Utility of late pulmonary artery banding in single-ventricle physiology: A mid-term follow-up

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ABSTRACT

Background : **The standard first-stage palliation for univentricular heart with unrestricted pulmonary blood flow (PBF) is surgical pulmonary artery (PA) banding for which the ideal age is within the first 8 weeks of life. This study aimed to look for the utility of PA band done beyond 3 months of age for patients presenting beyond the stipulated period.**

Materials and Methods : **This is a retrospective analysis of the outcome of twenty patients with single-ventricle (SV) physiology with unrestricted PBF who presented late and were selected on the basis of clinical, radiological, and echocardiographic parameters for PA banding.**

Results : **The median age of the patients was 5.5 months (3.5–96 months), and the median body weight was 4.7 kg (3.2–22.0 kg). The patients were divided into three groups as follows: ten patients between 3 and 6 months of age (Group A), seven patients between 6 months to 1 year of age (Group B), and three patients > 1 year of age with additional features of pulmonary venous hypertension (Group C). The mean reduction of PA pressures following PA band was 60.9%, 48.8%, and 58.3% and the mean fall in oxygen saturation was 10.4%, 8.0%, and 6.6% in the three groups, respectively. The postoperative mortality rate was 10%. The mean follow-up duration was 13.5 months (7–23 months). There was a statistically significant improvement in weight-for-age Z scores following PA band (*P* = 0.0001). On follow-up cardiac catheterization, the mean PA pressures were 16.6 (±3.6), 22.7 (±5.7), and 33.3 (±12.4) mmHg, respectively, in the three groups, and the mean pulmonary vascular resistance index was 1.86 (±0.5), 2.45 (±0.7), and 3.5 (±1.6) WU.m2, respectively. Subsequently, seven patients in Group A, three patients in Group B, and one patient from Group C underwent successful bidirectional Glenn (BDG) surgery.**

Conclusions : **Late PA band in selected patients with SV physiology can have definite benefit in terms of correction of heart failure symptoms and subsequent conversion to BDG and can potentially change the natural history of disease both in terms of survival and quality of life.**

Keywords : Late pulmonary artery band, pulmonary vascular disease, single ventricle, unrestrictive pulmonary blood flow

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INTRODUCTION

Multiple stages of palliation are the mainstay of management for single-ventricle (SV) physiology with unrestricted pulmonary blood flow (PBF). The basic aim of the treatment is to achieve unobstructed systemic cardiac output and to provide controlled source of PBF.[1,2] Pulmonary artery (PA) banding is the universal first-stage palliation in the absence of systemic outflow obstruction.[1-5] The ideal age for PA banding is within the first 8 weeks of life, and it is usually not recommended beyond 12 weeks.[6] However, in developing countries like ours, often the patients present late and miss the ideal age of the intervention.

The aim of the study is to look for definitive outcome after late surgical PA band in terms of improvement of the clinical symptoms and subsequent suitability for second-stage surgery, i. e., bidirectional Glenn (BDG) shunt.

MATERIALS AND METHODS

This retrospective study was done in the Department of Pediatric Cardiac Sciences at Narayana Superspeciality Hospital, Howrah, from January 2018 to December 2019. Patients with SV physiology with unrestricted PBF who underwent PA banding surgery were included in the study based on the following criterion.

Patient population

Inclusion criteria

i. Children with SV physiology with unrestricted PBF with age >3 months
ii. Patients should have features of increased PBF (based on clinical, radiological, and echocardiography findings)
iii. Patients with SV physiology with associated structural abnormality producing pulmonary venous or left atrial hypertension (mitral stenosis, supramitral membrane, and obstructive cor-triatriatum with restricted atrial septal communication).

Exclusion criteria

i. SV physiology with pulmonary stenosis
ii. SV physiology with unrestricted PBF where features of increased PBF were questionable (based on clinical, radiological, or echocardiographic parameters)
iii. SV physiology with unrestrictive PBF with significant atrioventricular valvular regurgitation
   - In these conditions, we did not perform PA banding
iv. PA banding done in other cardiac anatomy apart from SV physiology
iv. Complex cardiac lesions where PA banding was done along with other surgical procedures such as arch reconstruction, coarctation repair, and re-routing of pulmonary veins
vi. PA banding done in <3 months of age
   - In these conditions, we did PA band, but the patients were not included in this study.

A total of twenty patients who had fulfilled the inclusion criteria and underwent PA banding ± atrial septectomy were included in this study.

Preoperative assessment

As per our institutional protocol, all the patients underwent proper history taking, clinical examination, chest X-ray, and detailed echocardiographic assessment. Patients who were found to have SV physiology with unrestricted PBF were taken up for surgery. Clinical history of recurrent respiratory tract infection, poor weight gain, feeding difficulty, and excessive sweating were important parameters. Room air oxygen saturation was checked for all patients. Any room air saturation >85% was taken as favorable and room air saturation >90% was considered definitive evidence of increased PBF in a SV physiology. Chest X-ray was done to look for features of pulmonary plethora and clear-cut evidence of cardiomegaly. Echocardiography was done to define the anatomy, to look for atrioventricular valve regurgitation, and to look for features of increased PBF. As per institutional practice, the following parameters were looked for to define increased PBF: echocardiographic measurement of pulmonary and systemic blood flow ratio (>2:1 was taken as a favorable point for selection in this study), brisk pulmonary venous return, and flow acceleration across mitral valve. Seventeen patients out of the twenty had clear evidence of increased PBF and were directly sent for surgery. Preoperative cardiac catheterization was not routinely considered in these patients in view of fallacious resistance calculations with such high-flow admixture physiologies. Three patients had SV physiology with unrestricted PBF with some form of pulmonary venous hypertension. All these three patients underwent cardiac catheterization to measure the severity of pulmonary venous obstruction and to measure the transpulmonary gradient. All of them underwent atrial septectomy along with PA banding.

Operative procedure

All patients underwent PA banding through midline sternotomy. Cardiopulmonary bypass was used for three patients who underwent atrial septectomy. Otherwise, PA banding was done as an off-pump procedure. The ductus arteriosus was always ligated before PA banding. A 3-mm wide, 0.6-mm thickness GORE-TEX® strip (WL Gore and Associates, Flagstaff, AZ, USA) was used for PA banding. Minimal dissection was done between the aorta and main PA and care was taken to place the band, avoiding distortion of the branch PAs. The band was fixed to the main PA adventitia with 6/0 polypropelene suture. Trusler's formula (24 mm + 1 mm for each kg of body weight) was used for the initial assessment of the diameter of the band. Further readjustment was done to achieve a distal PA pressure <50% of the systemic and to achieve an oxygen saturation of 80% approximately on 21% fraction of inspired oxygen. Any new-onset arrhythmia was taken as nontolerance of the band. On table, epicardial echocardiography was used to assess the supravalvar narrowing compared to pulmonary valve, and approximately 50% reduction in diameter was accepted.

Postoperative management

All the patients received standard postoperative care as per our institutional protocol and extubated based on their clinical status. Echocardiographic evaluation was done on the day of surgery in the operating room, on the 1st postoperative day, and before discharge and on SOS basis if clinical condition warranted.

Follow-up

Detailed clinical examination, echocardiography, and chest X-ray were done on the 3rd month and 6th month after the surgery. Clinical symptoms, weight gain, and features of heart failure were noted. Features of pulmonary plethora and evidence of differential vascularity were looked for in chest X-ray. In echocardiography, we looked for the position of PA band, gradient across the band, amount of AVVR, and ventricular function. Diagnostic cardiac catheterization was planned for all patients between 4 and 6 months of surgery to document PA anatomy, PA pressure, position of the PA band, transpulmonary gradient, and suitability for the 2nd stage of surgery. Subsequently, BDG was done for the patients in whom catheterization data were found to be suitable for single-ventricular palliation. As a protocol, pulsatile BDG was done in all patients unless mean PA pressures were >20 mmHg where PA interruption was considered.

Statistical analysis

The continuous variables were expressed as mean ± standard deviation for normally distributed data and median with range for nonnormally distributed data. Categorical variables were presented as percentages and compared between groups using Chi-square test with Yates correction (due to small sample size). Comparison of continuous variables between paired and unpaired samples was done by nonparametric Wilcoxon paired and Mann–Whitney tests, respectively, assuming non-Gaussian distribution of small sample size. $P < 0.05$ was considered statistically significant. Correlation analysis between two independent variables was done using Spearman's correlation coefficient (r). All the statistical analyses and relevant graphs were procured using (GraphPad Software, San Diego, CA, USA).

RESULT ANALYSIS

Baseline data

A total of twenty patients who fulfilled the inclusion criteria were included in the study [Table 1]. The median age of the patients was 5.5 months (3.5–96 months), and the median body weight was 4.7 kg (3.2–22.0 kg). Eight patients had a double-inlet left ventricle with unrestricted PBF, seven of them had a double-outlet right ventricle with SV physiology with or without malposition of the great vessel with or without heterotaxy syndrome with unrestricted PBF, three of them had unbalanced atrioventricular septal defect with or without heterotaxy syndrome with unrestricted PBF, and two of them had tricuspid atresia with unrestricted PBF. Three patients had associated pulmonary venous hypertension (one of them had mitral atresia with restricted interatrial communication, one of them had severe mitral stenosis, and the last patient had obstructive cor-triatriatum with parachute mitral valve). Overall, 55% of the patients enrolled in this study had SV of left ventricular morphology and 45% had SV of right ventricular morphology. Based on the age at the time of PA band, the patients were subdivided in three groups [Figure 1]: patients aged between 3 and 6 months were labeled as Group A, patients aged between 6 months and 1 year were labeled as Group B, and patients aged >1 year were labeled as Group C. All the patients in Group C were incidentally having features of significant pulmonary venous hypertension. Group A comprised ten patients, while Groups B and C comprised seven and three patients, respectively.

Operative data

On table, PA pressure was measured before PA banding. The mean PA pressures were 40.5 (±13.3 mmHg),

Table 1: Demographic, clinical, and operative data of the studied population

Parameters	Values
Total number of patients	20
Sex distribution (%)	
Male	80
Female	20
Age (median)	5.5 months (3.5-96 months)
Body weight (median)	4.7 kg (3.2-22.0 kg)
Underlying cardiac anomaly (%)	
Single ventricle of LV morphology	55
Single ventricle of RV morphology	45
Preoperative SpO_2 (mean±SD)	89.2% (±2.9%)
Preoperative mean PA pressure (mean±SD)	41.5 mmHg (±12.7 mmHg)
Duration of ventilation (mean±SD)	8.5 (±7.9) h
Duration of ICU stay (mean±SD)	4.1 (±0.9) days
Postoperative SpO_2 (mean±SD)	81.3% (±1.9%)
Postoperative mean PA pressure (mean±SD)	18.1 mmHg (±5.3 mmHg)

SD: Standard deviation, ICU: Intensive care unit, PA: Pulmonary artery, LV: Left ventricular, RV: Right ventricular

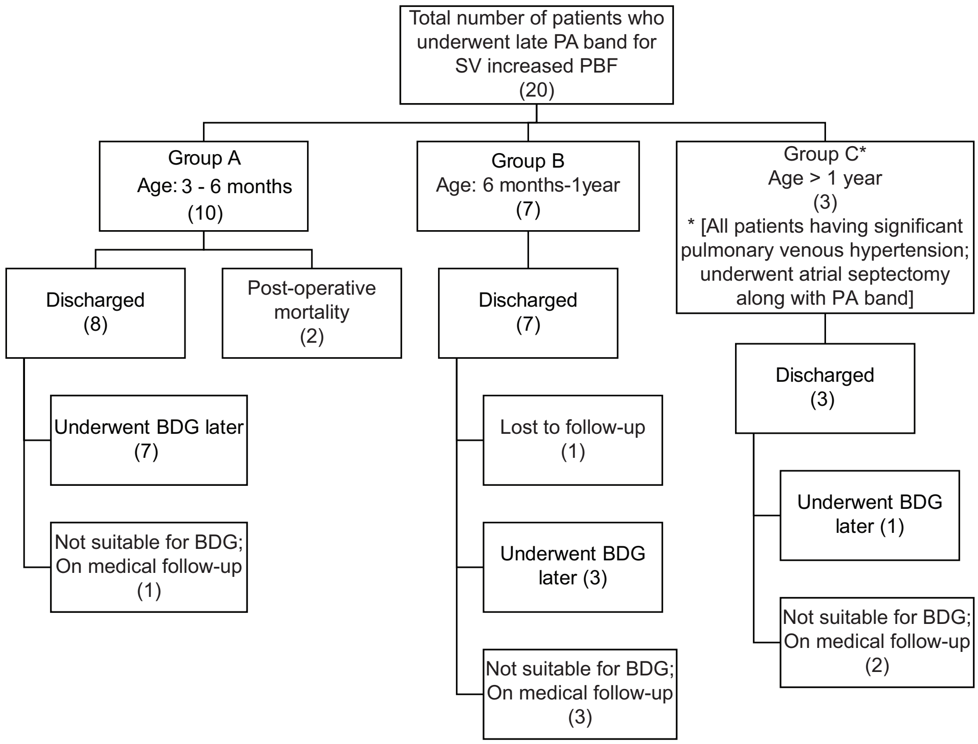

Figure 1: Distribution of the study population with overall outcome

40.7 (±10.8 mmHg), and 46.3 mmHg (±13.4 mmHg), respectively, for patients of Group A, Group B, and Group C, respectively. The intraoperative reduction of PA pressures from baseline following PA band in the three groups was 60.9%, 48.8%, and 58.3%, respectively. The mean fall in oxygen saturation was 10.4%, 8.0%, and 6.6% in Group A, Group B, and Group C, respectively. Nine out of the ten patients, i.e., 90% of the patients in Group A, were found to have a mean PA pressure <19 mmHg; four out of the seven, i.e., 57.1% of the patients in Group B, had a mean PA pressure <19 mmHg; and only one patient in Group C (33.3%) had a mean PA pressure <19 mmHg following PA banding. Ductal ligation was done for all patients. Atrial septectomy was performed as an additional procedure for Group C patients. None of the patients required re-operation.

Two patients died during the postoperative period. Both the patients belonged to Group A. The first patient died on the 1st postoperative day (POD) because of low cardiac output syndrome and the second patient died on the 5th POD due to sepsis. The overall mortality following late PA banding in this cohort was 10%. The mean duration of ventilation was 8.5 h (3–24 h), and the mean duration of stay in the intensive care unit (ICU) was 4.3 days (3–6 days).

Follow-up data

Out of 18 surviving patients post PA band, one child in Group B was lost to follow-up. The remaining 17 patients were followed up for an average duration of 13.5 months (7 months–23 months). There was a significant improvement in weight of all the patients during the initial period following PA banding. Patients in Group A had increment in mean body weight from 4.1 to 7.6 kg, within an average follow-up period of 6.2 months. The mean body weight of patients in Group B had increased from 5.5 to 7.7 kg, within an average follow-up period of 5.6 months. The mean body weight of patients in Group C had increased from 14.2 to 16.0 kg, within a follow-up period of 5.3 months. In the patients of Group A, the WHO weight-for-age average Z score improved from −3.7 to −1.3 Z, while the same in Group B improved from −3.5 to −2.5 Z [Figure 2]. The overall increment in WHO weight-for-age Z scores from baseline, in patients of Group A and B, following PA band, was found to be highly statistically significant ($P = 0.0001$). On the other hand, patients in Group C had only a minor increment in WHO weight-for-age Z scores (−2.9 to −2.5 Z). Overall, the patients did not exhibit any features of significant cardiac failure on follow-up. None of them had pulmonary plethora or differential lung vascularity (sign of band migration) on chest X-ray. All the patients had PA band in proper place, and there was no evidence of band migration on echocardiography. Neither of them showed any increment in the amount of AVVR, nor had any ventricular systolic dysfunction on echocardiography during the follow-up. All the 17 patients on follow-up subsequently underwent diagnostic cardiac catheterization to measure the PA pressure and pulmonary vascular resistance index (PVRI)

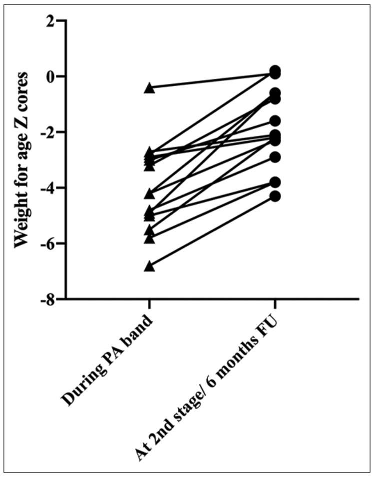

Figure 2: Significant improvement in WHO weight-for-age Z scores from baseline to 6-month follow-up or completion of second stage (bidirectional Glenn)

and to delineate the PA anatomy. The mean duration between PA band surgery and follow-up cardiac catheterization was 5.7 months (3.5–14.4 months). Patients with mean PA pressure <20 mmHg and PVRI <3 WU.m^2 were considered suitable for BDG as per the current recommendations.

On pre-BDG catheterization, the mean PA pressure of the patients in Group A was 16.6 (±3.6) mmHg and the mean PVRI was 1.86 (±0.5) WU.m^2. Seven out of these eight patients underwent successful BDG (87.5%). One patient of unbalanced atrioventricular septal defect who had a PA band at 4.5 months had a mean PA pressure of 24 mmHg and PVRI of 2.9 WU.m^2, which were found not suitable for BDG. In Group B, the mean PA pressure was 22.7 (±5.7) mmHg and the mean PVRI was 2.45 (±0.7) WU.m^2. Two patients in this group were found to be directly suitable for BDG. Another one child who underwent PA band at 6.5 months for tricuspid atresia, had a mean PA pressure of 22 mmHg, but the PVRI was 2.3 WU.m^2 during follow-up cardiac catheterization. Echocardiography revealed a significant forward flow across the PA band. She underwent BDG along with complete forward-flow occlusion (post-BDG PA pressures –16 mmHg). The rest of the patients were found not to be suitable for BDG. Hence, among the six patients in Group B, 50% could undergo successful BDG. We plotted the relationship between the initial age of PA banding and the pre-BDG PA pressure and PVRI data in patients of Groups A and B [Figure 3a and b]. There was a moderately positive correlation suggesting an increasing trend of PA pressure and PVRI with advancing age of PA band. The three patients in Group C had higher mean PA pressures of 33.3 (±12.4) mmHg and higher mean PVRI of 3.5 (±1.6) WU.m^2 compared to the other two groups. Only the youngest in the cohort was found to be suitable for BDG (33.3%). This child had a significant reduction in mean PA pressures after initial PA band

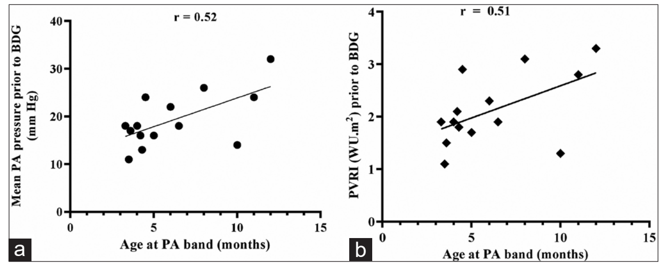

Figure 3: Correlation between age at the time of pulmonary artery banding and pre bidirectional Glenn mean pulmonary arterial pressures (a); pre bidirectional Glenn pulmonary vascular resistance index (b)

and atrial septectomy, and pre-BDG catheterization revealed acceptable values (PA mean –16 mmHg, PVRI – 1.8 WU.m^2). The other two patients in this group were kept on medical follow-up. Significant symptomatic relief was, however, seen in all the three patients due to abolition of pulmonary venous hypertension.

Overall, out of the twenty patients, 55% (11) could undergo successful BDG procedure. The procedure was not associated with any major complications. There was no operative mortality during the BDG procedure. One patient in Group A and another in Group B have been kept on pulmonary vasodilators with a plan of repeat catheterization in future. All successful BDG patients are being followed up for future Fontan completion.

DISCUSSION

The diagnosis of SV physiology with unrestricted PBF often gets delayed compared to SV with pulmonary stenosis group because of the absence of clear cyanosis and harsh murmur. The ideal age of PA banding in these patients is 4–8 weeks as per the current recommendations, and it can be done up to 12 weeks according to some experts. [6] Thus, early diagnosis is of paramount importance for further management in this group of patients. This becomes a huge issue in a developing nation like ours with limited availability of fetal echocardiography and scarcity of robust neonatal screening program and mandatory neonatal pulse oximetry recording.[7-9] Moreover, these patients remain relatively asymptomatic in the first few weeks of life and often miss the opportunity of first-stage palliation (PA band) and subsequently become forced to follow the pathway of natural selection.

The natural history of SV physiology suggests that 75% of the children succumb within the first 3 years of life.[10] Children with SV physiology with unrestricted PBF fare even worse and merely 10% survive beyond 3 years of age.[11,12] Most of the early mortality can be attributed to recurrent respiratory infections, refractory heart failure, and severe growth failure. Those who survive beyond 3 years by virtue of natural selection tend to develop early-onset pulmonary vascular disease (PVD).[13,14] This progression to PVD is much faster and earlier when compared to the standard left-to-right shunts. Studies have shown that compared to routine Eisenmenger patients, patients with such complex lesions have poorer survival by nearly two decades.[15-17]

One of the main objectives of our study was to see that, in selected patients, with a late PA band, whether we can change the course of disease progression. Most of the patients in this study who had clinical features of heart failure due to increased PBF showed significant improvement in symptomatology during their 6-month follow-up following PA band. This was very much evident by improvement in weight gain and reduction in episodes of respiratory tract infections. One of the most consistent parameters of infantile well-being is persistent weight gain. In our study, we could document statistically significant change in weight-for-age Z score in our patients compared to their baseline status (Groups A and B). This would indicate toward a successful intervention in majority of these patients albeit at the cost of fall in saturation. Obviously, such dramatic improvements in weight parameters were not seen in Group C patients. We feel that it may be due to the associated pulmonary venous hypertension which would limit the hyperdynamic state and thus have less effect on the baseline weights. Our postoperative mortality following PA band was 10%, which was similar to the mortality rate of 4%–10% as reported in some of the other reports with a larger patient population.[18-21] We did not have any late mortality during the BDG procedure. Interestingly, both the deaths occurred in patients <6 months of age, but this difference in mortality between patients in Groups A and B was not found to be statistically significant ($P = 0.62$).

The other main objective of our study was to observe whether these patients undergoing late PA band can ultimately progress to successful second-stage palliation, i.e., BDG. Out of the total twenty patients, 55% of the patients had successful conversion to BDG in our study. We compared patients in Groups A and B with the likely expectation that Group A containing the younger subsets <6 months are likely to fare better than the children where PA banding was done beyond 6 months of age [Table 2]. There was, however, no statistically significant difference between Group A (seven out of eight) and Group B (three out of six) patients in terms of progression to BDG ($P = 0.35$). Both the groups had similar ventilator requirement and ICU stays following PA band procedure. On expected lines, patients in Group A tended to have lower mean PA pressures and PVRI values on pre-BDG catheterization, compared to those in Group B, but without any statistical significance. The only statistically significant difference between the two groups was that the baseline saturation in Group A was marginally higher than those in Group B (91.1% vs. 87.9%, $P = 0.014$). However, as stated above, it did not translate into statistically significant difference in outcome between the two groups. Group C patients represented a different subset of patients and were thus excluded from this comparative analysis.

Table 2: Comparison between Group A and Group B in terms of baseline characteristics and operative outcomes

Parameters	Group A	Group B	*P*	Significance
Mean baseline SpO_2 (%)	91.1	87.9	0.014	Significant
Mean post-PA band SpO_2 (%)	81.6	80.9	0.52	Not significant
Mean duration of ventilation (h)	7.6	9	0.85	Not significant
Mean duration of ICU stay (days)	4.3	4.29	0.78	Not significant
Mortality rate of PA band procedure (%)	20	0 (none)	0.62	Not significant
Pre-BDG mean PA pressure (mmHg)	16.6	22.7	0.062	Not significant
Pre-BDG mean PVRI (WU.m^2)	1.86	2.45	0.14	Not significant
Conversion to BDG (%)	87.5	50	0.35	Not significant

ICU: Intensive care unit, PA: Pulmonary artery, BDG: Bidirectional Glenn, PVRI: Pulmonary vascular resistance index

As stated above, patient population in Group C had unique hemodynamics compared to the other two groups due to the presence of significant pulmonary venous hypertension. All the three patients in this group were older and had higher preoperative mean PA pressures and lower baseline saturation. The effect of relief of pulmonary venous hypertension on precapillary hypertension is best documented in adult patients with rheumatic mitral stenosis.[14,22-24] In children with complex cyanotic heart disease, how this situation unfolds is not very clearly understood. However, precapillary reflex arteriolar constriction is almost always present in these patients, which elevates the PA pressure and the transpulmonary gradient out of proportion to the degree of PVD.[22-24] We achieved significant fall in PA pressure in all the patients in the group following surgery, but only one child was ultimately suitable for BDG. Kalantre *et al*. reported a similar study of two patients with SV unrestrictive PBF, where successful conversion to BDG was possible in only one following a late PA band and atrial septectomy.[25] We believe that relief of pulmonary venous hypertension in these patients is absolutely necessary. However, such a step alone can potentially increase PBF, thus hastening the process of PVD in these patients. Hence, coupling the atrial septectomy procedure with a PA band takes care of any such risks.

There are many previous studies on the outcome after PA band in univentricular patients. However, even after extensive search of literature, we could only find one study concerning late PA band in this subset of patients. Sasikumar *et al.* in this study looked at the outcome of late PA band in 32 patients over a period of 8 years.[26] The age cutoff in this study was 28 days, and quite a few patients in this study were below 3 months of age. Nearly 34% of the patients in this study were aged >6 months at the time of PA band compared to 50% in our study. The study population included patients requiring arch repair, Damus Kaye Stansel repair, ventricular septal defect enlargement, etc., as additional procedures. We excluded those patients from our study to maintain uniformity of surgical risks during PA band and only included patients requiring atrial septectomy as an additional procedure (Group C). This study had slightly higher mortality rates compared to ours (15.5% vs. 10%). Thirteen patients could ultimately undergo BDG, and subsequent Fontan completion was possible in seven patients at the time of the publication. Hence, similar to our study, a significant number of late PA bands could ultimately progress to univentricular palliation in this group of patients.

Based on the outcome of our study, we strongly feel that there needs to be better judgment in not offering PA band to patients with univentricular heart, presenting beyond 3 months of age. Proper patient selection for PA band in this subgroup assumes paramount importance. All selected candidates must have clear-cut evidence of increased PBF. We compared the baseline SpO_2 trends in patients who underwent BDG versus those whom we had kept on medical management following the initial PA band. However, we did not find any statistically significant difference (90.4% vs. 88.7%, $P = 0.32$). We still recommend that any patient with SPO_2 >85% in room air with evidence of increased PBF on clinical, radiological, and echocardiographic grounds probably deserves a chance irrespective of the age of presentation and more so within the first 6 months of life [Figure 4]. We feel that PA band may still halt the progression of the development of PVD and in fact may make a substantial few suitable for SV palliation, as was seen in our study. Such patients who would ultimately go into the Fontan pathway are unequivocally going to have better long-term outcome compared to if they were kept for natural selection. Patients with borderline data can be kept on follow-up with pulmonary vasodilators and can be considered for tightening of PA band and future BDG, if possible. The patients who would not be suitable for SV palliation are still going to have an overall improved survival with better symptomatic status as was evidenced in our study, at least in the initial few years. Later on, if and when they become progressively cyanosed, there is always the option of PA de-banding. However, it is difficult to chart the future course of these patients at this point, and they are also likely to develop PVD in the long run.

Limitations of the study

Our study represents a single-center experience of outcome after late PA band in univentricular patients with increased PBF. The total number of patients in our study was only twenty. More number of prospective studies are needed with higher patient numbers before a definitive conclusion can be drawn. Patient selection for late PA band in our study was based on clinical, radiological, and echocardiographic grounds. It was a conglomeration of multiple parameters based on which a clinical decision was taken. Being a retrospective analysis, standardization of any such parameters was not possible. In addition, the assessments were done

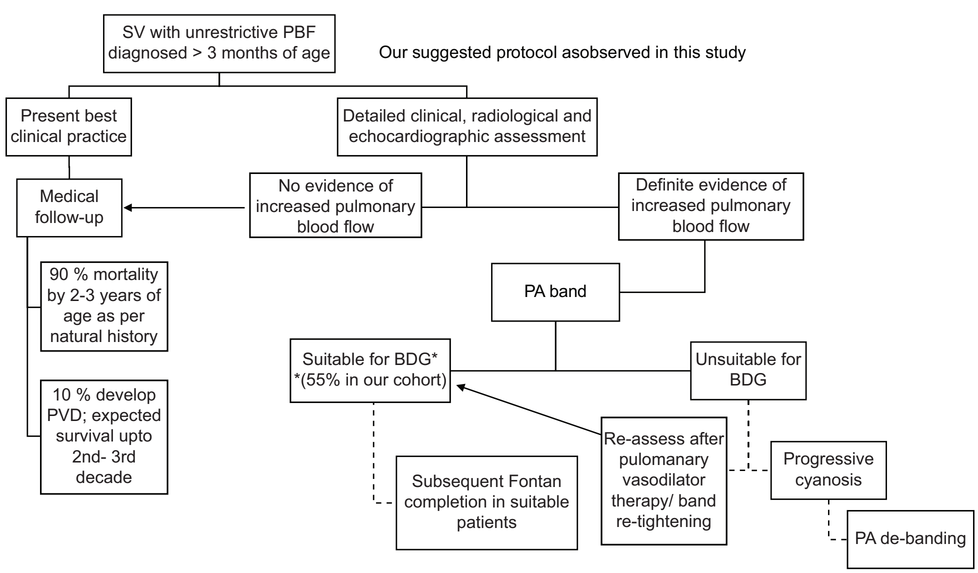

Figure 4: Medical follow-up versus late pulmonary artery band in single-ventricle patients with unrestrictive pulmonary blood flow (>3 months of age); dotted lines indicate possible future outcomes

by different operators at different points of time, thus lacking strict uniformity. Finally, the present study being a mid-term review, we need to have lengthier follow-up in our patients to understand the long-term issues of patients undergoing late PA band with this physiology. Such data will make the utility of late PA band even more relevant.

CONCLUSION

Management of infants with SV unrestrictive PBF remains a difficult challenge in the developing world due to late detection often beyond the first 3 months of life. PA band, even when done beyond the stipulated period, can have significant benefits in patients who have definite evidence of increased PBF. A substantial number of such late PA bands may also have the potential to progress to SV palliation. Even patients who do not fit into such category are likely to have better survival than patients left for natural selection.

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Conflicts of interest

There are no conflicts of interest.

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