Cardiology in the Young

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Percutaneous pulmonary valve implantation in a patient with a single pulmonary artery and distal narrowing

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Brief Report

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Abstract

Percutaneous pulmonary valve implantation is established as a safe and effective method of treating patients with disfunction of right ventricular outflow tract. Modifications of this method allow for an increasingly wider use of this less invasive treatment. We present a staged percutaneous pulmonary valve implantation into a single-branch pulmonary artery in a paediatric patient with tetralogy of Fallot after patch repair.

A significant group of patients after surgical reconstruction of the right ventricular outflow tract, especially with using a transannular patch, need several re-interventions during their lifetime. Percutaneous pulmonary valve implantation is an alternative to surgical replacement of dysfunctional grafts. We present a case of percutaneous pulmonary valve implantation into the proximal part of a single right pulmonary artery with simultaneous dilation of the distal part.

A 16-year-old boy (55 kg) with tetralogy of Fallot (severe multilevel obstruction with hypoplastic left pulmonary artery) underwent right-sided Blalock-Taussig shunt (3rd week of life) followed by a total correction, including a transannular patch and bilateral pulmonary artery enlargement (14th month of life).

Over the years of observation, the patient remained asymptomatic. However, due to recurrent respiratory infections, a chest CT scan was performed at 12 years of age. The study showed a dilated right ventricular outflow tract and proximal part of the main pulmonary artery with tight narrowing in the distal part of the right pulmonary artery, the left lung with reduced volume and aeration, and an absent left pulmonary artery. (Fig. 1a, Supplementary Video S1).

Echocardiogram showed mild tricuspid valve regurgitation, with a maximal gradient of 37 mmHg, significant pulmonary valve regurgitation, and severe right pulmonary artery narrowing in the distal part with maximal gradient of 29 mmHg.

Two years later (at the age of 14), the diagnostic cardiac catheterisation visualised an enlarged right ventricular outflow tract (30 mm) at the level of the transannular calcified patch with significant regurgitation. The minimal diameter of the proximal part of right pulmonary artery was 21 mm. A significant stenosis in the distal part of the right pulmonary artery, at the site of previous Blalock-Taussig shunt, was also noted. Complete obstruction of the left pulmonary artery was confirmed with numerous aorto-pulmonary collaterals to the left lung. An aortogram confirmed the course of the distal part right pulmonary artery under the aortic arch, between the enlarged ascending and descending aorta. Hemodynamic measurements are included in the Supplementary Table T1.

The patient was referred to us at the age of 15 years. At a multidisciplinary meeting, the decision was made to perform a distal right pulmonary artery dilation and attempt a percutaneous pulmonary valve implantation into the proximal right pulmonary artery.

Initial angiography performed during the first stage of treatment showed narrowing of the distal right pulmonary artery just prior to take-off of dilated lobar branches (Fig. 1b, Supplementary movie 1). A 39 mm Cheatham Platinum stent (NuMed) mounted on a 20 mm Balloon in Balloon catheter (Numed) was implanted to the distal narrowing of the right pulmonary artery and dilatated with 22 × 20 mm high-pressure balloon (Atlas Gold, Bard). After excluding coronary compression, a landing zone was prepared with a 45 mm covered Cheatham Platinum stent, mounted on a 24 mm Balloon in Balloon catheter. To avoid compression on the dilated aortic root, the stent was implanted in the proximal part of right pulmonary artery, in a supra-pulmonary position (Fig. 1c).

After four months, the second stage of the treatment was performed. Fluoroscopy at the beginning of cardiac catheterisation showed significant fractures and anterior-posterior compression of the Cheatham Platinum stent in the distal part of right pulmonary artery. Mild fractures were also noted in the proximal stent (Fig. 1d). For that reason, another 34 mm Cheatham Platinum stent mounted onto a 20 mm Balloon in Balloon catheter was implanted

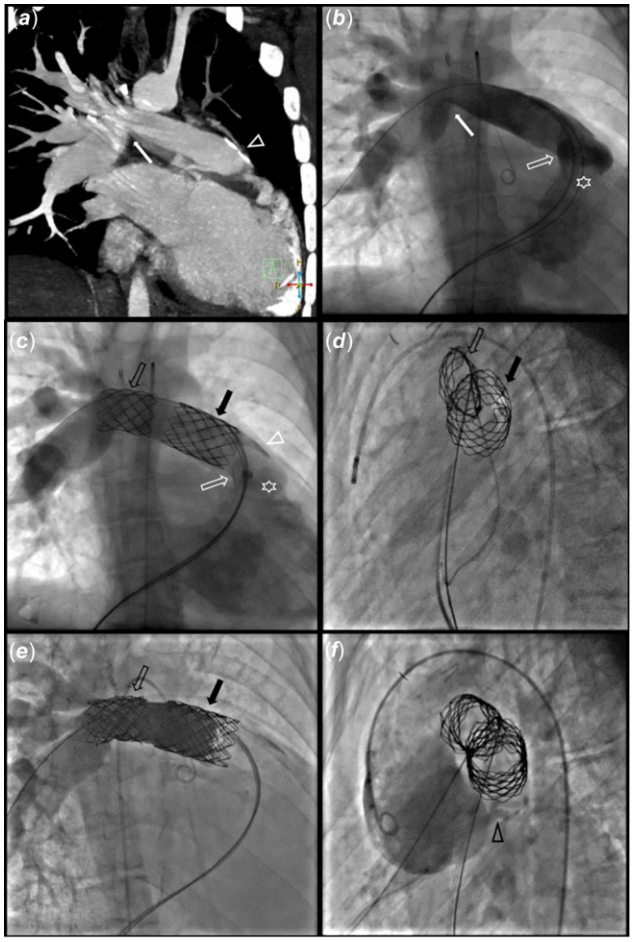

Figure 1. Two-stage stenting of the single right pulmonary artery and the Melody valve (Medtronic) implantation. ***a***: Contrast-enhanced CT scan: the heart shifted to the left due to discontinued left pulmonary artery and hypoplasia of the ipsilateral lung, dilated main pulmonary artery with calcifications at the site of transannular patch (arrow head), narrowed distal right pulmonary artery (white arrow) at the site of systemic-to-pulmonary artery shunt. ***b***: Initial angiography in posterior-anterior projection at the beginning of the first stage procedure: dilated main pulmonary artery (empty white arrow) at the level of the transannular patch, significant pulmonary regurgitation (white star), and distal right pulmonary artery narrowing (white star). ***C***: Control angiogram after the first stage of percutaneous treatment: stent implanted into the narrowed distal part of right pulmonary artery (black empty arrow), another stent implanted into the proximal part, as a "landing zone" (black arrow). Pigtail catheter as a marker indicating aortic arch course. ***d***: Initial fluoroscopy (left lateral projection) at the beginning of the second stage procedure (four months after the first stage): significant fractures and anterior-posterior stent crushing in the distal part of right pulmonary artery (black empty arrow), and minor fractures of the proximal stent (black arrow). ***e***: Control angiogram after the second stage of percutaneous treatment (posterior-anterior projection): two stents in the distal right pulmonary artery (black empty arrow); two stents and the valve in proximal segment (black arrow); and excellent function of the valve without regurgitation. Pigtail catheter as a marker indicating aortic course. ***f***: Final aortography in the left lateral projection: fully expanded stents in proximal and distal right pulmonary artery, and no compression on the aortic root or the left coronary artery (black empty arrowhead).

into the distal right pulmonary artery and the proximal stent was reinforced with a 45 mm Cheatham Platinum stent delivered on a 22 mm Balloon in Balloon catheter. Appropriate preparation of a landing zone was confirmed angiographically, and the Melody valve (Medtronic) was subsequently implanted on a 22 mm Ensemble delivery system (Medtronic) (Fig. 1e, f; Supplementary video S1). Final haemodynamic results were summarised in Supplementary Table T1.

Follow-up fluoroscopy at three (Fig. 2a, b) and eight months (Fig. 2c, d) after implantation showed unchanged proximal stents and the Melody valve, except for the distal stents, which had mild anterior-posterior flattening, without new fractures. Transthoracic echocardiogram showed good function of the implanted valve with trivial central regurgitation.

Discussion

The standard percutaneous pulmonary valve implantation procedure has been well described.[1–3] In situations where valve implantation in the pulmonary position is suboptimal due to the wide right ventricular outflow tract, close proximity to a coronary artery or potential compression of the aortic root, percutaneous pulmonary valve implantation in supra-pulmonary position may be an alternative solution.[4–6] In the presented patient with discontinuity of the left pulmonary artery, a long segment of proximal right pulmonary artery was available for valve positioning. This location allowed for avoiding compression on the dilated aortic root and its straight, tubular course reduced the risk of stents embolisation. However, due to the lack of a sufficient grip of the stent, it was left for endothelialisation along with obtaining a stable landing zone for subsequent valve introduction.[7,8]

Stenting of the distal part of right pulmonary artery was challenging considering the possibility of covering lobar branches, as well as cranially pulling the artery by the neonatal shunt and its subaortic course with dynamic forces leading to anterior-posterior compression.[9,10] The latter concerns turned out to be valid immediately at the beginning of the second stage of cardiac catheterisation when isocentre was set up and initial fluoroscopy was performed.

Implantation of additional stents provided significant improvement in diameters, which was confirmed in follow-up fluoroscopy. A slight ovalization of the distal stents raises concerns over longer capability of Cheatham Platinum stent withstanding compression from the ascending and descending aorta. Alternatively, stents with higher radial force and a pulmonary valve based on a stronger frame would have provided better long-term durability.

Conclusions

Percutaneous branch pulmonary valve implantation may be considered in selected patients as the less invasive alternative to the surgical treatment of right ventricular outflow tract dysfunction. When stents are placed in a pulmonary artery coursing under the aortic arch, higher risk of fracture should be acknowledged. Repeated fluoroscopy enables detection of stent damage, which may be successfully addressed with implantation of additional stents.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S104795112300416X.

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Competing interests. One author is a consultant for Medtronic.

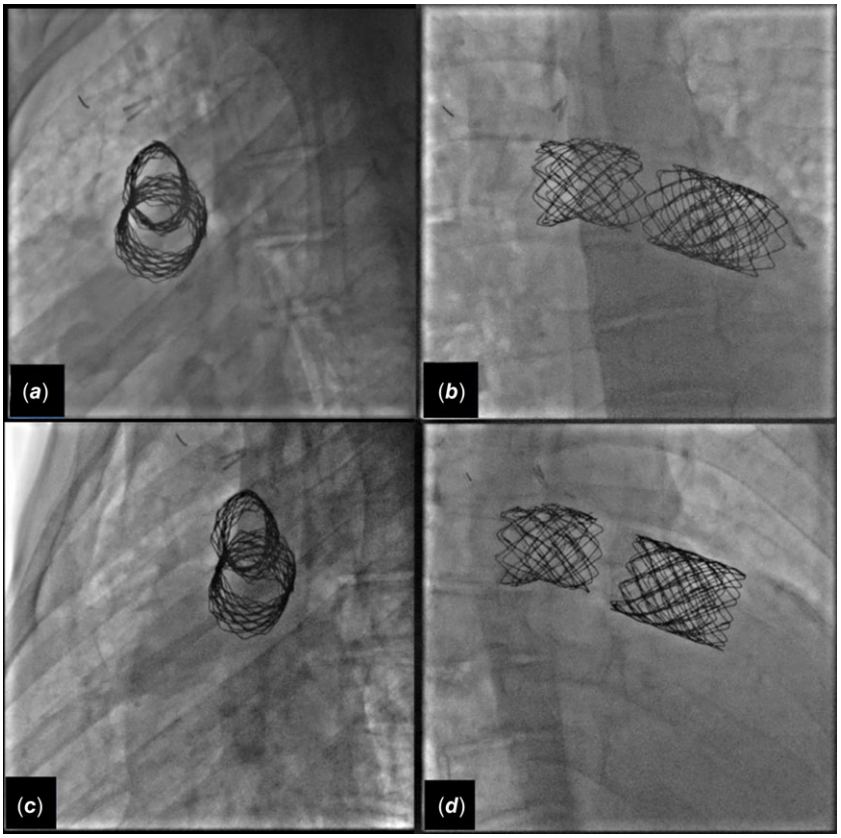

Figure 2. Follow-up fluoroscopy after stenting of the distal right pulmonary artery and proximal pulmonary valve implantation. Fluoroscopy in lateral (panel ***a***) and posterior-anterior (***b***) projection three months after procedure. Fluoroscopy in lateral (panel ***c***) and posterior-anterior (***d***) projection eight months after procedure. Stents and the valve in the proximal segment of right pulmonary artery maintain their correct shape. Mild anterior-posterior flattening of the distal stents, without new fractures.

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