



## Development of PR & Restenosis after Percutaneous Balloon Pulmonary Valvuloplasty

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### Abstract

**Background:** Pulmonary stenosis is not an uncommon congenital heart disease in our population. Various age groups present with severe pulmonary stenosis require intervention either surgical or percutaneous catheter-based. Often lifesaving surgical intervention is not feasible considering procedural risk, the patient's physical condition, and young age. Percutaneous balloon pulmonary valvuloplasty is safe, effective, almost painless, economical, and less hospital stay in any age group with immediate and long-term success. This study aimed to analyze the rate of development of (Pulmonary Regurgitation) PR & restenosis after Percutaneous Balloon Pulmonary Valvuloplasty (PBPV). **Material & Methods:** This hospital-based prospective observational study was conducted in the Department of Paediatric Cardiology Combined Military Hospital (CMH), Dhaka from January to December 2021. 0-18 years aged 50 population with PS who were referred to the Paediatric Cardiology Department of CMH Dhaka during the study period were selected as study subjects as per inclusion criteria. The purposive Sampling technique was used in this study. Data were collected with a predesigned standard data collection sheet. Statistical significance was set as a 95% confidence level at a 5% acceptable error level. Categorical variables were expressed as frequency and percentages. Mean, standard deviation, and/or medians with interquartile ranges were used to express the continuous variables. Paired t-test was performed in categorical comparison. A p-value of <0.05 was considered statistically significant. Collected data were analyzed using SPSS Version 24. Written informed consent was taken from every parent. Ethical clearance was taken from the Ethics Review Committee of CMH Dhaka for conducting the study. **Results:** 50(6.39%) had isolated valvular PS. The international standard for the prevalence of isolated PS is 8-10% which is very close to this study's result. In this study, male predominance was found with the male-female ratio of 3:2 though there was no gender dominance found in other studies. Out of 50 cases, 3(6%) are neonates, 7(14%) are infants, 27 (54%) are 1-5 years aged, and 13(26%) are more than 5 years aged. A total of 13(26%) cases developed PR, and all 13 patients developed trivial PR on D1 echo, out of them 1 patient developed mild PR on D30 Echo but in D90 and D180 Echo patients persisted the same mild PR. Out of 50 cases, 46(92%) were successful and 4 cases were procedure failed. None of the successful cases developed restenosis.



Out of 4 procedure failed cases 1 patient developed restenosis on D30 follow up and 2 patients develop restenosis on the D90 follow-up. At D180 follow up none of the patients developed restenosis. All the restenosis cases had dysplastic pulmonary valves. One patient's PS gradient persisted at 30-50 mm of Hg throughout the follow-up period. Overall restenosis in 180-day follow-up is 3(6%) and the remaining 47(94%) cases lead a healthy life in 6 months follow-up. Reballooning was done immediately after diagnosis of restenosis in stenosed cases. **Conclusion:** Immediate and intermediate-term (6 months) follow-up with Doppler echocardiography showed excellent outcomes in all cases except 3 (6.0%) restenosis cases and 13 (26.0%) insignificant PR cases. The baby who all had restenosis, had the risk factor, like- dysplastic PV. It may be concluded that balloon valvuloplasty is the procedure of choice for moderate, severe, and critical pulmonary valve stenosis.

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## INTRODUCTION

Pulmonary stenosis (PS) refers to a dynamic or fixed anatomic obstruction to flow from the right ventricle (RV) to the pulmonary arterial vasculature, which leads to RV pressure overload that in turn causes increased contractility and dilation and results in increased wall stress and compensatory RV hypertrophy.<sup>[1]</sup> The pulmonary commissures are fused, and the valve is domed and has a small central or eccentric opening; there is post-stenotic dilatation of the main pulmonary artery. The pulmonary valve is occasionally bicuspid. PS occurs in 8% to 10% of all congenital heart diseases (CHD) including valvular,<sup>[2]</sup> supralvalvular and subvalvular. PS is often associated with other CHDs, such as Tetralogy of Fallot (TOF), Single Ventricle, Ventricular Septal Defect, Patent Foramen Ovale, Atrial Septal Defect, Persistent Ductus Arteriosus, and others. PS may be valvular, subvalvular (infundibular) or supralvalvular.<sup>[3]</sup> In valvular PS, the pulmonary valve is thickened, with fused or absent commissures

and a small orifice. Although the RV is usually normal in size, it is hypoplastic in infants with critical PS (with a nearly atretic valve). Dysplastic valves-consisting of thickened, irregular, immobile tissue and a variably small pulmonary valve annulus and are frequently seen with Noonan's syndrome.<sup>[4]</sup> Isolated infundibular PS is rare but may be seen as part of the Tetralogy of Fallot (TOF). Supralvalvular PS (stenosis of the pulmonary arteries) is usually associated with a syndrome such as Williams's syndrome, Noonan's syndrome, Alagille syndrome, Ehlers-Danlos syndrome, and Silver-Russell syndrome, or congenital rubella syndrome.<sup>3</sup> Percutaneous Balloon Pulmonary Valvuloplasty(PBPV)was first done in 1982 by Kan et al in an eight years old child under fluoroscopic guidance.<sup>[5]</sup> Since then it is the gold standard treatment for moderate to severe PS. In Bangladesh, it was first performed in 1999 at CMH Dhaka.<sup>[6]</sup> Now a day it is performed under echo guidance.<sup>[7]</sup> But in our lab, we are practicing under fluoroscopy. The main disadvantage of fluoroscopy is radiation injury. Surgery is indicated if balloon

valvuloplasty is unsuccessful, or contraindicated and associated with infundibular stenosis and right ventricular outflow tract (RVOT) muscle bundle. The balloon procedure carries an extremely low risk, is painless, less costly than surgery, and shorter hospital stay. The outcome is good in 85% of cases. Restenosis after balloon dilatation is extremely rare but PR is common, occurring in 10% to 40% of patients. PR is usually well tolerated, although rarely some of these patients may become candidates for pulmonary valve implantation. The recently recommended balloon/annulus ratio is 1.2 to 1.25. Restenosis means gradient across PV  $>50$ mm of Hg at follow-up echo. Significant predictors of restenosis include balloon/annulus ratio  $<1.2$  and immediate post-PBPV gradient  $\geq 30$  mmHg, valvular pulmonary stenosis associated with other complex heart diseases, dysplastic PV annulus, dysplastic PV leaflets, hypoplastic PV.<sup>[8,9]</sup> The term immediate outcome means echo gradient across the pulmonary valve on day one of the procedure and intermediate means on day 180 of the procedure. The study aimed to determine the immediate and intermediate outcome of PBPV in 0-18-year-old patients. Follow-up will be emphasized to see the reduction of the transvalvular pressure gradient, normalization of hemodynamic disorders, the need for a second intervention, the occurrence of different complications dependent on the type and degree of stenosis, and the age of treated patients. Immediately after the procedure cut-off point of the transvalvular pressure gradient is 30 mm of Hg, if it is less procedure is successful and if it is more then the procedure is not successful or failed. All patients will be followed up on days 1,30,90 and 180 of the procedure.

## Objective

### General Objective

- To see the rate of development of PR & restenosis after percutaneous balloon pulmonary valvuloplasty.

### Specific Objectives

- To see the gender and age distributions of the subjects.

## MATERIAL AND METHODS

This hospital-based prospective observational study was conducted in the Department of Paediatric Cardiology Combined Military Hospital (CMH), Dhaka from January to December 2021. 0-18 years aged 50 population with PS who were referred to the Paediatric Cardiology Department of CMH Dhaka during the study period were selected as study subjects as per inclusion criteria. The purposive Sampling technique was used in this study. The study followed the guidelines of the Helsinki declaration. Detailed history, thorough physical examination, and relevant investigations are done. Vulvar PS was confirmed by echocardiography. Study children were undergone Interventional procedures after full filling the inclusion and exclusion criteria. Data were collected with a predesigned standard data collection sheet. Statistical significance was set as a 95% confidence level at a 5% acceptable error level. Categorical variables were expressed as frequency and percentages. Mean, standard deviation, and/or medians with interquartile ranges were used to express the continuous variables. Paired t-test was performed in categorical comparison. A p-value of  $<0.05$  was considered statistically significant.

Collected data were analyzed using SPSS Version 24. Written informed consent was taken from every parent. Ethical clearance was taken from the Ethics Review Committee of CMH Dhaka for conducting the study.

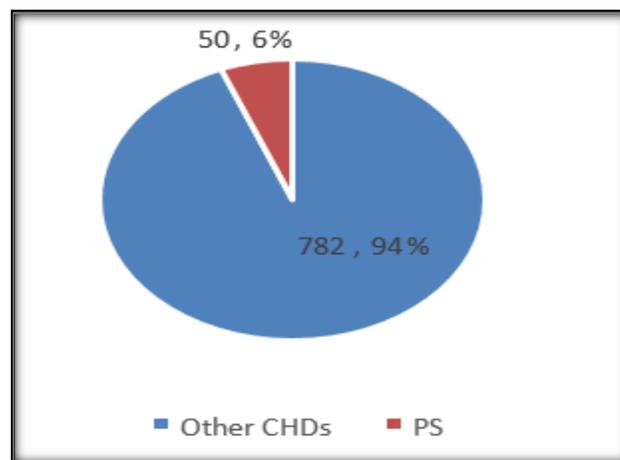
### Inclusion Criteria

- 0-18 years old patient with Valvular Pulmonary Stenosis.
- Echocardiographic gradient of PS >50 mm of Hg.
- Patients who had given consent to participate in the study.

### Exclusion Criteria

- Child, who had any medical or surgical intervention.
- Pulmonary stenosis associated with other complex CHD, Tetralogy of Fallot (TOF), Transposition of Great Arteries(TGA), Tricuspid Atresia(TA), Single Ventricle, etc., but not associated with simple CHD like- ASD, PDA which are amenable to catheter intervention.
- Patients who did not give consent to participate in the study.

## RESULTS



**Figure 1:** Frequency of PS among the Children of this study population (N=50)

During the study period, 782 children were admitted with different varieties of CHD, out of them 50(6.39%) had isolated valvular PS. The international standard for the prevalence of isolated PS is 8-10% which is very close to this study's result. [Figure 1]

**Table 1:** Gender Distribution of the patients (N=50)

Gender	N	%
Male	30	60
Female	20	40
Total(N)	50	100%

Out of 50 cases 30(60%) are male and 20(40%) are female. In this study, male predominance was found with the male-female ratio of 3:2 though there was no gender dominance found in other studies. [Table 1]

**Table 2:** Age distribution of patients (N=50)

Age	N	%
Neonate (0-1 month)	3	6
Infant (1 month- 1 year)	7	14
Child (1-5 years)	27	54



> 5 years	13	26
Total(n)	50	100

Out of 50 cases 3(6%) are neonates,7(14%) are infants, 27 (54%) are 1-5 years aged, and 13(26%) are more than 5 years aged. [Table 2]

**Table 3:** Echocardiography analysis of the study subjects (N=50)

Events		D-1 Follow up	D-30 Follow up	D-90 Follow up	D-180 Follow up
PS gradient	<30 mm of Hg	46	46	46	46
	30-50 mm of Hg	4	3	1	1
	>50 mm of Hg	0	1	2+1	2+1
PR	Trivial	13	12	12	12
	Mild	0	1	1	1
	Moderate	0	0	0	0
	Free	0	0	0	0

A total of 13(26%) cases developed PR, and all 13 patients developed trivial PR on D1 echo, out of them 1 patient developed mild PR on D30 Echo but in D90 and D180 Echo patients persisted the same mild PR. Out of 50 cases, 46(92%) were successful and 4 cases were procedure failed. None of the successful cases developed restenosis. Out of 4 procedure failed cases 1 patient developed restenosis on D30 follow up and 2 patients develop restenosis on the D90 follow-up. At D180 follow up none of the patients developed restenosis. All the restenosis cases had dysplastic pulmonary valves. One patient's PS gradient persisted at 30-50 mm of Hg throughout the follow-up period. Overall restenosis in 180-day follow-up is 3(6%) and the remaining 47(94%) cases lead a healthy life in 6 months follow-up. Reballooning was done immediately after diagnosis of restenosis in stenosed cases. [Table 3].

## DISCUSSION

Balloon pulmonary valvuloplasty is a commonly performed procedure in many centers around the world as well as in Bangladesh. For congenital pulmonary valvular stenosis, it is a safe and effective procedure and it is the initial treatment of choice. We are performing this procedure in all age groups of patients with moderate to severe pulmonary valve stenosis at our Combined Military Hospital Dhaka since 19996. The data on balloon pulmonary valvuloplasty in children and adolescent population is scanty in our part of the world. Ninety-four percent of our patients lead healthy life without any complications. The use of a smaller diameter balloon may result in significant residual PS while the oversized balloon may not warranty good long-term results without complications.<sup>[10]</sup> This ratio is also an important factor in immediate post-procedure outcome.<sup>[11]</sup> The PBPV is a very safe procedure with a low incidence of complications. Stanger P et al,<sup>[12]</sup> in the VACA registry of 26 institutions reported

only a 0.35 % major complications rate while a 0.24 % death rate from a total of 822 cases of balloon pulmonary valvuloplasty. There has been a high incidence of complications of the procedure in neonates, infants, and children,<sup>[13]</sup> while most of the studies describe no major complications of PBPV in children, adolescents, or adult populations.<sup>[14,15]</sup> Similarly, Ezhumalai B et al,<sup>[16]</sup> in their study in India reported 12% complications including major (3.7%) and minor complications (8.3%). In our study, self-limited vasovagal syncope as a minor complication was not recorded but our total study subjects were only 50. There was not a single case of arrhythmia, pericardial effusion, significant residual PS, venous injury, thromboembolic phenomenon, or death. Sievert H et al,<sup>[17]</sup> in the early era of interventions, reported that post-PBPV significant pulmonary valve regurgitation is rare and more commonly seen in surgical pulmonary valvotomy. A study from Iran showed 57 % of patients had mild pulmonary regurgitation in the immediate post-PBPV period.<sup>[18]</sup> Similarly, mild PR was noted in 55% of patients in Idrizi S et al,<sup>[19]</sup> study while 34% of patients developed mild PR in Qian X et al study.<sup>[8]</sup> The incidence of trivial and mild pulmonary valve regurgitation in the immediate post-PBPV period was 13 (26%) in our study while there was not a single case of moderate or free pulmonary regurgitation. This study showed that the incidence of PR after PBPV was variable and depends on different factors like age, balloon annulus ratio, and morphology of the pulmonary valve. The success of the procedure in our case is due to the use of an appropriate size balloon with an adequate balloon annulus ratio which is per other studies in the available literature. The outcome of balloon valvuloplasty for critical PS

in newborn babies is also excellent. One study conducted in Taiwan showed 79% definitive success of balloon valvuloplasty in neonates with critical PS.<sup>[20]</sup> In our study, we had 06 patients with critical PS. 01 critical case developed restenosis and our success rate is 83.34% in respect of critical PS which is very much nearer to the Taiwan study. Sex distribution of patients is about equal, but in our study males were predominant. In our study, follow-up echocardiography revealed 92 % procedural success and only 6 % restenosis. One study conducted in Osaka, Japan showed a decrease in mean pressure gradient immediately after balloon valvuloplasty (BVP) from  $61 \pm 27$  mmHg to  $28 \pm 20$  mmHg and the reduced gradient continued at follow-up in most cases.<sup>[21]</sup> One study conducted on 34 cases of adults showed good medium-term results.<sup>[22]</sup> In a study in Bangladesh, Fatema NN showed the success of multiple interventions in a single setting.<sup>[23]</sup> Another study in Bangladesh by ABMA Salam et al,<sup>[24]</sup> showed 2 cases of ASD Device closure with BVP to lead a healthy life without any complications. A long-term follow-up study in the USA showed, 06 out of 107 consecutive patients undergoing balloon valvuloplasty developed increasing pulmonary valve incompetence during a follow-up period of 0.5 to 10 years (mean 7.2 years). In our series, none of the patients had developed moderate to severe pulmonary valve incompetence.<sup>[25]</sup>

### Limitations of the Study

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community. Follow up period was too short and there were chances of biasedness present as there was no



randomization because of many logistic and ethical reasons.

## CONCLUSIONS

Immediate and intermediate-term (6 months) follow-up with Doppler echocardiography showed excellent outcomes in all cases except 3 (6.0%) restenosis cases and 13 (26.0%) insignificant PR cases. The baby who all had restenosis, had the risk factor, like- dysplastic PV. It may be concluded that balloon

valvuloplasty is the procedure of choice for moderate, severe, and critical pulmonary valve stenosis.

## Recommendation

Balloon Pulmonary Valvuloplasty should be taken as the first line of treatment for moderate to severe Valvular Pulmonary Stenosis. Moreover, further studies should be conducted involving a large sample size and multiple centers.

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