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Balloon Dilatation of Right ventricle to Pulmonary Artery Conduit Stenosis in Children

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Abstract. Right ventricular outflow tract reconstruction with implantation of right ventricle to pulmonary artery (RV-PA) conduit is one of the widespread methods of surgical correction of different complex forms of congenital heart diseases. Despite direct good results after the operation, follow-up observations show high risk of conduit dysfunction in form of stenosis, failure, and their combination.

Objective. To determine the efficacy of balloon dilatation of the RV-PA conduit stenosis in children and its influence on terms of reoperation.

Materials and methods. The paper presents the retrospective analysis of information on 70 patients, which had balloon dilatation of RV-PA conduit stenosis over the period from January 1, 2013 to December 31, 2018 in the Ukrainian children's cardiac centre.

Results. 70 patients underwent successful balloon dilatation of RV-PA conduit. The mean age at the time of balloon dilatation was 10.5±6.5 (0.25-17) years, the mean weight was 39±20 (3.85-95) kg. According to cardiac catheterization results, RV-PA mean systolic pressure before balloon dilatation was 49±15 (10.5–100) mm Hg, after balloon dilatation – 31±13 (5-83) mm Hg. Reduction of RV-PA systolic pressure gradient was reported in 64 (91%) patients. The mean interval before the next reintervention after conduit stenosis balloon dilatation was 19±10 (0.5–64) months. The median range of follow-up after conduit stenosis balloon dilation is 38.5 (3-75) months. Further follow-up observations showed that 24 (34%) patients did not require any reinterventions, while 45 (64%) required reinterventions. Repeated balloon dilatation of conduit stenosis was carried out in 4 (5.7%) patients, while 41 (58%) patients had conduit replacement within 1.6 years after balloon dilatation.

Conclusion. Balloon dilatation of RV-PA conduit is an effective procedure that reduces systolic gradient of stenotic conduit in children in 91% cases and allows delaying the operation for conduit replacement by a mean of 1.6 years.

Keywords: *conduit, balloon dilatation, endovascular interventions, congenital heart disease, cardiac catheterization.*

Right ventricular outflow tract reconstruction with implantation of right ventricle to pulmonary artery (RV-PA) conduit is one of the widespread methods of surgical correction of different complex forms of congenital heart diseases for more than 30 years [1]. Heart defects such as pulmonary atresia, truncus arteriosus, require conduit implantation at an early age.

Despite direct good results after the operation, follow-up observations show high risk of conduit dysfunction in form of stenosis, failure, and their combination. It is noteworthy that a proportion of such changes prevails in children, as opposed to adults [2]. The most common reasons for decreased conduit suitability include its discrepancy in size in the follow-up period for growing children and degenerative changes, especially calcification [1, 2]. Impaired haemodynamics with conduit stenosis is caused by an obstruction to blood output from the right ventricle, which can be at any level, but more often at the level of the valve mechanism of the conduit. The degree of severity of the obstruction determines the level of pressure increase in the right ventricle [3, 4]. Conduit stenosis is evidenced by a pressure gradient on the conduit greater than 30 mmHg according to echocardiography findings, the presence of echocardiographic signs of the right ventricular dysfunction, increased pressure in the right ventricle according to echocardiography findings and catheterization of the heart cavities, confirmed narrowing of the conduit during angiocardiography.

Now percutaneous procedures are actively developed to improve the conduit functionality and to delay the recurrence of surgical interventions. These include balloon dilatation of conduit stenosis, endovascular stenting, and transcatheter pulmonary valve implantation. The effect of balloon dilatation on a stenosed conduit implanted into the pulmonary position is controversial given the complexity of the evaluation of the procedure effectiveness and a small number of publications on the outcomes. Some publications have reported that balloon dilation does not extend the viability of conduits, so the authors recommend abandoning this technique [5]. However, recent retrospective studies have shown that balloon dilatation of pulmonary artery conduit stenosis has a beneficial effect in children and adolescents, significantly delaying recurrent surgery, thus reducing the overall number of conduit replacement operations [1–3].

The objective of the work is to determine the efficacy of balloon dilatation of the RV-PA conduit stenosis in children and its influence on terms of reoperation.

Materials and methods

The paper presents a retrospective analysis of the data of consecutive patients who underwent balloon dilatation of pulmonary artery conduit stenosis on the basis of the State Institution “Scientific and Practical Medical Centre of Paediatric Cardiology and Cardiac Surgery of the Ministry of Health of Ukraine” for the period from January 01, 2013 to December 31, 2018. Balloon dilatation was performed according to the standard technique on AXIOM ARTIS ZEE Siemens and

AXIOM Artis BC angiographs. The decision to perform balloon dilation was made on the basis of the analysis of the patient's congenital defect, the protocol of the primary surgery, the data of the patient's clinical status, the evaluation of Doppler echocardiography and hemodynamic parameters during catheterization of the heart cavities.

Results and discussion

In total, 75 balloon dilations were performed in 70 patients diagnosed with pulmonary artery (PA) conduit stenosis. The mean age at the time of balloon dilatation was 10.5±6.5 (0.25-17) years, the mean weight was 39+20 (3.85-95) kg. The distribution of patients by primary diagnosis and their characteristics are given in Table 1. The mean age at implantation of the PA conduit was 7 ± 5.4 (0.004–16.2) years. The average time between conduction of implantation and balloon dilation was 44 ± 29 (0.5–142) months. The median interval after balloon dilatation of PA conduit stenosis prior to conduit replacement surgery was 19 + 10 (0.5–64) months.

According to cardiac catheterization results, RV-PA mean systolic pressure before balloon dilatation was 49±15 (10.5100) mm Hg, after balloon dilatation — 31±13 (5-83) mmHg. Reduced systolic pressure gradient between the right ventricle and the pulmonary artery was reported in 64 (91%) patients. There was also an improvement in blood flow through the conduit during right ventriculography (Fig. 1). In 6 (9%) patients, balloon dilation was ineffective: pressure in the right ventricle remained unchanged. The average follow-up period for patients after balloon dilatation of PA conduit stenosis was 35±17 (3-73) months.

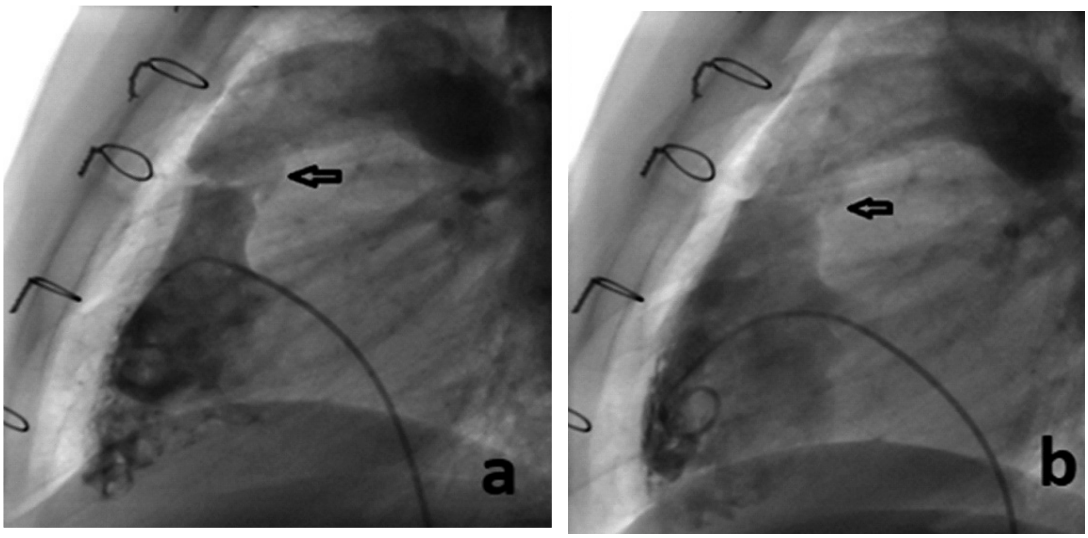

Fig. 1. Patient L., 14 years, case history no. 1012, 2016.
Angiograms before (a) and after (b) balloon dilatation of PA conduit stenosis in a patient after Ross procedure. The arrow indicates the level of the valve mechanism of the conduit

In the follow-up period after balloon dilatation of the conduit, 24 (34%) patients did not require any re-intervention, 45 (64%) required re-intervention. Of these, repeated balloon dilatation of PA conduit stenosis was performed in 4 patients, and conduit replacement was performed in 41 cases. One patient after Ross procedure had two conduit replacements and one balloon dilation. According to cardiac catheterization results, the residual mean systolic gradient of RV-PA after repeated balloon dilation was 30 ± 10 (10-50) mmHg. According to echocardiography, a decrease in the systolic gradient of RV-PA was also observed, with an average of 90 ± 20 mmHg to 51 ± 20 mmHg as well as improvement of systolic and diastolic function of the right ventricle.

Table 1. Characteristics of patients who underwent balloon dilatation of the PA conduit stenosis

Primary interventions and diagnosis	Number of patients	Age (mo)	Weight (kg)	Interval between surgery and balloon dilation (mo)	Interval between balloon dilation and re-intervention (mo)	Number of patients (%) who required conduit replacement
Ross procedure	31	109.2±47.2	37.6±14.4	52±17	20±9.7 (43.2-0.96)	17 (54.8%)
Pulmonary atresia, I-II type	12	46±26.9	20.9±8.7	48±36	14.4±12.3 (48.9-0.48)	12 (100%)
Truncus arteriosus	11	1.7±1.6	3±0.7	20.4±11.04	15.3±4.2 (24-3)	7 (63%)
Tetralogy of Fallot	9	117±57	35±15	34.9±9.9	24±6.9 (27.6-18.9)	3 (33%)
Transposition of great vessels	5	126.6±36.4	41.2±9.04	75.2±30	16.8±8.4 (21.6-0.48)	2 (40%)
Corrected transposition of great vessels	1	132	43	7.3	-	-
Absent pulmonary valve syndrome	1	84	21	4.5	-	-
Total	70	126±78	39±20	44±29 (0.5-142)	19±10 (0.5-64)	41 (58%)

It should be noted that the highest efficacy of balloon dilatation of conduit stenosis in delaying surgical correction is observed in patients diagnosed with tetralogy of Fallot and after Ross procedure, and the least effective in patients with pulmonary artery atresia, type I-II. Regardless of the initial diagnosis, in 41 (58%) patients who underwent conduit replacement surgery it was possible to delay the intervention time to older age – by 1.6 ± 0.8 years. Four (5.7%) patients who underwent repeated balloon dilatation of PA conduit stenosis did not need a conduit replacement in the follow up. After endovascular intervention, we did not observe thromboembolic complications, signs of ischemia, and worsening of conduit

deficiency. One patient died at home, death was not associated with cardiac pathology.

Although the interval between balloon dilatation of PA conduit stenosis and recurrent conduit replacement surgery was in some cases small, delaying further recurrent surgery is important, especially for paediatric patients. It should also be borne in mind that conduit replacement re-intervention is associated with resternotomy, which is accompanied with an increased risk of bleeding and other complications.

Conclusions

Balloon dilatation is an effective procedure for reducing the pressure gradient on stenotic right ventricular conduit in children in 91% of cases and allows delaying the operation for conduit replacement by an average of 1.6 years.

There is no conflict of interest.

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