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Case Report

Antegrade transvenous balloon angioplasty for coarctation of the aorta in infants with ventricular septal defect

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ABSTRACT

For a newborn, surgical correction has been the primary treatment of native coarctation at most centers; however, there has been an increased use of balloon angioplasty (BA). The anterograde transvenous (AT) technique is another alternative way for coarctation (AoC) angioplasty in low weight patients with large ventricular septal defect (VSD).

Four, 5-day-old to 7-month-old, infants weighing 2500, 2700, 2800, and 3400 g, respectively presented to emergency unit (EU) with cyanosis, tachypnea, and loss of weight. Echocardiography demonstrated AoC and VSD. All four children were admitted to the EU with hemodynamic compromise and critically ill status. We used femoral vein for sheath and used VSD to enter left ventricle from right antegrade route, and performed BA without any complication.

AT described in this report is another alternative way for coarctation angioplasty in patients with large VSD. We suggest that AT BA can be applied to small infants in situations where surgery might have been hazardous.

1. Introduction

Surgical correction is the primary option at most centers to treat native coarctation. In young patients, the surgical resection of native coarctation of the aorta (CoA) is a good option, with early and long-term results. Different surgical techniques are used according to the type/localization of the disease, such as extended arch aortoplasty, which has shown excellent results.[1,2]

Although there are good results in reports of the surgical correction of neonates with CoA and cardiogenic shock,[3] in critically ill infants, emergency surgery can sometimes be challenging because of limiting technical issues or patients' poor clinical conditions.[4] These patients' conditions are likely to worsen, even if the obstruction is relieved immediately. Balloon dilatation is an effective transient palliation for newborns with critical coarctation and left ventricle (LV) dysfunction. Nevertheless, coarctation is inevitable and must be addressed. Balloon dilatation has shown limited results,

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Table 1 – Clinical characteristic, echocardiographic, and angiographic finding of all patients.

Patient no	Age	Weight (g)	Diagnosis	Gradient	Status of PDA	Residual gradient	Long term outcome
Patient 1	5 Days	2500	Mitral atresia + Hypoplastic LV + VSD + DORV + AoC + PAPVR	35	+	5	Single ventricle palliation
Patient 2	5 Months	6000	Parachute mitral valve + Supramitral membrane + MS + AoC + VSD + PHT	22	+	1	VSD closure supramitral ring resection
Patient 3	7 Days	2700	AoC + VSD + PHT	52	+	2	VSD closure AoC repair
Patient 4	15 Days	2800	AoC + VSD + Necrotizing enterocolitis	61	+	40	VSD closure AoC repair

AoC, aortic coarctation; DORV, double-outlet right ventricle; LV, left ventricle; MS, mitral stenosis; PAPVR, partial abnormal pulmonary venous return; PHT, pulmonary hypertension; VSD, ventricular septal defect.

with an overall reintervention rate of 53%; therefore, it should mainly be performed as a rescue procedure or for recurrent CoA in neonates.[1]

There are studies comparing surgery and balloon dilatation, where significantly lower reintervention and complication rates were achieved after surgery than after balloon angioplasty (BA).[5,6] However, the 2011 American Heart Association (AHA) pediatric guidelines noted an increased use of BA for a transcatheter intervention in CoA.[7] During cardiac catheterization, the use of the retrograde approach via the femoral artery, after the introduction of the catheter into a vessel of narrow lumen, infrequently led to the observation of a vascular injury or occlusion. The anterograde transvenous (AT) technique is another alternative to the retrograde arterial approach for coarctation angioplasty in patients with a low weight and with a ventricular septal defect (VSD). In this study, we describe BA via an anterograde approach in four infants with CoA.

2. Technique

All the patients were evaluated clinically, and cardiac defects were revealed by transthoracic echocardiography. Antegrade transvenous cardiac catheterization was performed in patients with a poor clinical condition caused by CoA and who had a VSD. Cardiac catheterization was undertaken under general anesthesia. Access was obtained through the femoral vein using Seldinger's technique. A 4/5-Fr sheath was placed into the right femoral vein. Diagnostic angiography was performed using catheters of different sizes and shapes. After the diagnostic catheterization, 4/5-Fr JR4 catheters were positioned at the right ventricular apex. The tip of the catheter was redirected through the VSD through clockwise rotation and slight retractions. A coronary or 0.035-inch hydrophilic guide wire (Terumo Medical Systems, Tokyo, Japan) was advanced through the catheter. The guide wire was placed into the aorta through the VSD using gentle manipulation. During this procedure, close attention was paid to ensure the catheter tip was free. After the guide wire was satisfactorily positioned in the aorta, the catheter was advanced to the aorta over the guide wire. Pressure gradients were recorded, and diagnostic angiography for coarctation was performed. Then, the guide wire was placed into the descending aorta. The aortic dimensions of the arcus aorta, coarctation segment, and descending aorta were measured. The catheter was then removed, and BA catheters of different sizes, which were selected based on the obtained measurements, were placed into the coarctation segment over the guide wire. At that point, attention was paid to the rhythm when the balloon catheter was crossing the VSD. Balloon angiography was performed in the coarctation, after which time the balloon catheter was removed. Postprocedure angiography was performed, and pressure gradients were recorded. A brief summary of patient information is provided in Table 1.

3. Case reports

3.1. *Case 1*

A 5-day-old newborn infant weighing 2500 g presented to the emergency unit (EU) with cyanosis and tachypnea. He was born at 36 weeks gestation by cesarean section and discharged within 24 h after a routine check-up. In the emergency room, on physical examination, the infant showed cyanosis, tachycardia, tachypnea, weak femoral pulse, and a soft systolic murmur at the left sternal edge. The patient had multiple organ failure and was taken to the intensive care unit and intubated. Echocardiography demonstrated mitral valve atresia, a hypoplastic LV, a large perimembranous VSD, a double-outlet right ventricle, a partial pulmonary venous return abnormality, and CoA with mild arcus hypoplasia. The patient was deemed by surgeons to be in an inappropriate condition for surgery, and we decided to carry out transcatheter BA as a first-choice therapy. The patient underwent cardiac catheterization, and BA was performed using the antegrade approach, as described above. After BA, the clinical and hemodynamic conditions of the patient improved, and the patient was extubated. Ten days later, he underwent the first stage of single ventricle palliation, and he underwent aortic arch reconstruction and atrial septectomy.

3.2. *Case 2*

A 5-month-old infant weighing 6000 g was referred to our unit from another country for corrective surgery. He was diagnosed as having a parachute mitral valve, a supramitral membrane, mitral stenosis, CoA, a large VSD, and pulmonary hypertension. He had severe heart failure and a clinically poor condition at admission. Cardiac catheterization was performed to confirm the diagnosis and to evaluate the hemodynamic

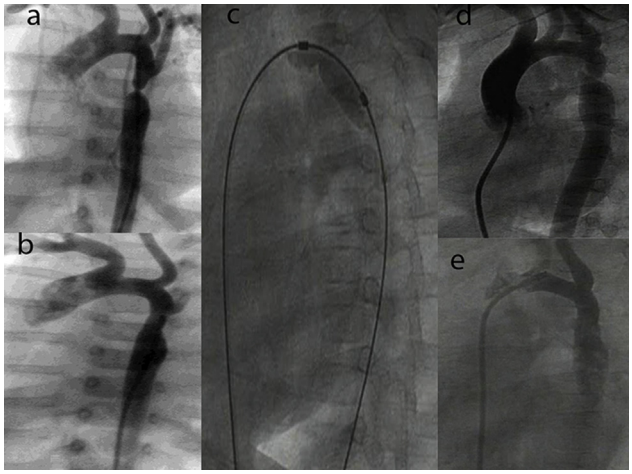

Fig. 1 – (a) A 5-month-old infant weighing 6000 g (case 4), diagnosed as having a parachute mitral valve, a supramitral membrane, mitral stenosis, coarctation of the aorta (CoA), a large ventricular septal defect (VSD), and pulmonary hypertension; anteroposterior view before the balloon dilatation angiocardiography. (b) The same baby; figure presentation after balloon dilatation. (c) Lateral view during balloon dilatation angiocardiography. (d) A 2-week-old neonate weighing 2800 g taken to the emergency department with respiratory distress, hypoxia, and abdominal distension (case 2). Baby diagnosed as having CoA, a VSD, and necrotizing enterocolitis. Patient had coarctation balloon angioplasty as a rescue procedure to gain time, because of his critical clinical situation before abdominal surgery; anteroposterior view before the balloon dilatation angiocardiography. (e) The same baby; figure presentation after balloon dilatation.

status. To improve the baby's clinical and hemodynamic conditions before surgery, BA was performed via the antegrade approach (Fig. 1d and e). After BA, the child showed clinical signs of improvement. After one week, the infant underwent surgery; the VSD was closed and the supramitral ring was resected. There was no need to correct the CoA during surgery. The baby was discharged from the hospital 14 days later, after spending five days in the intensive care unit following surgery. As the baby was introduced from his country to our center for an operation, he had returned home (Iraq/Duhok), and follow-up was not part of the agreement, so we had no medical record after discharge from the hospital.

3.3. *Case 3*

A 7-day-old neonate weighing 2700 g presented to the EU with poor feeding. He was born at 39 weeks gestation and was discharged within 24 h after a routine check-up. A physical examination showed tachycardia, tachypnea, a weak femoral pulse, cold feet, and a soft systolic murmur at the left sternal edge. An echocardiographic examination revealed severe CoA, a large perimembranous VSD, and pulmonary hypertension at the systemic level. Because of the deep cyanosis and hemodynamic compromise, the baby underwent cardiac catheterization for coarctation BA. Subsequent inflations demonstrated no residual waste formation at the coarctation site. The general condition of the baby improved after the procedure. One month after BA for coarctation, successful surgical correction was accomplished. Eight months after the surgery, the infant had a 30-mmHg coarctation gradient at the surgery site, as determined based on echocardiography performed during a routine follow-up. He had a 110/60-mmHg blood pressure, and the pressure gradient between the upper and lower extremities was 20 mmHg. The child was scheduled for coarctation BA.

3.4. *Case 4*

A two-week-old neonate weighing 2800 g was born at 41 weeks gestation to a healthy mother. Two weeks later, the mother noticed symptoms of irritability, sweating, rapid breathing, and poor feeding behavior in the baby. The child was then taken to the emergency department and found to have moderate respiratory distress, hypoxia, abdominal distention, and a little blood in the stool. A precordial exam was normal with the exception of a faint 1/6 systolic murmur. The patient was intubated and taken to the neonatal intensive care unit. Clinical and laboratory evaluations revealed severe CoA, a perimembranous VSD, and necrotizing enterocolitis. As he was in a critical situation with hemodynamic compromise, cardiac catheterization was performed for CoA before abdominal surgery. BA was performed via the anterograde approach (Fig. 1a and b). One month after BA for coarctation, successful surgical correction was achieved. Now, the patient is 3 years old and doing well, and he has a 20-mmHg continuous wave Doppler echocardiographic gradient measured at the coarctation site.

4. Discussion

Balloon dilatation is an effective transient palliation for newborns with critical coarctation and LV dysfunction, and it should mainly be performed as a rescue procedure. The hazard of catheterizing the femoral arteries of small infants with a large angioplasty catheter is the major problem in BA for coarctation. There have been reports of thrombotic obstructions, hematomas, and vascular traumas after femoral arterial angioplasties in infants weighing <10 kg.[8] Different techniques have been reported to avoid these predictable problems. While some authors used a double balloon instead of one large balloon, others used antegrade transseptal puncture or transhepatic antegrade routes.[9–12] The antegrade transvenous approach for CoA is a technique that was first described by Beekman et al.[13] In their report, they described the first successful application of an AT approach to coarctation angioplasty. The procedure was performed in a 5.4-kg child using a 5-mm balloon catheter introduced through a 6-Fr transseptal sheath and which did not require entry into the infant's femoral arteries.

The AT technique described in this report is another alternative to the retrograde arterial approach for coarctation angioplasty in patients with a VSD. It has advantages over the technique described by Berkman et al. and transhepatic

routes. The anterograde approach defined by Beekman et al.[13] has the disadvantage of requiring a transseptal left heart catheterization, which carries a risk of cardiac perforation. In addition, the transhepatic approach may cause hepatic capsular hematomas and peritoneal hemorrhages.

In our patients, we used the femoral vein for intervention and we used the VSD to enter the ascending aorta from the right antegrade route. The VSD in each case was large and available for passing through. There are a few disadvantages with the antegrade approach through the VSD: first, when advancing the balloon catheter through the septal defect, rhythm problems can occur; second, the tricuspid valve and its chordae could be damaged via this approach. However, the perimembranous defects in our patients were in secure positions, and while advancing the catheter, we paid close attention to electrocardiogram (ECG) recordings to be aware of any possible rhythm abnormalities. We suggest antegrade balloon coarctation angioplasty be applied to small infants with a VSD in situations where surgery might be hazardous.

Conflicts of interest

The authors have none to declare.

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