Hybrid Pulmonary Valve Implantation: Injection of a Self-Expanding Tissue Valve Through the Main Pulmonary Artery
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An 8-year-old (35 kg) boy presented with progressive right ventricular outflow tract enlargement (28 mm) and progressive tricuspid regurgitation after transannular repair of tetralogy of Fallot and was scheduled for pulmonary valve replacement. To spare reoperation on full sternotomy, a transverse mini-thoracotomy through the third intercostal space was used to implant an injectible 29-mm stented porcine valve directly through an incision of the pulmonary artery bifurcation. The procedure was performed while rapid ventricular pacing and right ventricular unload by a short running femorally implanted cardiopulmonary bypass. The stented valve was fixed with three single sutures to avoid embolization. The interventional result was well with full competence of the valve. The boy was discharged at day 4 after the procedure.


The optimal timing of pulmonary valve replacement in patients with pulmonary valve regurgitation after repair of tetralogy of Fallot (TOF) still lacks clear criteria [1, 2]. Until now, putting in a tissue valve in the pulmonary position set the clock for life-long repeated exchange operations.

First corrective surgery on TOF was performed in this patient at the age of 15 months using a polytetrafluoroethylene patch to reconstruct an 8-mm right ventricular outflow tract (RVOT) to the diameter of 14 mm. Primary surgical outcome was good with no residual RVOT obstruction, no residual shunts, and an uneventful clinical course. On regular echocardiography follow-ups a continuous enlargement of the RVOT and the right ventricle was noticed. At the age of 5 years, right heart catheterization showed high-graded pulmonary regurgitation.

Right ventricular pressure was 27/0 to 3 mm Hg, and diameter of the pulmonary valve annulus was 25 mm. Three years later at the age of 8 years (35 kg), an echocardiography showed further enlargement of the pulmonary valve annulus to 28 mm (Fig 1) and further enlargement of the right ventricle and tricuspid valve annulus with the development of tricuspid valve regurgitation on echocardiography, thus giving us indication for pulmonary valve replacement. To spare reopening of the median thoracotomy, the new technique was applied as follows: after exposure of the main pulmonary artery through the third intercostals space a pursestring suture was put on the upper side of the pulmonary artery bifurcation. After full heparinization (300 IE/kg/kg), the femoral artery and vein was cannulated and connected to the cardiopulmonary bypass. Off pump, the pulmonary artery was incised within the pursestring suture, and the introducer system with the stented valve was placed.

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Fig 1. (A) Transthoracic short-axis echocardiographic view. Arrows mark the pulmonary valve annulus, which is scaled with a diameter of 29 mm (blue line). There are no residual pulmonary valves to be identified. (B) Transthoracic short-axis echocardiographic view (3.5 mHz transducer) showing the pulmonary artery as before. Color flow Doppler echocardiography in diastole shows free regurgitation of the pulmonary artery (red colored flow signal directed backward into the right ventricular outflow tract [RVOT]). (Ao = aorta; LPA = left pulmonary artery; PA = main pulmonary artery; RPA = right pulmonary artery.)

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under transesophageal guidance into the RVOT (Figs 2, 3). During a brief episode of rapid ventricular pacing, plus additional unloading of the right ventricle using the cardiopulmonary bypass, the valve was implanted. Thereafter, the introducer system was withdrawn and the pursestring suture was tightened. To avoid migration of the valve, the metal stent was anchored with three additional Prolene sutures (Ethicon Inc, Somerville, NJ) to the free wall of the pulmonary artery. Postoperative echocardiography demonstrated perfect valve function with no residual regurgitation (Fig 4). The patient recovered uneventfully and he was discharged on day 4 after surgery.

Comment

Transcatheter-based implantations of tissue valves for pulmonary regurgitation have been used sporadically as an alternative procedure to conventional valve surgery in recent years. Limitations of the method are given by the dimensions of the device (“too small”) or the introducer materials (“too large”). Until now, transcatheter-based valve implantations of stented tissue valves have been reported in patients with an RVOT that does not exceed 22 mm in diameter and have been preferably used in
calcified RVOTs [3, 4]. However, the most common condition after repair of TOF is pulmonary regurgitation and enlargement of the RVOT, not suitable for transcatheter sent fixation. To overcome this limitation, the Munich group has established a transventricular approach [5], which allows the implantation of stented porcine pulmonary valves with a diameter as great as 31 mm without the use of the cardiopulmonary bypass. However, this approach requires complete dissection of the heart after full sternotomy [5].

We believe this is the first report of a transpulmonary implantation of a 29-mm stented tissue valve (Shelhigh injectable porcine pulmonic valve; Shelhigh Inc, Fumeda Medizintechnik, Herne, Germany) through a transverse mini-thoracotomy in the third intercostals space in an 8-year-old boy (35 kg) after transannular repair of TOF. Our new technique allows the implantation of large stented tissue valves through a small mini-thoracotomy. Migration of the valve can be avoided after fixing the stent of the valve to the pulmonary artery wall with additional sutures, which might be important in patients with enlarged flexible RVOTs. The transpulmonary approach avoids ventriculotomy and myocardial damage. Although the procedure can theoretically be done without the use of cardiopulmonary bypass we recommend preparing the femoral vessels for cannulation to implant the stented valve safely during ventricular unloading and to be able to control unexpected events such as bleeding from the pulmonary artery or repositioning of the device.

In conclusion, hybrid implantation of large pulmonary valves can be safely performed without a full sternotomy. The available introducer system (stiff and straight) was developed for transventricular valve application and has to be modified for routine valve implantation through a mini-thoracotomy in a wide spectrum of different RVOT anatomies.

References

Percutaneous Closure of Left Ventricular Pseudoaneurysms After Ross Procedure

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Pseudoaneurysm formation is a dangerous, but uncommon, complication after the Ross procedure. We describe a patient in whom two pseudoaneurysms formed at the proximal suture line of the pulmonary autograft. These were successfully treated percutaneously, one by placement of an Amplatzer Septal Occluder (AGA Medical, Golden Valley, MN), and the other with coil embolization.


The use of pulmonary autografts for aortic valve replacement (the Ross procedure) has gained a role as treatment for aortic valve disease [1–4]. Pseudoaneurysm (PA) formation in the left ventricular outflow tract (LVOT) related to the proximal end of the pulmonary autograft has been reported [5–7]. The PAs were repaired surgically in these cases.

We report a patient in whom two PAs formed after the Ross procedure. These were treated percutaneously using an Amplatzer Septal Occluder (ASO) (AGA Medical, Golden Valley, MN) and Flipper coil embolization (Cook Medical, Bloomington, IN).

A 13-year-old boy with anomalous origin of the left coronary artery from the right sinus of Valsalva with an intramural course underwent an unroofing procedure. Immediately after the procedure he was found to have hemodynamically significant aortic valve regurgitation and after 6 months of medical therapy he underwent a Ross procedure. His postoperative course was uneventful. A few weeks later, routine echocardiogram showed a PA from the LVOT below the aortic valve. Follow-up weekly echocardiograms were performed and 2 weeks later revealed that the PA had grown in size to measure at least 2 × 5.6 × 4.4 cm.

Given his high surgical risk he was referred for percutaneous management. He was taken to the cardiac catheterization laboratory where a transesophageal echocardiogram confirmed the anatomy with the origin of the large PA posterior and rightward in the LVOT (Fig 1A). Angiography documented the presence of two PAs: one large PA extending from the posterior aspect of the LVOT just below the aortic valve and a

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