# Balloon dilatation angioplasty of stenosed systemic - pulmonary artery shunts

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SUMMARY: Saltık İL, Eroğlu AG, Öztunç F, Sarıoğlu A. Balloon dilatation angioplasty of stenosed systemic-pulmonary artery shunts. Turk J Pediatr 2000; 42: 43-47.

Seven children and an adult patient with cyanotic congenital heart defects underwent balloon dilatation angioplasty (BDA) of a stenosed systemic-pulmonary artery shunt to improve arterial oxygen saturation. We attempted to perform BDA using the transvenous route in all patients in whom the aorta connected with the right ventricle, such as in tetralogy of Fallot or double outlet right ventricle, in an effort to avoid femoral artery injury. We could use the transvenous route (antegrade) in three children with tetralogy of Fallot and in one child with tetralogy of Fallot and pulmonary atresia (one of them was 6.6 kg). Fallowing BDA, there was an increase in arterial oxygen saturation from a mean of 65.9 ± 12.8% to a mean of 78.1 ± 8.3% ($p < 0.05$). On follow-up three to 37 months (mean 16.5 ± 11.2 months) after BDA, the condition of all patients had improved. Pulmonary hypertension developed in one patient during the follow-up period. It is concluded that BDA of stenosed systemic-pulmonary artery shunts is reasonable, effective and safe. Use of the transvenous route, if possible, to perform balloon dilatation angioplasty facilitates the safe advancement of the larger balloons in low-weight children.

*Key words: balloon dilatation angioplasty, systemic-pulmonary artery shunts, Blalock-Taussig shunts.*

Systemic-pulmonary artery shunts are standard palliative treatment for various cyanotic congenital heart defects with reduced pulmonary blood flow. Early or late occlusion of systemic-pulmonary artery shunts occurs in approximately 10 percent of cases[1,2]. Recently, balloon dilatation angioplasty (BDA) of stenosed systemic-pulmonary artery shunts has been used successfully in pediatric patients who were not amenable for surgical correction and in those in whom the correction needed to be delayed, in order to avoid the morbidity and potential mortality of a new systemic-pulmonary artery shunt operation. BDA, performed in a retrograde manner through the femoral artery, has been well described in the literature[3-8]. We attempted to perform the procedure using the transvenous route in all patients in whom the aorta connected with the right ventricle, such as in tetralogy of Fallot or double outlet right ventricle, to avoid femoral artery injury and to safely advence the larger balloons.

In this report, we review our experience with balloon dilatation angioplasty of stenosed systemic-pulmonary artery shunts and illustrate the usefulness of using the transvenous route, if possible.

## Material and Methods

*Study Patients*: From November 1994 to November 1996, seven children aged 1 to 11.6 years (mean 4.3 ± 3.7 years) and one adult aged 38 years underwent BDA of stenosed systemic-pulmonary artery shunts to improve arterial oxygen saturation. After clinical assessment and the usual laboratory studies suggestedd hypoxemia and pulmonary oligemia in association with a cyanotic heart defect, cardiac catheterization was performed both to confirm the clinical diagnosis and to prepare for possible balloon dilatation angioplasty, (Figs. 1a, 1b, 1c).

*Technique*: We attempted to use the transvenous route (antegrade) in five patients and could pass

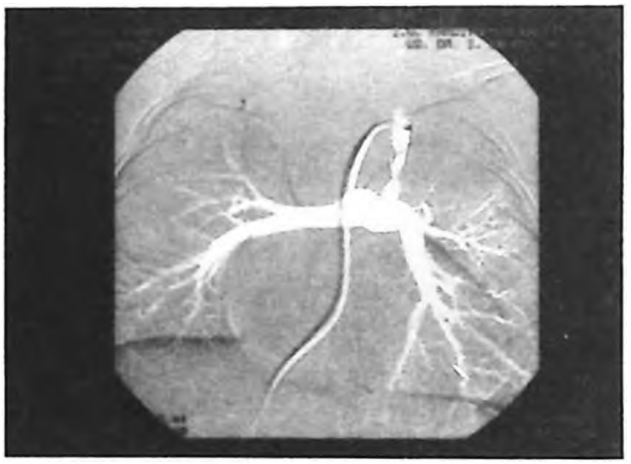

Fig. 1a. Digital subtraction angiography of left modified Blalok-Taussig shunt demonstrates marked narrowing of the shunt (transvenous route).

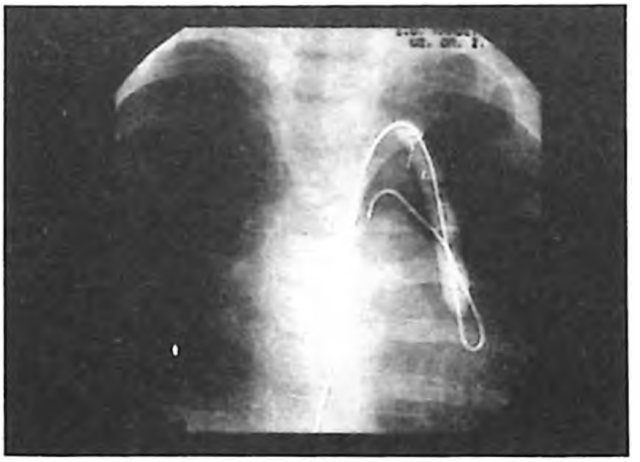

Fig. 1b. Position of balloon dilatation catheter during inflation.

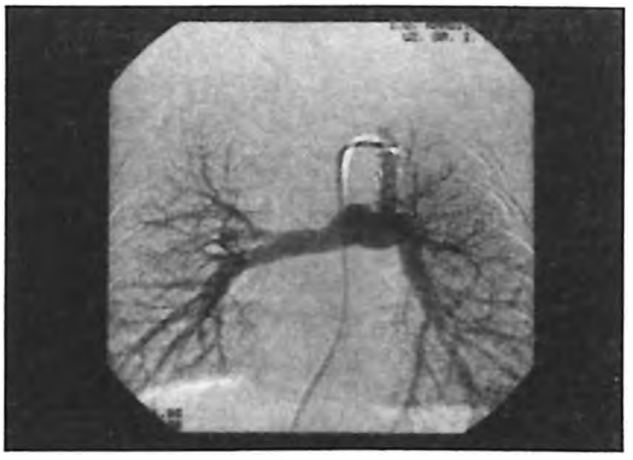

Fig. 1c. Digital subtraction angiography of left modified Blalock-Taussig shunt demonstrates relief of stenosis of the shunt and improvement in pulmonary flow.

a catheter into the aorta through the femoral vein in four of them (Cases 2, 3, 6, 8). We used arterial routes (retrograde) in four patients (Cases 1, 4, 5, and 7). In each case 50 units/kg of heparin (maximum 2500 units) were administered immediately after introduction of the sheath. A 6F right coronary artery catheter in Cases 2, 6, and 8 and a 6F LIMA catheter in Case 3 was placed in the right ventricle by femoral venous route. The tip of the catheter was positioned in the mouth of the aorta via the ventricular septal defect. A floppy guide wire was advanced through the catheter and positioned within the aorta with suitable guidewire manipulation. The catheter was advanced over the floppy guidewire into the aorta and then placed at the origin of the systemic-pulmonary artery shunts. A 6F right coronary artery catheter or a 6F LIMA catheter, and in one case a 4F multipurpose catheter, was passed retrogradely through the femoral artery and placed at the origin of the systemic-pulmonary artery shunts. After pressure and saturation measurements, shunt angiography was performed in all patients to confirm the site and the severity of the stenosis and to measure the diameter of the shunt. A floppy guidewire or hydrophilic wire (Terumo) could be passed across the stenosed systemic-pulmonary artery shunt in all patients and the catheter placed in the pulmonary artery over the guidewire.

A 260 cm long 0.032 inch exchange guidewire in seven patients and a standard coronary guidewire in Case 7 was advanced through the catheter and positioned distally within the pulmonary artery. The catheter was removed and a balloon dilatation catheter (meditech) with appropriate balloon diameter was then inserted over the exchange

guidewire and advanced into the systemic-pulmonary artery shunt so that the midsection of the balloon was at he point of stenosis. The balloon was inflated until the balloon waist disappeared, to a maximum of 10 atmospheric pressure. After the procedure, saturation, pressure measurements and angiography were repeated in all cases. All patients were discharged within 24 hours of the procedure.

### *Follow-up*

Follow-up clinical studies, hematocrit and echo-Doppler studies were available in all patients after three to 37 months (mean 16.5 ± 11.2 months). Recatheterization was performed in Case 1 at 31 months, in Case 2 at 28 mnths and in Case 7 at 15 months after BDA.

### *Statistics*

Data are expressed as mean ± SD. The Student's t test was used for comparison of data obtained prior to and following angioplasty. Statistical significance was inferred at a value of $p < 0.05$.

## Results

Anthropometric characteristics, diagnoses, sites and types of the systemic-pulmonary artery shunts and other characteristics about balloon dilatation angioplasty are shown in Table I. Continuous murmur of the shunt was absent in four patients and decreased in the others. All patients were cyanotic with increased hematocrit values of mean 57 ± 8.3 percent, with a range of 48 to 68 percent. There was moderate to severe hypoxemia with a mean oxygen saturation of 65.9 ± 12.8 percent, with a range of 50 to 82 percent. In Case 5, despite high arterial oxygen saturation (82%), balloon dilatation angioplasty was performed because of severe anatomical narrowing of the shunt.

In all patients there was significant improvement. Auscultation revealed continuous murmur of the shunt. The stenosis diameter increased from 1.9 ± 0.8 mm to 4.4 ± 0.4 mm following BDA ($p < 0.05$). the arterial oxygen saturation increased from a mean of 65.9 ± 12.8 percent to, mean of 78.1 ± 8.3 percent ($p < 0.05$). Pulmonary arterial peak systolic pressure was mean 13 ± 5 mmHg before the procedure and mean 18 ± 7 mmHg, with a range of 7 mmHg to 30 mmHg, after the procedure. no complications were encountered during the procedure.

The patients were followed three months to 37 months (mean 16.5 ± 11.2 months). The patients with symptoms of exercise intolerance improved markedly, although all of them remained cyanotic. Hematocrit values decreased from mean 57 ± 8.3 percent to mean 48.8 ± 7.4 percent ($p < 0.05$). Auscultation revealed continuous murmur of the shunt and the shunts were patent on echo-Doppler study in all patients. Three patients underwent repeat cardiac catheterization. In the adult patient (Case 1) congestive heart failure developed two months after BDA and was treated with digoxin and diuretics. Left pulmonary artery pressures of 105/65 mmHg, with an aortic pressure o 125/70 mmHg, were obtained. Angiography demonstrated a widely patent subclavian to left pulmonary artery shunt. Pulmonary artery pressures were normal and shunts were patent in Case 2 28 months and in Case 7 15 months

**Table I.** Patient Data: Balloon Dilatation of Stenosed Systemic-Pulmonary Artery Shunts

| | | | | Shunt | | Stenosis D (mm) | | SAT (%) | | Pa press (mmHg) | | Ao press (mmHg) | | Hct (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pt | Age (year) | Weight (kg) | Diagnosis | Site type | BD (mm) | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Follow-up (mos) |
| 1 | 38 | 61 | TA, PS, HPA, RGA | L BT | 5,7 | 0.7 | 5.4 | 80 | 89 | 19 | 30 | 120 | 75 | 68 | 57 | 37 |
| 2 | 11.6 | 26 | FT, PA, HPA, APT, OC, LMBT | R BT | 5,6,7 | 0.7 | 4.7 | 73 | 83 | 7 | 15 | 95 | | 48 | 40 | 28 |
| 3 | 1 | 6b6 | FT, PA, HPA | L MBT | 6 | 2.3 | 4.5 | 50 | 70 | 15 | 17 | 100 | 110 | 53 | 46 | 7 |
| 4 | 5.3 | 22 | M, AVD, ASD, VSD, DORV, PS | L MBT | 6 | 2.8 | 4.6 | 63 | 74 | 10 | 18 | 110 | 100 | 62 | 50 | 3 |
| 5 | 5.3 | 20 | DORV, VSD, PS, ALPA | R CEN | 5 | 1.8 | 4 | 82 | 89 | 12 | 20 | 90 | | 60 | 52 | 11 |
| 6 | 4 | 10 | FT, HPA | L MBT | 6 | 1.8 | 4.4 | 48 | 68 | 7 | | 100 | 90 | 65 | 50 | 18 |
| 7 | 0.75 | 8.3 | AVD, DORV, VSD, PS | L MBT | 5 | 2.6 | 4.9 | 50 | 62 | 17 | 20 | 80 | | 44 | 37 | 15 |
| 8 | 2.2 | 10 | FT, PA | R MBT | 5 | 2.5 | 5 | 71 | 80 | 17 | 20 | 85 | 90 | 56 | 50 | 13 |

ALPA: absence of the left pulmonary artery, Ao press: aorta systolic pressure, APK: aortapulmonary collateral arteries, ASD: atrial septal defect, AVD: atrioventricular discordance, BD: balloon diameter, BT: Blalock-Taussig, D: diameter, DORV: double outlet right ventricle, FT: tetralogy of Fallot, Hct: hematocrit before dilatation and at the last follow-up, HPA: hypoplastic pulmonary arteries, L: left, M: mesocardia, MBT: modified Blalock-Taussig, OC: occluded, PA: pulmonary atresia, Pa press: pulmonary artery systolic pressure, PS: pulmonary stenosis, R: right, RGA: right Glenn anastomosis, SAT (%): systemic oxygen saturation before and after dilatation, TA: tricuspid atresia, VSD: ventricular septal defect, LMBT: left modified Blalock-Taussig, CEN: central.

after BDA. In case 2, the McGoon ratio was increased from 1.5 to 1.7 and total correction was performed. In other cases the McGoon ratio did not change during the follow-up period, but it was short in Case 3 and Case 4 (7 months and 3 months, respectively).

## Discussion

When a systemic-pulmonary artery shunt becomes stenosed in a cyanotic congenital heart defect with reduced pulmonary blood flow, the therapeutic options include the creation of another systemic-pulmonary artery shunt or, if suitable, correction of the underlying cardiac malformation earlier than planned[1,2]. Transcatheter balloon dilatation of stenosed shunts has been proposed as an alternative to a new systemic-pulmonary artery shunt[5]. In published reports, transcatheter balloon dilatation of stenosed systemic-pulmonary artery shunts was done via the arterial route (retrograde)[3-8]. We used the transvenous route to perform coronary angiography in the patients with tetralogy of Fallot and to measure pulmonary artery pressure passing through the systemic-pulmonary artery shunt in the patients with an aorta that connects with the right ventricle, such as tetralogy of Fallot, double outlet right ventricle or transposition of great arteries, to avoid femoral artery injury. It is easier to pass through the right modified Blalock-Taussig shunt than the left modified Blalock-Taussig shunt. We could use the transvenous route in three children with tetralogy of Fallot and pulmonary atresia and in one patient with tetralogy of Fallot, (1 weighed only 6.6 kg). We used the arterial route in the adult patient with tricuspid atresia and pulmonary stenosis and in two patients with double outlet right ventricle and atrioventricular discordance in whom the systemic venous atrium was not connected with the right ventricle. We also used the arterial route in a patient with double outlet right ventricle and central shunt because of insufficient experience with passing a central shunt. There is potential risk of arrhythmia with the transvenous technique because the catheter passes through the heart. We decreased this risk using a floppy or hydrophilic guidewire to pass into the aorta via the ventricular septal defect, and our patients did not have any arrhythmia. Using the transvenous route, if possible, to perform BDA prevents femoral artery injury and permits the safe advancement of the larger balloons.

Transcatheter balloon dilatation of stenosed systemic-pulmonary artery shunts was successful, but the results depended on the size of the balloon in relation to the size of the shunt[4,6,7,9]. An oversized balloon, for example, may cause increased pulmonary blood flow leading to congestive heart failure in the short term and pulmonary hypertension in the long term[9]. In order to avoid these complications, we completed the procedure when the diameter of the anastomotic site increased to 5 mm, except in the adult patient (Case 1). In this Case, a 7 mm balloon catheter was used and stenosis diameter neached 5.7 mm after the balloon dilatation angioplasty. Pulmonary hypertension developed during follow-up. A remaining fundamental question is the magnitude of ideal dilatation. Recently, successful balloon dilatation angioplasty and stent implantation have been reported in pediatric patients with stenosed or occluded systemic-pulmonary artery shunts[10,11].

We believe that balloon dilatation angioplasty of stenosed systemic-pulmonary artery shunts is a reasonable and safe alternative to reoperation in those patients who are amenable to total surgical correction and in those in whom the correction needs to be delayed. Using the transvenous route, if possible, to perform balloon dilatation angioplasty permits the safe advancement of the larger balloons in low-weight children.

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