patients with Type B dissections are often excluded from open surgery due to co-morbidities or the extent of the dissection. In recent years, hybrid debranching surgery has emerged as a safer and less invasive treatment option for patients with thoracic aortic dissections. In this technique, a covered stent graft is inserted into the thoracic aorta to seal the dissection. The covered stent graft is then deployed in line with the dissection to preserve the aortic branches. This technique has been shown to be effective in reducing the risk of aortic rupture and improving patient outcomes.

Iliac Aneurysms – Iliac Branched Device (IBD)

Up to 30% of aortic dissections are associated with concomitant iliac artery dissections, mostly in the common or external iliac arteries. In this subset of patients, up to 50% have bilateral iliac artery dissections. Indications for treatment include diameter more than 2.5 cm, development of symptoms or presence of a concomitant aortoiliac aneurysm. Prior to the development of endovascular treatment, surgical treatment often required both iliac and inguinal incisions, which can be associated with significant morbidity. By definition, Type B dissections begin just distal to the left subclavian artery and the term does not extend into the iliac arteries. Type B dissections, however, can extend into the iliac arteries and can be associated with significant morbidity.

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Concerns with EVAR Repairs

There are a few concerns with the use of EVAR for aneurysmal disease. Nephrotoxicity may result from increased radiation exposure for patient and operator (of which the effects are unknown) and is also a concern in complex cases, especially multi-branch or fenestrated stent grafts. The need to monitor for endoleaks also means that patients may undergo annual CT scan for life. However, with better imaging techniques (high resolution fluoroscopy) and improved stent designs, coupled with better operator skills, the operative radiation exposure time and contrast load are expected to decrease. Moreover, monitoring of endoleaks can now be done using advanced ultrasound techniques, instead of CT scans, thus reducing patient radiation dose and costs.

The Future

Several innovations in stent graft design are in the pipeline. Amongst these are the developments of branched and fenestrated devices to accommodate the aortic arch vessels. Pre-fabricated stent grafts with mobile branch limbs that can be used off the shelf, and stent grafts with better proximal seal zone mechanisms. These developments will certainly contribute to better treatment outcomes for complex aneurysms.

Conclusion

With the advent of new stent graft designs and the improvement of endovascular techniques, the scope of treatment for complex aortic aneurysms has widened. With continued advances in these areas, patients who were previously deemed unsuitable or unfit for repair of their complex aneurysms may now be candidates for endovascular treatment. All patients with aneurysms should thus be referred for evaluation and treatment by a vascular specialist.

References:

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