Stenting in peripheral vascular disease

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Metallic stents have made an enormous impact on the percutaneous treatment of arterial and venous disease, allowing a range of lesions to be treated using this minimally invasive technique which was not possible previously. This article details the range of stents which are available and how these have revolutionized the treatment of vascular disease.

For the last 10 years, it has been possible to place metallic stents in the peripheral vascular system. This technique was met with great enthusiasm by the early proponents. It was hoped that this would solve some of the problems of balloon angioplasty, including cases suffering early or late failure. Since its introduction the technology has altered and the indications for stent placement have been partially clarified. There are still many issues which have yet to be resolved in the placement of intravascular stents; however, there is no doubt that the advent of these devices has greatly expanded the role and complexity of endovascular therapy. This article will outline the present status of stents in the peripheral (non-coronary) arterial system and will also indicate some of the controversial areas presently being investigated.

HISTORY

Percutaneous transluminal angioplasty (PTA) of arterial occlusive disease has become an integral part of the treatment of patients with flow-limiting disease and has made many advances since 1974, when Gruentzig and Hopff first introduced useable balloons. PTA, along with almost all interventions in the vascular system, has had problems with acute failures as a result of a poor primary result, or later failure as a result of restenosis. A variety of techniques have been applied to attempt to overcome these, including the use of effective antiplatelet medication, advanced balloon designs, laser-assisted angioplasty and more recently stent placement.

Balloon PTA, while often being a successful treatment option, may fail in the acute phase with abrupt closure of the artery as a result of:

- Flow limiting dissection flaps
- Elastic recoil of the arterial wall
- Failure of the lesion to respond to PTA (particularly with heavily calcified lesions or total occlusions).

A stent placed in the artery to support the intimal surface of vessel may ‘paste back’ dissection flaps, resist the tendency to elastic recoil and ensure an adequate lumen in a wider range of clinical situations. The concept of stent placement is not a new one. Charles Dotter is credited with proposing this first in 1969, but widespread use of stents has not been possible until the early 1990s when stents became commercially available.

STENT TYPES

Modern stents fall into two groups, open mesh stents and covered stents, the latter group being a more recent addition. They are also referred to as ‘stent-grafts’ and ‘grafted stents’, and will be discussed in the section on aneurysmal disease. Open mesh stents comprise two subsets (*Table 1*):

- Balloon expanded stents
- Self-expanding stents.

Balloon expanded stents may be supplied either already mounted on a balloon, in which case their length and diameter are predetermined, or unmounted, where they may be placed onto a defined range of balloon diameters and will shorten to a predictable degree. The majority of these type of stent are made from stainless steel.

In contrast the self-expanding stents may be made of either stainless steel or Nitinol. Nitinol is a remarkable alloy of nickel and titanium, which, when treated appropriately, may have a thermal memory imparted into it. The result is a stent which can be placed on a relatively small delivery system (typically 7F outer diameter). When this is released into the artery, and warmed to body temperature by the blood, the stent attempts to re-attain its intended diameter. Therefore if a vessel is

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being treated, a stent is placed inside which has a memory for a size slightly larger than the native diameter. This has two advantages: first the stent will have sufficient initial friction on the intimal lining to prevent migration and second it will exert a radial force to prevent recoil of the artery and to maintain the intended lumen. Self-expanding stents may also be placed in regions of the body where they are subject to crushing forces (e.g. the carotid artery) as they have the ability to recover from the deformation and retain the arterial lumen.

OCCLUSIVE DISEASE

PTA has been useful in the treatment of occlusive disease in many areas of the body, and the advent of stents has increased the range of areas, not only as a result of their ability to rescue a poor result of PTA, but also to allow endovascular therapy where it was previously considered too risky. As a result it is technically possible to place a stent in almost any vessel. However, the following are amenable to endovascular stenting:

- Iliac arteries
- Aorta
- Superficial femoral artery
- Renal arteries
- Visceral arteries
- Subclavian/brachiocephalic arteries
- Carotid arteries
- Superior vena cava.

It is not surprising that the less complex the disease the more successful are endovascular techniques, hence simple stenoses are technically easier to treat with stents. However, to be able to perform the procedure is not reason enough to pursue it. A variety of factors must be taken into account including:

- Patient symptoms
- Alternative treatment options (including PTA alone, conservative therapy and surgery)
- The risks of attempting PTA before stenting
- The short-term result
- The durability of the treatment chosen
- Patient-related factors (such as prognosis)
- Cost
- Available expertise.

As a result, most stenting is performed and most research is done in the aorto-iliac segment. Tetteroo et al (1996) showed that the most cost-effective method of treating stenotic disease, considered suitable for endovascular treatment, is to primarily attempt PTA. If this is considered to have failed to produce a sufficiently good result, a stent should be used as a secondary event during the same procedure.

This recommendation assumes the present situation where stents are expensive (in general between £500–750 per stent in the UK); if they were cheaper, there is some evidence from Bosch and Hunink (1997) to suggest that a stent may improve the durability of the endovascular procedure, in which case primary stenting may be justified. In the case of complete occlusions, the situation is less clear. There is little doubt that the degree of technical difficulty posed by occlusions is greater than stenoses, and that the complications of PTA increase as the occlusion length increases, as described by Belli et al (1990).

Dyet et al (1997) have shown that stents have made many of these lesions amenable to endovascular techniques, to the extent that occlusions of the entire common and external iliac artery may be treated endovascularly (*Figure 1*). It has not yet been shown how these compare with surgery in terms of durability; however, it may not be necessary for these to be directly comparable to surgery as they can be performed in patients not suitable for general anaesthesia who may not require long-term patency. Indeed they can be performed as a day case. In other arterial beds stents may not confer any durability

TABLE 1.
Commonly used vascular stent types

Type	Name	Manufacturer
Balloon expanded	Palmaz	Johnson & Johnson
	Bridge	AVE, Medtronic
	Perflex	Cordis
	Jostent	Jomed
	Saxx	Bard
	VIP	Medtronic
Self-expanding	Wallstent	Schneider, Boston Scientific
	Memotherm	Bard
	Smart	Cordis
	Symphony	Boston Scientific

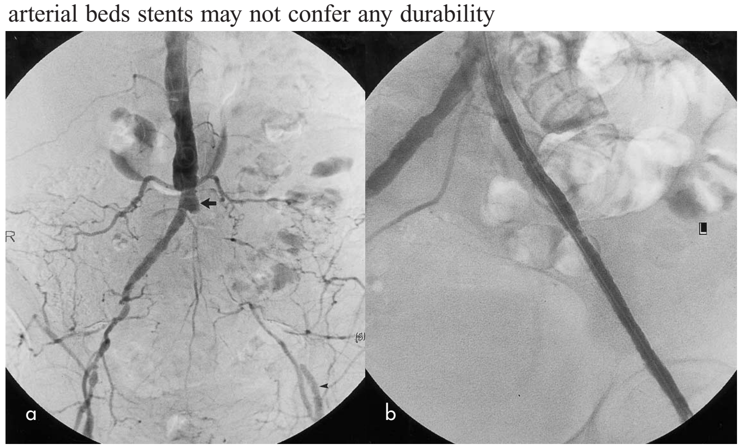

Figure 1. a. A full length left iliac occlusion extending from the aortic bifurcation (arrow) to the distal external iliac artery (arrow head). b. Reconstructed left iliac system following stent placement.

advantage over PTA, such as the superficial femoral artery, however, they still provide a useful 'bail-out' option when PTA fails.

ANEURYSMAL DISEASE

Abdominal aortic aneurysms (AAA) are the most frequently encountered arterial aneurysm, however, it should be remembered that aneurysms may occur in the thoracic aorta and other peripheral arteries, such as the popliteal artery. Aneurysms present two main problems, rupture and embolization, which have traditionally been treated by surgical repair. More recently the technology has become available to place a covering on metallic stents. These can then be placed across the aneurysm, from a remote site such as the femoral artery (Woodburn et al, 1998). These allow the aneurysm sac to be excluded from the circulation, preventing both rupture and embolization.

The available technology has undergone enormous development since the early experimental devices of Parodi et al (1991). Contemporary AAA stent-graft systems require at least one open femoral artery access, if not bilateral access, because they have to accommodate the large diameter (up to 30 mm) stent, along with the covering. For present devices, this is in the region of 14–21F. Undoubtedly as manufacturing designs improve, delivery systems will reduce in size until they become truly percutaneous. However, considerable controversy remains over such techniques and their role in the management of AAA; despite continuing technological advances a randomized trial is about to start in the UK comparing endovascular AAA repair with conventional surgery.

Thoracic aortic aneurysms (TAA) present a very different situation. This is a result of the higher mortality and morbidity of surgical TAA repair and the associated comorbidity which precludes many patients from the surgical option. Unlike AAA, which almost always need a bifurcating system, the thoracic aorta is a single tube (distal to the left subclavian artery) without major side branches until the coeliac trunk. There are smaller branches such as the intercostal and bronchial arteries, but these do not appear to cause problems with refilling of the TAA.

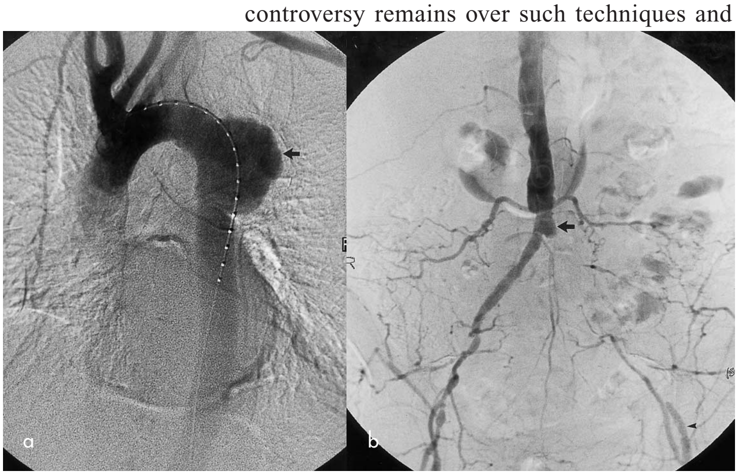

Figure 2. a. Arch aortogram, with a measuring catheter, showing a saccular aneurysm of the descending thoracic aorta (arrow). b. The aneurysm sac has been excluded from the circulation by the placement of a stent-graft.

KEY POINTS

- Stents have greatly widened the range of endovascular therapy options.
- Stents may be balloon expanded or self-expanding, open mesh or covered.
- Open mesh stents are mainly used for stenotic disease, whereas covered stents are used for aneurysmal disease.
- Stent technology has advanced rapidly, and will continue to do so.

THE FUTURE

Open mesh stents

The basic design of modern stents probably represents the end of the development process and although novel ideas will undoubtedly emerge, future advances are likely to be concentrated on:

- More accurate placement
- Brachytherapy (either radiotherapy at the time of stent placement or on the stent itself)
- Local drug therapy
- Stent coatings
- Removable/temporary stents.

Covered stents

The main focus of stent-graft changes are centred around the need to make them small enough to be delivered percutaneously, and to make them suitable for a wider range of morphological patterns. Thus far, covered stents have been almost useless for treating stenotic disease, other than to rescue rupture following PTA. Future developments may alter this. HM

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