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Brief Report

An experience suggesting an expanded role for the excimer laser catheter in neonates with obstructive lesions in the heart

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Abstract I have previously reported the successful use of the 0.9 millimetre excimer laser catheter in 2 neonates with pulmonary valvar atresia and intact ventricular septum. In this report, I describe the expanded role of the excimer laser in a premature infant weighing 1.8 kilograms who presented with an occluded right pulmonary artery secondary to an organized thrombus. Successful reconstruction of the right pulmonary artery was performed by sequential use of lasers of 0.9, 1.4, and 2 millimetres diameter, followed by conventional balloon angioplasty. As is now the situation in adults, laser catheter intervention should now be an integral part of the armamentarium of the paediatric cardiac interventionalist.

Keywords: Laser therapy; interventional catheterization

THE USE OF DEVICES INTRODUCED ON CATHETERS to alleviate critically stenotic or atretic congenital cardiac malformations in neonates has evolved over the years. In pulmonary valvar atresia with intact ventricular septum, the techniques to achieve continuity from the right ventricle to the pulmonary arteries have included perforation of the valve using a stiff guide wire, a thin laser wire and, more recently, radiofrequency wires, all of which are followed by conventional balloon dilation. I reported the use of the 0.9 millimetre excimer laser catheter in 2 neonates in this setting, illustrating the ease with which this technique, in concert with conventional balloon valvoplasty, can effectively decompress the hypertensive right ventricle.[1]

Recannulation of a completely occluded venous or arterial structure secondary to an organized thrombus can be technically challenging in any patient, and especially in small infants. One potential solution in this particular clinical situation is to use the Spectranetics CVX 300 excimer laser catheter (Colorado Springs, CO, USA), this being a flexible laser operating at 50 degrees Celsius. Use of the excimer laser is now well established for adults with stenosis of aortocoronary saphenous vein grafts, or stenoses developing after endovascular stenting.[2] The laser uses light in the ultraviolet wavelength, at 308 nanometers, and ablates tissue by delivering extremely short bursts of very high light energy that result in disruption of molecular bonds. When light from the laser is emitted into optically absorbent materials, it produces acoustic shock waves, which vaporizes plaques and surrounding absorbent tissues, resulting in microscopic particles. As the penetration of the energy is no more than 35 to 50 microns, there is little surrounding thermal tissue damage, and thus the ablation is localized. Currently, the Spectranetics Excimer laser catheter is approved by the Food and Drugs Administration of the United States of America for percutaneous revascularization in patients with occlusive coronary arterial and peripheral vascular disease. In this report, I describe my initial experience using the catheter in a premature neonate with a completely occluded right pulmonary artery secondary to a long-standing organized thrombus.

Case report

A 29-week premature infant, weighing 1.8 kilograms, was found at approximately 1 month of age to have an organized thrombus originating on a pre-existing umbilical venous catheter and extending through the inferior caval vein into the right atrium.

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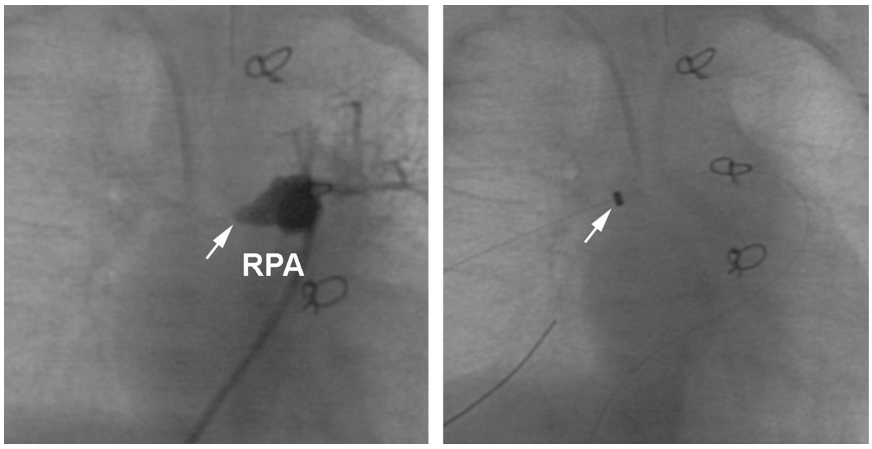

Figure 1.
An angiogram in the pulmonary trunk, shown in frontal projection, and performed prior to excimer laser intervention (left panel), reveals complete occlusion of the proximal right pulmonary artery (white arrow). The right panel shows an excimer laser catheter of 2 millimetres diameter placed within the distal part of the right pulmonary artery immediately following the delivery of energy (white arrow). Note the floppy tipped guide wire of 0.014 inches diameter within a branch of the artery feeding the lower lobe.

The infant was commenced on subcutaneous Lovenox as soon as the thrombus was discovered. Approximately 3 weeks following the initiation of Lovenox, when the neonate was aged 6 weeks, the thrombus embolized to the pulmonary trunk and right pulmonary artery, resulting in acute respiratory distress, with no antegrade flow into the right pulmonary artery detected by echocardiography. The infant was transferred to a different institution, where the thrombus was reported as surgically removed from both the right atrium and pulmonary artery. Transthoracic echocardiography the following day, however, demonstrated a persistent echogenic mass within the proximal right pulmonary artery, with no obvious antegrade flow. One month later, at 3 months of age, the infant was transferred to our institution for persistent respiratory problems, and once again transthoracic echocardiography with colour flow mapping and lung perfusion imaging demonstrated no flow within the right lung.

After informed consent was obtained, the patient was electively intubated, following which cardiac catheterization was performed. An angiogram in the pulmonary trunk demonstrated complete occlusion of the right pulmonary artery (Fig. 1, left). Floppy tipped coronary guide wires of 0.014 and 0.018 inch diameter could not be advanced into the distal right pulmonary artery either around or through the thrombus. Without the use of a guiding catheter, I advanced a standard "over the wire" 0.9 millimetre excimer laser catheter against the thrombus over an existing guide wire of 0.014 inch diameter. The laser catheter was first calibrated with a fluence of 50 millijoules/millimetre^2 at 25 hertz, following which a 3 second train of energy was applied, using a total emission of 75 pulses. Following the application of laser energy, the floppy tipped guide wire of 0.014 inch diameter was easily advanced into a branch of the pulmonary artery supplying the distal right lower lobe. Further recannulation of the vessel was then performed over the existing guide wire, using the standard laser catheters of 1.4 and 2.0 millimetres diameter (Fig. 1, right). I did not concomitantly inject saline during delivery of energy. I then carried out conventional balloon angioplasty using a balloon which was 4 millimetres in diameter and 2 centimetres long (MS Classique, Medi-tech Corp., Watertown, MA, USA), which I inflated up to 10 atmospheres of pressure, followed by inflation up to 16 atmospheres of pressure of a Titan Mega coronary angioplasty balloon (Cordis Corp., Miami, FL, USA) which was 5.5 millimetres in diameter and 2 centimetres long. This resulted in a nominal diameter of the balloon of 6 millimetres. Immediately following intervention, repeat angiography demonstrated improved perfusion of the right lung, although the distal branches of the pulmonary arteries feeding the right lower lobe were diffusely hypoplastic (Fig. 2, left). Subsequent to catheterization, the patient remained on intravenous heparin, and soon after was started on daily injections of Lovenox for a presumed hypercoaguable syndrome. The Lovenox was later switched to aspirin at low doses, which was continued for several months after the intervention. Significantly improved perfusion of the right lung was confirmed by nuclear perfusion imaging less than 1 week after catheterization, with one-third of the pulmonary flow then reaching the right lung. At follow-up 4 months later just over half the flow perfused the right lung. Cardiac catheterization 7 months after demonstrated continued growth of the right pulmonary artery, albeit with mild stenosis of the branch to the right lower lobe (Fig. 2, right).

Discussion

The use of catheters to alleviate critically stenotic or atretic congenital cardiac malformations has evolved over the years. In 1991, Qureshi et al.[3] described the successful use of a very small laser wire for treatment of patients up to 2 years of age with pulmonary valvar

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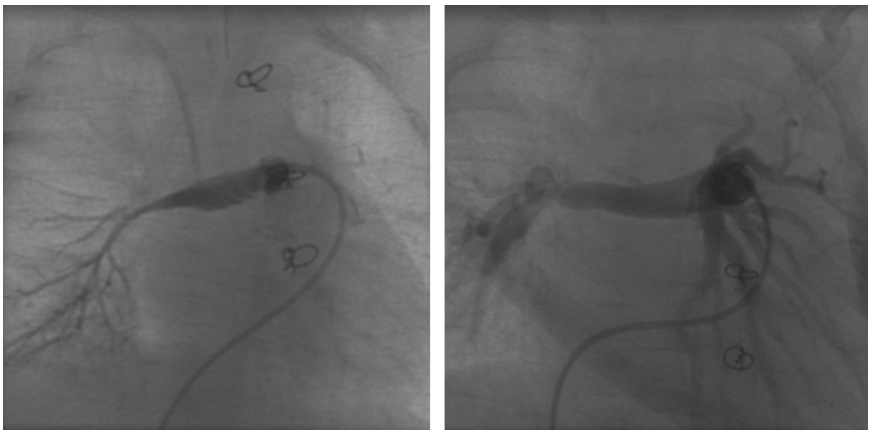

Figure 2.
The left panel shows an angiogram made in the pulmonary trunk immediately after reconstruction using the laser and conventional balloon angioplasty. The proximal part of the right pulmonary artery is now widely patent, whereas the first order branches are hypoplastic, and there is absence of flow to the upper lobe. The right panel shows a comparable angiogram performed 7 months after intervention. The proximal part of the right pulmonary artery is now widely patent, and there is only mild stenosis of the proximal branch to the right lower lobe, albeit still with no flow to the upper lobe.

atresia with or without a ventricular septal defect. Subsequently, in 1993, the successful use of radiofrequency catheter perforation was reported in patients with both discrete pulmonary valvar atresia and long segment muscular atresia of the right ventricular outflow tract.[4,5] In 1998, Park et al.[6] described the successful use of a small radiofrequency catheter in 3 neonates with pulmonary valvar atresia. Recently, Cheung et al.[7] reported their experience in 15 neonates with pulmonary valvar atresia and intact septum, again using a laser guidewire of 0.018 inch diameter. As I previously reported in 2 neonates with pulmonary valvar atresia,[1] the Spectranetics excimer laser catheter simplifies the procedure, since perforation of the imperforate valvar membrane requires little or no force applied by the operator via the groin of the patient. Since the laser is a coaxial system, a guide wire of small diameter can be advanced through the lumen of the laser, over which low profile balloons can easily be manipulated to perform standard valvoplasty techniques.

The advantage of using laser therapy to reconstruct occluded vessels is the vaporization of the thrombus that comes into contact with the tip of the laser. With the lasers currently available, this could theoretically create a circumferential lumen of up to 2 millimetres diameter along the length of the vessel, and produce a greater likelihood of successful angioplasty. The use of this system, employing "over the wire" technology, simplifies the exchanging for either laser catheters of larger diameter or diagnostic catheters. Otherwise, a guiding catheter of larger diameter would have been needed in such a small infant. Laser catheters are currently being developed with larger diameters, which would further increase the future likelihood of successful reconstruction of vessels in patients of all sizes. Alternatives to reconstruction using lasers include radiofrequency perforation followed by conventional balloon angioplasty. The diameter of the Bayliss Medical radiofrequency catheter, however, is only 1.9 French, limiting the amount of circumferential vaporization of the thrombus that could be achieved. A more recent alternative, described by Vincent et al.,[8] is to perform a mechanical thrombectomy, using the AngioJect system, albeit that thus far this technique has been used only for treatment of acute thrombus. This would have been unlikely to have been effective in our patient, since the thrombus had embolized to the right pulmonary artery approximately 6 weeks prior to laser intervention.

I submit, therefore, that the excimer laser catheter is a promising new therapeutic tool for the treatment of children with various obstructed or atretic cardiac defects. Subsequent to its use in neonates with pulmonary valvar atresia and intact ventricular septum, I have now described its use in a small premature infant in recannulation of an occluded branch of the pulmonary trunk secondary to a long-standing embolized thrombus. The availability of such laser catheters with various diameters will prove advantageous for our population of children, while the small profile and flexibility of the laser having a diameter of 0.9 millimetres is ideal for small neonates, and even premature infants. This technique should, therefore, become an integral part of the armamentarium of the paediatric cardiac interventionalist.

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