Percutaneous Transluminal Balloon Valvuloplasty in Congenital Pulmonary Valve Stenosis

Christian Rey, M.D., Philippe Marache, M.D., and Claude Dupuis, M.D.

From March 1984 to September 1986, 49 transluminal balloon valvuloplasties (TBVs) were performed in 44 consecutive patients with congenital pulmonary valve stenosis, aged 1 day to 60 years. Seventeen of the patients were infants aged less than 1 year, five of whom were neonates. The peak systolic gradient was greater than 50 mm Hg (mean, 80.0 mm Hg) in 36 patients and was less than 50 mm Hg (mean, 35.4 mm Hg) in eight. A single balloon catheter was used in 41 cases, and two balloon catheters were used in eight cases. In patients with a gradient greater than 50 mm Hg, the mean right ventricular peak systolic pressure was reduced from 99.8 to 51.8 mm Hg, and the mean transvalvular gradient was reduced from 80.0 to 22.4 mm Hg. In infants and neonates, the mean right ventricular pressure expressed as a percentage of systemic pressure decreased from 122.2% to 63.5%. Follow-up cardiac catheterization 1 to 17 months later (in 19 cases) revealed no significant change in the right ventricular systolic pressure (which had decreased from 53.0 to 48.5 mm Hg) or the peak systolic pressure gradient (which had decreased from 29.0 to 24.5 mm Hg), in comparison with the changes seen immediately after TBV. Thus, TBV is an effective method of relieving pulmonary stenosis in patients of all ages, including neonates. ***(Texas Heart Institute Journal 1986; 13: 387-392)***

Key words: Pulmonary valve stenosis; transluminal balloon valvuloplasty

PERCUTANEOUS transluminal balloon angioplasty (PTCA) has been shown to be effective in treating patients with stenosis of the peripheral pulmonary artery, including coarctation of the aorta, coarctation restenosis, superior vena cava obstruction, pulmonary artery or vein stenosis, and obstructed total anomalous pulmonary venous return.[1-6] In addition, PTCA has been used to treat aortic valve stenosis and pulmonary valve stenosis.[7-16]

This report describes our experience with the first 44 patients to undergo percutaneous transluminal balloon pulmonary valvuloplasty (TBV) at our hospital.

PATIENT POPULATION

From March 1986 to September 1986, 49 TBVs were performed at our institution in 44 consecutive patients with congenital pulmonary valve stenosis. Nineteen patients were females, and 25 were males. The patients ranged in age from 1 day to 60 years (mean, 7.1 years). Seventeen were infants less than 1

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year old. Five neonates had this procedure because the pulmonary valve stenosis with intact ventricular septum was so severe as to reach the point of pulmonary atresia.

Forty-one patients had typical pulmonary valve stenosis with domed stenotic pulmonary valves that were apparent on cineangiograms, and three patients had dysplastic pulmonary valves. In addition, three patients had Noonan's syndrome, and 15 had a small atrial septal defect with a left-to-right shunt.

HEMODYNAMIC STUDIES

All patients underwent cardiac catheterization after being premedicated with morphine chlorhydrate (0.1 mg/kg body weight, intramuscularly) and pentobarbital (3 mg/kg body weight, maximal 120 mg). Neonates were premedicated only with pentobarbital (3 mg/kg body weight). In infants, pullback pressure recording was done across the pulmonary valve, and the right ventricular pressure was expressed as a percentage of the systemic pressure before and after TBV. In older patients, the peak systolic gradient between the right ventricle and the pulmonary artery was determined by simultaneously recording the right ventricular and pulmonary artery pressures. Venous catheters were placed percutaneously in the right and left femoral arteries. In 29 cases, the left ventricular pressure was measured through the patent foramen ovale simultaneously with the right ventricular pressure. When crossing the foramen ovale was not possible, the arterial blood pressure was measured at the femoral or brachial artery. Right- and left-sided cardiac hemodynamic data were obtained before and after (15 minutes or longer) valvuloplasty. The diagnosis of pulmonary valve stenosis was confirmed by right ventricular cineangiography in the antero-posterior and lateral projections (with an injection of Hexabrix*, 1 mL/kg body weight), and the size of the pulmonary valve annulus was measured. Cineangiograms were taken after the pressure gradients were measured before and after TBV. Follow-up cardiac catheterization was performed in 19 cases at intervals of 1 to 17 months after valvuloplasty (mean, 7.7 months). In each case, follow-up catheterization was attempted percutaneously through the right femoral vein (in neonate or infant, three right femoral venous occlusions and one bilateral femoral venous occlusion).

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TECHNIQUE OF VALVULOPASTY

A Meditech or an Olbert balloon catheter was introduced percutaneously over a 0.035-inch Rosen guidewire. The balloons measured 30 or 40 mm in length, and their maximum inflatable diameters were between 6 and 20 mm. In each case, the balloon was 1 to 2 mm larger than the pulmonary annulus. The peak inflation pressure was approximately 10 atm for the Olbert balloon and 3 to 5 atm for the Meditech model, as recommended by the manufacturers. The balloon catheter was positioned across the pulmonary valve and was inflated to maximum pressure with diluted contrast medium for 10 to 15 seconds; as full inflation was achieved, the visible balloon indentation caused by the stenotic valve was abolished; the balloon was then rapidly deflated. During valvuloplasty, the patient was given oxygen via a mask. At the end of the procedure, the balloon catheter was withdrawn, and repeat hemodynamic data were obtained. In ten patients, the results were unsatisfactory, so another dilatation catheter with a larger balloon was introduced, and repeat valvuloplasty was performed. In eight patients, two balloon catheters were positioned across the pulmonary valve and were inflated simultaneously because of the large diameter of the annulus. This procedure was used early in the series.[14]

RESULTS

Before TBV, the right ventricular peak systolic pressure ranged from 45 to 145 mm Hg (mean, 93.0 mm Hg), and the peak systolic pressure gradient across the pulmonary valve was 15 to 135 mm Hg (mean, 72.9 mm Hg). This gradient was greater than 50 mm Hg (mean, 80.0 mm Hg) in 36 patients and was less than 50 mm Hg (mean, 35.4 mm Hg) in eight. With TBV, the mean right ventricular

peak systolic pressure was reduced from 93.0 to 50.5 mm Hg, and the mean transvalvular gradient was reduced from 72.9 to 26.3 mm Hg. In the patients who had a transvalvular gradient greater than 50 mm Hg before TBV, the mean right ventricular pressure dropped from 99.8 to 51.8 mm Hg, and the mean gradient decreased from 80.0 to 22.4 mm Hg. In this group, all 36 patients had hemodynamic evidence of relief of pulmonary valve stenosis immediately after TBV (Fig. 1).

In infants, right ventricular pressure expressed as a percentage of systemic pressure ranged from 79% to 170% (mean, 122.2%) before TBV and from 35% to 133% (mean, 63.5%) after TBV (Fig. 2). As the balloon totally occluded the pulmonary valve, the right ventricular pressure increased and the aortic or systemic pressure dropped. Bradycardia and a few premature ventricular beats occurred. Some of the sedated patients experienced restlessness. After TBV, the systemic pressure returned to normal, and the aberrant beats disappeared. In infants, systemic hypotension was minimal during TBV. In these cases, a patent foramen ovale may have allowed shunting of blood from the right atrium to the left.[10]

In six patients, an infundibular pressure gradient ranging from 10 to 35 mm Hg was noted immediately after TBV. Four of these patients were treated with propranolol, with satisfactory results.

Right ventriculography, which was performed after TBV in 42 cases, showed evidence of widening in the valvular area in all but five cases.

Follow-up cardiac catheterization 1 to 17 months after valvuloplasty revealed no significant change in the right ventricular systolic pressure (which had decreased from 53.0 to 48.5 mm Hg) or the peak systolic pressure gradient (which had decreased from 29.0 to

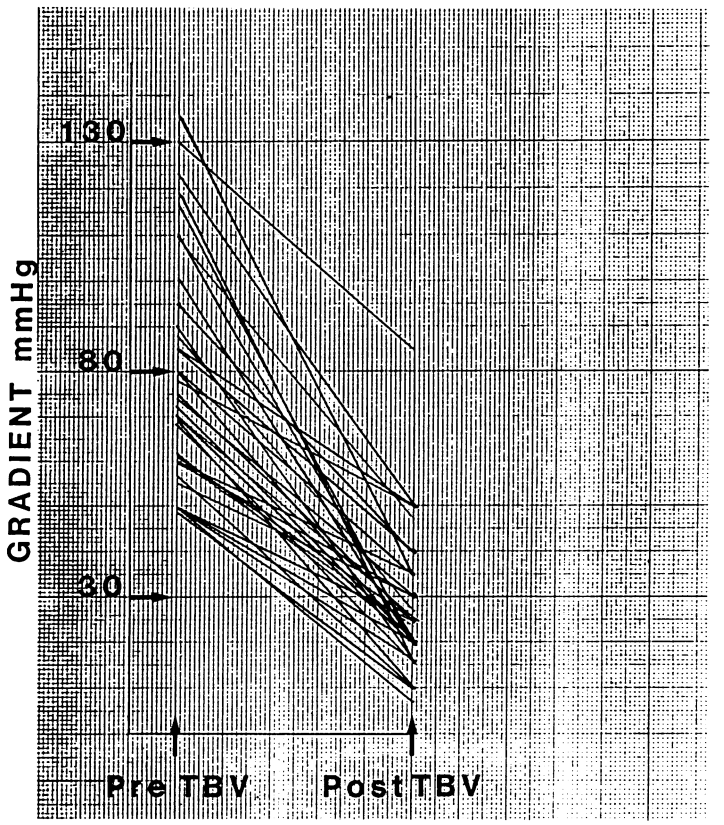

Fig. 1 Peak systolic pressure gradient before and immediately after TBV in patients with gradients greater than 50 mm Hg before TBV.

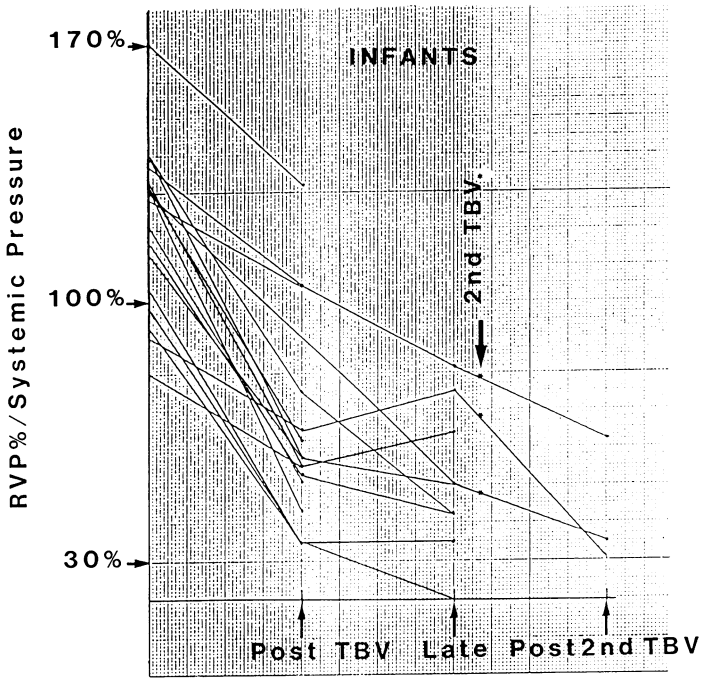

Fig. 2 Right ventricular pressure, expressed as a percentage of the systemic pressure (RVP %/SP), before and after TBV in infants.

24.5 mm Hg), compared with the changes seen immediately after TBV (Fig. 3).

Five patients (two of whom were neonates) underwent a second TBV at the time of follow-up catheterization because the residual gradient was greater than 50 mm Hg (Fig. 3). The results of the repeat TBV were satisfactory.

DISCUSSION

Transluminal balloon valvuloplasty appears to be an effective method of relieving pulmonary valve stenosis.[9-19] Only one patient in our series was treated with a surgical valvulotomy after undergoing TBV. This patient had first had a Brock procedure during the neonatal period because cardiac catheterization revealed a suprasystemic right ventricular pressure. After the patient underwent surgical valvuloplasty, his right ventricular pressure fell to the infrasystemic level. Eleven months later, however, it had increased to 170% of the systemic pressure. Cineangiography disclosed a dysplastic pulmonary valve. A TBV was attempted, but the result was not satisfactory (Fig. 2). After TBV, the right ventricular pressure expressed as a percentage of systemic pressure decreased to only 133%. In the opinion of several authors,[12,17] a dysplastic pulmonic valve is a poor indication for valvuloplasty. In our series, however, two patients with dysplastic pulmonic valves underwent a TBV with good results, immediately afterward and at follow-up catheterization.

In eight early cases, two balloons were inflated simultaneously across the pulmonary valve. This technique has three benefits: (1) it allows dilatation of pulmonary valve stenoses in which the diameter of the annulus is greater than 20 mm; (2) because two smaller balloon catheters are used (each of which is introduced into a femoral vein) rather than a single large balloon catheter, the size of the venotomy is decreased, particularly in infants; and (3) because the two inflated balloons are not completely obstructive, this technique is better tolerated than the single-balloon technique.[17,20]

The results of valvuloplasty were unsatisfactory in five of our early cases, perhaps because the balloons were too small. After TBV, these patients had peak systolic gradients greater

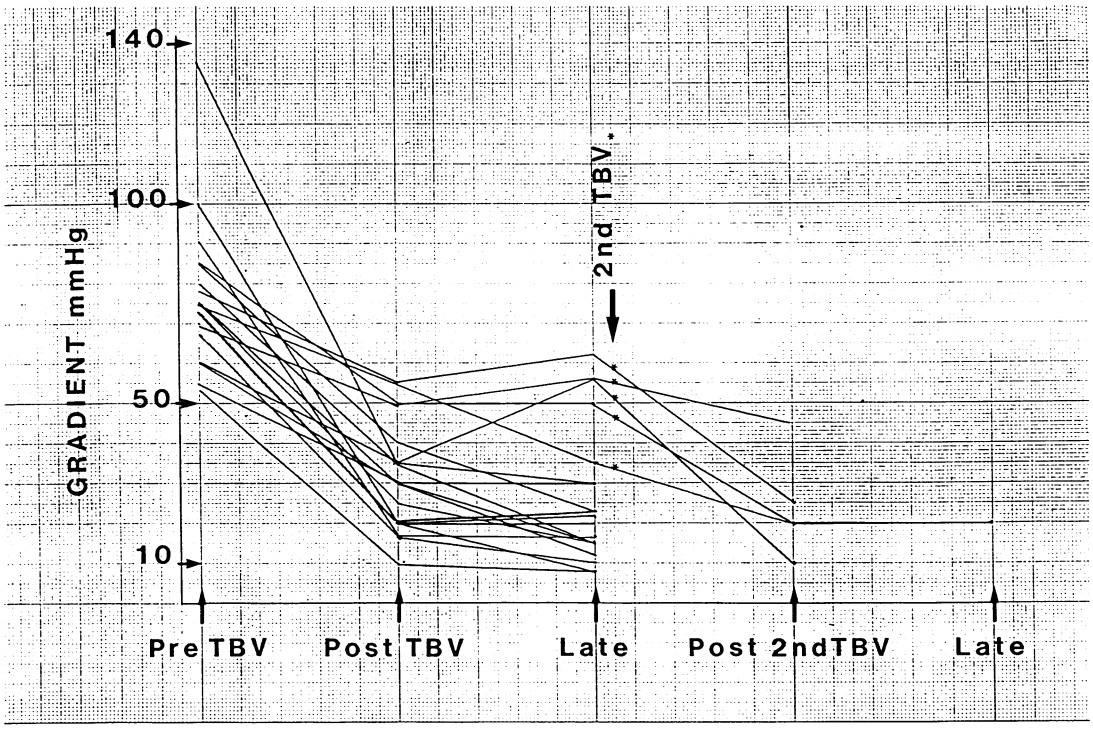

Fig. 3 Follow-up data for 19 patients.

than 50 mm Hg. All five patients later underwent a second TBV with a larger balloon, which produced good results. If the residual gradient is greater than 50 mm Hg, a larger balloon is necessary.[19] In normal newborn lambs, dilatation of the pulmonary valve annulus with an oversized balloon can produce considerable trauma if the balloon is 50% larger than the annulus.[21]

In all of our patients, TBV was well tolerated clinically. Post-TBV angiography showed no cardiac trauma or extravasation of contrast material. So far, the literature has reported few successful results in neonates.[9,14] In our five neonates, all of whom had a suprasystemic right ventricular pressure, TBV was performed with balloons that measured 6 to 10 mm in diameter. In one case, the right ventricle was hypoplastic, with pulmonary valve stenosis and intact ventricular septum, amounting to pulmonary atresia. In such cases, passing the balloon across the pulmonary valve is quite difficult.

Development of an infundibular gradient after TBV has been well-documented,[10,12,14,16,18] and infundibular obstruction with a right ventricular pressure greater after TBV than before TBV has been reported.[22] In our series, the maximal infundibular gradient was only 35 mm Hg.

In conclusion, we believe that percutaneous transluminal balloon valvuloplasty is a safe and effective method for treating pulmonary valve stenosis in patients of any age, including neonates. In our series, follow-up cardiac catheterization revealed no significant change in the peak systolic pressure gradient, and no restenosis occurred.

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