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Patients' characteristics following reoperation after Modified Blalock-Taussig Shunt (MBTS) in Cardiac Centre National General Hospital Cipto Mangunkusumo from 2018-2020

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ABSTRACT

Background: Modified Blalock-Taussig shunt (MBTS) is a common palliative procedure for congenital heart defect to connect the systemic to the pulmonary circulation via a synthetic shunt from a subclavian artery to a pulmonary artery. However, certain postoperative complications do exist, such as blockage. Early identification of modifiable risk factors is important to prompt early intervention for better outcomes.
Material: This article is a descriptive narrative retrospective study. We gather data from the Cipto Mangunkusumo Hospital Cardiovascular Center medical report of 8 patients having undergone reoperation post-MBTS surgery as their first operation between January 2018 and October 2020. Data were analyzed using SPSS version 20 for Windows.
Results: The patient's age ranged from 3 months to 30 years old. Seven of them suffered from shunt occlusion complications, while the other suffered from the bleeding problem. The laboratory results showed that preoperative hemoglobin (18.9±4.1 g/dL vs. 16.90 (10.80-19.20) g/dL), hematocrit (58.8±12.40% vs. 42.9±14.30%), platelet counts (284.487±147.003 vs. 210.625±104.688) 10^3/uL, and oxygen saturation (86.00 (75.00-89.00) vs. 70.00±17.00) levels were higher than the pre-reoperative. The coagulation markers showed that PT value has increasing trend (1.10 (0.90-2.30) vs. 1.30±0.20) while aPTT (5.90 (2.90-6.30) vs. 2.30 (1.60-5.30)) seconds and activated clotting time (ACT) (205.00±86.00 vs. 165.00 (114.00-255.00)) showed the opposite.
Conclusion: MBTS remains the first-choice bridging palliation surgery to increase the pulmonary blood flow in congenital heart defects. The cause of shunt failure remains inconclusive in this study. Other studies suggest that graft material choice, S/PA ratio, S/W ratio, operative approach, thrombus formation, and aPTT value contribute to shunt failure, thus needing a reoperation.

Keywords: Characteristic, Modified Blalock-Taussig Shunt, Re-operation.
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INTRODUCTION

Congenital heart disease accounts for approximately 1 in 1,000 live births incidence rate.[1] At the same time, cyanosis is commonly associated with the disease—the pathology results from decreased pulmonary blood flow caused by inadequate oxygenation and hypotension.[2] The degree of right-sided cardiac obstruction determines the severity of the anomaly, from mild to life-threatening condition.[1,2]

Modified Blalock-Taussig shunt (MBTS) is a common palliative procedure to create a systemic connection to the pulmonary circulation via a synthetic shunt originated from the subclavian artery to the pulmonary artery.[2] This procedure is sufficient to provide adequate pulmonary blood flow and alleviate deleterious outcomes from desaturation in vulnerable patients not feasible for definitive surgical correction.[3,4] However, certain complications may occur after MBTS surgery. One of which is postoperative shunt blockage, which causes a sudden deterioration outcome due to profound hypoxemia, leading to potential cardiac arrest, especially in unstable patients.[4,5] Early detection and preventive strategy to the modifiable risk factors would allow an immediate re-operative procedure or adequate medical management to enable a better outcome.[2]

The incidence of shunt occlusion ranges from 2.5 to 20%.[6-10] Previous studies described several perioperative risk factors, including low body weight, low activated partial thromboplastin time (aPTT), small pulmonary artery size, and polycythemia.[11-13] However, the data published results have not been conclusive, and no studies had been conducted on Asian populations. Based on those mentioned above, this study aims

Table 1. Characteristic of patients' reoperation

Case	Gender	Age (Month)	Weight (kg)	Diagnosis	RPA size (mm)	LPA size (mm)	Intervention	Incision	Graft size (mm)	PDA ligated/ not	Echo PreReOp	Reoperation Indication	Reoperation Intervention	Time to reoperation
1	Female	24	11	ToF, Small PV, PDA, MAPCA	4.37	1.89	RMBTS	Sternotomy	4.0	+	Flow (+)	Block	LMBTS	2 years
2	Female	24	6.7	DORV ToF Type	5.37	4.60	RMBTS	Thoracotomy	5.0	-	Flow (+)	Block	LMBTS	1 year
3	Male	11	5.7	TA, VSD	4.18	5.32	RMBTS	Thoracotomy	5.0	-	Flow (+)	Block	Thrombectomy, Reanastomosis distal graft	5 hours
4	Female	372	33	ToF, Bilateral SVC	11.97	7.24	LMBTS	Thoracotomy	6.0	-	Flow (++)	Bleeding	Bleeding control, tampon, delayed sternal closure	24 hours
5	Female	3	4	PA, Small PDA	3.60	3.20	Modified Central Shunt	Sternotomy	3.5	+	Flow (+)	Block	Tampon release	2.5 hours
6	Male	12	6.9	ToF, Smallish PA	4.87	4.06	RMBTS	Thoracotomy	4	-	Flow (++)	Desaturation	Evaluation RMBTS	7.5 hours
7	Male	12	9	Dextrocardia, Mirror image, DORV, TGA, PS, bilateral SVC	5.60	5.60	RMBTS	Thoracotomy	4	-	Flow (+)	Block	Modified Central shunt	2 months
8	Female	11	6	MA, PA, Small PDA	4.84	5.86	RMBTS	Thoracotomy	3.5	+	Flow (-)	Block	Upsize RMBTS	4 days

ToF: Tetralogy of Fallot; PV: Pulmonary Valve; PDA: Patent Ductus Arteriosus; MAPCA: Major Aortopulmonary Collateral Artery; RMBTS: Right Modified Blalock-Taussig Shunt; LMBTS: Left Modified Blalock-Taussig Shunt; DORV: Doublet Outlet Right Ventricle; TA: Tricuspid Atresia; VSD: Ventricular Septal Defect; SVC: Superior Vena Cava; PA: Pulmonary Artery; TGA: Transposition of Great Arteries; PS: Pulmonary Stenosis; MA: Mitral Atresia.

to describe our experience and explore the incidence of shunt occlusion in patients undergoing MTBS surgery in our center and identify any possible perioperative risk factors.

METHODS

This was a descriptive narrative retrospective cohort study. The medical records of 8 patients undergoing reoperation post-MBTS surgery as their first operation between January 2018 and October 2020 were retrieved from the medical record.

The patients' characteristics and demographic data were recorded. Documentation was made of the variables related to the increased risk of shunt occlusions: Pulmonary artery size, Type of MBTS, approach, CPB utilization. Other variables: the polytetrafluoroethylene (PTFE) shunt, complete blood count, blood gas analysis value, electrolyte value, coagulation marker, hemodynamic (preoperative, postoperative, pre-reoperative, and post-reoperative variables).

The diagnosis of acute shunt occlusion was based upon a combination of clinical signs and investigations, including the absence of an audible shunt murmur, a decrease in the partial pressure of arterial oxygen (PaO_2), or an oxygen saturation (SpO_2) of more than 20% from baseline. The incidence of acute shunt occlusion was recorded after the confirmative diagnosis was established from the echocardiographic evidence for poor shunt flow. All patients were treated with the reoperation according to the hospital protocol.

This study's primary objective was to identify and describe the characteristic of patients who have shunt occlusion after MBTS. Result data will be presented in a descriptive study manner. Demographic and variables data were analyzed using descriptive statistics. The mean and standard deviations were shown for continuous variables with normal distribution; otherwise, the median with minimum and maximum was presented. The statistical analysis was performed using SPSS version 20 for Windows.

Table 2. Laboratory and coagulation study

Parameter	Mean±SD	Median (Minimum-Maximum)
Hemoglobin (g/dL)		
Preoperation	18.90±4.10	
Postoperation	15.50±3.80	
Pre-Reoperation		16.90 (10.80-19.20)
Hematocrit (%)		
Preoperation	58.80±12.40	
Postoperation	48.90±12.70	
Pre-Reoperation	42.90±14.30	
Platelet (10^3/uL)		
Preoperation	284.487±147.003	
Postoperation	227.625±67.058	
Pre-Reoperation	210.625±104.688	
O_2 saturation (%)		
Preoperation		86.00 (75.00-89.00)
Postoperation	73.00±12.00	
Pre-Reoperation	70.00±17.00	
PT (seconds)		
Preoperation		1.10 (0.90-2.30)
Postoperation		1.30 (0.80-2.30)
Pre-Reoperation	1.30±0.20	
aPTT (seconds)		
Preoperation	5.90 (2.90-6.30)	
Postoperation	5.90 (3.00-6.30)	
Pre-Reoperation	2.30 (1.60-5.30)	
ACT		
Postoperation	205.00±86.00	
Pre-Reoperation	165.00 (114.00-255.00)	

RESULTS

Subjects collected in this study are 8 people. Subject demographic data shows that most of them are women (62.50%) (Table 1). The ages of the subjects varied from 3 months to 30 years. Judging from the diagnosis, almost all who experienced reoperation were patients who underwent MBTS because there was a small flow problem to the lungs. The largest RPA and LPA sizes were 11.97 mm and 7.24 mm in subjects weighing 33.00 kg. The type of Systemic to Pulmonary Shunt performed is mostly Right-MBTS with per thoracotomy access. The size of the PTFE graft that is used is 3.50-6.00 mm, depending on the surgeon's preference. All patients who were found to have intraoperative PDA had PDA ligation performed (Table 1).

Reoperation was indicated in the subject because of postoperative complications. Most of them were occluded shunts, one subject was reoperated with an indication of bleeding. Complications that occur are evidenced by combining physical examination and supporting modalities, one of which is through echocardiography. The finding that most of the flow in the shunt is minimal. Reoperation interventions were carried out in various ways: Modifying, moving or re-anastomosing the shunt. There was also thrombectomy, bleeding control, and tampons release until it was decided to do delayed sternal closure. The interval for complications and reoperation was 2.5 hours to 2 years after the first surgery.

The laboratory and coagulation studies in the subjects showed a varying trend between preoperative to pre-reoperative values (Table 2). Preoperative hemoglobin levels were higher than pre-reoperative (Table 2). The same was found in the higher levels of Haematocrit, Platelet, and Oxygen Saturation at the preoperative time than when complications were identified. For coagulation markers, the value of PT showed an increasing trend from preoperative to pre-reoperative. However, aPTT and ACT show the opposite direction.

DISCUSSION

A palliative procedure assumes an important role for infants with restrictive blood flow in developing countries.[3] One of the procedures is modified Blalock-Taussig shunt (MBTS). MBTS remains a top choice palliative procedure in our hospital, but unfortunately, we still do not know what affects our patients' shunt failure. Therefore, we decide to show our patients' characteristics and findings who have done reoperation for shunt failure.

The patients' age and body weight in our study remain not as ideal as in other studies. Sisli E et al. showed their patients' age characteristic of 6.00 (3.00-24.00) days with shunt thrombosis and 4.00 (2.00-19.50) days that do not have shunt thrombosis.[4] A huge age gap exists in this study, and the youngest patient is 3 months, the oldest is 372 months.[4] We find it challenging to gather samples as MBTS reoperation is a rare occurrence in our hospital. As for bodyweight, Sisli E et al. have patients with 2.60 (2.00-3.10) kg that has shunt thrombosis and 3.30 (3.00-3.80) kg that do not have shunt thrombosis.[4] We could not determine the effect of those two factors for shunt thrombosis or failure in our study. It is rather difficult to find studies that have done MBTS in older age patients.

Our study found that the median of PTFE shunt grafts we used is 4.00 (3.50-6.00) mm. In Shibata et al. study, younger patients received smaller 3.00 mm PTFE shunt grafts; 3.50 mm for older patients. Shibata M et al. also found that a smaller graft reduced the interval between MBTS to intracardiac repair with increased body weight gain with the same amount of SaO_2 after the procedure.[5] Optimal graft size for larger patients remains a controversial issue.[5,6] In other studies, smaller shunts have been associated with an increased risk of thrombotic occlusion.[3,5] Graft material choice also contributes to shunt thrombosis and stenosis, as Kaur et al. showed in their study that cryopreserved saphenous has a more favorable outcome than PTFE regarding thrombosis and stenosis.[5] Study conducted by Arnaz A et al., also revealed that the shunt anastomosis angle also affects the pulmonary blood flow. Still, its effect regarding pulmonary artery growth remains to be studied.[7]

Pulmonary artery size also a contributing factor to predict shunt thrombosis. As Sisli E et al. shown in their study, shunt diameter to pulmonary artery ratio (S/PA) is used to predict shunt thrombosis and shunt to body weight ratio (S/W).[4] Our study suggests that both ratios still need to be explored as the lowest S/PA ratio of the data set is from subject number 7 with a S/PA ratio of 0.70 and the highest is from subject number 1 with a ratio of 2.10. While the lowest S/W ratio is from subject number 4 with an S/W ratio of 0.20 and the highest is from subject number 3 with a ratio of 0.90. Our data set didn't match with a study conducted by Sisli E et al where the previous study showed a S/PA ratio ≥9 and S/W ratio ≥ 1.30 increase the risk of shunt thrombosis.[4]

The complications that occur after the MBTS procedure are influenced by many factors, both technical and laboratory. The choice of surgical technique, whether by sternotomy or thoracotomy, may affect the quality of the MBTS made. The right technique will make the anastomosis easier, resulting in better patency of the shunt. The operative approach was a significant predictor of shunt failure. The sternotomy approach was associated with advantages like less pulmonary artery distortion, ease of technical performance, a cosmetic advantage of single sternotomy incision, ease of ligation of the patent ductus, less phrenic nerve injury, and less thoracotomy induced scoliosis.[8] But in the other study, patients undergoing a BT shunt via the median sternotomy approach have a longer duration of ventilation and inotropic requirements leading to longer intensive care unit stay and hospital stay.[9]

Postoperative events that are often encountered are shunt occlusion and bleeding at the shunt anastomosis site. In the study of Moszura T et al., MBTS acute occlusion occurred at 1-14 days post-treatment. More than that, it is said to be late occlusion.[10] In this study, the intervals of occlusion varied. Five subjects experienced acute occlusion. Four of them occurred during treatment in the ICU and one subject during treatment in the ward. The rest experienced late occlusion after being outpatient. The most common cause of shunt occlusion is acute thrombus covering the lumen graft. The condition is worsened by the narrowing, especially in the anastomosis between the graft and the pulmonary artery. The cause of occlusion can be a thrombus obstruction in the lumen of the graft, or the presence of another structure, the extraluminal pressing on the graft. The extra lumen structure that has the potential to suppress the graft is the presence of a clot formed around the graft or gauze used as a tampon, as was the case with subject number 5.

The occurrence of shunt occlusion can be detected through echocardiography examination, showed by decreased continuous flow in the shunt or even no flow when experiencing total occlusion. The disappearance of the murmur on the shunt that was present, clinical and hemodynamic deterioration can also signal the shunt's occlusion. In this study, almost all subjects who had shunt occlusion showed worse pre-reoperative echocardiography than after surgery. A shunt flow that is not very smooth or even lost is a pre-reoperation echocardiographic finding. One patient who experienced total occlusion showed significantly different echocardiography in the absence of graft flow. Subjects who experienced bleeding, echocardiography showed no problem with MBTS flow. In the case report published by Loyd A et al., it is said that there is a partial occlusion that can be seen from the echocardiography picture in the form of aliasing of color flow, which is usually seen throughout the length of a patent shunt.[11]

Interventions to overcome occlusion can be pharmacologically, minimally invasive by catheter-based, or reoperative. Subjects diagnosed with shunt occlusion or bleeding were subjected to reoperation for graft exploration and evaluation. For acute occlusion, a thrombus evacuation is performed, then reanastomosis. If needed, an upsize graft can be done. For late occlusion, the graft is transferred to the contralateral or made into a central shunt. Similar to the research conducted by Thorpe MH et al., interventions carried out in MBTS patients with acute shunt complications are percutaneous thrombectomy, shunt stenting, shunt revision, and shunt replacement. More than 80% survive and undergo outpatient care.[12]

We have ligated the PDA in 3 of 8 subjects of this study. Other studies suggest that PDA ligation did not contribute to shunt thrombosis, shunt failure, postoperative morbidity or, mortality.[13-15] But Kucuk M et al., found that ligated PDA leads to over-circulation of the shunt and is quickly managed with shunt reduction or inotrope and decongestive therapy resulting in no death noted.[3]

Laboratory results such as hemoglobin, hematocrit, platelet, PT, and aPTT shown in Table 2 have not been found to be a contributing factor for shunt thrombosis except for aPTT. A low aPTT or PT can be a sign of a hypercoagulable state.[3,6] Guzzeta et al. found preoperative and postoperative aPTT values lower in patients who had shunt thrombosis than those who did not.[16] In our study, preoperative, postoperative, and reoperative PT values in our patients not much differ from baseline PT as they only increase 1.10 (0.90-2.30), 1.30 (0.80-2.30), and 1.30±0.20 seconds, respectively. Meanwhile, the preoperative and postoperative median aPTT value was 5.90 (2.90-6.30) and (3.00-6.30) seconds than control, respectively, which is higher than other studies suggest for shunt thrombosis.

Shibata M et al., and Li D et al. showed that subjects who have received MBTS shown an elevated level of SaO_2.[5,14] Our data set indicated otherwise and needs reoperation to repair the shunt. A previous study by Ismail SR et al. have demonstrated the importance of SaO_2 level to detect over or under-shunt of MTBS and its treatment.[15] As for activated clotting time (ACT), we still could not find any study associated with MBTS.

CONCLUSION

Our center MBTS remains the first-choice palliation surgery to increase the pulmonary blood flow and act as a bridge for intracardiac repair. The cause of shunt failure remains inconclusive for this study. But other studies suggest that graft material choice, S/PA ratio, S/W ratio, operative approach, the formation of thrombus, and aPTT value as contributing factors for shunt failure, thus needed a reoperation.

CONFLICT OF INTERESTS

The authors declared explicitly that there are no conflicts of interest concerning the authorship and/or publication of this article.

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ETHICAL CONSIDERATIONS

The authors stated that this article corresponds to the hospital research protocol and the approval has been granted from the clinical directorate of Cipto Mangunkusumo Hospital Cardiovascular Centre.

AUTHOR CONTRIBUTIONS

All authors contributed to data gathering, analysis, drafting, as well as revising and approving the article in respect to this research to be published.

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