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Original Article

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Efficacy and outcomes of pulmonary artery banding: Our experience in Azerbaijan

Abstract

Aim: We conducted a retrospective analysis of 35 patients with various congenital heart defects who underwent pulmonary artery banding (PAB) between January 2018 and September 2023. Our objective was to evaluate the outcomes of PAB and discuss its application in a staged approach for these patients.

Material and Methods: The median age at PAB was 5 months (range: 2 to 20 months) with a median weight of 5.2 kg (range: 3 to 9 kg).

Results: The hospital and total mortality rates were 11.4% (4). The median intensive care unit stay was 2 days (range: 1 to 22 days), and the median hospital stay was 5 days (range: 5 to 36 days). The second stage (either total correction or cava-pulmonary anastomosis) was achieved in 40% (14/35) of patients at a median age of 15 months. The mean interval to repair was 8 months, with 12 out of 14 patients undergoing complete biventricular repair.

Conclusion: Our study demonstrates that PAB could be performed with acceptable outcomes, serving as a viable palliative measure for neonates and extremely small infants who are at high risk for cardiopulmonary bypass. Our study results exhibit a comparable trend to previously reported findings, emphasizing the importance of PAB in managing congenital heart malformations characterized by increased pulmonary blood flow. While the effectiveness of PAB has been validated in our study, future investigations could delve into refining surgical protocols, optimizing band adjustment techniques, and exploring potential preventive measures for common postoperative complications.

Keywords: Pulmonary artery banding, palliative heart surgery, pediatric heart surgery, congenital heart surgery, congenital heart defect

INTRODUCTION

Pulmonary artery banding (PAB) is a simple palliative surgical technique invented by Muller and Damman in 1952 to reduce pulmonary overcirculation in certain congenital heart diseases (1). Its primary role includes preventing or reversing cardiac failure, protecting or reversing pulmonary hypertension, and sustaining optimal systemic output, especially in cases involving a pronounced left-to-right shunt or univentricular heart defects (2,3). The widespread adoption of PAB followed swiftly as a treatment modality for various congenital heart defects (CHDs) characterized by increased pulmonary blood flow. Over time, advancements in perfusion and surgical techniques, along with refined perioperative management, have facilitated the possibility of early definitive repair in small infants with complex congenital heart defects, resulting in promising outcomes and subsequently reducing the necessity for PAB. While the contemporary era has witnessed a decline in the frequency of PAB procedures, the operative mortality associated with PAB in neonates and small infants has persistently ranked among the highest within our field (2-5).

Despite the decreasing utilization of PAB in recent years, it continues to remain relevant in the treatment of congenital heart disease associated with pulmonary overflow (2,3,6). Many medical units in developing nations continue to adopt a staged approach to this day. The rationale underlying this practice stems from recognizing that the diagnosis of an intracardiac

lesion often coincides with a child's presentation to a healthcare facility showing severe failure to thrive, often compounded by a severe lower respiratory tract infection requiring intensive care unit admission. Furthermore, several cardiac anomalies benefit from early PAB, particularly in cases where left ventricular (LV) preparation and "training" are deemed necessary (3,4).

Nevertheless, relevant debates persist, encompassing aspects such as the optimal degree of band tightness, individual variations in ventricular adaptive responses, the most suitable timing for debanding, and the necessity for reoperations and pulmonary artery reconstruction during the debanding procedure (2). Several authors have also highlighted the negative effects of PAB, such as pulmonary arterial branch distortion, abnormal right ventricular hypertrophy, pulmonary valve insufficiency, and sub-aortic obstruction.

Our study aims so analyze the outcomes of PAB procedures performed at our center in neonates and small infants.

MATERIAL AND METHODS

A retrospective analysis was done in all patients undergoing a PAB procedure at Merkezi Klinika between January 2018 and September 2023. Neonates and infants less than 10 kg were included in our cohort. Thus, 35 patients, who underwent PAB were reviewed and form the study group. In our group of patients, the criteria for banding were mainly symptomatic patients with significant left-to-right shunt with high risk of biventricular repair, patients with pulmonary hypertension and patients with univentricular heart that needed staged approach. Patients presented with severe failure to thrive, a history of frequent respiratory infections or with suspicion of an active or recent lower respiratory tract infection not responding to medical management, symptomatic patients with small weigh were regarded as high risk for cardiopulmonary bypass and PAB was performed for these patients. Cardiac catheterization was done in 51% of the study group (18/35). The median age at PAB was 5 months (min 2 and max 20 months) with a median weight of 5.2 kg (min 3 and max 9 kg). The diagnostic categories are shown in Table 1.

Table 1. Diagnosis of patients

VSD	22
AVSD	3
DORV	3
TGA and associated lesions	2
Other (different single ventricle pathologies)	5

VSD: ventricular septal defect, AVSD: atrio-ventricular septal defect, DORV: double outlet right ventricle, TGA: transposition of great arteries

Ethical Approval

The study was approved by ethics committee of Merkezi Klinika (10.10.2023. No 44765).

Statistical Analysis

Data were presented as frequencies and percentages and subsequently analysed using the Statistical Package for Social Sciences (SPSS) version 20.

Data Collection

The hospital records were thoroughly reviewed, encompassing preoperative data such as the patient's age and weight at the time of the operation, detailed operation notes, hospital observations, echocardiography and catheterization reports, and the duration between the initial PAB procedure and the subsequent second-stage surgical intervention. Furthermore, the duration of stay in the intensive care unit (ICU), the overall hospital stay, and the identification of any short-term or long-term postoperative complications were meticulously recorded.

The outcomes were defined as follows:

1. In-hospital mortality following banding procedure. This was reported as such if the patient died prior to hospital discharge, irrespective of the period following the banding procedure.

2. Inter-stage mortality following banding procedure.

3. Total mortality following banding procedure, defined as 1+2.

4. Definitive correction, mortality or the closure date of the study were viewed as endpoints.

5. Follow-up status of patients who were not yet corrected was determined. All data collection was approved by the institutional ethics board.

Surgical Procedure

The surgery was performed through median sternotomy, a method commonly used. In most cases, a standard median sternotomy was performed with a partial opening of the pericardium. The incision in the pericardium was confined to the area covering the major blood vessels, creating a tissue plane between the pulmonary artery and the aorta through limited dissection. In some recent cases, we adopted a partial sternotomy approach (j-form) to minimize adhesions for subsequent corrections. Once complete access to the pulmonary trunk was attained, a pre-prepared band, following modified Trussler's formula (7), was placed around it. For biventricular repair, we were preparing generally 22 mm+weight, while for univentricular hearts we prepare 20 mm+weight. The tightness of the band was further adjusted based on systemic arterial saturation and pulmonary artery pressures. To prevent distal migration, the band was secured using 6-0 Prolene sutures.

RESULTS

A total of 35 patients underwent a PAB procedure at our hospital between 2018 and 2023 with a hospital mortality of 11.4% (n=4). The median intensive care unit stay was 2 days (min 1 day, max 22 days), with a median hospital stay of 5 days (min 5, max 36 days). Postoperative complications include band rupture (reopened

band) in 1 patient during hospital stay, resulting in congestive heart failure. This patient was reoperated during same hospitalization stay 25 days after initial PAB surgery. The operation was the closure of the VSD. This patient went well and was discharged 2 weeks after the 2nd operation (VSD closure). 2 patients presented with pericardial effusions in postoperative period that did not necessitate drainage. One of these patients was reoperated 6 months after PAB with total correction (atrioventricular septal defect repair - AVSD). Other patients' pericardial effusion was managed medically. 1 patient needed delayed sternum closure (sternum was left open for 24 hours). 2 patients presented sternal dehiscence (without infection) after the PAB surgery, which was corrected during the corrective surgery (1 ventricular septal defect patient and 1 double outlet right ventricle patient). Another 2 patients presented thoracic deformity (without dehiscence) after the PAB surgery. At the time of correction, debanding was performed for all biventricular repairs without need of additional intervention on pulmonary artery during the surgery. However, 1 patient presented pulmonary stenosis after the complete repair (combined valvular and subvalvular), that did not yet needed reoperation. He is still on our follow-up for his pulmonary stenosis. In 2 patients, subaortic membrane was noted after PAB that was resected during the corrective operation. One patient presented left ventricular outflow tract obstruction (LVOTO) 6 months after the complete repair. This patient is in follow-up. The 2nd stage (total correction or cava-pulmonary anastomosis) was achieved in 40% (14/35) of patients at a median age of 15 months. The mean interval to repair was 8 months. 12 patients of 14 had complete biventricular repair while 2 patients had cava-pulmonary anastomose. There was no mortality after the 2nd stage operation. There was no mortality while awaiting definitive repair. The total mortality was 11.4% (4/35).

Postoperative complications after 2nd stage include complete heart block requiring permanent pacemaker in 1 patient, pulmonary valve stenose in 1 patient (still on follow-up) and LVOTO in 1 patient (still on follow-up).

DISCUSSION

Although primary early corrective surgery is generally favored, certain scenarios warrant a two-stage approach involving initial palliative banding of the main pulmonary artery (PA), followed by corrective surgery months later (8).

Similar to other pediatric cardiac institutions, the rationale behind employing PAB before corrective surgery was to combat respiratory infections, manage cardiac failure, and facilitate healthy growth (3,4).

In our cohort, the hospital mortality of 11.4% appeared acceptable and aligned with other reported series (3-6,9). Notably, there were no interstage or additional mortalities following the second stage in our cohort. One of the most prevalent complications after PAB in our study was sternum-related issues, with two patients experiencing sternum dehiscence and two others presenting thoracic deformities. Prolonged ICU and hospital stays, typically reported in various studies as significant complications after PAB, were within acceptable limits in our study (9-11). Prolonged ICU stays in our population were associated with very low-weight infants (less than 4 kg) and additional concurrent defects (neurological or infectious problems). One patient experienced extended ICU stay due to the failure of the banding procedure (band rupture). Fourteen patients underwent the second stage without any mortality. Among these patients, one required a permanent pacemaker due to complete heart block. This patient had inlet type VSD closure. Another patient presented moderate pulmonary valve stenosis, while one more patient displayed moderate left ventricular outflow tract obstruction (LVOTO), both asymptomatic and under regular follow-up care. Subaortic membrane was noted after PAB in two patients, which was subsequently resected during corrective surgery.

Among the 17 surviving patients who have yet to undergo correction, four individuals did not engage with the medical system until now. All other patients have shown favorable progress and are routinely monitored.

Remarkably, we did not encounter in our cohort complications as band displacement, pulmonary artery distortion, or erosion of the band into the pulmonary artery. Only one patient experienced band rupture. We attribute the absence of such complications to the relatively short interval between surgical stages, a standardized surgical procedure, band securement with sutures, and rigorous postoperative follow-up protocols.

Regarding the optimal size of the PA band, considerable deliberations persist. At our center, we employ a modified Trussler's formula (2,7) to determine the initial band size, as mentioned earlier. The band can be tightened further with the aim of ensuring near-normal pressures distal to the band, but precautions must be taken to prevent any deterioration in LV function. In our experience, typically, for biventricular repair, a size of 22 mm+weight is adequate, whereas for univentricular hearts, a size of 20 mm+weight is utilized.

Notably, there were no instances of surgical hemorrhage or neurological complications following the second-stage surgery. Corrective surgery, which includes the removal of the band for biventricular hearts or cava-pulmonary anastomosis for univentricular hearts, may be performed several months after the PAB surgery, depending on the infant's improved clinical condition.

Limitations

This study is limited by its retrospective and observational nature. Additionally, the small number of patients available for study restricted the power of our analysis.

CONCLUSION

Our study demonstrates that PAB could be performed with acceptable outcomes, serving as a viable palliative measure for

neonates and extremely small infants who are at high risk for cardiopulmonary bypass. Our study results exhibit a comparable trend to previously reported findings, emphasizing the importance of PAB in managing congenital heart malformations characterized by increased pulmonary blood flow. While the effectiveness of PAB has been validated in our study, future investigations could delve into refining surgical protocols, optimizing band adjustment techniques, and exploring potential preventive measures for common postoperative complications.

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Ethics Committee Approval: The study was approved by ethics committee of Merkezi Klinika (10.10.2023. No 44765).

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