CASE REPORT

Using the Valeo dilatable stent in coarctation stenting for small children: expanding the inclusion criteria for coarctation stenting?

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SUMMARY

The application of coarctation stenting has grown in paediatric and adult practice in recent years. Stent and delivery sheath technology has improved; however, we remain technically limited when implanting small calibre stents through small sheaths in small children, which then have the potential to be dilated to adult size as time passes. We describe the first reported use of the Valeo Biliary Pre-mounted Re-dilatable Stent (Edwards Life Sciences, California, USA) in aortic coarctation with 1 year follow-up including cross-sectional imaging. This 14 kg 3-year-old girl presented following an intracerebral haemorrhage secondary to severe systemic hypertension. Despite implantation through a 7-French sheath, this stent can be postdilated up to 20 mm, and therefore provides an important new addition to the interventional armamentarium.

BACKGROUND

The cut-off point in terms of age and weight of moving from surgical repair of coarctation to interventional balloon dilation or stent implantation is a highly debated topic. There is a significant variability between large centres in standard practice, with some units moving to interventional catheter treatment after 6 weeks of age and others opting for primary surgical treatment up until late teenage years.^{1,2}

Coarctation stenting has been shown to provide superior pressure gradient relief compared with balloon angioplasty alone.³ Unlike balloon angioplasty, it is not necessary to over-dilate the aorta when a stent is implanted, decreasing wall stress and the risk of complications such as dissection and aneurysm.⁴ Stents provide radial strength to prevent vessel recoil and can be redilated serially as the patient grows.⁴ They also provide a scaffold for smooth neointimal growth and thus appear to prevent acute negative remodelling of the aortic wall and pseudoaneurysm formation.^{3,4}

These advantages are technically difficult to apply to infants, toddlers and small children. The size of sheath required to position a stent, which will be capable of redilation to adult size, have adequate radial strength to eliminate stenosis in aortic tissue, at the same time crimp down adequately to load onto a small enough balloon for the initial dilation is often prohibitive.³ Stent implantation is generally the procedure of choice in those patients who can safely accept these large

sheaths, namely children of approximately 20 kg (approximately 6 years of age) or more.^{1,3,5}

Premounted stents often require smaller calibre sheaths because of superior nesting to the balloon.^{3,6} Their major drawback is often the inability to redilate to diameters in excess of 12 mm, without a combination of significant shortening, decreased mechanical integrity and radial strength.³ This has mainly limited the use of small calibre pre-mounted stents to exceptional circumstances including palliative treatment.³

The ideal stent for aortic coarctation would be expandable to diameters of 24 mm, with limited shortening and loss of radial strength.⁷ It would have a low profile, with the ability to crimp down onto balloons of less than 8 mm to allow introduction in smaller children.⁷⁻⁹ In addition to high trackability and flexibility to negotiate anatomical curvatures, rounded edges would minimise the risk of aortic wall injury and balloon rupture during inflation. It would also have a high level of radiopacity and MRI compatibility.⁶⁻⁸ Unsurprisingly, this stent has not yet been developed.

The Valeo Biliary Stent (Edwards Life Sciences, California, USA) represents a major advance in pre-mounted stent design and achieves many of the desirable characteristics of the 'ideal stent'.³ It is flexible, made as an open lattice design in 316L stainless steel and premounted onto a Nylon balloon accepting a 0.035-inch guide wire and accommodating inflation pressures of up to 14 atm.³ Unlike other premounted stents it has been successfully redilated to a maximal diameter of 20 mm with acceptable shortening allowing for maintenance of mechanical adequacy into adulthood.³ Bench testing has shown that even at maximal dilation the stent still has adequate radial strength to overcome most coarctations encountered in infancy and childhood.³

CASE PRESENTATION

A previously well 14 kg 3-year-old girl presented to a local hospital with sudden onset of headache, facial weakness and a left-sided hemiplegia. She was hypertensive with systolic blood pressures of up to 158 mm Hg. A CT scan showed a right-sided intraparenchymal haemorrhage, with extension into the lateral, third and fourth ventricles. An MRI scan of the head showed no primary vascular anomaly. The patient was transferred for tertiary cardiovascular assessment and treatment. Clinically, the patient had coarctation of the aorta with absent femoral pulses and a significant upper limb to

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lower limb blood pressure discrepancy of 50 mm Hg. Echocardiography showed good left ventricular function with an ejection fraction of 88% (50–80%) and evidence of ventricular hypertrophy (intraventricular septum=7 mm (4–6 mm), posterior wall=8 mm (4–6 mm)). There was an increased systolic velocity of 3.9 m/s in the proximal descending aorta with a significant typical diastolic tail.

Cardiac MRI showed a mildly hypoplastic left-sided arch and a short segment severe focal coarctation at the aortic isthmus with significant collateralisation (figure 1). There was normal arch branching. The aortic valve was bicuspid and non-stenotic. The aortic root, sinus of Valsalva and ascending aorta Z scores were within normal limits. Anatomy of the abdominal aorta, renal arteries and kidneys was normal.

TREATMENT

Oral propranolol was started to modulate the blood pressure in preparation for stent implantation and the patient was discharged for 8 weeks as to provide time for recovery after her haemorrhagic stroke rather than performing a procedure which required systemic heparinisation so soon.

The right femoral artery was accessed with ultrasound guidance under general anaesthesia. The coarctation was crossed with a J-tip Terumo glide wire (Terumo Medical Corporation, New Jersey, USA) and a Judkins right coronary catheter. The pullback gradient across the narrowing was 38 mm Hg. The coarctation was then recrossed and angiography performed with a 5-French pigtail catheter. This confirmed tight coarctation of the aorta, with multiple collaterals and a large internal mammary artery. A target diameter of 10 mm was selected based on the systolic measurements in the transverse and distal descending aorta (figure 2). A 26 mm long premounted Valeo Stent (Edwards Life Sciences, California, USA) on a 10 mm balloon was selected, prepared and positioned via a 7-French Destination sheath (Terumo Medical Corporation, New Jersey, USA) over a superstiff Amplatzer wire (St Jude Medical, Minnesota, USA) positioned in the right subclavian artery. Accurate stent positioning was achieved with hand injections through the side arm of the sheath. The stent was dilated gradually with slow, controlled dewaisting to midway between

nominal pressure and the rated burst pressure. There was minimal recoil and only a slight central waist remained. The stent had a maximal diameter of 11 mm proximally and 10.5 mm distally and a minimum diameter of 8.8 mm at the slightly waisted central portion. The total stent length after inflation was approximately 25 mm. Balloon withdrawal and wire retrieval were uneventful and check angiography was satisfactory with no angiographic complications. There was no residual pullback gradient. Haemostasis was achieved by direct pressure and the patient recovered uneventfully. Femoral pulses were subsequently palpable bilaterally. A focused echocardiogram showed good left ventricular function, with no effusion and a descending aortic continuous wave velocity of 2.7 m/s systolic with no diastolic tail. A frontal and lateral chest radiograph confirmed stable stent position, with minimal stent wasting as seen in figures 3 and 4. Immediately postprocedure the patient was too unsettled to record accurate lower limb pressures, so only upper right limb pressures were measured, which were 122/72 mm Hg postprocedure and 101/65 mm Hg the following day on discharge.

The propranolol was continued and the patient was also discharged with 6 months of antiplatelet therapy (aspirin 75 mg once daily).

OUTCOME AND FOLLOW-UP

At 6 weeks postintervention peripheral and femoral pulses remained equal and easily palpable, with a right arm pressure on propranolol therapy of 115/52 mm Hg. Echocardiography showed a descending aortic continuous wave velocity of 3 m/s systolic with no diastolic tail.

A routine 3-month follow-up CT angiogram scan showed resolution of the aortic narrowing with a minimal central waist and no evidence of radiographic complications. A chest X-ray was performed to obtain stent measurements, with maximal stent diameters of 10 mm proximally and 10 mm distally, minimum diameter of 8 mm at the slightly waisted central portion and a length of 25 mm. The patient's blood pressure was normotensive at 98/40 mm Hg on oral propranolol and the remaining abnormal neurology from the preimplantation intracerebral haemorrhage had completely resolved.

Figure 1 Pre-stent MRI. (A) Image showing a lateral projection with a discrete narrowing in the typical position. (B) an oblique sagittal projection demonstrating the narrowing.

Figure 2 Image showing tight coarctation with normal arch measurements.

At the routine 12-month follow-up right upper limb pressure remained normotensive at 96/60 mm Hg on oral propranolol therapy. First and second heart sounds were normal with a one-sixth systolic murmur heard anteriorly and two-sixth posteriorly. Echocardiography showed good left ventricular function, with no significant left ventricular hypertrophy. The descending aortic continuous wave Doppler velocity was 2.5 m/s in systole with no diastolic tail.

Figure 3 Image showing the expanded stent in position with good vessel calibre matching.

Figure 4 Lateral day 1 poststenting chest radiograph showing good stent positioning and minimal stent wasting (arrow).

DISCUSSION

This is the first reported use of the Valeo Pre-mounted Re-dilatable Biliary Stent (Edwards Life Sciences, California, USA) in the treatment of aortic coarctation.

Modern hybrid stent designs (combination of open and closed cell) now allow a combination of a lower profile, good radial strength over a large radius range and dilation to adult size with an acceptable level of stent shortening. We have also used the Valeo Stent (Edwards Life Sciences, California, USA) in the setting of pulmonary artery stenting to take advantage of these characteristics.

The potentially beneficial features of this stent are its initial insertion characteristics and its long-term serial dilation ability. Initially, the stent can be inserted in a standard manner through a small calibre long sheath over a 0.035 wire, similar to the techniques used for larger coarctation stent procedures. The nominal pressures required are low enough not to produce significant shear stresses in the vessel wall (approximately 6 atm) and the balloon characteristics are favourable with a low profile after deflation in our experience. The hybrid nature of the stent, however, does encourage individual struts to partially peel away from the balloon when tracking around tight corners; however, we have only seen this occur during pulmonary stenting through the curves of the right heart.

Despite the published favourable characteristics of this stent and encouraging early data, unofficial bench testing would suggest that the radial strength of this stent is decreased on extreme dilation.³ In addition, as patients such as ours grow to adult size, they may require the support of an additional stent, implanted within the Valeo rather than simple redilation.

Although our report is limited to a single case and the follow-up period is relatively short at 1 year, it does demonstrate the feasibility and success of this stent for this purpose. Technically, the combination of the Valeo system (Edwards Life Sciences, California, USA) and the Destination sheath (Terumo Medical Corporation, New Jersey, USA) appears to be an attractive option for the smaller subgroup of patients (<20 kg). Therefore, the availability of the Valeo Pre-mounted Re-dilatable Biliary Stent (Edwards Life Sciences, California, USA) provides a valuable addition to our armamentarium for interventional management of coarctation.

Learning points

- ▶ Stent implantation provides an alternative to surgical therapy for coarctation of the aorta even in smaller patients.
- ▶ Limitations in stent technology have thus far inhibited the progress of this therapy in this patient group.
- ▶ Development of stents such as the Valeo stent may allow stent therapy in selected cases at a much lower weight than had previously been accepted.

Contributors ES gathered the information and wrote the initial drafts. GMC helped with the final draft and submission. GM masterminded the treatment and finalised the case report.

Competing interests None.

Patient consent Parental/guardian consent obtained.

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