Cardiology in the Young (2018), **28**, 507–510
doi:10.1017/S1047951117002694

Brief Report

Pulmonary valve cusp augmentation for pulmonary regurgitation after percutaneous balloon pulmonary valvuloplasty of valvular pulmonary stenosis

Irfan Tasoglu, Atakan Atalay, Omer Nuri Aksoy, Vural Polat

Turkiye Yuksek Ihtisas Research and Training Hospital, Department of Pediatric Cardiovascular Surgery, Ankara, Turkey

Abstract Pulmonary valvular stenosis is a relatively common disorder, accounting for approximately 10% of all CHDs. Pulmonic valvular disease can get clinically detected at different ages of life. The more severe the obstruction, the earlier detected the valvular abnormality. Surgical pulmonary valvotomy has been available as a treatment since 1956. This article is about a case of pulmonary annular and valvular stenosis in a 1-year-old child, and it also explores surgical operation of this condition. Transannular patches are usually used within the 1st year of age in pulmonary annular and valvular stenosis. In recent years, anterior leaflet augmentation has been preferred for annulus enlargements. In our 1-year-old case, we expanded the annulus by the anterior leaflet expansion technique and we also augmented other leaflets by polytetrafluoroethylene patch.

Keywords: Pulmonary valve stenosis; augmentation; repair

Received: 25 September 2017; Accepted: 11 November 2017; First published online: 8 January 2018

Case report

A 1-year-old patient was brought into our hospital with easily induced fatigue and dyspnoea. About 6 months earlier, at another hospital, the patient had undergone pulmonary balloon valvotomy twice in 3 months owing to pulmonary stenosis. At the current examination, auscultation revealed a systolic ejection and regurgitant murmur. Transthoracic echocardiography revealed severe pulmonary stenosis and insufficiency that was due to prolapse and incomplete coaptation of the leaflets of the pulmonary valves. Pulmonary artery valvular transgradient pressure was 100 mmHg and mean pressure was 51 mmHg. The other echocardiographic findings were as follows: a left ventricular ejection fraction of 0.60, normal-sized left chambers, enlarged right chambers, and a dilated main pulmonary artery after stenosis.

Standard cardiopulmonary bypass was performed. After pulmonary arteriotomy, we saw right pulmonary leaflet perforation from the commissure line adjacent to the anterior pulmonary leaflet, anterior leaflet seemed thickened, and there was perforation from the adjacent commissural line of the right pulmonary leaflet. The left pulmonary leaflet seemed thickened and retracted. Because of the near-normal morphology of the leaflets, we made the decision to repair them. The incision was extended from the basal mid cusp line of the anterior leaflet to below the annulus to provide adequate enlargement of the right ventricular outflow tract. Enlargement of the pulmonary annulus remained under control via passing a hegar bougie (13 mm), which was calculated in accordance with the body surface area. Polytetrafluoroethylene was used as a patch. Patch size to enlarge the anterior leaflet and right ventricular outflow tract was estimated by using the hegar bougie. Right pulmonary leaflet was repaired using a 0.1-mm polytetrafluoroethylene patch. The left pulmonary leaflet was opened towards the annulus level, and the 0.1-mm polytetrafluoroethylene patch was used to enlarge the coaptation zone (Fig 1). Perioperative pulmonary artery was then filled with saline solution so as to complete the assessment of the leaflets. After the operation, control transthoracic echocardiography showed minimal

Correspondence to: A. Atalay, MD, Turkey Yuksek Ihtisas Hospital, Ankara 06460, Turkey. Tel: +90 5053593390; Fax: +90 312 306 10 00; E-mail: atakan1973@yahoo.com

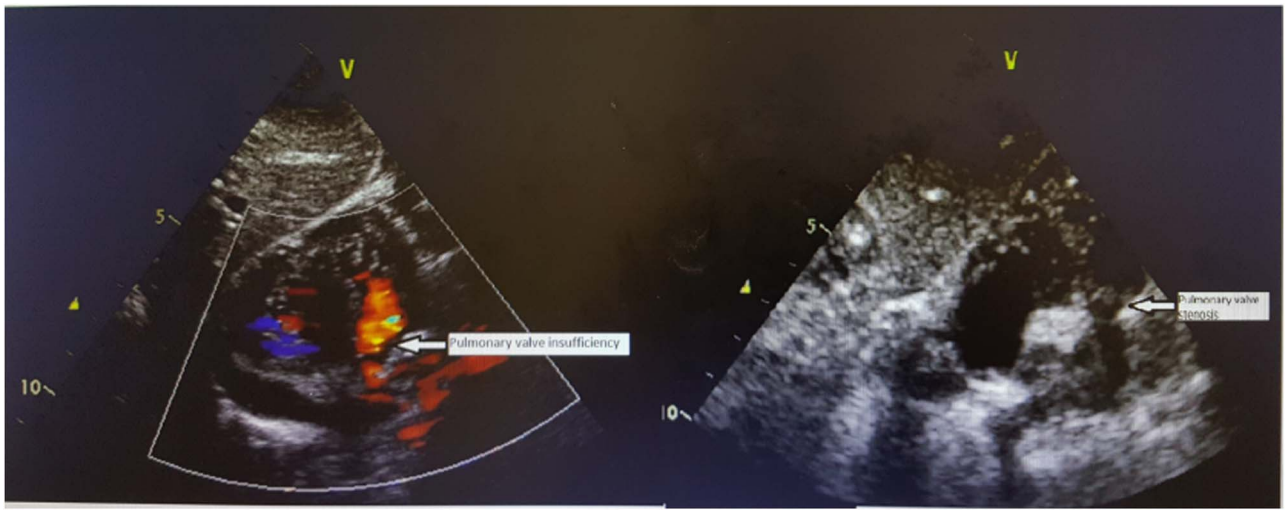

Figure 1.
Intraoperative view of polytetrafluoroethylene augmented valves.

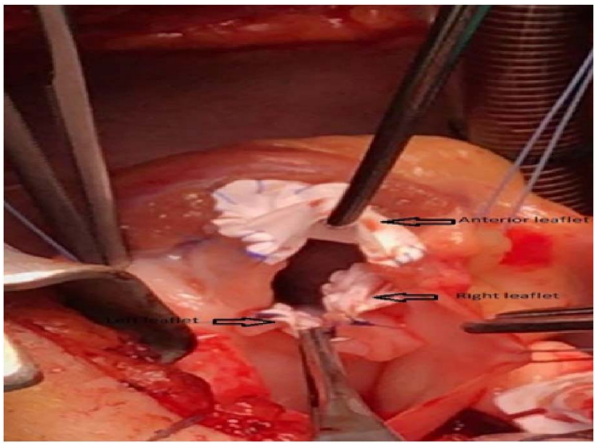

Figure 2.
Postoperative and preoperative echocardiography.

pulmonary insufficiency. As well as 18 mmHg gradient at the pulmonary artery was detected with decrease in the size of the right chambers and it showed an improved left ventricular systolic function. After this, the patient was discharged without any problems. During the 1st month's control, echocardiography revealed a 15-mmHg gradient at the level of the valve and 1st-degree regurgitation (Fig 2).

Discussion

Congenital pulmonary valve stenosis is a common CHD. Isolated pulmonary valve stenosis comprises 8–10% of all the CHDs.[1] Valvar stenosis is the most common type of pulmonary stenosis, and is typically characterised by fused or absent commissures with thickened leaflets of the pulmonary valve.[1]

Surgical treatment was the only option for valvular pulmonary stenosis before the use of balloon angioplasty.[2] The surgical approach evolved from closed valvulotomy, which was first performed in 1948, to open valvulotomy using inflow occlusion, and finally open valvulotomy with the use of cardiopulmonary bypass.[3] With the latter technique, the extent of surgery can be adapted to the needs of each individual patient and can vary from a simple commissurotomy to a complete right ventricular outflow tract reconstruction. Between 2–4 years of age is the most ideal age for pulmonary valvuloplasty, and the ideal age for surgery is 5–12 years.[4]

While surgically recognising potential advantages of a less invasive approach, the first attempts at percutaneous catheter-based dilation of stenotic pulmonary valves were performed in the 1950s[5,6]. Balloon pulmonary valvuloplasty has significantly improved and the approach has become the standard of care for treating pulmonary valve stenosis.[7]

Although pulmonary valvuloplasty remains the preferred treatment for isolated pulmonary valve stenosis, it is not definitive therapy in the setting of complex CHD. However, it can occasionally be applied to these more complex patients as a palliative treatment until more definitive surgical repair can be performed.

The mortality and major complications rate of transcatheter balloon valvuloplasty have been found in range between 0.24 and 0.35%, respectively, in a multi-centre study.[8]

Recurrent pulmonary valve stenosis is observed in the frequency of 8–14 % after initial intervention[9], Percentage of re-intervention as high as 30% was noted in neonates compared with older children who are mostly suffered from re-stenosis. The incidence of

https://doi.org/10.1017/S1047951117002694 Published online by Cambridge University Press

pulmonary valve regurgitation after pulmonary balloon valvuloplasty is reported to be between 41 and 88%.[9,10] Our patient had severe pulmonary insufficiency after balloon valvuloplasty owing to the incomplete coaptation of the leaflets.

Because of higher percentage of re-stenosis after transcathater balloon valvotomy in neonates and young children, surgical valvotomy has been the preferred treatment for pulmonary valve stenosis in most occasions. Here we reported a 1-year-old infant who had balloon re-intervention twice. After transcatheter balloon valvuloplasty, she had severe pulmonary regurgitation and recurrent stenosis. She approximately had 100 mmHg transvalvular pulmonary valve gradient, and thus we had to operate as soon as possible.

Especially dysplastic pulmonary valves are resistant to balloon valvuloplasty and simple valvotomy is usually not enough. Occasionally, transannular patch is required to relieve the right ventricular outflow tract obstruction but it might cause significant pulmonary insufficiency. In the long term after valvotomy, freedom from re-stenosis is excellent.[11] Nonetheless, severe pulmonary insufficiency is common and ranges between 57 and 90% in different studies.[11,12] In our patient's situation, three cusp augmentations prevent pulmonary insufficiency.

When correcting pulmonary stenosis or insufficiency, most surgeons use a homograft or xenograft; however, they sometimes use a mechanical prosthesis or a self-expanding stented valve.

Leaflet augmentation, valved homografts, and xenografts were proposed as the most anatomic and physiologic ways to resolve right ventricular outflow tract stenosis and insufficiency, but all will eventually need replacement because of patient growth and conduit deterioration.[13] Pulmonary allografts were extensively used for right ventricular outflow tract reconstruction. They were not always readily available, were less durable, and developed higher degrees of pulmonary stenosis particularly in patients under the age of 2 years. Children with allograft right ventricular outflow tract reconstruction frequently required early valve reoperation.[14]

The use of a monocusp valve created from pericardium, xenograft valve cusps, fascia lata, autologous pulmonary artery wall, or polytetrafluoroethylene has been shown to decrease short-term pulmonary insufficiency.[15] However, even the monocusp has limited durability. Gundry et al[15] reported that by 24 months only 14% of their patients with a homograft monocusp-bearing transannular patch had a competent valve despite excellent short-term function. Similarly, in a report from the University of Indiana, most of the patients had deterioration of the polytetrafluoroethylene monocusp valve function by the 3rd year, even though the valve function was still better when compared with the free pulmonary insufficiency experienced by the patients with a transannular patch. However, Sasikumar et al[16] reported that calcification and loss of mobility were observed in a significant number of patients 1 year after the operation.

Bileaflet hand-sewn pulmonary valves were seen in previous publications; polytetrafluoroethylene (PTFE) patches may be preferable in the augmentation of heart valves in this age group because of its ease of use. Their shape and size allow placement in young children with a reasonable expectation that they will remain competent with growth of the native annulus and not require replacement.[17] Hand-sewn pulmonary valve augmentation with PTFE is more durable at long-term follow-up.

The augmentation of the three pulmonary valve cusps with polytetrafluoroethylene is simple, it does not significantly prolong the operation, reduces the degree of pulmonic regurgitation in the immediate postoperative period, and improves the early outcome. However, our technique presented here reduces pulmonic regurgitation while avoiding risks such as calcification associated with the use of homografts and heterografts. Use of a polytetrafluoroethylene augmentation of all pulmonary valves prevent short-term pulmonary valve insufficiency and significantly reduces long-term pulmonary valve insufficiency. It is inexpensive, easy to construct, and demonstrates no evidence of stenosis, calcification, or embolisation. Despite slightly longer cardiopulmonary bypass times, it reduces ICU stay and minimises operative morbidity and mortality.

Acknowledgements

None.

Financial Support

This research received no specific grant from any funding agency, commercial, or not-for-profit sectors.

Conflicts of Interest

None.

Ethical Standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national guidelines and with the Helsinki Declaration of 1975, as revised in 2008, and has been approved by the institutional committees (Boston Children's Hospital).

References

1. Moss AJ, Adams FH. Heart Disease in Infants, Children, and Adolescents: Including the Fetus and Young Adults, 7th edn. Lippincott Williams & Wilkins, Philadelphia, PA, 2008.
2. Kan JS, White RI, Mitchell WE, Andersen JH, Gardner TJ. Percutaneous transluminal balloon valvuloplasty for pulmonary valve stenosis. Circulation 1984; 69: 554–560.
3. Brock R. The surgical treatment of pulmonary stenosis. Br Heart J 1961; 23: 337–356.
4. Yadav SK. The diagnosis and treatment of pulmonary valve stenosis in children. Asian Journal of Medical Sciences. DOI: 10.3126/ajms.v6i6.12017.
5. Rubio-Alvarez V, Limon R, Soni J. Intracardiac valvulotomy by means of a catheter. Arch Inst Cardiol Mex 1953; 23: 183–192.
6. Rubio V, Limon-Lason R. Treatment of pulmonary valvular stenosis and tricuspid stenosis using a modified catheter. 2nd World Congress of Cardiology, Washington, DC, 1954.
7. Rao PS. Percutaneous balloon pulmonary valvuloplasty: state of the art. Catheter Cardiovasc Interv 2007; 69: 747–763.
8. Stanger P, Cassidy SC, Girod DA, Kan JS, Lababidi Z, et al. Balloon pulmonary valvuloplasty: results of the Valvuloplasty and Angioplasty of Congenital Anomalies Registry. Am J Cardiol 1990; 65: 775–783.
9. Karagoz T, Asoh K, Hickey E, Chaturvedi R, Lee KJ, et al. Balloon dilation of pulmonary valve stenosis in infants less than 3 kg: a 20-year experience. Catheter Cardiovasc Interv 2009; 74: 753–761.
10. Rao PS, Galal O, Patnana M, Buck SH, Wilson AD. Results of three to 10 year follow up of balloon dilatation of the pulmonary valve. Heart 1998; 80: 591–595.
11. Hayes CJ, Gersony WM, Driscoll DJ, Keane JF, Kidd L, et al. Second natural history study of congenital heart defects. Results of treatment of patients with pulmonary valvar stenosis. Circulation 1993; 87: 28–37.
12. Nugent EW, Freedom RM, Nora JJ, Ellison RC, Rowe RD, et al. Clinical course in pulmonary stenosis. Circulation 1977; 56: 38–47.
13. Sano S, Karl TR, Mee RB. Extracardiac valved conduits in the pulmonary circuit. Ann Thorac Surg 1991; 52: 285–290.
14. Homann M, Haehnel JC, Mendler N, et al. Reconstruction of the RVOT with valved biological conduits: 25 years experience with allografts and xenografts. Eur J Cardiothorac Surg 2000; 17: 624–630.
15. Gundry SR, Razzouk AJ, Boskind JF, Bansal R, Bailey LL. Fate of the pericardial monocusp pulmonary valve for right ventricular outflow tract reconstruction: Early function, late failure without obstruction. J Thorac Cardiovasc Surg 1994; 107: 908–912.
16. Sasikumar D, Sasidharan B, Tharakan JA, Dharan BS, Mathew T, Karunakaran J. Early and 1-year outcome and predictors of adverse outcome following monocusp pulmonary valve reconstruction for patients with tetralogy of Fallot: a prospective observational study. Ann Pediatr Cardiol 2014; 7: 5–12.
17. Nunn GR, Bennetts J, Onikul E. Durability of hand-sewn valves in the right ventricular outlet. J Thorac Cardiovasc Surg 2008; 136: 290–296.