Percutaneous balloon valvuloplasty for the treatment of pulmonary valve stenosis in children – a single centre experience

Piotr Weryński, Andrzej Rudziński, Wanda Król-Jawień, Jacek Kuźma

Department of Pediatric Cardiology, Jagiellonian University *Collegium Medicum*, Krakow, Poland

Abstract

Background: Isolated pulmonary valve stenosis (PVS) is a common heart defect (6-9%); the preferred treatment is balloon pulmonary valvuloplasty (BPV).

Aim: To assess BPV results in children with isolated PVS treated between 1988 and 2004, with a mean follow-up of 6.1 ± 3.4 years.

Methods: The studied group consisted of 137 children (76 males and 61 females), aged 5.4 ± 4.8 years. The diagnosis was based on physical examination, ECG, chest radiograph, echo, haemodynamic and angiocardiographic studies. The patients were divided into three groups, depending on the ratio of right ventricular systolic (RVSP) to systemic pressure (SP): I (n = 58) – RVSP ≤ 75% of SP, II (n = 41) – RVSP = 76-100% of SP, III (n = 38) – RVSP > 100% of SP. In 7.3% of patients, dysplastic pulmonary valve (DPV) was seen. The balloon diameter to pulmonary valve annulus ratio was 1.29 ± 0.1, and 1.42 ± 0.1 in DPV children.

Results: Immediately post-BPV, the patients showed significantly ($p < 0.001$) decreased pressure gradient across PVS (I: 49.3 ± 11.1 - 12.5 ± 7.6, II: 75.6 ± 12.3 - 17.0 ± 13.0, III: 117.3 ± 28 - 17.9 ± 15.5 mmHg), decreased RVSP (I: 65.3 ± 10.3 - 28.6 ± 7.6, II: 91.7 ± 11.6 - 35.0 ± 14, III: 133.0 ± 27.3 - 38.4 ± 19.2 mmHg) and end-diastolic RV pressure (I: 6.2 ± 3.0 - 5.6 ± 7.6, II: 6.3 ± 3.0 - 5.5 ± 2.9, III: 8.5 ± 3.0 - 7.2 ± 2.3 mmHg), non-significant ($p > 0.05$) increase in pulmonary artery pressure in group I (15.8 ± 1.1 - 16.8 ± 0.9 mmHg) and II (15.8 ± 1.2 - 17.8 ± 1.3 mmHg) and a significant ($p < 0.003$) rise in group III (14.5 ± 1.3 - 19.4 ± 2.1 mmHg). The procedure was ineffective only in one (2.4%) child in group II, who required surgery. Complications were seen in five (3.6%) patients, including one case of a balloon being lodged in the iliac vein (surgical repair). Follow-up echo showed similar to immediate post BPV values of pressure gradients across PVS. Pre-BPV subpulmonary stenosis was seen in 5.1%, post-BPV – 15.3%, and end of follow-up – only 3.6% of children, mainly from group III. Pre-BPV tricuspid insufficiency > II° was noted in 8.8%, significantly more frequently in group III; while in late follow-up, it was seen in 7.2%, e.g. twice as often in group III vs. groups I and II. Pulmonary regurgitation > II° increased from 2.2% before BPV to 25.5%, i.e. 17.2%, 24.4% and 39.5%, respectively in groups I-III. Restenosis was observed in eight (5.8%) patients (group I – 1, III – 7), of whom five had re-BPV, two were operated on and one was disqualified due to insignificant restenosis.

Conclusions: These long-term follow-up data confirm efficacy and safety of BPV performed in children with isolated PVS.

Key words: pulmonary valve stenosis, balloon pulmonary valvuloplasty, pulmonary insufficiency

Kardiol Pol 2009; 67: 369-375

Introduction

Isolated pulmonary valve stenosis (PVS) is detected in 0.33/1000 newborns and makes up 6-9% of all congenital heart defects among children. Pulmonary valve stenosis appears in a typical modification (80-90%) and as the effect of dysplastic changes (10-20%). The type of stenosis may be the deciding point for the method of therapy, surgical or interventional, and its effects. Since Kan's publication (1982), balloon pulmonary valvuloplasty (BPV). has been the preferred alternative in treatment of the defect. The short-term and especially long-term effects of this therapy are still an area of interest of interventional cardiologists in the following aspects: reduction of the transvalvular (pulmonary valve) pressure gradient, normalisation of haemodynamic disorders, the need of second intervention, the occurrence of different complications dependent on type and degree of stenosis, and age of treated patients.

The purpose of the study was to evaluate the early and late effects of BPV in children with PVS (excluding critical form among infants) treated between 1988 and 2004.

Address for correspondence:

Piotr Weryński MD, Klinika Kardiologii Dziecięcej, Uniwersytet Jagielloński *Collegium Medicum*, ul. Wielicka 265, 30-663 Kraków, tel.: +48 12 658 13 90, fax: +48 12 658 10 81, e-mail: werpiotr@interia.pl

Received: 20 October 2008. **Accepted:** 21 January 2009.

Methods

Patients

The study included 137 children (76 boys, 61 girls) treated in the age range from 1 month to 16.3 years (mean age 5.4 ± 4.8). Three of the investigated children had earlier performed (at the age of: 1 month; 2 years and 2.5 years) surgical valvuloplasty of PVS. Because of the recurrence of PVS they were qualified for BPV.

Diagnosis

The heart defect was diagnosed as a result of physical examination, EKG, chest X-ray, echocardiography and detailed haemodynamic and angiocardiographic examination.

Patients at the end of the 1980s and beginning of the 1990s were qualified for BPV on the basis of increased transvalvular gradient over 25 mmHg in Doppler echocardiography. During the intervention the following parameters were analysed: the degree of stenosis and load of the right ventricle (the estimation of right ventricle systolic (RVSP) and end-systolic (ESPRV), systolic pulmonary artery pressure (SPAP), transvalvular gradient of the systolic pressure), the diameter of balloons and its proportion to the diameter of the valvular ring, the type of catheter used, and the need for use of double-balloon technique. Immediately after BPV, reduction of the gradient of transvalvular systolic pressure, reduction of end-diastolic RV pressure, changes of the systolic pressure in the pulmonary artery, presence/intensification of subvalvular stenosis of the pulmonary artery, appearance of insufficiency of the pulmonary valve, or other complications were analysed. An effective intervention was defined as one which decreased the stenosis by at least 50% of the initial value. Patients were divided into 3 groups, depending on the systolic pressure in RV according to the system pressure obtained in the haemodynamic procedures: group I (n = 58) – mild to moderate valvular stenosis of the pulmonary artery (RVSP ≤ 75% blood pressure); group II (n = 41) – severe valvular stenosis of the pulmonary artery (RVSP = 76-100% blood pressure); group III (n = 38) – profound valvular stenosis of the pulmonary artery with pressure in the RV exceeding the blood pressure (RVSP > 100% blood pressure). In each group age, results of the clinical examination, basic diagnostic methods (ECG; chest X-ray), complex echocardiography and interventional treatment were analysed.

Statistical analysis

Parametric data were entered into a Microsoft Excel 8.0 spreadsheet. Results are presented as mean ± SD or numbers and percentages. Student's t-test with 0.05 level of statistical significance was used to estimate the significance of the differences. The χ^2 test was performed to compare the frequency of occurrence of phenomena and observations. Calculations were made using the statistical program STATISTICA. The observation period was 1-10 years (mean 6.1 ± 3.4 years).

Results

The age of subjects was: group I, 6.0 ± 4.9 years; group II, 4.1 ± 3.8 years; group III, 5.6 ± 5.6 years. Patients aged 2-6 years constituted 55% of group I, 54% of group II, and 32% of group III. The percentage of infants increased (8.6%, 24.4% and 28.9% in each group, respectively). The echocardiographic analysis showed that most of the subjects (92.4%) had typical stenosis (Figures 1 and 2), whereas dysplastic stenosis was diagnosed in 10 children (7.3%) (Figure 3); only 4/41 from group II and 6/38 from group III had the highest grade of stenosis. The most frequent was the tricuspid type of stenotic pulmonary valve (67.9%), however in 20% of patients it was not possible to asses valve structure. Insufficiency > II° and subvalvular stenosis of the pulmonary valve in the base echocardiography were rare (3/137 and 7/137). The frequency of subvalvular stenosis increased slightly with the degree of valvular stenosis of the pulmonary artery.

There was no significant relationship between valvular stenosis of the pulmonary artery (p = 0.07) and insufficiency of the pulmonary valve (p = 0.07) in any group. The occurrence of insufficiency of the tricuspid valve was significantly higher in group III (9/38) than in group I (0/58) or group II (3/41) (p < 0.002).

Echocardiographically and angiographically assessed diameter of the pulmonary valve annulus in group I was 15.0 and 15.7 mm, in group II – 13.1 and 13.9 mm, and in group III – 11.8 and 13.9 mm respectively; there were no significant differences between measures in both tests. The mean values of the transvalvular gradient were: group I – 56.8 vs. 49.3 mmHg, group II – 73.5 vs. 75.6 mmHg, group III – 99.1 vs. 115.6 mmHg; here there was a significant difference between these two methods in group I, in which the value of the gradient was overestimated by the echocardiography (p < 0.001) and group III, where the mentioned value was underestimated (p < 0.001); the results in group II were not different (p = 0.09). The comparison of these two methods showed that the echocardiography understimates the diameter of the pulmonary valve annulus, but the differences were not significant. In the Doppler estimation of the gradient according to the haemodynamic estimation, the result was overstimated in the mild valvular stenosis of the pulmonary artery and understimated in the advanced changes (by 15%).

The proportion of the diameter of balloon catheters used to the pulmonary valve annulus was similar in the groups (group I, II, III – 1.3 ± 0.1, 1.29 ± 0.1, 1.28 ± 0.1).

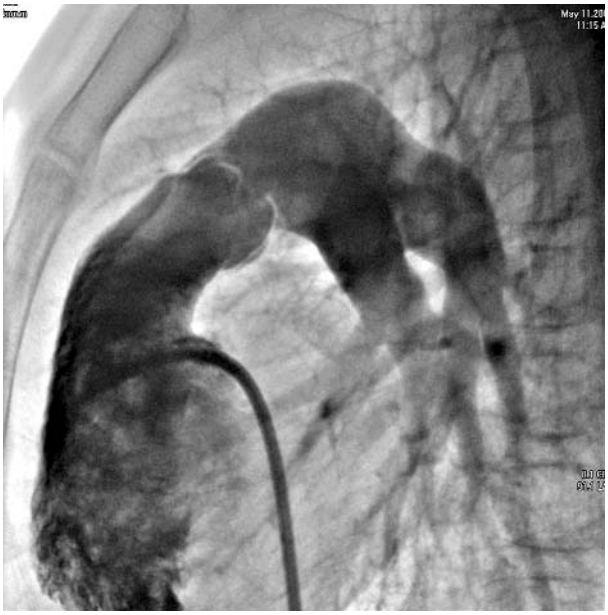

Figure 1. Angiographic view of the PVS after application of contrast agent to the right ventricle. Domed shape of the valvular cuspids ('doming' arrows), visible extension of the pulmonary trunk

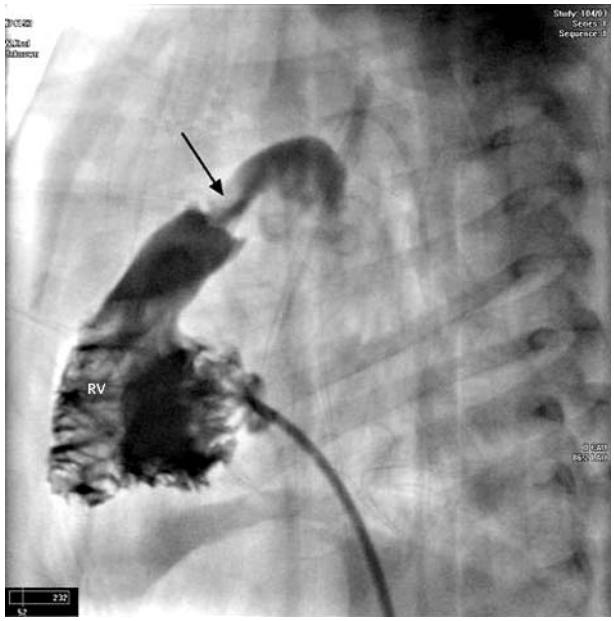

Figure 2. Image of narrow blood jet (arrow) through the severe PVS

The comparison of some haemodynamic parameters before and directly after BPV are shown in Table I.

Intervention with double-balloon technique was necessary in 8 children (6 from group I and 2 from group II). It was effective in all of them. In the group of subjects with dysplastic form of stenosis the proportion of the diameters of balloons and annulus were significantly ($p < 0.002$) higher (group II – 1.4 ± 0.13, group III – 1.43 ± 0.13). The intervention was successful in all of the children from group I and none of them needed re-intervention. The result of intervention of one patient from group II was good, but there was a need to perform another procedure after 5 years because of recurrence of the stenosis. In the other case the intervention was not effective and surgical treatment had to be performed. The results of BPV among children from group III were good. However, 7 of them (18.4%) needed later (mean 7.3 years after the first intervention) a second procedure, because of recurrence of stenosis. Four of them had effective BPV, 2 children were qualified for surgical treatment and one was disqualified (transvalvular gradient was 20 mmHg).

Five children developed complications, one of them was severe (wedge up of detached balloon – Balt BDC – in femoral vein) and needed surgical intervention. Three children needed blood transfusion and one received adenosine because of supraventricular tachycardia. In the long-term observation, in one patient who underwent secondary intervention, detachment of the internal membrane in the pulmonary trunk was detected by echocardiography. It was probably associated with re-stenosis.

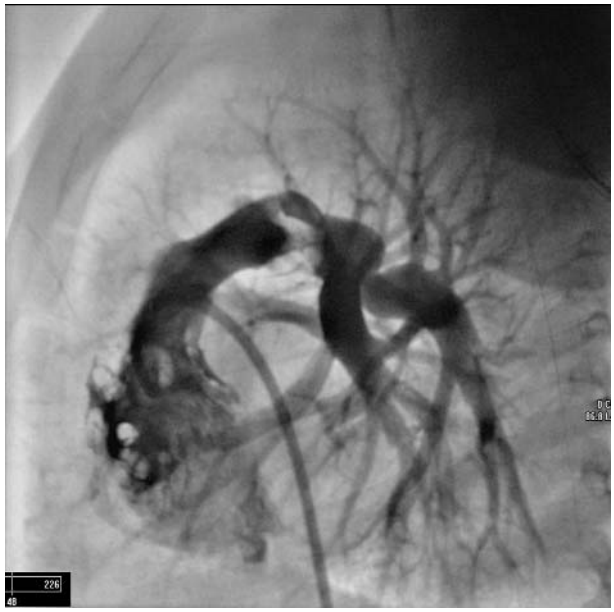

Figure 3. Image of dysplastic stenosis of pulmonary artery, narrow annulus of the valve and no signs of extension of the pulmonary trunk

In the subsequent prospective echocardiographic investigations (every 12 months) a gradient of systolic transvalvular pressure remained similar to the post-interventional measurements in each group of children. These values at the end of the observation were as follows: group I – 13.4 ± 6.9 mmHg; group II – 16.9 ± 12.1 mmHg; and group III – 17.1 ± 12.2 mmHg. The incidence of subvalvular stenosis of pulmonary artery

Table I. Comparison of values of systolic transvalvular gradient (stenosis of pulmonary artery) (Δ), right ventricular systolic pressure (RVSP), end-systolic pressure of the right ventricle (ESPRV), systolic pulmonary artery pressure (SPAP), before and after BPV in children from the investigated groups

	Δ [mmHg]	RVSP [mmHg]	ESPRV [mmHg]	SPAP [mmHg]	
Group I:	before BPV	49.3 ± 11.1	65.3 ± 10.3	6.2 ± 3.0	15.8 ± 1.1
	after BPV	12.5 ± 7.6	28.6 ± 7.6	5.6 ± 7.6	16.8 ± 0.9
		p < 0.001	p < 0.001	p < 0.001	p > 0.05
Group II:	before BPV	75.6 ± 12.3	91.7 ± 11.6	6.3 ± 3.0	15.8 ± 1.2
	after BPV	17 ± 13.0	35.0 ± 14	5.5 ± 2.9	17.8 ± 1.3
		p < 0.001	p < 0.001	p < 0.001	p > 0.05
Group III:	before BPV	117.3 ± 28	133.3 ± 27.3	8.5 ± 3.0	14.5 ± 1.3
	after BPV	17.9 ± 15.5	38.4 ± 19.2	7.2 ± 2.3	19.4 ± 2.1
		p < 0.001	p < 0.001	p < 0.001	p < 0.001

decreased in each group: I – 8.6-0%, II – 12.2-2.4%, III – 28.9-10.5% of subjects. Insufficiency of the tricuspid valve > I° was diagnosed more frequently (p = 0.07) in subjects from group III (group I – 5.2%, group II – 4.8%, group III – 13.2%). Significant insufficiency of the pulmonary valve was observed significantly more often (p < 0.007) among children from this group (group I – 17.2%, group II – 24.2%, group III – 39.5%).

Discussion

Congenital pulmonary stenosis is a progressive defect, which needs adequate treatment in different periods of life. The decision about the type of treatment should be made according to the degree of haemodynamic changes. Besides very early detection of changes it is very important to follow them. Even in mild or moderate disease very fast progression in infancy or early childhood was documented [1-3]. Patients with severe stenosis should undergo treatment even if it is well tolerated and is asymptomatic at the beginning, because of the possibility of dangerous complications [4, 5]. The analysis of our own data showed that children with mild PVS (group I) qualified for BPV constituted the majority (42.4%). The amount of children with moderate (group II) and severe (group III) was similar – 29.9% and 27.7%. As expected, the mean age of children with mild PS who underwent the intervention was 6 years. The mean age of children from group II and III was 4.1 and 5.6 years. The age difference was not significant (p = 0.07). The percentage of infants increased in successive groups: 8.6%, 24.4% and 28.9%. The intervention among subjects from group I and II was undertaken between age 2 and 6. This is consistent with the knowledge that the dynamics of changes of PVS after the second year of life is slow. However, it is worth performing the treatment before school age. The clinical status of almost all of the children was good and this finding is compatible with observations of other authors [6]. Subjects with mild to moderate stenosis are usually asymptomatic and their exercise capacity is normal. In group III (severe stenosis), symptoms are intensified and are seen much earlier. Dyspnoea and persistent fatigue may be associated with RV heart failure. These symptoms are indications for urgent intervention [7, 8]. Increased fatigue was the only alarming symptom in the group of older children.

Complex echocardiographic diagnosis is the most valuable method in children with PVS. The transvalvular gradient (pulmonary valve) in Doppler echocardiography > 25 mmHg as an indication for intervention was the result of lack of a clear echocardiographic criterion at the beginning of the history of BPV. Currently, the indication for intervention is a gradient > 40 mmHg [9]. The analysis of echocardiographic data of our patients showed that the majority (92.4%) of children with PVS had the typical form; the dysplastic one was present only in 7.3% and it was associated with moderate and severe stenosis. Mostly it was the tricuspid type of valve, however in 20% it was not precisely described. Co-existing subvalvular stenosis and insufficiency of the pulmonary valve > II° in Doppler echocardiography was very rare. The association between higher prevalence of insufficiency of the tricuspid valve in group III was significant (p < 0.002). The is proof of the damaging effects of increased afterload on function of the valve.

The differences in diameter of the annulus of the pulmonary valve assessed by echocardiography or angiography were insignificant. Generally, echocardiography tended to underestimate the result, especially among children from group III. This may be associated with the highest grade of deformations of the stenotic valve. However, Doppler echocardiography tends to overestimate the transvalvular gradient of systolic pressure in mild cases of PVS, in comparison to haemodynamic assessment. These methods are different because of the reference of time of measurement and the curve of the pressure.

The transvalvular gradient of systolic pressure in Doppler echocardiography (maximum flow velocity) is higher (10%) than according to the haemodynamic data. The invasive measurements are obtained from the 'peak

to peak' continuous record, from which is measured the difference between the maximal systolic pressure in RV and pulmonary artery. However, the peak systolic pressures in RV and pulmonary artery are not available at the same moment of systole. The Doppler method demonstrates 'maximal momentary gradient'. The values of gradient in echocardiography are higher than those obtained from haemodynamic measurements, especially among children from group I and II. The underestimation of a result is associated with higher (> 20°) than acceptable divergence between the ultrasound beam and the direction of blood flow. This situation may be caused by deformation of the cusp, which is associated with dispersion of the blood flow. This is very important and needs a lot of caution in the interpretation of the border gradient values in Doppler echocardiography as an indication for interventional treatment.

The double-balloon technique was applied in 8 (5.8%) children. It was caused by the large diameter of the annulus of the stenotic valve (> 20 mm) and the lack of an appropriate balloon. Despite the greater difficulty the intervention was effective. None of patients needed re-intervention and in the long-term observation there was no insufficiency of the pulmonary valve > II°. There are single reports describing the application of 3 balloons to perform the valvuloplasty [10]. Among all of the children from group I the results of the intervention are very good. In group II (40 children), good results were observed in 39 (97.6%) of them. However, in one (2.4%) of them with Noonan syndrome and dysplastic pulmonary valve (DPV) the result of intervention was not satisfactory. He needed surgical treatment. However, all children from group III had good direct results of interventional treatment. These data should encourage BPV to be performed in the first stage of treatment, even among children with dysplastic changes of the valves. In the case of unsatisfactory results, the child should be referred for surgical treatment. Besides the significant decrease of transvalvular (pulmonary valve) gradient of systolic pressure a decrease of systolic and normalisation of RV end-diastolic pressure were observed.

There was also an increase of systolic pressure in the pulmonary artery, especially among children from group III. In severe cases of PVS, BPV leads to an increase of the systolic pressure in the pulmonary artery, sometimes even to pulmonary hypertension (PH), which normalises after reducing RV hypertrophy. Sudden reduction of stenosis of the pulmonary valve leads to increase of the dynamic subvalvular stenosis. This requires the use of propanolol. This relationship was observed in our study. Only 5 (3.6%) patients took propanolol, directly after intervention (2 from group II and 3 from group III).

Despite the experience and technical progress the valvuloplasty is associated with some risk. The complications are divided into groups: severe, moderate and mild. According to the Valvuloplasty and Angioplasty of Congenital Anomalies (VACA) registry, severe complications are diagnosed in 0.6%, moderate in 1.3% and mild in 2.6% of interventions. The presence of complications is proportional to age and was mostly found in the group of infants [11]. There are the following complications after BPV: injury of a vessel (perforation, embolism), injury of the tricuspid valve (perforation, partial tear of the cuspid), injury of the annulus or the cuspid of the pulmonary valve, perforation of the RV outflow tract, disruption of the pulmonary trunk and its consequences such as cardiac tamponade or sudden cardiac arrest as the result of closed RV outflow tract. The other group of complications comprises arrhythmias.

Insufficiency > II° of the pulmonary valve is also one of the complications. It is associated with the diameter of the balloons used during the intervention. According to literature the occurrence of this problem is from 10% to 50% of patients with PVS who underwent the surgical treatment or balloon valvuloplasty. For many years there was a belief that this state should be well tolerated by patients. The summary data suggest that in long-term observation serious insufficiency is not well tolerated. Shizamaki et al. showed that there were no symptoms at all in 77% of patients for 37 years, 50% of patients for 49 years and only 24% of patients for 64 years. These data are based on analysis of a study on 72 subjects with isolated PVS treated surgically [13]. This study suggests that more intensified than moderate pulmonary valve insufficiency leads to dysfunction of RV (and based on it arrhythmias) in an increasing number of patients over time. As patients get older, the possibility of increase of pulmonary valve insufficiency is greater. This situation is associated with the need for surgical or interventional treatment (replacement of the valve), especially among older patients [5, 12, 14].

Injury of the annulus or cusp of the pulmonary valve takes place when the diameter of the balloon markedly exceeds the diameter of the annulus or the translocation of the balloon along the axis of the pulmonary trunk occurs. The group of patients who primarily underwent the surgical treatment should be taken into consideration as a risk group for the above-mentioned complications. The disruption of the annulus of the pulmonary valve may lead to haemorrhage to the pericardial sac and tamponade. That is why the choice of the right diameter of the balloon is so important. It is best to choose it according to the data obtained from echocardiography and angiocardiography [15]. In case of divergence between the results of those two tests, the best way to avoid complications is to use a balloon which is smaller than the smallest diameter of the annulus from the most reliable measurement. If this intervention is ineffective, the next balloon should be 20-40% bigger. This problem did not occur in our group.

Perforation of RV happens mostly as the result of manoeuvres with the catheter or leader during the displacement to the pulmonary trunk. It is common in new-born children with critical type or infants with

the most severe PVS. Injury of the pulmonary trunk, pulmonary branches or capillaries is usually associated with manoeuvres with the leader in the system of pulmonary vessels. This is a very rare complication [16]. In our study there was only one case of detachment of the internal membrane of the pulmonary trunk. It happened during the second intervention (suspicion of recurrence of valvular stenosis of the pulmonary artery in echocardiography). This was a mild lesion and did not need any treatment.

Injury of the tricuspid valve is most frequently caused by strained passage of the diagnostic catheter or leader and balloon catheter between the tendinous chords and papillary muscle of the tricuspid valve. It may also be associated with the use of a too long balloon. During the expansion of the balloon and pulling back the empty one there is a possibility of injury of the tendinous chords and insufficiency of the tricuspid valve. Serious insufficiency of the tricuspid valve may even require plastic surgery [17].

In the successive echocardiographic examinations performed every 12 months after BPV the transvalvular gradients were similar to the post-interventional values. At the same time the frequency of subvalvular pulmonary artery stenosis was decreased. Among the investigated groups (excluding group I), a decrease of the frequency of insufficiency of the tricuspid valve > II° was found. There was also increased presence of insufficiency of the pulmonary valve > II°. This was associated with a decrease of the pressure load of the RV and injury of primarily damaged structure of the pulmonary valve (most advanced in group III). There is no clear explanation for the development of insufficiency of the tricuspid valve in long-term observation in 2 children from group I. In the baseline echocardiography there were no signs of this disease.

Conclusions

1. In the qualification for balloon valvuloplasty, complex echocardiographic diagnostics play the key role.
2. The results of long-term observations confirm the usefulness and effectiveness of balloon valvuloplasty in the treatment of valvular stenosis of the pulmonary artery even in children with dysplastic changes.
3. Recurrences of the stenosis are rare and may need a second BPV.
4. The presence of reflexive subvalvular stenosis of the outflow tract of the right ventricle decreases after the BPV.
5. Significant insufficiency of the pulmonary artery valve which is the effect of the BPV may increase with age. Therefore it needs observation especially among patients with severe PVS.
6. The risk of complications after percutaneous balloon valvuloplasty is small if it is performed with caution.

References

1. Gielen H, Daniels O, van Lier H. Natural history of congenital pulmonary valvar stenosis: an echo and Doppler cardiographic study. *Cardiol Young* 1999; 9: 129-35.
2. Moller I, Wennevold A, Lyngborg KE. The natural history of pulmonary stenosis. Long-term follow-up with a serial heart catheterizations. *Cardiology* 1973; 58: 193-202.
3. Freedom RM, Benson L. Congenital pulmonary stenosis and isolated congenital pulmonary insufficiency. The natural and modified history of congenital heart disease. *Futura*, *Blackwell Pub*., New York 2004; 107-718.
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. Berman W Jr, Fripp RR, Raisher BD, et al. Significant pulmonary valve incompetence following oversize balloon pulmonary valvuloplasty in small infants: A long-term following-up study. *Catheter Cardiovasc Interv* 1999; 48: 61-5.
6. Buheitel G, Böhm B, Koch A, et al. Balloon dilatation of the pulmonary valve. Short-, middle- and long-term results. *Z Kardiol* 2001; 90: 503-9.
7. Demkow M, Rużyłło W, Lubiszewska B, et al. Percutaneous pulmonary valvuloplasty in 135 patients. *Kardiol Pol* 1992; 37: 67-73.
8. Steinberger J, Moller JH. Exercise testing in children with pulmonary valvar stenosis. *Pediatr Cardiol* 1999; 20: 27-31.
9. Blieden LC, Berant M, Zeevi B. Pulmonic stenosis. In: Moller JH, Hoffmann JIE (eds.). Pediatric cardiovascular medicine. *Churchill Livingstone*, Philadelphia 2000; 552-8.
10. Escalera RB 2nd, Chase TJ, Owada CY. Triple-balloon pulmonary valvuloplasty: an advantageous technique for percutaneous repair of pulmonary valve stenosis in the large pediatric and adult patients. *Catheter Cardiovasc Interv* 2005; 66: 446-51.
11. McCrindle BW. Independent predictors of long-term results after balloon pulmonary valvuloplasty. Valvuloplasty and Angioplasty of Congenital Anomalies (VACA) Registry Investigators. *Circulation* 1994; 89: 1751-9.
12. Poon LK, Menahem. Pulmonary regurgitation after percutaneous balloon valvoplasty for isolated pulmonary valvar stenosis in childhood. *Cardiol Young* 2003; 13: 444-50.
13. Shizamaki Y, Blackstone EH, Kirklin JW. The natural history of isolated congenital pulmonary valve incompetence: surgical implications. *Thorac Cardiovasc Surg* 1984; 32: 257-9.
14. Bouzas B, Kilner PJ, Gatzoulis MA. Pulmonary regurgitation: not a benign lesion. *Eur Heart J* 2005; 26: 433-9.
15. Roos-Hesselink JW, Meijboom FJ, Spitaels SE, et al. Long-term outcome after surgery for pulmonary stenosis (a longitudinal study of 22-33 years). *Eur Heart J* 2006; 27: 482-8.
16. Abreu AR, Campos MA, Krieger BP. Pulmonary artery rupture induced by a pulmonary artery catheter: a case report and review of the literature. *J Intensive Care Med* 2004; 19: 291-6.
17. Attia I, Weinhaus L, Walls JT, et al. Rupture of tricuspid valve papillary muscle during balloon pulmonary valvuloplasty. *Am Heart J* 1987; 114: 1233-5.

Wyniki przezskórnej plastyki balonowej w leczeniu zastawkowego zwężenia tętnicy płucnej u dzieci

Piotr Weryński, Andrzej Rudziński, Wanda Król-Jawień, Jacek Kuźma

Klinika Kardiologii Dziecięcej, Uniwersytet Jagielloński *Collegium Medicum*, Kraków

Streszczenie

Wstęp: Izolowane zwężenie zastawki tętnicy płucnej (ZZTP) należy do częstszych (6–9%) wad wrodzonych serca, preferowanym leczeniem jest walwuloplastyka balonowa (WPB).

Cel: Ocena wyników WPB u dzieci z ZZTP leczonych w latach 1988–2004, w okresie obserwacji 6,1 ± 3,4 roku.

Metody: Grupę badaną stanowiło 137 dzieci (76 płci męskiej i 61 płci żeńskiej) w wieku 5,4 ± 4,8 roku. Rozpoznanie postawiono na podstawie wyników badania fizycznego, EKG, RTG klatki piersiowej, echokardiografii, diagnostyki hemodynamicznej i angiokardiograficznej. Badanych podzielono na 3 grupy, zależnie od stosunku ciśnienia skurczowego w prawej komorze (CSPK) do ciśnienia systemowego (CS): grupa I (n = 58) z CSPK ≤ 75% CS, grupa II (n = 41) z CSPK = 76–100% CS, grupa III (n = 38), z CSPK > 100% CS. U 7,3% dzieci ZTP była dysplastyczna. Stosunek średnicy balonów do pierścienia płucnego wynosił 1,29 ± 0,1, a u dzieci z dysplastyczną ZTP 1,42 ± 0,1.

Wyniki: Bezpośrednio po WPB w badaniu hemodynamicznym stwierdzono: istotne ($p < 0,001$) obniżenie gradientu ciśnienia skurczowego przez ZZTP (grupa I: z 49,3 ± 11,1 do 12,5 ± 7,6 mmHg, grupa II: z 75,6 ± 12,3 do 17,0 ± 13,0 mmHg, grupa III: z 117,3 ± 28 do 17,9 ± 15,5 mmHg), obniżenie CSPK (grupa I: z 65,3 ± 10,3 do 28,6 ± 7,6 mmHg, grupa II: z 91,7 ± 11,6 do 35,0 ± 14 mmHg, grupa III: z 133,0 ± 27,3 do 38,4 ± 19,2 mmHg) i ciśnienia końcoworozkurczowego w prawej komorze (grupa I: z 6,2 ± 3,0 do 5,6 ± 7,6 mmHg, grupa II: z 6,3 ± 3,0 do 5,5 ± 2,9 mmHg, grupa III: z 8,5 ± 3,0 do 7,2 ± 2,3 mmHg), nieistotny ($p > 0,05$) wzrost ciśnienia w tętnicy płucnej w grupie I (z 15,8 ± 1,1 do 16,8 ± 0,9 mmHg) i grupie II (z 15,8 ± 1,2 do 17,8 ± 1,3 mmHg), a istotny ($p < 0,003$) w grupie III (z 14,5 ± 1,3 do 19,4 ± 2,1 mmHg). Tylko u jednego (2,4%) dziecka z grupy II zabieg był nieskuteczny i konieczna była operacja. Różne powikłania wystąpiły u 5 (3,6%) chorych, w tym u jednego zaklinowanie odwarstwionego balonu w żyle biodrowej, który został usunięty operacyjnie. W trakcie obserwacji w badaniu echokardiograficznym stwierdzano stabilizację wielkości gradientu ciśnienia skurczowego przez ZTP. Zwężenie podzastawkowe tętnicy płucnej przed WPB w badaniu echokardiograficznym miało 5,1% dzieci, po WPB 15,3%, a pod koniec obserwacji tylko 3,6%, głównie z grupy III. Niedomykalność zastawki trójdzielnej powyżej II stopnia w badaniu echokardiograficznym przed WPB występowała u 8,8% dzieci, istotnie częściej w grupie III, a w badaniach odległych u 7,2%, nadal 2-krotnie częściej w grupie III niż w I i II. Stwierdzono wzrost występowania niedomykalności ZTP powyżej II stopnia, z 2,2% chorych przed WPB do 25,5% po WPB, odpowiednio w grupach: 17,2, 24,4 i 39,5%. Nawrót zwężenia wystąpił u 8 (5,8%) chorych (u jednego z grupy II i 7 z grupy III), z których 5 ponownie poddano WPB, 2 operowano, a jednego nie zakwalifikowano (nieistotny gradient przez ZZTP).

Wnioski: 1) W kwalifikacji do WPB decydującą rolę, pomimo pewnych ograniczeń, odgrywa kompleksowa diagnostyka echokardiograficzna. 2) Wyniki obserwacji odległych potwierdzają przydatność i skuteczność WPB w leczeniu ZZTP nawet u dzieci ze zmianami dysplastycznymi tej zastawki. 3) Nawroty zwężenia są rzadkie i mogą wymagać powtórnej walwuloplastyki balonowej. 4) Odruchowe podzastawkowe zwężenie drogi wypływu z prawej komory po skutecznej WPB ulega regresji. 5) Istotna niedomykalność ZTP powstała po skutecznej WPB może narastać z wiekiem, co wymaga dalszej obserwacji, zwłaszcza u chorych z najbardziej zaawansowanym ZZTP. 6) Ryzyko powikłań przezskórnej płucnej walwuloplastyki balonowej jest niewielkie pod warunkiem przestrzegania zasad procedury.

Słowa kluczowe: zastawkowe zwężenie tętnicy płucnej, plastyka balonowa, niedomykalność zastawki tętnicy płucnej

Kardiol Pol 2009; 67: 369-375

Adres do korespondencji:

dr n. med. Piotr Weryński, Klinika Kardiologii Dziecięcej, Uniwersytet Jagielloński *Collegium Medicum*, ul. Wielicka 265, 30-663 Kraków, tel.: +48 12 658 13 90, faks: +48 12 658 10 81, e-mail: werpiotr@interia.pl

Praca wpłynęła: 20.10.2008. **Zaakceptowana do druku:** 21.01.2009.