A simple and fast technique for radiofrequency-assisted perforation of the atrial septum in congenital heart disease

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ABSTRACT

Radiofrequency (RF) assisted perforation of the atrial septum was performed successfully in three infants using a 0.035″ RF wire deployed through a Williams right posterior catheter. Balloon atrial septoplasty was performed over the 0.035″ RF wire in two of them, shortening the procedural time.

Keywords: Congenital heart disease, intact atrial septum, radiofrequency perforation of interatrial septum

INTRODUCTION

Radiofrequency (RF) assisted perforation of the atrial septum is as an alternative to conventional needle puncture in infants and children with congenital heart disease.[1,2] Indications for left atrial access include hemodynamic measurements (left atrial pressure and trans-mitral pressure gradient) and therapeutic interventions (atrial septoplasty and balloon atrial septostomy).[3-5] Hypoxemia in the presence of an intact/very restrictive atrial septum and univentricular heart, requires the rapid creation of an atrial communication. We describe a method to quickly engage the atrial septum with a Williams right posterior catheter followed by RF assisted entry of the atrial septum and balloon dilation of the atrial septum over the RF wire.

CASE REPORTS

Case 1

A 2.8 kg male presented with shock and hypoxemia on day 1 of life due to hypoplastic left heart syndrome (mitral stenosis and aortic atresia) with an extremely restrictive patent foramen ovale and pulmonary edema. His preductal oxygen saturation was 50% with a pO2 26 mmHg and arterial pH 7.1. Urgent cardiac catheterization was performed with extra corporeal membrane oxygenation standby. A right femoral arterial line was placed for invasive monitoring, and a 6F sheath was placed in the left femoral vein. The procedure was performed under fluoroscopic and transthoracic echocardiographic guidance. Initial attempts to engage the patent foramen ovale of the bulging atrial septum were unsuccessful with standard catheters (4 French right coronary and 4 French Cobra). A 6 French Williams right posterior curve guide catheter (3D RunWay, Boston Scientific, Marlborough, MA, USA) [Figure 1], engaged with the atrial septum on the first attempt by a simple rotation [Figure 2]. A 0.035″ RF wire with a bent tip (PowerWire, Baylis Medical, Montreal, QC, Canada) was advanced and perforated the atrial septum with one pulse (5W, 3 s duration). The 0.035″ PowerWire was advanced into the left atrium and used as a guide wire for a series of progressively larger balloons (4 mm, 7 mm, and 10 mm diameter (Powerflex, Cordis Corporation, Fremont, CA, USA) to perform the static atrial septoplasty [Figure 3]. There was a significant improvement in the oxygenation of the child with preductal saturations rising to the high 87-89%, with only a 1 mmHg-pullback

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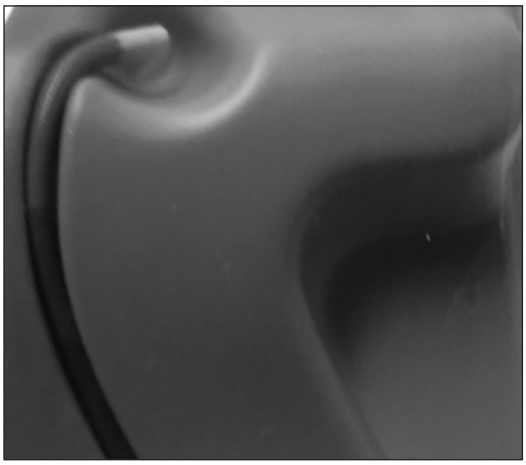

Figure 1: Williams right posterior catheter

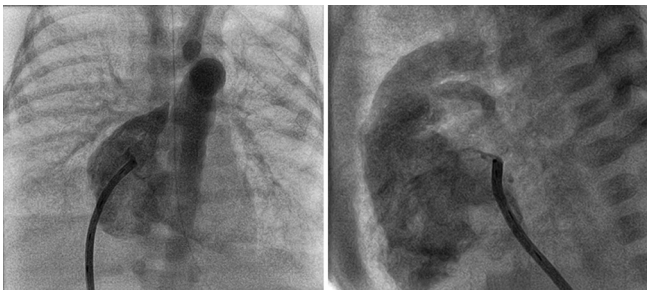

Figure 2: Frontal (left panel) and lateral (right panel) view of the Williams right posterior curve catheter engaging the atrial septum prior to radiofrequency-assisted perforation

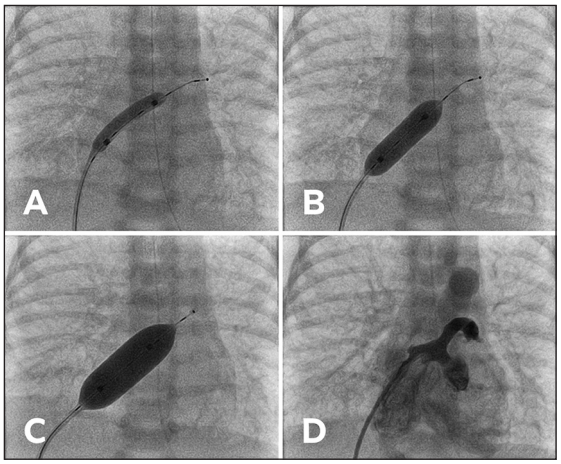

Figure 3: Static atrial septoplasty with 4 mm (a), 7 mm (b), and 10 mm (c) balloons deployed over the radiofrequency wire. Control hand injection performed in the left atrium (d) demonstrates a hypoplastic left ventricle, left atrial appendage, and flow of contrast across the newly created atrial septal defect to the right atrium

gradient at the atrial level and an atrial septal defect of 3 mm diameter.

Case 2

A 7-week-old, 2.6 kg girl (born prematurely at 31 weeks) with Taussig-Bing syndrome, severe subpulmonary stenosis, cleft mitral valve, and an intact atrial septum bowing into the right atrium was referred for creation of an atrial communication. Her preductal pulse oximetry was 70%, and she was ventilator and prostaglandin dependent with bilaterally thrombosed femoral veins and clots in her inferior vena cava. Transhepatic venous access was achieved through the middle hepatic vein, and 6 French sheaths was deployed to the inferior vena cava-right atrial junction. Under fluoroscopic and transthoracic echocardiographic guidance, a 0.035″ PowerWire with a bent tip was opposed to the atrial septum and used to perforate and enter the left atrium uneventfully. The 0.035″ PowerWire was used to deploy 4, 10, and 12 mm diameters balloons and perform static septoplasty of the atrial septum resulting in a 4 mm nonrestrictive atrial communication and a rise in the arterial saturation. The close proximity of the atrial septum to the vascular sheath in the middle hepatic vein, made a balloon atrial septostomy unfeasible as the atrial septum could not be stretched enough.

Case 3

An 8-month-old, 6.1 kg boy with an atrioventricular septal defect underwent standard two patch repair and intraoperative device closure of apical ventricular septal defects (VSDs) with two 4 mm Amplatzer muscular VSD occluders (St. Jude Medical, St. Paul, MN, USA). Postoperatively, he had a right ventricular hypertension, and the relative contribution of left atrioventricular valve regurgitation and residual VSDs were uncertain. At cardiac catheterization, under fluoroscopic and transthoracic echocardiographic guidance, a 5 French Williams right posterior curve catheter was used to easily engage the atrial septum, deploy the 0.035″ PowerWire and enter the left atrium. The 0.035″ PowerWire was advanced into a left pulmonary vein, and a 4 French right coronary catheter was advanced over the wire into the left atrium to measure the left atrial pressure directly. The dominant hemodynamic problem was related to mitral regurgitation with a mean left atrial pressure of 20 and a V-wave of 25 mmHg. Both by shunt calculation and angiography, the residual muscular VSDs were found to be small.

DISCUSSION

In neonates and small infants with congenital heart disease, access to the left atrium by needle puncture of a bulging or unusually positioned atrial septum can be difficult.[3,6,7]

This series demonstrates a simple approach with an appropriately shaped catheter (Williams right posterior) enabling stable engagement with the atrial septum with minimal manipulation, followed by perforation with a 0.035″ RF wire that is stiff enough to subsequently deliver and support balloons for static atrial septoplasty. Static atrial septoplasty is useful in infants with a thick, muscular, noncompliant septum, where balloon atrial

septostomy may be unsuccessful. The Williams right posterior catheter can usually be advanced and rotated into a stable position with minor manipulation, facilitating the most difficult part of the procedure. It possesses a third curve out of the plane of the primary and secondary curves of the usual Judkins right catheter that gives it a three-dimensional shape and allows it to engage the atrial septum without significant torque. This favorable geometry has also made it feasible to stent a stenotic coronary sinus in a 4-month-old and 4.1 kg boy on the first attempt, after a range of other catheters had failed.

To our knowledge, this is the first case report to describe the application of the PowerWire RF wire to perforate the atrial septum in infants for both diagnostic and interventional purposes. Asgar *et al.* reported their experience with the PowerWire to manage complete superior vena cava occlusion in two adults with complete transposition of the great arteries that underwent the atrial switch repair during infancy, which resulted in a successful stent implantation for one patient and the means by which to implant a transvenous pacemaker in the other.[8] The PowerWire is exchange length (250 cm), with graded stiffness with a more flexible distal end transitioning to the stiff proximal shaft and a low friction coating allowing device deployment.

Similar to mechanical perforation, potential complications during RF assisted perforation of the atrial septum include inadvertent puncture of adjacent structures (i.e., posterior free wall of the right atrium, superior or inferior vena cava, aortic root, and coronary sinus) as well as systemic embolization of clot or air. Fortunately, the major complications such as cardiac tamponade or death are extremely rare (<1%).[9] Accurate visualization of the atrial septum, the position of the catheter tip and RF wire, prior to RF perforation is critical. The wire always remains within the catheter, until its tip is gently opposed to the septum. At this point the catheter is usually still opposed to the septum, or may just be pushed slightly off the septum. There is no manipulation of a free wire within the atrium to try to obtain an adequate position. Positioning is achieved by the catheter, and often the catheter can be seen indenting the atrial septum by echocardiography. We have found echocardiographic guidance to be an essential supplement to fluoroscopy, and we frequently alternate between the two imaging techniques. Transthoracic echocardiography provided excellent imaging in these small infants, but transesophageal or intracardiac echocardiography may be required, depending on the clinical situation.[6,10]

CONCLUSION

The Williams right posterior curve catheter is useful to engage the atrial septum in neonates and small infants. The 0.035″ PowerWire can be used safely and effectively to perforate the atrial septum in this group. The combination allows rapid creation of an atrial communication even in the most urgent situations.

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Conflicts of interest

There are no conflicts of interest.

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