Balloon Pulmonary Valvuloplasty in Children, One Year Follow-up Experience At Ramathibodi Hospital

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Abstract

Balloon valvuloplasty has become the treatment of choice in pulmonary valvular stenosis. The objective of this report is to review the experience of this procedure in children at the Department of Pediatrics, Ramathibodi Hospital in the past 4 years (1991 - 1994) with at least one year follow-up.

During the study period, 19 children aged 2.1 - 14.3 years (mean 5.11 years) with the diagnosis of pulmonary valvular stenosis had successful pulmonary balloon valvuloplasty at this institution. The immediate peak systolic pressure gradient across the pulmonary valve by cardiac catheterization decreased from 92.05 $\pm$ 46.92 to 34.26 $\pm$ 25.30 mmHg, by Doppler from 78.58 $\pm$ 26.55 to 34.83 $\pm$ 15.60 mmHg. Peak pressure gradient across the pulmonary valve by Doppler of the last examinations, one to 4 years after the procedure (mean 1.9 years), was 23.05 $\pm$ 9.40 mmHg in 17 patients. The mean ratio of balloon size and pulmonary valve ring was 1.06. One patient still has a residual gradient of 54 mmHg and two were lost to follow-up. No serious complication was encountered during the procedures.

Conclusion: Balloon pulmonary valvuloplasty is effective in the management of children with valvular pulmonary stenosis. The intermediate term result is excellent.

Valvular pulmonary stenosis constitutes 7.5-12.0 per cent of all congenital heart defects[1]. Children with pulmonary valvular stenosis usually present themselves with asymptomatic murmurs, although they can also show signs of systemic venous congestion (right heart failure) due to severe right ventricular dysfunction or cyanosis because of right to left shunt across the atrial septum.

When the pulmonary valve obstruction is moderate to severe, relief of obstruction is recommended to relieve the symptoms or to prevent right ventricular pressure load causing fibrosis or dysfunction. In the past, surgical valvulotomy was the only treatment available.

The first catheter attempt to relieve the gradient was described by Semb[2] in 1979, using

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a carbon dioxide filled balloon in a retrograde manner across the pulmonary valve. This dynamic method was effective in relieving the gradient across the pulmonary valve. However, it did not gain wide acceptance because there was a high incidence of pulmonary valve leaflet avulsion. A static balloon dilatation was developed[3]. During the ensuing years, there were many reports of successful balloon pulmonary valvuloplasty[4-9]. Since then it has become the treatment of choice for pulmonary valve stenosis.

The purpose of this study is to evaluate the intermediate-term (at least one year follow-up) results of balloon pulmonary valvuloplasty by non-invasive method using Doppler echocardiography at the Department of Pediatrics, Ramathibodi Hospital.

PATIENTS AND METHOD

From 1991 to 1994, nineteen children underwent successful balloon pulmonary valvuloplasty in this institution. There were 10 males and 9 females, age ranging from 2.1 to 14.3 years, with mean age of 5.11 ± 3.25 years, and a weight ranging from 13 to 36 kg (mean 17.83 ± 6.33 kg). All patients had typical pulmonary valve stenosis, with domed stenotic pulmonary valve evident on echocardiography and cineangiogram performed before balloon pulmonary valvuloplasty. There was no pulmonary valve dysplasia, being defined as thick, immobile valve leaflets with the absence of post-stenotic pulmonary artery dilatation. No patient met criteria for the diagnosis of Noonan syndrome.

Intervention

Balloon pulmonary valvuloplasty was performed as previously reported by using a single balloon static dilatation[3]. Informed consents were obtained for all patients. After initial hemodynamic assessment, right ventricular angiography was performed, and the maximum internal diameter of the pulmonary valve from hinge point to hinge point during systole was measured from the lateral projection cineangiogram and corrected for magnification. This will hereafter be called pulmonary valve ring diameter. The mean pulmonary valve ring diameter was 15.84 ± 6.69 mm, with a range of 12 to 30 mm. Single dilatation balloons ranging from 15 to 23 mm in diameter were selected basing on the measured pulmonary valve ring diameter. Mean balloon to valve diameter ratio is 1.06 ± 0.19 with

a range of 0.66 to 1.35. The balloon was positioned straddling the pulmonary valve orifice and rapidly inflated by hand with diluted contrast material about 3 times to peak pressure corresponding with maximum disappearance of "waisting" of the balloon, as seen on fluoroscopy. Hemodynamic assessments were repeated after valve dilatation.

Doppler echocardiography were done before and shortly after balloon pulmonary valvuloplasty. Doppler estimation of gradients were calculated by the application of the modified Bernoulli equation at maximum continuous-wave Doppler systolic peak flow velocities across the right ventricular outflow tract and main pulmonary artery obtained from multiple transducer positions.

The patients were then followed at 6 month intervals by using Doppler echocardiography. There were 2 patients lost in the follow-up. Mean follow-up was 1.9 years (range 1-4 years).

The pressure gradient was expressed as a mean value $\pm$ standard deviation. A paired t test was used to test statistical significance, which was assured at the 5 per cent level ($p < 0.05$). In addition, a right ventricle to pulmonary artery peak systolic pressure gradient of less than 36 mmHg was used as a cut point to define success at both initial balloon pulmonary valvuloplasty and follow-up for each individual patient[9,10]. This cut point value was chosen because it corresponded to a continuous wave Doppler peak velocity of 3 m/sec.
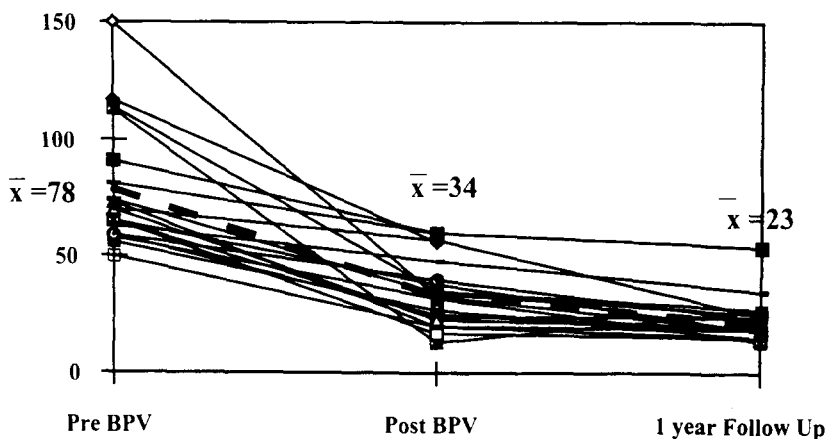
RESULT

The pressure gradients across the pulmonary valve by echocardiography and cardiac catheterization before intervention were not significantly different (78.58 ± 26.55 vs 92.05 ± 46.92 mmHg, $p = 0.125$). Immediately after initial balloon pulmonary valvuloplasty, right ventricular peak systolic pressures by cardiac catheterization were significantly decreased from 112.16 ± 47.11 to 56.16 ± 25.14 mmHg ($p < 0.001$). The peak systolic pressure gradients across the pulmonary valve decreased from 92.05 ± 46.92 to 34.26 ± 25.30 mmHg ($p < 0.001$) by cardiac catheterization comparing to 78.58 ± 26.55 to 34.83 ± 15.60 mmHg ($p < 0.001$) by Doppler. There was no significant difference between pressure gradient after procedure by means of cardiac catheterization and echocardiography (34.26 ± 25.30 vs 34.83 ± 15.60 mmHg, $p = 0.9$).

Table 1. Cardiac catheterization data of patients, pre (Pre BPV) and post (Post BPV) balloon pulmonary valvuloplasty.

Characteristics	Pre BPV (mmHg)	Post BPV (mmHg)	p value
Right ventricular systolic pressure	112 .16 ± 47.11	56.15 ± 25.14	<0.001
Pulmonary artery systolic pressure	19.89 ± 4.89	21.11 ± 7.77	NS
Pressure gradient across the pulmonary valve	92.05 ± 46.92	34.26 ± 25.30	<0.001

Fig. 1. Pressure gradient across pulmonary valve by Doppler before balloon pulmonary valvuloplasty (Pre BPV), immediate after (Post BPV) and follow-up at least one year (FU). Thick lines represent individual pressure gradients, dot line represents mean pressure gradient.

The pulmonary valve ring diameters measured by 2 D echocardiogram and cineangiogram were not statistical different (15.42 ± 2.43 vs 15.84 ± 6.69 mm, p = 0.8).

Seventeen patients (89%) were followed at a mean interval of 1.9 years (ranged 1-4 years) after the initial balloon pulmonary valvuloplasty. The pressure gradients by Doppler echocardiography were further decreased from 34.83 ± 15.06 to 23.05 ± 9.46 mmHg (p < 0.001).

There were 7 patients who had immediate residual pressure gradients of ≥ 36 mmHg (36.8%) (Fig. 1). After the procedures, at one year follow-

up there was only one patient who still had a residual gradient of ≥ 36 mmHg, and two patients were lost in the follow-up.

There was no serious complication during the procedures.

DISCUSSION

Since successful balloon pulmonary valvuloplasty was described in 1982[3], several reports have indicated that balloon pulmonary valvuloplasty is effective in reducing the degree of right ventricular outflow tract obstruction[4-10]. The intermediate-term outcome after balloon pulmo-

nary valvuloplasty was comparable to a matched surgical control group[11].

When using a pressure gradient of less than 36 mmHg across the pulmonary valve as a criterion for successful procedure. The immediate success rate of 63.1 per cent of this study is also comparable to those of previous reports[4-10]. Data from the large VACA Registry study[5,8] suggested that the majority of these significant residual gradients are at the infundibular level. The more severe the obstruction before balloon pulmonary valvuloplasty, the higher the infundibular gradient immediately after balloon pulmonary valvuloplasty was observed. Regression of infundibular hypertrophy has been associated with resolution of residual gradient in several patients[12]. In this study, 4 patients with significant immediate residual gradients had a further decrease in their pressure gradients at one year follow-up of less than 36 mmHg.

SUMMARY

The intermediate-term result assessed with Doppler echocardiography was good in 16 of our total 19 patients who had isolated valvular pulmonary stenosis with successful balloon valvuloplasty. The mean balloon to valve diameter ratio was 1.06. There was no serious complication during the procedure. We conclude that balloon pulmonary valvuloplasty is an effective method of relief of obstruction caused by pulmonary valve stenosis.

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REFERENCES

1. Fyler DC. In Pediatric Cardiology : Philadelphia: W.B. Saunders 1992: 459.
2. Semb BKH, Tijonneland S, Stake C, et al. Balloon valvulotomy of congenital pulmonary valve stenosis with tricuspid valve insufficiency. Cardiovasc Radiol 1979; 2: 239-41.
3. Kan JS, White RI, Mitchell SE, Gardner TJ. Percutaneous balloon pulmonary valvuloplasty : A new method for treating congenital pulmonary valve stenosis. N Engl J Med 1982; 307: 540-2.
4. Sullivan ID, Robinson PJ, Macartney FJ, et al. Percutaneous balloon valvuloplasty for pulmonary valve stenosis in infants and children. Br Heart J 1985; 54: 435-41.
5. Stanger P, Cassidy SC, Girod DA, et al. Balloon pulmonary valvuloplasty: Results of the Valvuloplasty and Angioplasty of Congenital Anomalies Registry. Am J Cardiol 1990; 65: 775-83.
6. Rao PS, Fawzy ME, Solymar L, et al. Long-term results of balloon pulmonary valvuloplasty of valvar pulmonic stenosis. Am Heart J 1988; 115: 1291-6.
7. Masura J, Burch M, Deanfield JE, Sullivan ID. Five-year follow-up after balloon pulmonary valvuloplasty. J Am Coll Cardiol 1993; 21: 132-6.
8. McCrindle BW. Independent predictors of long-term results after balloon pulmonary valvuloplasty. Circulation 1994; 89: 1751-9.
9. McCrindle BW, Kan JS. Long-term results after balloon pulmonary valvuloplasty. Circulation 1991; 83: 1915-22.
10. Fedderly RT, Beekman RH. Balloon valvuloplasty for pulmonary valve stenosis. J Interventional Cardiol 1995; 8: 451-61.
11. O' Connor BK, Beekman RH, Rocchini A. Intermediate-term outcome after pulmonary balloon valvuloplasty: Comparison with a matched surgical control group. J Am Coll Cardiol 1992; 20: 169-73.
12. Fontes VF, Esteves CA, Sousa JE, et al. Regression of infundibular hypertrophy after pulmonary valvuloplasty for pulmonic stenosis. Am J Cardiol 1988; 62: 977-82.

การติดตามผลการรักษาลิ้นหัวใจพุลโมนารีย์ตีบโดยการขยายด้วยบัลลูน

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เพื่อศึกษาถึงผลของการรักษาภาวะลิ้นพุลโมนารีย์ตีบโดยการใช้สายสวนหัวใจที่มีบัลลูนขยายลิ้นหัวใจในผู้ป่วยเด็ก 19 ราย ระหว่างปี พ.ศ.2534–2537 (คณะผู้ศึกษาได้รวบรวมผู้ป่วยดังกล่าวตั้งแต่ปี พ.ศ.2534 ถึงพ.ศ. 2537 เป็นจำนวนทั้งสิ้น 19 ราย) โดยสามารถติดตามการรักษาได้อย่างน้อย 1 ปี 17 ราย พบว่าผู้ป่วยมีอายุระหว่าง 2.1–14.3 ปี (เฉลี่ย 5.11 ปี) หลังจากใช้บัลลูนขยายลิ้นหัวใจที่ตีบไปแล้ว ความแตกต่างของแรงดันซิสโตลิกระหว่างเวนตริเคิลขวากับเส้นเลือดแดงพุลโมนารีย์ที่วัดได้จากการตรวจสวนหัวใจลดลงจาก 92.05 $\pm$ 46.92 เหลือ 34.26 $\pm$ 25.3 มม.ปรอท ที่วัดได้จากคลื่นเสียงสะท้อนหัวใจลดลงจาก 78.58 $\pm$ 26.55 เป็น 34.83 $\pm$ 15.6 มม.ปรอท ในวันเดียวกับที่ทำการขยายลิ้นหัวใจ และเมื่อติดตามการรักษามาอีกอย่างน้อย 1 ปี ความต่างของแรงดันซิสโตลิกนี้จะลดลงเหลือ 23.05 $\pm$ 9.40 มม.ปรอท สัดส่วนของขนาดบัลลูนต่อขนาดของลิ้นหัวใจพุลโมนารีย์มีค่าเฉลี่ย 1.06 มีผู้ป่วย 1 รายที่ยังคงมีความต่างของแรงดันซิสโตลิก 54 มม.ปรอท ไม่พบภาวะแทรกซ้อนที่เป็นอันตรายจากการรักษาด้วยวิธีนี้ จึงสรุปได้ว่าการขยายลิ้นหัวใจพุลโมนารีย์ที่ตีบโดยใช้บัลลูนได้ผลดี ทั้งในระยะสั้นและระยะยาวปานกลาง

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