Ascending aortic approach for balloon aortic valvuloplasty with concomitant bilateral pulmonary artery banding in a very low-birth-weight neonate with critical aortic stenosis and poor left ventricular function

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Abstract

An 1186-g infant was born at 27 weeks' gestation. Echocardiography showed critical aortic stenosis, a dilated left ventricle (left ventricular end-diastolic diameter, 16.9 mm), and poor left ventricular function (left ventricular ejection fraction, 8.5%). Due to duct-dependent systemic circulation, the patient underwent a hybrid intervention consisting of bilateral pulmonary artery banding (PAB) and balloon aortic valvuloplasty (BAV) via the ascending aorta on day 2. A stainless steel tip and a 6-French introducer were combined to create an access device. The access device was inserted into the ascending aorta, through which balloon catheters were manipulated. On day 4, echocardiography showed a left ventricular ejection fraction of 48% and dominant antegrade blood flow in the aortic arch. The pulmonary artery bands were removed and the ductus was clipped on day 8 to establish in-line circulation. After re-balloon aortic valvuloplasty for restenosis, the patient was discharged from the hospital at 7 months of age. The clinical implications of this case are: the ascending aortic approach is feasible for BAV in low-birth-weight neonates; and bilateral PAB performed concomitantly with BAV may be efficient for neonates with critical aortic stenosis and poor left ventricular function.

Keywords: Balloon aortic valvuloplasty • Aortic stenosis • Vascular access device • Ascending aortic approach • Bilateral pulmonary artery banding • Low-birth-weight neonate

INTRODUCTION

Balloon aortic valvuloplasty (BAV) is a first-line-treatment option for critical aortic stenosis (AS) [1, 2]. Vascular access for balloon valvuloplasty is a concern in very small infants [1–3]. Neonatal critical AS is often accompanied by left ventricular (LV) systolic dysfunction and, therefore, entails morbidity and mortality [3–5].

CASE REPORT

An 1186-g male infant was born at 27 weeks of gestation by cesarean section for a complicated pregnancy due to maternal infection. Echocardiography showed a critically stenotic bicuspid aortic valve, a patent ductus arteriosus (PDA), and an atrial septal defect. An aortic valve annular diameter was 4.5 mm, an LV end-diastolic diameter (LVDd) was 16.9 mm (z score = +3.0 [6]), and an LV ejection fraction (LVEF) was 8.5% (Fig. 1). There was no mitral stenosis or aortic coarctation on echocardiography. Retrograde blood flow was dominant in the aortic arch. Prostaglandin E1 infusion was initiated to maintain systemic flow via the PDA. Due to congestive heart failure, hypoxic gas therapy using nitrogen was started on day 1.

On day 2, the patient underwent a hybrid intervention consisting of bilateral pulmonary artery banding (PAB) and BAV. The bilateral pulmonary arteries were banded with 8.5-mm-circumference polytetrafluoroethylene (PTFE) bands via a median sternotomy using the modified methods described by Galantowicz et al. [7]. The bands were fashioned by creating a 2.5-mm-wide ring from a 4.0-mm PTFE tube graft. After bilateral PAB, the systolic blood pressure increased from 35 mmHg to 45 mmHg and systolic oxygen saturation remained at 70% on 21% inspired oxygen. Intraoperative epicardial echocardiography or transesophageal echocardiography was not performed due to the patient's small size. A hand-made stainless steel tip and a 6-French Radifocus introducer (Terumo Corporation, Tokyo, Japan) were combined to create an access device (Fig. 2). This stainless steel tip was a cylinder with a luminal diameter of 1.5 mm and characterized by a mushroom-like projection at the tip to prevent inadvertent dislodging. The access device was inserted into the ascending aorta through a purse-string suture. A guide wire inserted through the device easily crossed the aortic valve under fluoroscopic guidance. The aortic valve was dilated retrogradely with a 4 mm Sterling balloon (Boston Scientific Corporation, Natick, MA, USA), measuring 90% of the aortic valve annular diameter (Fig. 2). Total fluoroscopy time was
10 min. After valvuloplasty, the device was removed and the purse-string suture was tied. Shortly after the operation, echocardiography showed trivial aortic regurgitation and forward blood flow via the aortic valve reaching the aortic arch. Prostaglandin infusion was continued.

On day 4, echocardiography showed improved LV function (LVEF 48%, LVDd 12.3 mm). Antegrade aortic arch blood flow was dominant. The systemic saturation ranged between 80% and 90% with 40% inspired oxygen. On day 8, the PABs were removed and the PDA was clipped to establish biventricular in-line circulation. After PDA clipping, echocardiography showed trans-aortic valve flow of 1.7 m s$^{-1}$.

Successful BAV via the ascending aorta was performed on day 56 for recurrent AS with trans-aortic valve flow of 4.4 m s$^{-1}$ on echocardiography. At 7 months of age, the patient was discharged from the hospital with a weight of 3893 g. Echocardiography at discharge disclosed trans-aortic valve flow of 3.3 m s$^{-1}$, LVEF of 49%, and LVDd of 23.3 mm.

**DISCUSSION**

Four approaches for BAV in low-birth-weight infants have been reported in the literature [1–3, 8]. The first approach is the femoral arterial approach, which is the vascular access of choice for BAV. Shortcomings of this approach include occlusion of the artery, disruption of aortic layers, and difficulties in advancing the catheter across the valve [1, 2]. Egito et al. reported that all 20 neonates who underwent balloon dilatation through a femoral artery initially had pulse loss, with late restoration in 35% [9]. It is presumed that the risk of occlusion of the artery is even higher in low-birth-weight infants. The second approach is the umbilical arterial approach. Podnar et al. reported four neonatal cases with successful BAV via the umbilical artery, including two low-birth-weight neonates [3]. The third and fourth approaches include the right carotid artery cut-down approach [2] and the trans-apical approach [8].

In the present patient, we elected a median sternotomy for bilateral PAB. A concomitant ascending aorta approach for BAV eliminated vascular complications in a very low-birth-weight infant. Deep insertion of a sheath may result in insufficient allowance for balloon dilatation, whereas shallow insertion of a sheath may result in inadvertent removal of the sheath. To solve this problem, we invented a new access device. The distance from the aortic valve to the end of the access device inserted was 13.2 mm. This distance was long enough to comfortably manipulate a balloon catheter with a balloon length of 20 mm, resulting in very short fluoroscopic time (Fig. 2).

Neonatal critical AS presents soon after birth with signs of congestive cardiac failure or cardiogenic shock. Some of these cases show impaired LV systolic function, resulting in PDA-dependent systemic circulation [4]. The present patient had sufficient LV size but could not maintain systemic circulation due to impaired LV function. Because LV-dependent systemic circulation was deemed unattainable, bilateral PAB was chosen to achieve temporary, well-balanced, right-ventricle-dependent systemic circulation. Poor LV function that cannot maintain the systemic circulation worsens postoperative mortality in neonatal critical AS [3–5]. Brown et al. reported bilateral PAB and PDA stenting performed 26 days after BAV for pulmonary hypertension [10]. In the present case, bilateral PAB was performed concomitantly with BAV and stabilization of circulation by PAB was achieved in the early postoperative period.

Based on our experience of bilateral PAB in low-birth-weight neonates, we attempted 8.5-mm-circumference bilateral PAB. A 10-point increase in systolic blood pressure and acceptable oxygen saturation after attempted bilateral PAB indicated proper tightness of the bands [7].

**CONCLUSION**

An ascending aortic approach is feasible for BAV in low-birth-weight neonates with critical AS, and bilateral PAB...
concomitantly with BAV may be efficient for neonates with critical AS and poor LV function.

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**REFERENCES**


