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Editorial

Stent implantation in congenital heart disease

Intravascular stents are increasingly being used to maintain vessel patency in peripheral and coronary arteries.[1,2] Lately their use has been extended to treat patients with congenital heart disease. O'Laughlin and colleagues reported on 30 patients in whom 45 stents were implanted with encouraging short-term results.[3] A paper on page 240 of this issue and two earlier case reports extend the range of congenital heart defects for which stents will be useful.[4-6]

Mulcahy *et al* reported clinical improvement after implantation of a self expanding stent in a patient with stenosis of a pulmonary artery branch that was resistant to balloon dilatation.[4] O'Laughlin implanted 36 balloon expandable stents in 23 patients with pulmonary artery stenoses: 22 of them had had operations for other lesions.[3] The mean systolic gradient fell from an average of 51 mm Hg to 16 mm Hg and the vessel diameter of the stenosis doubled. More importantly, O'Laughlin *et al* showed redistribution of blood flow to the previously hypoperfused lung in those patients in whom perfusion was measured. One patient died after the procedure when a right atrial thrombus occluded his Fontan circulation. In two patients the stents were misplaced—in one the stent passed too far distally down the pulmonary artery and could not be retrieved. It was expanded there and when a second stent was placed more proximally at the lesion site the clinical result was good. In the second patient the stent could not be placed correctly in the distal right ventricular outflow tract and had to be removed surgically from the right ventricle. A branch of the pulmonary artery was ruptured after balloon dilatation but this did not preclude subsequent stent implantation. While in most patients flow into side branches covered by the stent was not impaired, in two patients the right upper lobe branch was partially obstructed, possibly by compression of the ostium. Mulcahy *et al* described a further complication, that of transient pulmonary oedema secondary to high flow into the lung segment perfused through the stent; but this has also been seen after balloon dilatation alone.[4]

The Senning and Mustard operations for complete transposition may be associated with obstruction to the systemic venous pathways. Though the superior caval pathway is more commonly the obstructed pathway, occasionally both the systemic pathways can become obstructed and in an extreme form this can cause a debilitating protein-losing enteropathy. Balloon dilatation of the narrowed pathways can be effective but in these large calibre, low pressure vessels, large balloons are required to achieve a satisfactory result.[7] Recoil of the stenosis is not uncommon and balloon dilatation is ineffective if the pathway is kinked. Chatelain *et al* have highlighted the important benefit that stents can produce in this situation.[5] It is encouraging to note that patency of the pathways was well maintained 11 months after the procedure and after anticoagulation for the initial three months. O'Laughlin *et al* also used stents in the large venous pathways that form part of the Fontan circulation. Good results were achieved in five patients but follow up was much shorter.

Implantation of stents into the arterial ducts of sick neonates is likely to be technically more demanding than implantation in larger patients. These difficulties are highlighted by Gibbs *et al* in this issue.[6] They used this procedure as a palliative treatment in two patients with duct dependent cyanotic heart disease.[6] It is vital to implant the stent or stents to cover the whole length of the duct without protruding into either the pulmonary artery or aorta. The variable tortuosity and length of the arterial duct can hamper accurate identification of its exact limits. This difficulty is increased by the distortion and displacement caused when rigid catheters are placed across the duct. Optimal screening is essential and good radio-opacity of the stent is mandatory if the difficulties reported by Gibbs *et al* are to be avoided. In newborn lambs we found it difficult to implant poorly radio-opaque stents of the type used by Gibbs *et al* but radio-opaque stents (both balloon expandable and self expanding types) remained patent for at least nine months. We found that stent implantation was much better than balloon dilatation alone and, like Gibbs *et al*, we believe that it may avoid the need for neonatal systemic to pulmonary artery shunt operations in patients with duct dependent cyanotic heart disease. However, we witnessed the sudden death of a lamb in which the duct and stent were patent at postmortem examination. This incident and the sudden deaths in the two patients reported by Gibbs *et al* are disquieting and further evaluation is required.

Stents have also been used for palliation in patients with the hypoplastic left heart syndrome. Ruiz implanted stents in six patients in the hope of palliation until a heart transplant could be performed (personal communication). Three patients have undergone heart transplantation but the other three died. If a suitable donor heart distal does not become available those patients will need distal pulmonary artery banding or a Norwood procedure.

There has been much greater experience of stent implantation in coronary artery disease. In these patients primary stent implantation is used for lesions at high risk of restenosis or where an occlusive dissection might have catastrophic results. The duration of ischaemia produced by shorter inflation times and the immediate tacking of the dissection against the vessel wall are seen as major advantages of stents. O'Laughlin *et al*[3] used stents to tack acute balloon induced dissections in two patients in whom they had already elected to implant a stent (in a pulmonary artery branch in one, and a pulmonary artery conduit in another). In addition they also used a stent for this purpose in a patient with unexpected aortic dissection after balloon dilatation of aortic coarctation. Could primary stent implantation for aortic coarctation have advantages over

balloon dilatation alone? The stents might prevent acute dissections, serve as a barrier to aneurysm formation, and reduce the recurrence rate.

To date stents have been implanted predominantly in older children and young adults in whom little or no further growth of the relevant vessels is expected. Their use in the arterial duct is a notable exception. Intravascular stents of a fixed diameter implanted into vessels that are expected to grow will eventually become rigid "stenoses" and will significantly reduce flow. Balloon dilatation might then not be effective and the only option would be surgical excision of the stent with conduit interposition. An option that must be examined is the implantation of stents with potential final diameters that are considerably larger than their diameter at implantation. Such stents could be balloon expandable or self expanding. Balloon expandable stents could then be redilated after the vessel has grown, possibly many years later. Indeed O'Laughlin *et al* were able to redilate stents after a few months but it is unlikely that the vessels had grown appreciably. They were probably simply improving an initially suboptimal result. If a self-expanding stent with a considerably greater potential diameter than the vessel itself were implanted, continued expansion of the stent could keep pace with growth of the patient and avoid obstruction. However, it is possible that in thin-walled structures, acute expansion of such an oversized stent could erode the vessel or produce an aneurysm. Furthermore, though expansion might proceed at a rate similar to the growth of the underlying vessel for a time, the stent could eventually become constrained by peri-intimal scarring. Subsequent balloon dilatation would still be needed but perhaps later than after implantation of a balloon expandable stent. We are currently investigating these issues in a growing animal model (lambs).

At present it seems sensible to restrict stent implantation to vessels that have attained their final size or have nearly done so. That stent implantation will have an increasingly useful role in congenital disease is surely not in doubt.

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