

## *30-Day Mortality of Palliative Shunt Surgery for Cyanotic Congenital Heart Disease at Maharat Nakhon Ratchasima Hospital*

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### **Abstract**

**Background:** Palliative shunt surgery in pediatric patients with cyanotic conditions is complex and challenging. Corrective surgery is necessary for patients with reduced pulmonary blood oxygenation to address these abnormalities. Following surgery, patients demonstrate an improved survival rate. However, this operation has a considerable mortality compared to the survival benefit.

**Objective:** To examine the 30-day postoperative mortality rate following palliative shunt surgery in patients with congenital heart disease for each type of procedure and to assess blood oxygen levels before and after surgery.

**Patients and Methods:** This study is a retrospective analysis collecting data on pediatric patients with cyanotic conditions who underwent palliative shunt surgery between January 1, 2020, and January 1, 2023. The patients were categorized into 4 procedural groups: Group 1, patients who underwent the modified Blalock-Taussig-Thomas shunt; Group 2, those who received the modified Waterston shunt; Group 3, patients with the central shunt; and Group 4, those who had the modified Pott's shunt, respectively.

**Results:** A total of 86 pediatric patients with cyanotic congenital heart conditions underwent palliative shunt surgery, primarily closed-heart procedures. Nearly three-quarters of the patients (65 cases, 75.5%) were between 1 day and 1 year old. The modified Blalock-Taussig-Thomas shunt was the most common procedure performed in 56 patients (65.1%). Postoperative blood oxygen levels showed a statistically significant increase compared to preoperative levels in both the modified Blalock-Taussig-Thomas shunt and modified Waterston shunt procedures. Among the 56 patients who underwent the modified Blalock-Taussig-Thomas shunt, the 30-day mortality rate was 3.6%. For the modified Waterston shunt performed on 24 patients, the 30-day mortality rate was 12.5%. The Central shunt procedure was performed on 5 patients, with a 30-day mortality rate of 4 cases (80%). Overall, the 30-day mortality rate across all 86 cyanotic congenital heart disease patients undergoing palliative shunt surgery was 10.5%.

**Conclusion:** Four palliative shunt procedures are closed-heart surgeries intended as interim measures before major corrective surgery to address intracardiac abnormalities. Following the corrective surgeries, postoperative blood oxygen levels were higher than preoperative levels.

**Keywords:** Palliative shunt surgery, Modified Blalock-Taussig-Thomas shunt, Modified Waterston shunt, Central shunt, Modified Pott's shunt

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## INTRODUCTION

The incidence of congenital heart disease in the past was relatively low due to the limited availability of pediatric cardiologists and echocardiography equipment, which often resulted in undiagnosed cases and unexplained child fatalities. However, diagnostic advancements and expanding medical services into remote areas have significantly increased access to diagnosis and treatment for children with heart conditions, improving survival rates. Cyanotic conditions due to congenital heart disease are particularly prevalent and crucial to address. Cyanotic congenital heart disease can be categorized into two main groups. The first includes patients with increased pulmonary blood flow, where the mixing of oxygenated and deoxygenated blood occurs within the heart, resulting in inadequate oxygen levels in the systemic circulation. Conditions in this group include transposition of the great arteries, total anomalous pulmonary venous connection, tricuspid atresia, mitral valve atresia, and atrioventricular canal defect. The second group consists of patients with reduced pulmonary blood flow, often accompanied by a similar mixing of deoxygenated and oxygenated blood but with narrowed or obstructed pulmonary blood flow pathways (Right Ventricular Outflow Tract Obstruction). This results in decreased oxygen levels in the systemic circulation, with examples including tetralogy of Fallot, pulmonary atresia, and double outlet right ventricle with pulmonary stenosis.<sup>1</sup>

In pediatric cyanotic patients with reduced blood flow to the lungs, temporary surgery is currently performed to increase pulmonary blood flow by using a systemic-to-pulmonary shunt, thereby reducing cyanosis.<sup>2</sup> Once the critical phase is passed, an assessment is conducted to evaluate whether the pulmonary artery has grown enough to support a complete corrective surgery at a later stage, often involving a second shunt procedure. Systemic to pulmonary shunts are classified into 2 types: Peripheral shunts, which include the Blalock-Taussig-Thomas shunt that connects the subclavian or brachiocephalic artery to the right or left pulmonary artery. Central shunts (consisting of the Waterston shunt connecting the ascending aorta to the pulmonary artery), the Pott shunt (connecting the descending aorta to the pulmonary artery), and a central shunt that connects the ascending aorta to the main pulmonary artery. Previously, De Leval developed a method using synthetic grafts instead of natural vessels, which became widely used

in Blalock-Taussig shunts.<sup>3</sup> Currently, synthetic PTFE grafts are employed, with the term “Modified” added to distinguish these from the original procedures that did not use synthetic grafts.

The surgery to create a systemic to pulmonary shunt in patients with congenital cyanotic heart disease is a therapeutic approach aimed at alleviating cyanosis in patients with limited pulmonary blood flow due to this condition. This procedure is particularly relevant for patients who are not yet candidates for complete corrective surgery, such as newborns, young children, or those whose conditions are unstable for definitive surgical intervention.<sup>4</sup> Acute shunt occlusion or blockage is a significant complication in pediatric patients undergoing systemic to pulmonary shunt surgery, potentially leading to mortality.<sup>5-7</sup> Various aspects will be considered to investigate the factors influencing patient mortality, which may benefit diagnosis and preventive planning. These include the size of the prosthetic vessel used in each procedure and the urgency of the surgery, whether elective or emergency. This information may assist in reducing subsequent complications.

In this study, we examined the outcomes of surgeries to create a prosthetic vessel to increase pulmonary blood flow in the modified Blalock-Taussig-Thomas shunt (mBTTS), modified Waterston shunt (mWTS), Central shunt (CentralS), and modified Pott’s shunt (mPottS) procedures. Specifically, it focused on the 30-day mortality rate and the increase in blood oxygen levels before and after surgery in patients with congenital cyanotic heart disease.

## PATIENTS AND METHODS

Ethical committee approval was obtained from the Maharat Nakhon Ratchasima Hospital Institutional Review Board (022/2024). After informed consent, since this is a Retrospective descriptive study, data from eighty-six patients who underwent Operate Modified Blalock Taussig shunt, Modified Waterston shunt, Central shunt, and Modified Pott’s shunt, respectively, were collected retrospectively from January 2020 to January 2023.

The primary outcome was 30-day mortality, and secondary outcomes were pre- and postoperative oxygen saturation, the correlation between the type of shunt and 30-day mortality, and the relationship between the elective emergency case and 30-day mortality.

## DATA COLLECTION

The authors collected demographic data, age, types of procedures, urgency of the operation, types of operations, graft size, cardiac care unit stays, hospital stays, and, lastly, 30-day mortality from the medical records.

## STATISTICAL ANALYSIS

The data were analyzed using SPSS version 29.0 and compared using an independent sample *t*-test. Categorical variables were reported as frequency and percentage of the total group and compared using the chi-square test. All *p*-values  $\leq 0.05$  were considered significant.

## SURGICAL TECHNIQUE

The operation can be performed on either side through a lateral thoracotomy incision in the fourth intercostal space. The pulmonary artery is dissected for a modified Blalock-Taussig-Thomas shunt. An azygous vein was divided, and then a plane of dissection along the posterior superior vena cava (SVC) was dissected and mobilized anteriorly. The pericardial cavity was entered in this step. The ascending aorta and brachiocephalic artery were identified and mobilized. Heparin was given at 1 mg./Kg. A PTFE graft was selected for a mBTT shunt. Selection is based on the weight correlated with the graft size (shown in Table 1). A thin-wall PTFE graft was selected for shunting. The ascending aorta was clamped partially, aortotomy as long as the anastomotic line was decided, and then anastomosis was done with Prolene 6/0-7/0. The dissected pulmonary artery (PA) branch was clamped as proximally as possible, and arterotomy was created vertically. The distal end of the shunt was decided and trimmed for appropriate anastomosis on the pulmonary artery. Local heparin was rinsed into the

**Table 1** Correlation between body weight and PTFE graft size

Body weight (Kg.)	PTFE graft size (mm.)
< 2	3
2-3	3.5
3-5	4
5-15	5
>15	6

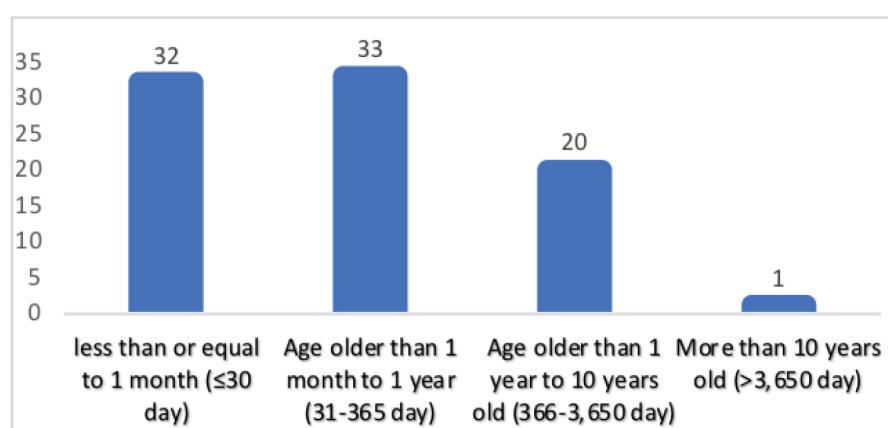
shunt, and distal shunt anastomosis was done. Deairing by intermittent declamping of the pulmonary artery was done before the completion of the distal anastomosis. Subsequently, the pulmonary artery clamp was released, followed by the release of the aortic clamp. Finally, the lung was fully re-expanded.

Following the anastomosis, hemodynamic parameters and oxygen saturation were monitored to compare values before and after the shunt. A chest drain was placed and connected to a water-sealed drainage system. The chest wall was then closed in layers. The patient was extubated when appropriate and transferred to the cardiac intensive care unit as part of the routine protocol.

## RESULTS

### Baseline patient characteristics

In the study, a total of 86 patients underwent palliative shunt surgery for congenital cyanotic heart disease, with closed-heart procedures performed. Nearly three-quarters of the patients (65 cases, 75.5%) were aged from 1 day to 1 year, while 20 patients (24.1%) were aged between 1 year and 10 years (shown in Figure 1).



**Figure 1** Age distribution of patients

### Comparison of pre- and postoperative oxygen saturation

Postoperative blood oxygen levels significantly increased compared to preoperative levels, with a statistical significance of  $P < 0.01$  for both procedures: modified

Blalock-Taussig-Thomas shunt and modified Waterston shunt. In contrast, the postoperative blood oxygen levels for both the central shunt and modified Pott's shunt procedures did not show a statistically significant difference from preoperative levels (shown in Table 2).

**Table 2** Oxygen saturation level in the pre- and post-operative period

Operation	O <sub>2</sub> Sat Pre-operation	O <sub>2</sub> Sat Post-operation	P-Value
mBTTS	77.89%	87.32%	< 0.01
mWTS	77.12%	88.58%	< 0.01
CentralS	77.2%	72.8%	0.49
mPottS	83%	85%	**

\*\* The correlation and t cannot be computed because the sum of case weights is less than or equal to 1.

In the modified Blalock-Taussig-Thomas shunt procedure, there were 43 elective cases with no 30-day mortality. However, among the 13 emergency cases, the 30-day mortality was 15.4%. For the modified Waterston shunt procedure, there were 13 elective cases, resulting in a 30-day mortality of 2 patients (15.4%). In contrast, among the 11 emergency cases, there was 1 patient who

died within 30 days (9.1%). Lastly, all 4 emergency cases resulted in 30-day mortality in the central shunt procedure. Overall, among the 86 patients with congenital cyanotic heart disease who underwent palliative shunt surgery, there were 9 deaths within 30 days, resulting in a mortality rate of 10.5% (shown in Table 3).

**Table 3** Elective and emergency cases with 30-day mortality

Operation	Total	Elective case	Elective case dead	Emergency case	Emergency case dead	Mortality
mBTS	56	43	0	13	2 (15.4%)	2 (3.6%)
mWTS	24	13	2 (15.4%)	11	1 (9.1%)	3 (12.5%)
CentralS	5	1	0	4	4 (100%)	4 (80%)
mPottS	1	0	0	1	0	0
<b>Total</b>	<b>86</b>	<b>57</b>	<b>2</b>	<b>29</b>	<b>7</b>	<b>9 (10.5%)</b>

### DISCUSSION

Palliative shunt surgery is a supportive surgical procedure for pediatric patients with cyanotic congenital heart disease. The modified Blalock-Taussig-Thomas shunt (mBTT shunt), introduced in 1981, has been widely employed for various cyanotic congenital heart diseases with increased pulmonary blood flow<sup>8</sup> and has remained a popular surgical intervention. This procedure has proven effective in treating pediatric patients with pulmonary atresia. However, in cases of severe cyanotic congenital heart disease, the shunt serves to facilitate blood flow to the lungs, thereby reducing cyanosis in patients and allowing time to prepare for corrective surgery in the future.

In our institution, the mBTT shunt has demonstrated

a low mortality rate because it effectively provides adequate pulmonary blood flow and is simple to construct and take down for total corrective procedures.<sup>9,10</sup>

Research has identified several factors influencing mortality following mBTT shunt surgery in pediatric patients with congenital heart disease. These factors include low birth weight, underlying genetic syndromes, duct dependency, and an oversized shunt relative to the patient's weight.<sup>11</sup> Additionally, studies indicate that the primary causes of postoperative complications and mortality after shunt placement are shunt occlusion and pulmonary overcirculation, which occur due to an excessively large shunt size.<sup>12</sup>

Research from Oman<sup>7</sup> offers recommendations for reducing postoperative mortality rates. It emphasizes the importance of appropriate patient selection for surgery, choosing a suitably sized shunt, and effectively administering anticoagulant therapy.

Our study evaluates the 30-day postoperative mortality rate to identify differences between elective and emergency surgical cases. The study focuses on four key types of procedures involving blood shunt placement to the pulmonary arteries, commonly performed in patients with congenital heart defects and reduced pulmonary blood flow. This categorization aims to better understand the associated risk factors and outcomes.

Emergency case surgeries in critically ill patients generally have higher mortality rates compared to elective surgeries. Similarly, the modified Blalock-Taussig-Thomas shunt (mBTTS) procedure in emergency cases has a higher mortality rate compared to elective cases (15.4% vs. 0%), as does the central shunt procedure (100% vs. 0%).

Conversely, the modified Waterston shunt (mWTS) procedure shows a lower mortality rate in emergency cases compared to elective cases (9.1% vs. 15.4%), while the modified Pott shunt (mPottS) procedure has no reported mortality. However, the latter observation is based on only a single patient undergoing this type of surgery.

The data suggest the following:

1. The mBTTS procedure is associated with a higher survival rate in elective cases.
2. The mWTS procedure may be a more favorable option in emergencies.
3. Future studies should investigate the lower mortality rate of the mWTS procedure in emergency cases compared to elective cases.

## CONCLUSION

This research focuses on palliative shunt surgical procedures in pediatric patients, aiming to provide guidance for reducing morbidity and mortality rates. The modified Blalock-Taussig-Thomas shunt (mBTTS shunt) is the most commonly performed procedure and shows a lower 30-day mortality rate compared with other procedures, both in elective and emergency cases.

## LIMITATIONS

This study may be limited by a small sample size and data collection from only a single institution.

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