Catheterization and Cardiovascular Interventions 77:696–699 (2011)

A Flow Restrictor Implanted Percutaneously Across a Loose Pulmonary Artery Band

Matthias Gorenflo, MD, PhD and Marc Gewillig,* MD, PhD

Pulmonary artery banding usually is performed as a palliative procedure. In patients with elevated pulmonary vascular resistance and complex congenital heart disease, it may not be possible at the time of surgery to obtain sufficient restriction to optimize the patient for further treatment; additional restriction may be needed in time. We present a technique where we used a combination of two devices (a 10-mm Amplatzer ASD occluder fenestrated with a Palmaz Genesis 9/19 mm stent) to percutaneously further reduce the flow to the lungs 1 month after surgical placement of a pulmonary artery band in a 16-year-old girl with complex univentricular heart. Eight months after the banding the patient successfully underwent completion of the Fontan circulation by total cavopulmonary connection. This technique allows to reduce flow without redo surgery. In well-selected patients, this new percutaneous technique allows to better prepare such complex patients for future surgery. © 2011 Wiley-Liss, Inc.

Key words: percutaneous valve; perforation; occlusion

INTRODUCTION

Pulmonary artery banding has been introduced as a palliative procedure in 1952 by Muller [1] to control excessive pulmonary blood flow in small children that were not yet amenable for full repair. Many lesions are now fully repaired at a younger age and/or a lighter weight, resulting in less frequent application of this palliative surgical maneuver. However, indications still persist such as (a) to control pressure and flow in the pulmonary artery in complex congenital heart disease and (b) to retrain the left ventricle in patients with ventriculoarterial discordance.

At the time of banding, the surgeon may not be able to tighten the band to the desired level, either because of excessive cyanosis due to increased pulmonary vascular resistance or because of ventricular failure of the nonpressure-trained subpulmonary ventricle. However, after initial "optimal" banding, the restriction may become too loose, as pulmonary vascular resistance may decrease or the subpulmonary ventricle gets trained. More restriction may then be desired to optimize the patient for further treatment.

Further relative narrowing of the band is automatically obtained in a growing child. An adjustable telemetric banding device such as the FlowWatch® Device [2] is available but it must be implanted at initial banding, and there are technical and financial drawbacks. Further surgical narrowing of the band is not attractive: it involves redo surgery, and tightening a band across a scarred pulmonary trunk to provide a better balance of flow, pressure, and saturation after the initial operation is difficult.

We present a technique where we used a combination of devices to percutaneously further reduce the flow to the lungs after surgical placement of a pulmonary artery band in a patient with additional pulmonary flow (Glenn shunt).

CASE REPORT

A 16 year-old-girl with complex univentricular heart (double inlet left ventricle, d-malposition of the great arteries, significant subvalvular pulmonary stenosis, and preferential pulmonary flow) had well balanced hemodynamics with good exercise tolerance for many years. At the age of 13.5 years, she had a mean pulmonary artery pressure of 15 mm Hg and her saturation was 93%; any invasive treatment was refused.

Department of Pediatric and Congenital Cardiology, University Hospitals Leuven, Belgium

Conflict of interest: Nothing to report.

*Correspondence to: Marc Gewillig, MD, PhD, University Hospital Gasthuisberg, Herestraat 49, B 3000 Leuven, Belgium.
E-mail: marc.gewillig@uzleuven.be

Received 26 August 2010; Revision accepted 5 October 2010

DOI 10.1002/ccd.22863
Published online 14 March 2011 in Wiley Online Library (wileyonlinelibrary.com)

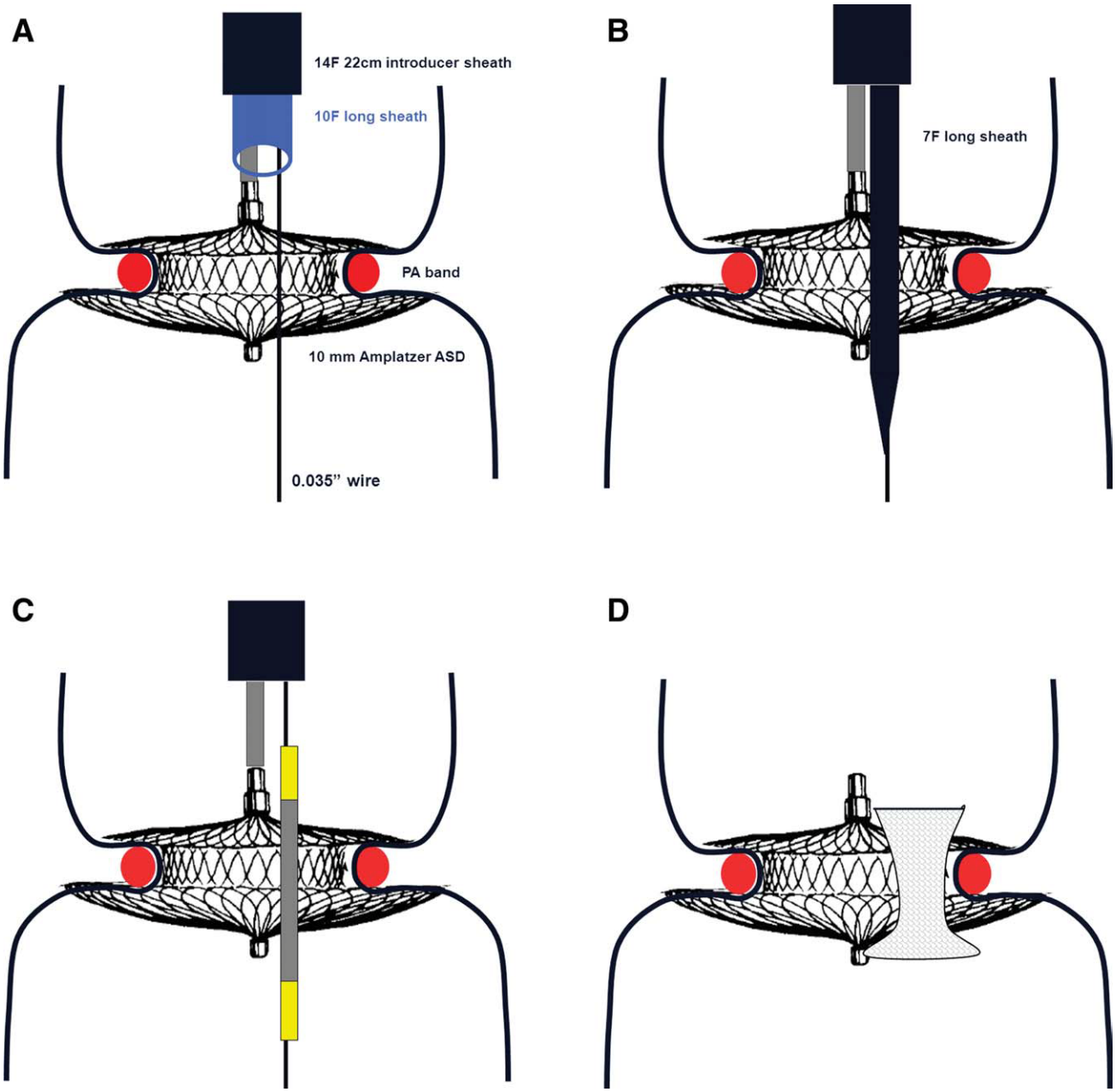

Fig. 1. A: A 10-mm ASD Amplatzer (still connected on a 2-mm cable) has been deployed over an 0.035″ wire through a 10F sheath through a 14F sheath; B: The Amplatzer has been redilated by the 7F sheath over the wire; C: A stent has been positioned over the wire and the 7F sheath has been withdrawn; D: The stent has been opened in diabolo across the Amplatzer; the wire, delivery cable and sheaths have been withdrawn. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

At the age of 15.5 years, she noticed a progressive reduction of her exercise capacity. A re-evaluation showed a Qp/Qs = 2.5, a mean PA pressure of 23 mm Hg with an aortic saturation of 91%. We expected the pulmonary resistance to further increase over the following decade in an accelerated way. Aiming for a Fontan circuit in a single operation was estimated to be too risky because of the increased pulmonary vascular resistance. We chose to go for a stepwise conversion: first a bidirectional Glenn shunt with placement of subtotal dilatable PA band, later followed by Fontan completion.

At the time of operation, the surgeon did tighten the band as much as possible resulting in low arterial

saturations of 80%. Over the following days, the saturation increased as pulmonary vascular resistance decreased, but the postoperative course was complicated by bilateral chylothorax. Reoperation with tightening the band was considered, but the patient and parents preferred a percutaneous option. Informed consent according to local ethical committee guidelines was obtained.

OCCLUDER TECHNIQUE

The restriction occluder consisted of an ASD Amplatzer to restrict the flow but perforated by a bare stent to allow limited flow.

A 0.035″ Amplatz wire was placed via right jugular access over the Glenn anastomosis across the pulmonary arterial band and the pulmonary valve into the left ventricle. The orifice of the band was sized to 11 mm with a balloon (15 mm × 3 cm, Tyshac II, Numed, NY); we anticipated to place a 10-mm Amplatzer ASD occluder. At one point during the procedure, a 2 mm cable (to hold the ASD occluder) and a 7F sheath (to allow placement of a stent through the ASD occluder) would be side by side in one sheath; this sheath was therefore required to have a 14F lumen. Such 14F sheath was then positioned in the pulmonary trunk (Daig, Minnetonka, MN).

A 10-mm Amplatzer ASD occluder (AGA Medical, Plymouth, MN) was then prepared: the occluder was punctured with the 0.035″ wire; the hole was predilated with a 7F sheath (that would later be used to position the stent). The Amplatz occluder together with the 0.035″ wire were loaded into a 10F sheath.

The 10-mm Amplatzer ASD occluder was deployed over the wire with its "left atrial" disc proximal to the band and with its "right atrial" disc distal to the PA band (Fig. 1A). The 10F sheath was removed, but the ASD Amplatzer was still attached on the 2 mm delivery cable through the 14F sheath. A 7F sheath was advanced over the 0.035″ wire through the predilated "fenestration" (Fig. 1B); a premounted Genesis PG1990PPX 9/19 mm (Johnson & Johnson, New Brunswick, NJ) was positioned within the 7F sheath across the Amplatzer (Fig. 1C). The stent was then subtotally deployed by sequential inflation of the balloon (Figs. 1 and 2).

After this procedure, the transcutaneous oxygen saturation dropped to 85%, the pleural effusions disappeared but the patient felt uncomfortable with respect to her functional capacity. The stent in the flow reductor was then further dilated to 10 mm after 1 month.

We allowed the pulmonary vasculature to recover from the previous volume overload; 8 months after the banding, the patient successfully underwent completion of the Fontan circulation by total cavopulmonary connection with an uneventful postoperative stay.

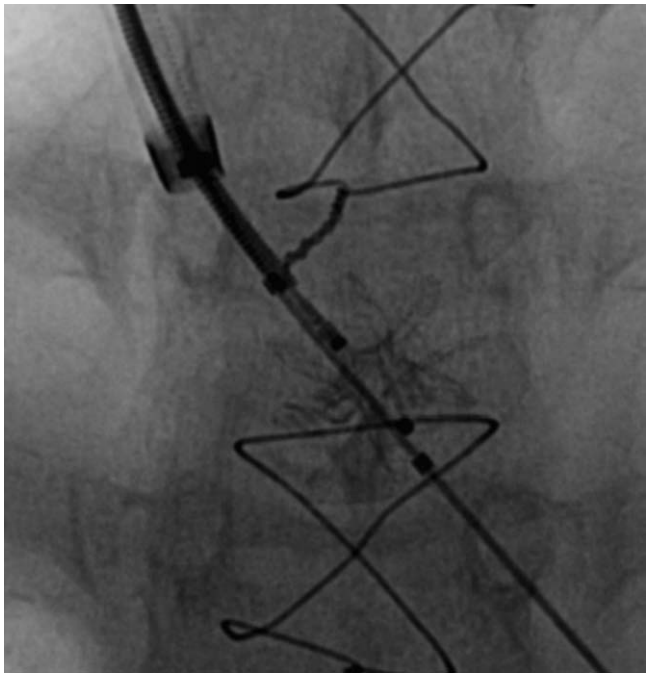

Fig. 2. Flow reductor in position of pulmonary artery banding. Note that the 10 mm ASD Amplatzer is still on the delivery cable and the 0.035″ wire is through the stent.

SUMMARY

We describe a technique to restrict pulmonary flow in patients with complex CHD that presented with insufficient pulmonary artery banding.

Until now reduction of effective pulmonary artery diameter after placement of a PA band has been reported either by a surgical redo or by a priori use of an adjustable telemetric banding device such as the FlowWatch® [2].

We here report on a new percutaneous technique to obtain restricted flow. A perforated septal occluder has already been used in low pressure atrial septal defects or atrial fenestrations with good result [3]. This report illustrates that such a construction can also be deployed in high pressure situations, provided there is adequate support by a restrictive lesion such as a band. We chose an ASD occluder because of the wide shoulders on the high pressure side to retain the device, and the short distance between both disks, as it only had to allow for the thickness of the band and twice the vessel wall; the ASD Amplatzer occluder configured nicely as expected. Obviously, this technique can also be performed with a nonpremounted stent that allows dilation

up to "adult" restriction. Currently, such stents can be delivered through a 6F sheath, allowing to reduce the sheath size. It is our impression that this technique can also be used in younger patients. This technique could be offered to this specific patient as she had a Glenn shunt and a ventricular septal defect, allowing adequate pulmonary and systemic circulation during the short period of total occlusion of the band (after deployment of the ASD Amplatzer occluder until deflation of the balloon in the stent). In patients with neither an alternative pulmonary circulation nor the possibility of right-to-left shunt, an adapted strategy may be necessary (making temporary atrial communication, short run on ECMO).

The advantage of this technique is that flow reduction can be achieved without redo surgery and that the costs are considerably lower compared with the commercially available FlowWatch® device. In well selected patients, this technique allows to better tailor the pulmonary circulation.

REFERENCES

1. Muller WH, Danimann JF. The treatment of certain congenital malformations of the heart by the creation of pulmonic stenosis to reduce pulmonary hypertension and excessive pulmonary blood flow; A preliminary report. Surg Gynecol Obstet 1952;95: 213–219.
2. Corno AF, Ladusans EJ, Pozzi M, Kerr S. FloWatch versus conventional pulmonary artery banding. J Thorac Cardiovasc Surg 2007;134:1413–1419.
3. Lammers AE, Derrick G, Haworth SG, Bonhoeffer P, Yates R. Efficacy and long-term patency of fenestrated amplatzer devices in children. Catheter Cardiovasc Interv 2007;70:578–584.