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Brief Report

Creation with a stent of an unrestrictive lasting atrial communication

Marc Gewillig, Derize Boshoff, Luc Mertens

University Hospitals Leuven, Leuven, Belgium

Abstract A new technique is presented to create percutaneously an unrestrictive and lasting atrial communication in small children. In 2 infants, a stent was deployed in a restrictive atrial communication and first inflated with an 8 mm balloon. The stent was then further expanded up to 10 or 12 mm. The gradient and turbulent flow between the two atriums disappeared completely. The stent retained a very stable position without embolisation. Other complications, such as formation of thrombus or arrhythmia, were not observed until elective explantation after 2 and 11 months. We conclude that, in infants, dilation of the atrial septum with a stent can provide a safe, lasting, and unrestrictive atrial communication.

Keywords: Percutaneous intervention; stent; atrial septal defect

THERE ARE FEW INDICATIONS WHERE AN unlimited atrial connection is advantageous for the patient. Such situations are severe mitral stenosis or atresia in the setting of complex hypoplasia of the left heart, severe tricuspid stenosis or atresia in the setting of complex hypoplasia of the right heart, or discordant ventriculo-arterial connections with ventricular septal defect and unpreferential flow. A limited atrial communication will cause, respectively, decreased pulmonary runoff with retrograde pulmonary hypertension, decreased systemic venous runoff with low systemic output, or insufficient mixing at atrial level with profound cyanosis.

In the management of such patients, a Rashkind balloon septostomy is frequently performed in the neonatal period. In infants with a thick muscular atrial septum, the septal defect thus created may close prematurely. If the infant is not yet suitable for subsequent surgery, a new Rashkind procedure, blade septostomy, or static balloon dilation can be performed.[1–3] These techniques, however, are less successful for a lasting unrestrictive defect in infants with a small left atrium and a thick fibromuscular septum.

With increasing experience of stents in various locations in the cardiovascular system, the idea grew to use a stent to produce in infants an atrial communication which was both large and lasting. Animal studies, and implants in humans, have shown good tolerance of such prostheses when used for creation of a restrictive atrial fenestration.[4–5] We describe our experience with a new technique designed to produce a large, lasting and unrestrictive atrial communication in infants.

Procedure

The atrial septal defect is crossed with a catheter, and a 0.035" stiff wire is placed in a left pulmonary vein. A P104 stent (Palmaz, Johnson & Johnson) is hand crimped at the distal end of a short tapered 8 mm/2 cm Opta balloon. Excessive crimping with a wire or pliers must be avoided in order to allow the balloon to open on both sides of the stent simultaneously.

Deployment of the stent can significantly be facilitated by first tagging the atrial septum with a Brockenbrough needle. The X-ray tube must be put perpendicular to the plane of the atrial septum. This will usually be at 30–40° cranial and 30–40° left

Correspondence to: Marc Gewillig, Paediatric Cardiology, University Hospitals Leuven, B-3000 Leuven, Belgium. Tel: +32 16 343865; Fax: +32 16 343981; E-mail: marc.gewillig@uz.kuleuven.ac.be

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anterior oblique. The whole procedure can be monitored with multiplane transesophageal echocardiography. A plane must be found showing as much wire as possible on both sides of the atrial septum. This usually will be at around 40–70°.

The atrial septal defect is balloon sized by gently inflating a 10 mm balloon. This allows determination of the minimal required size of the stent at first inflation, and ensures there is enough room for expansion of the balloon in the left atrium without it being pushed back into the right atrium.

Before advancing the balloon through the 7 French Mullins sheath, the sheath must be properly positioned in the left atrium or pulmonary vein. It is preferable to use the dilator in order to advance the sheath well beyond the rim of the oval fossa.

The mounted stent is advanced through the Mullins sheath until it straddles the atrial septum. This position is checked with fluoroscopy and echocardiography. The sheath is withdrawn into the right atrium beyond the proximal end of the balloon, avoiding advancement of the balloon and stent during inflation. At this point, the position can be further checked with contrast flushed through the sheath (Fig. 1a).

When the position is satisfactory, the balloon is minimally inflated. If the stent is not crimped excessively, the balloon will open on both sides of the stent simultaneously, causing the stent itself to flail on both ends. At this point, minor shifts in position still can be made. It also allows the stent to "autocentre" across the septum. The stent is then fully deployed to the nominal value of the balloon

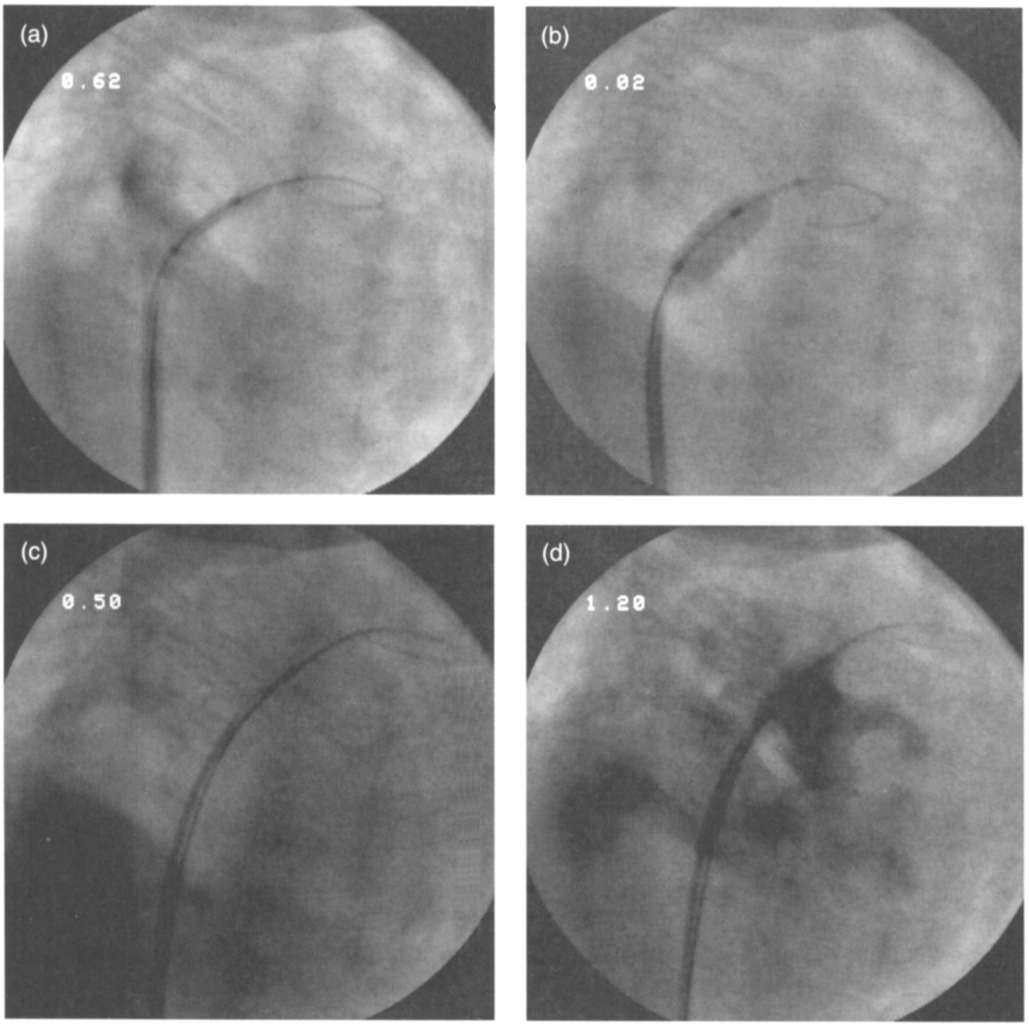

Figure 1.
(a) Hand injection in right atrium through 7F sheath, cine at 30°–30°: the P104 stent is well positioned across the atrial septum prior to balloon inflation; (b) Inflation of the 8 mm balloon makes the stent shrink from a length of 10 mm down to 8 mm; (c) Expansion of the stent up to 12 mm made the length further shrink down to 3 mm; (d) angiogram through a 5F Multitrack catheter in the left atrium: the new stented septal opening is well delineated. The length of the stent is similar to the thickness of the septum.

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(Fig. 1b). The balloon is carefully withdrawn and exchanged for a bigger balloon of 10 or 12 mm diameter in order to produce a larger communication. The stent at this point will become very short, respectively 5 and 3 mm (Fig. 1 c and d).

Results

This procedure was attempted in 2 patients. Informed consent of the parents was obtained. In the case of failure or misplacement of the stent, it was agreed the preferred option would be surgical retrieval of the stent with a large septectomy.

The first patient had double outlet right ventricle with severe mitral stenosis and a small left ventricle. A Rashkind balloon septostomy and banding of the pulmonary trunk had been performed in the neonatal period. Restriction of the atrial septum reoccurred within 18 weeks. At the age of 4 months, when the infant weighed 6.4 kg, a stent was successfully deployed as described above. The stent was dilated at implantation up to 12 mm. Subsequent echocardiograms showed a stable position with laminar flow through the atrial communication. No thrombus or arrhythmias were observed at any time until explantation after 11 months. At the time of a control catheterisation 7 months later, the stent was further dilated up to 14 mm because of a mild 2 mm gradient. The gradient disappeared, and the length of the stent further shrank down to 1.5 mm.

The second patient had mitral valvar atresia, hypoplastic left ventricle, double outlet right ventricle, and aortic coarctation. In the neonatal period, a Rashkind procedure, coarctectomy and banding of the pulmonary trunk were performed. At the age of 7 weeks, the infant presented with progressive cyanosis because of severe restriction of the atrial septal defect.

The procedure was performed as described above. The atrial opening was 6 mm as measured with the balloon. While mounting the stent, the Mullins sheath had to be withdrawn into the right atrium because of extreme desaturation. The tip of the sheath was then readvanced into the left atrium without use of the dilator. When the sheath was withdrawn into the right atrium leaving the stent and balloon across the septum, it was not possible to keep a stable position. It was only then appreciated that the tip of the balloon had hooked into the base of the atrial septum, pushing it forward and dragging the rest of the septum into the left atrium. While trying to cross the oval foramen, the stent was pushed backward on the balloon. The balloon was then partially opened, allowing the balloon to be retrieved, leaving the stent on the wire. A smaller balloon with better profile was used to grab the stent and pull it into the atrial communication like a "button in a buttonhole". The stent was then deployed and expanded to 8 mm. A 10 mm balloon was advanced into the stent and inflated, rupturing the membrane of the oval fossa. This produced an unrestrictive communication between the atriums. The stent was explanted 2 months later (Fig. 2).

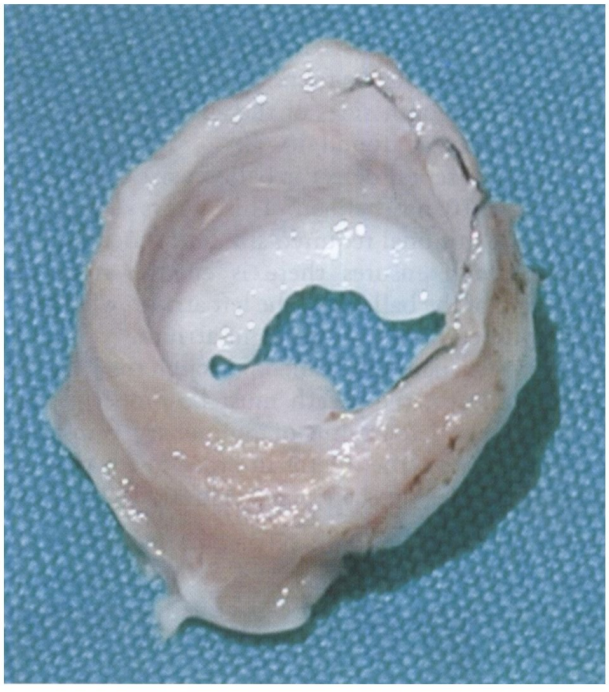

Figure 2.
Macroscopic view of the stent in our second patient explanted 2 months after deployment. The stent is well covered by endothelium. The septum is still visible at the left atrial side.

Discussion

We describe our experience in creating percutaneously a large and lasting atrial communication in small children. Such a communication permitted us to delay surgery until the patient had grown.

We chose not to exceed use of a 7 French sheath for delivery of the stent. The stent itself needed to be stretched up to 10 mm and beyond. With these limitations, and in light of current technology, we preferred to deliver the stent on an 8 mm/2 cm balloon. The balloon when folded is of 5 French dimension, permits adequate crimping and safe positioning of a stent without slippage, and allows full expansion of the stent without rupture.

We chose not to use a diabolo shaped stent, currently the stent of choice for creating a fenestration between the atriums.[6] Very big stents, sheaths and very big balloons would be required if this technique was used, making such a procedure impossible or

unsafe in infants. Previous animal studies have shown that a stent in the atrial septum is overgrown by endothelium within days or weeks.[4] We do not expect therefore any late embolisation of the stent.

Formation of a thrombus must be expected after insertion of any endocavitary structure. Experience with stents in the atrial septum is very limited worldwide, but no animal or human study has reported this complication. With our technique, almost no "free floating" metal is left in either atrium, further reducing the risk of formation of thrombus. Our patients received no anticoagulation therapy, and no thrombotic complications were observed in follow-up. As the stent is covered with endothelium within days to weeks, we expect no late thrombotic complications. These patients will have a further surgical intervention within months, allowing the surgeon to perform a subtotal atrial septectomy, and thus remove the stent completely. Long-term efficiency of the stent, therefore, is not an issue. The procedure, nonetheless, is technically complex and demanding; many difficulties need to be anticipated. By adopting a rigorous technique, the interventionalist should be able to avoid problems such as slippage of the stent on the balloon. The stent may end up in the left or right atrium during the procedure, but should at least remain on the wire. If necessary, the stent can temporarily be left in the left atrium or inferior caval vein. The possibility of surgical removal should clearly be mentioned when discussing all options, advantages and possible complications with the parents.

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