

A Novel Approach: Trans-ascending Aorta Balloon Aortic Valvuloplasty via Sternotomy for Treating Severe Valvular Aortic Stenosis in a Low-Weight Infant

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ABSTRACT

Background: Severe congenital aortic stenosis in infants is a life-threatening congenital heart anomaly that is typically treated using percutaneous balloon aortic valvuloplasty.

Methods: The usual route is the femoral artery under radiographic guidance. However, this procedure may be limited by the small size of the femoral artery in low-weight infants. An infant weighing only 7 kg with severe aortic stenosis (peak gradient was 103 mmHg) was successfully treated with a novel approach, that is trans-ascending aorta balloon aortic valvuloplasty guided by transesophageal echocardiography.

Results: The patient tolerated the procedure well, and no major complications developed. After the intervention, transesophageal echocardiography indicated a significant reduction of the aortic valvular peak gradient from 103 mmHg to 22 mmHg, no aortic regurgitation was found. Eighteen months after the intervention, echocardiography revealed that the aortic valvular peak gradient had increased to 38 mmHg and that still no aortic regurgitation had occurred.

Conclusions: In our limited experience, trans-ascending aorta balloon aortic valvuloplasty for severe aortic stenosis under transesophageal echocardiography guidance effectively reduces the aortic peak gradient. As this is a new procedure, long-term follow up and management will need to be established. It may be an alternative technique to treat congenital aortic stenosis in low-weight patients.

INTRODUCTION

Currently, percutaneous balloon aortic valvuloplasty (BAV) is an accepted first-line treatment for severe congenital aortic stenosis (AS) in infants [Lababidi 1984; Ewert 2011], but the small size of the femoral artery in low-weight infants makes it difficult to accommodate a large sheath. In addition, approaches through the carotid artery and umbilical artery

greatly increase the risk of puncture and infection [Krishnaswamy 2012]. However, there is another potential approach through the ascending aorta, where the passage through the aortic arch is avoided, and the balloon catheter can easily cross the aortic valve. So, more detailed information regarding valve morphology and annular dimensions is required to guide valvuloplasty.

Fluoroscopy provides some information in this regard, but this technique does not provide real time definition of valve structures or the location of catheters or devices.

Transesophageal echocardiography (TEE) may be more useful in this context [Krishnaswamy 2012].

A novel approach: BAV through the ascending aorta under TEE guidance has not been reported thus far.

We present a case wherein BAV through the ascending aorta under TEE guidance was used for the successful management of severe AS in an infant weighing just 7 kg.

METHODS

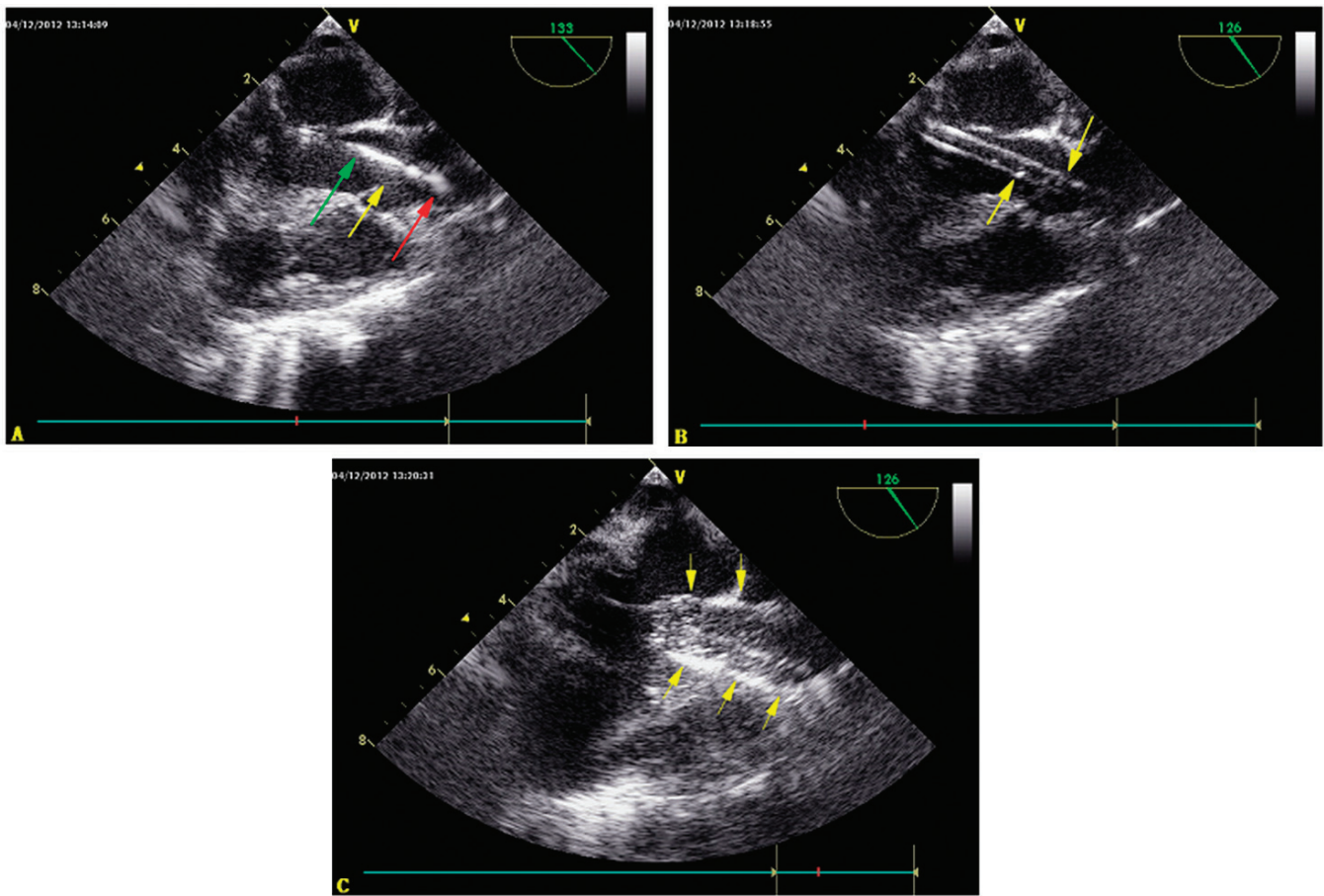
On March 31, 2012, a 22-month-old male infant who was small for his age (weight, 7 kg; height, 75 cm) was treated at our hospital and diagnosed with an ejection systolic murmur.

Transthoracic echocardiography revealed severe AS with a bicuspid aortic valve and a peak gradient (PG) of 103 mmHg without aortic regurgitation (AR). The left heart function was slightly impaired with an ejection fraction (EF) of 53%. Transthoracic echocardiography also revealed concentric left ventricular hypertrophy, but no other congenital cardiac malformations were found. The size of the aortic annulus was 15 mm, and the dimension of the ascending aorta was 20 mm. Because the patient was a low-weight infant, trans-ascending aortic BAV under TEE guidance was planned.

Informed consent for a BAV guided by TEE was provided by the parents. On April 12, 2012, the patient received general anesthesia in the operating room. For anticoagulation, full heparinization (1 mg/kg body weight) was administered. Partial median sternotomy was performed, and the ascending aorta was punctured using an 18-G BD trocar. Subsequently, under the guidance of TEE, a 0.035-inch guide-wire was introduced into the ascending aorta and advanced through the orifice of the aortic valve to the left ventricle (LV) (Figure 1A).

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A. Transesophageal echocardiography showing the guide-wire from the ascending aorta (red arrow) across the aortic valve (yellow arrow) to the left ventricle (green arrow); B. Transesophageal echocardiography showing the delivery sheath from the ascending aorta to the left ventricle (yellow arrow); C. Transesophageal echocardiography showing balloon inflation (yellow arrow).

Echocardiography Results Measured Before and After BAV

Object	Before Procedure	Post Procedure						
		15 minutes	4 days	1 month	3 months	6 months	12 months	18 months
PG, mmHg	103	22	23	25	28	33	36	38
LVEF(%)	53	55	62	64	65	66	68	69
IVS(d), mm	7.1	7.0	6.6	6.2	5.7	5.3	5.2	5.3
LVPW(d), mm	6.8	6.7	6.5	5.9	5.3	5.1	5.1	5.2

BAV indicates balloon aortic valvuloplasty; PG, peak systolic gradient through aortic valve; LVEF, left ventricular ejection fraction; IVS(d), thickness of interventricular septum (diastole); LVPW(d), thickness of left ventricular posterior wall (diastole).

A 9-F delivery sheath (Shanghai Shape Memory Alloy Co. Ltd, Shanghai, China) was fed over the guide-wire and manipulated into the LV through the aortic valve, and the guide-wire was then pulled out (Figure 1B). A 15-mm diameter balloon dilation catheter (BALT, 10 Rue, Croix Vigneron 95160 Montermorency France; length, 25 cm) was positioned across the aortic valve, and subsequently, the balloon was hand inflated three times (less than 5 seconds every time) with normal saline (Figure 1C) and withdrawn.

The catheter and sheath were removed, and the puncture site was closed using a purse string suture. The patient tolerated the procedure well, and no major complications, such as malignant arrhythmia, developed.

RESULTS

After the intervention, TEE indicated a reduction of the peak valvular gradient from 103 mmHg to 22 mmHg, no AR was found. An improvement of the left ventricular EF to 62% was observed within 4 days, and the patient's condition improved.

Eighteen months after the intervention, echocardiography revealed that the aortic valvular PG had increased to 38 mmHg and that still no AR had occurred. The left heart function had improved compared with before the intervention, and the thickness of the LV wall had decreased (Table). The patient was asymptomatic.

DISCUSSION

Severe congenital AS is a difficult clinical condition and may cause sudden death, heart failure, and severe arrhythmia. Therefore, it is necessary to treat this condition before such severe complications occur [Lerakis 2010]. In addition to supportive medical care, the relief of the stenosis is most important to patient survival [Feltes 2011].

Surgical aortic valvotomy was not an option for this patient because of the small aortic valve diameter. Percutaneous BAV is the primary therapy for congenital AS [Maskatia 2011], but this patient's 7-kg weight resulted in a femoral artery size that made it difficult to accommodate the necessary 9-F sheath. Therefore, a new approach was used.

This new approach, trans-ascending aortic balloon valvuloplasty for severe AS under TEE guidance, has some advantages that distinguish it from other approaches.

First, this approach has the shortest length from the puncture point to the aortic valve, and passage through the aortic arch is avoided. Real-time TEE guidance and monitoring yields good imaging of the guide-wire, delivery sheath, and balloon dilation catheter in the aorta and LV. Therefore, TEE accurately can guide the wire, sheath, and catheter across the stenotic aortic valve, thus allowing a perfect alignment of the sheath with the aortic valve and fast crossing of the stenotic aortic valve orifice. Additionally, the procedure reduces perforation of the aortic valve and aortic wall complications.

Second, this approach uses the largest available vessel in small infants, namely, the ascending aorta, which is large enough to accommodate a large sheath. The approach also preserves the femoral arteries for future transcatheter

intervention, if necessary. Additionally, in the case of fatal arrhythmia during balloon dilatation, surgeons quickly can perform an open cardiac massage to ensure the safety of patients.

Third, TEE is noninvasive and involves no radiation [Jayasuriya 2011]. Therefore, the patient and staff avoid radiation exposure. TEE provides accurate measurements of the aortic annulus diameters; this facilitates selection of a suitable balloon dilation catheter, resulting in a greatly reduced incidence of AR. TEE can be used to measure the aortic valvular PG immediately before and after balloon dilatation at any time and assess the effect of valvuloplasty and identify post-procedural complications, such as AR in a timely and accurate manner.

After our successful BAV, the aortic valvular PG decreased from 103 mmHg to 22 mmHg. No AR occurred, and LV function improved within a few days. At the 18-month follow-up, echocardiography revealed an increase of the aortic valvular PG to 38 mmHg and improved left heart function (EF, 69%), this is an acceptable effect [Ewert 2011].

Limitations

The limitation of this method is that an incision is required in the chest wall.

In our limited experience, trans-ascending aorta BAV for severe AS under TEE guidance effectively reduces the aortic PG and avoids some of the shortcomings of traditional percutaneous BAV.

To the best of our knowledge, this is the first case in which TEE-guided BAV with a trans-ascending aorta approach has been used in an infant with congenital severe AS. As this is a new procedure, long-term follow up and management will need to be established.

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