ORIGINAL ARTICLE

Surgical Outcomes of Arterial Switch Operations in Southern Thailand: A 15-Year Experience from a University Hospital

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Background: Transposition of the great vessels (TGA) is the second most common congenital cyanotic cardiac defect in infants. Fortunately, correction via arterial switch operations (ASO) is possible.

Objective: To review the early experiences of a university hospital in Southern Thailand performing ASO. Factors associated with 90-day survival were analyzed and compared with three anatomical subtypes of dextro-transposition for TGA, TGA with intact ventricular septum (TGA/IVS), ventricular septal defects (TGA/VSD), and Taussig-Bing anomaly (DORV/TGA).

Materials and Methods: Patient electronic medical records with TGA having undergone ASO at Songklanagarind Hospital, Thailand, between 2010 and 2024 were retrospectively reviewed. The primary outcome measurement was 90-day survival. Survival outcomes, re-operation, and complications were also analyzed. Data were compared between those with good and poor outcomes, and among types of TGA.

Results: Over the 15-year period, 78 consecutive cases were identified: TGA/IVS 48 (61.5%), TGA/VSD 20 (25.6%), and DORV/TGA 10 (12.8%). Median age at operation was 15 days (interquartile range 9.25 to 26.25), with the DORV/TGA group being the highest (45 days). Overall, the 90-day survival rate was 65.4%: trending towards improved survival over time. Surgical complications, especially valvular complications and pulmonary hypertension, were significantly associated with the 90-day mortality odds ratio. Pre-ASO balloon atrial septostomy was performed in 42.3% of cases, with the TGA/IVS group having a significantly higher frequency. The Kaplan-Meier survival curves indicated poorer survival in the DORV/TGA group, although the difference in survival probability among the three groups was not statistically significant. Patients receiving pre-ASO interventions had significantly higher survival rates.

Conclusion: Patient survival for TGA having undergone ASO improved with the learning curve. Perioperative care, especially pre-ASO intervention and early operation, may be the key to improving outcomes.

Keywords: Arterial switch operation; Congenital heart disease; Transposition of the great vessels

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Congenital cardiac anomalies represent a significant burden on global healthcare systems, with transposition of the great vessels (TGA) having a particular impact[1,2]. TGA occurs in 4.7 cases per 10,000 live births and is the second most common cyanotic cardiac defect after tetralogy of Fallot[3]. In this condition, the aorta arises from the right ventricle, and the pulmonary artery arises from the left ventricle, resulting in parallel circulation and inadequate oxygen delivery[4]. There are two main types of TGA: dextro-transposition (D-TGA), which accounts for more than 90% of cases, and the rarer type, levo-transposition (L-TGA). In D-TGA, the aorta is connected to the right ventricle, and the pulmonary artery is connected to the left ventricle. In this type, deoxygenated blood from the body is pumped back into the body, and oxygenated blood from the lungs is pumped back into the lungs. Systemic oxygenation is maintained through intracardiac shunting, such as through a patent foramen ovale or ventricular septal defect (VSD). The Taussig-Bing anomaly is a rare variant of D-TGA. It is characterized by a double outlet

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right ventricle (DORV), subpulmonic VSD, and malposition of the great arteries. The less common type is L-TGA, also known as congenitally corrected transposition, where the aorta is connected to the left ventricle, and the pulmonary artery is connected to the right ventricle[5,6]. This critical condition necessitates timely surgical intervention to ensure survival and improve the quality of life of affected infants. In general, the current survival rate of children with TGA is more than 90% after corrective surgery[7]. The arterial switch operation (ASO) has emerged as the gold standard treatment for TGA, aiming to restore normal anatomical and physiological relationships. This complex procedure involves transection and re-implantation of the great arteries, coronary artery transfer, and reconstruction of the ventricular outflow tracts[8]. A successful ASO results in the aorta arising from the left ventricle and pulmonary artery arising from the right ventricle; therefore, establishing normal serial circulation[9]. However, despite significant advancements in surgical techniques and perioperative care, ASO is associated with potential complications, such as coronary artery insufficiency, supravalvular pulmonary stenosis, and ventricular dysfunction[10]. The outcomes of ASO can vary depending on factors, including TGA type, anatomical variations, pre-operative conditions, surgical expertise, and institutional resources. While early mortality rates have significantly decreased over the years, long-term complications and the need for re-operation remain of concern[10,11]. Understanding the determinants of in-hospital mortality, identifying risk factors for re-operation, and evaluating the overall surgical outcomes are crucial for improving patient care in addition to optimizing resource allocation. The present study aimed to examine the determinants of in-hospital mortality, the 90-day mortality, and the subsequent need for re-operation at a single-center institution in Southern Thailand. Additionally, the authors reported on the overall surgical outcomes of patients who underwent ASO over a 15-year time period. By analyzing this comprehensive dataset, the authors aimed to contribute to the existing literature as well as to provide valuable insights into the management of TGA within the authors' region.

Materials and Methods

Ethical approval for the present study was obtained from the Human Research Ethics Committee, Faculty of Medicine, Prince of Songkla University, under protocol number REC.65-443-10-1.

Electronic medical records of pediatric patients aged less than 30 days who were diagnosed with TGA and underwent ASO at Songklanagarind Hospital were retrospectively reviewed. The analyses focused on patient demographics, anomaly types, preoperative conditions and interventions, surgery, and postoperative complications. The main outcome studied was the 90-day mortality, which indicated the survival status of the patients on day 90 after the operation. Operative death indicated death occurring within 24 hours of the operation. Preoperative interventions included prostaglandin therapy and balloon atrial septostomy (BAS). Postoperative complications and re-operation included those that occurred within 90 days postoperatively.

From the hospital information system, the extracted data were collected in a database file. Data pre-processing was performed using Microsoft Excel (Microsoft Inc.) and then imported into Stata, version 14 (StataCorp LP, College Station, TX, USA), for analysis. Continuous data were presented as medians, with interquartile ranges (IQRs), or means with standard deviations according to their distribution patterns. Comparisons were made using analysis of variance or the Wilcoxon rank-sum test. Categorical data were presented as percentages and were compared using the chi-squared or Fisher's exact test, as appropriate. The association between postoperative complications and the 90-day mortality was assessed using univariate logistic regression analysis.

Results

Seventy-eight infants, including 31 females and 47 males, with TGA underwent surgery during the study period. The median age at operation was 15 days (IQR 9.3, 26.3), and the median weight on the operation date was 3,020 g (IQR 2,813, 3,492) (Table 1). The median gestational age of the patients was 39 weeks (IQR 38, 40). Sixty-one patients (79.2%) experienced episodes of cyanosis (SaO_2 <85%) preoperatively. On echocardiography, the median preoperative ejection fraction was 75% (IQR 70, 78).

Before definitive surgery, 44 patients (56.4%) received prostaglandin E2 (PGE2) therapy, and 33 (42.3%) underwent BAS, of which 21 (26.9%) underwent both interventions. In most patients who received PGE2 (41 out of 44), the therapy began within the first day of life. Moreover, the mean duration of BAS was 4.5 days (range 0 to 34).

There were six operative deaths (7.7%). The 90-day survival rate was 65.4%. The number of

Table 1. Comparison of the preoperative clinical characteristics between cases with outcomes

	All	Operative survival	p-value	90-day survival	p-value
All; n (%)	78 (100)	72 (92.31)	-	51 (65.38)	-
Sex; n (%)			0.549		0.549
Female	31 (39.74)	30 (96.77)		22 (43.14)	
Male	47 (60.26)	42 (89.36)		29 (56.86)	
Age at operation (days); median (IQR)	15.00 (9.25, 26.25)	15.00 (10.00, 26.00)	0.447	15.00 (12.50, 22.50)	0.274
Gestational age (week); median (IQR)	39.00 (38.00, 40.00)	39.00 (38.00, 40.00)	0.063	39.00 (38.00, 40.00)	0.133
Weight at operation (g); median (IQR)	3,020.00 (2,812.50, 3,491.75)	3,010.00 (2,795.00, 3,468.50)	0.344	3,000.00 (2,800.00, 3,515.00)	0.667
Length at operation (cm); median (IQR)	49.00 (47.00, 51.12)	49.00 (47.00, 51.00)	0.175	49.50 (47.25, 51.38)	0.602
TGA type; n (%)			0.443		0.582
TGA/IVS	48 (61.54)	45 (93.75)		33 (68.75)	
TGA/VSD	20 (25.64)	17 (85.00)		13 (65.00)	
DORV/TGA	10 (12.82)	10 (100.00)		5 (50.00)	
Atrial septal defects; n (%)			0.041		1.000
No	34 (43.59)	29 (40.28)		22 (43.14)	
Yes	44 (56.41)	43 (59.72)		29 (56.86)	
VSDs; n (%)			0.670		0.470
No	48 (61.54)	45 (93.75)		33 (68.75)	
Yes	30 (38.46)	27 (90.00)		18 (60.00)	
Persistent foramen ovale; n (%)			0.235		0.631
No	33 (42.31)	32 (96.97)		23 (69.70)	
Yes	45 (57.69)	40 (88.89)		28 (62.22)	
Patent ductus arteriosus; n (%)			1.000		0.334
No	5 (6.41)	5 (100.00)		2 (40.00)	
Yes	73 (93.59)	67 (91.78)		49 (67.12)	
Coarctation of aorta; n (%)			1.000		1.000
No	75 (96.15)	69 (92.00)		49 (65.33)	
Yes	3 (3.85)	3 (100.00)		2 (66.67)	
Right-sided aortic arch; n (%)			1.000		0.346
No	77 (98.72)	71 (92.21)		51 (66.23)	
Yes	1 (1.28)	1 (100.00)		0 (0.00)	
Coronary artery pattern; n (%)			0.422		0.154
1LCx-2R	60 (76.92)	56 (93.33)		39 (65.00)	
1L-2RCx	9 (11.54)	8 (88.89)		4 (44.44)	
Others	9 (11.54)	8 (88.89)		8 (88.89)	
Preoperative SaO_2 (%); median (IQR)	81.00 (75.00, 85.00)	81.00 (75.00, 85.00)	0.893	82.00 (75.25, 85.00)	0.531
Preoperative ejection fraction (%); median (IQR)	77.00 (70.00, 85.00)	75.00 (70.00, 80.00)	0.375	75.00 (65.00, 85.00)	0.152
Preoperative intervention; n (%)			0.592		0.150
None	20 (25.64)	17 (85.00)		9 (45.00)	
PGE1	23 (29.49)	22 (95.65)		16 (69.57)	
Balloon atrial septotomy + PGE1	32 (41.03)	30 (93.75)		24 (75.00)	
Others	3 (3.85)	3 (100.00)		2 (66.67)	
Postoperative modified ultrafiltration; n (%)			1.000		0.086
No	67 (85.90)	62 (92.54)		41 (61.19)	
Yes	11 (14.10)	10 (90.91)		10 (90.91)	

TGA=transposition of the great vessels; IVS=intact ventricular septum; VSD=ventricular septal defect; DORV/TGA=Taussig-Bing anomaly; 1LCx-2R=one left circumflex and two right coronary arteries; 1L-2RCx=one left and two right circumflex coronary arteries; PGE1=prostaglandin E1; IQR=interquartile range

Continuous data are presented as median and IQR. Comparisons were performed using the Mann-Whitney U test, chi-squared test, or Fisher's exact test, as appropriate.

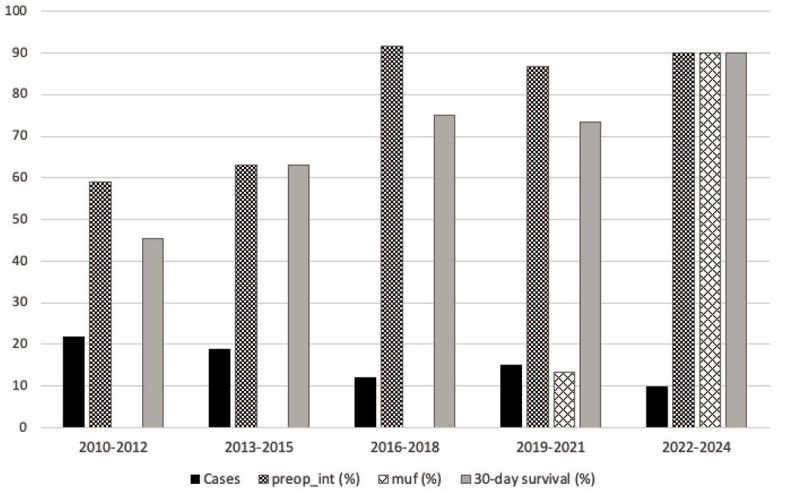

Figure 1. Number of operations, percentage of cases involving preoperative interventions, modified ultrafiltration, and percentage of cases with good outcomes according to the years of operation.

patients having undergone preoperative interventions increased over time (Figure 1). Comparing the period before and after 2016, TGA cases with at least one intervention before surgery increased from 58.5% to 86.5% ($p<0.01$), and the 90-day survival rate increased from 53.7% to 78.4% ($p=0.02$). Notably, preoperative interventions were performed more frequently in the TGA, with the intact ventricular septum (TGA/IVS) group having anomalies [87.5% for TGA/IVS, 50.5% for TGA/VSD, and 60% for Taussig-Bing anomaly (DORV/TGA), $p<0.01$].

All 78 patients had D-TGA, and among them, 48 (61.5%) had TGA/IVS, 20 (25.6%) had TGA/VSD, and 10 (12.8%) had DORV/TGA. The most common coronary artery pattern was one left circumflex and two right coronary arteries (76.9%), followed by one left coronary artery and two right circumflex branches. Except for a significantly higher incidence of ASD among the survivors, no preoperative factors were significantly associated with operative death.

ASO was performed at a significantly lower age in the TGA/IVS group than in the other groups (Table 2). This group also had a significantly higher proportion of patients who underwent BAS. Considering operative data, when VSD closure was performed in none of the cases in the TGA/IVS group, the procedure was a part of the operation in most patients in the TGA/VSD and DORV/TGA groups. In contrast, ASD closure was performed in a significantly higher proportion of patients in the TGA/IVS group than in the other groups. A trapdoor incision on both sides was the most common approach used in all cases. However, the TGA/IVS group required only a right-sided approach. The total operative duration was not significantly different among the three groups. However, the duration of cardiopulmonary bypass and aortic cross-clamping was significantly longer in the DORV/TGA group than in the other groups. In the present series, an extracorporeal membrane oxygenator was used intraoperatively in two cases (2.56%) in the TGA/IVS group.

Postoperative complications occurred in 60 patients (77%). DORV/TGA was associated with a higher incidence of complications (90.0%) than TGA/IVS (75.0%) or TGA/VSD (75.0%) ($p=0.54$). Common complications included cardiac complications such as ventricular failure, pulmonary artery stenosis, arrhythmia, superior vena cava obstruction, coronary artery obstruction, and valvular insufficiency, pulmonary hypertension, infectious complications, which were most commonly hospital-acquired pneumonia, hemorrhagic complications, and chylothorax (Table 3). Persistent postoperative hypertension was significantly associated with the 90-day mortality rate. Other complications included laryngomalacia, bronchomalacia, pneumothorax, atelectasis, small bowel complications, and endotracheal tube dislodgement, leading to hypoxic arrest. There were reoperations in 22 patients (28.6%). Patients with complications had a significantly higher mortality rate, with an odds ratio of 5.71 (95% CI 1.20 to 27.11). Two patients were lost to follow-up after one year. In the survival analysis, DORV/TGA was found to have the poorest survival among the three types of D-TGA. However, the difference was not

Table 2. Comparison of the operative data according to the anatomical variations of the transposition of great vessels

	All	TGA/IVS	TGA/VSD	DORV/TGA	p-value
All; n (%)	78 (100)	48 (61.54)	20 (25.64)	10 (12.82)	
Age at operation (days); median (IQR)	15.0 (9.3, 26.3)	13.0 (8.0, 16.0)	21.0 (11.5, 50.5)	45.0 (30.0, 89.0)	0.032
Preoperative SaO_2 (%); mean [SD]	81.0 [10.2]	78.1 [11.7]	80.4 [7.4]	83.7 [5.4]	0.244
Balloon atrial septostomy; n (%)					
No	45 (57.69)	22 (45.83)	15 (75.00)	8 (80.00)	0.027
Yes	33 (42.31)	26 (54.17)	5 (25.00)	2 (20.00)	
Closure of VSD; n (%)					
No	46 (59.74)	48 (100)	1 (5.00)	0 (0.00)	<0.01
Yes	31 (40.26)	0 (0.00)	19 (95.00)	10 (100)	
Closure of ASD; n (%)					
No	4 (5.13)	0 (0.00)	2 (10.00)	2 (20.00)	0.02
Yes	74 (94.87)	48 (100)	18 (90.00)	8 (80.00)	
Pulmonary artery debanding; n (%)					
No	77 (98.72)	47 (97.92)	20 (100)	10 (100)	1.00
Yes	1 (1.28)	1 (2.08)	0 (0.00)	0 (0.00)	
Intraoperative ECMO; n (%)					
No	76 (97.44)	46 (95.83)	20 (100)	10 (100)	0.66
Yes	2 (2.56)	2 (4.17)	0 (0.00)	0 (0.00)	
Modified ultrafiltration; n (%)					
No	67 (85.90)	40 (83.33)	19 (95.00)	8 (80.00)	0.412
Yes	11 (14.10)	8 (16.67)	1 (5.00)	2 (20.00)	
Operative duration (minutes); mean [SD]	454.7 [102.6]	451.0 [95.9]	446.8 [121.1]	488.8 [98.5]	0.53
CPB duration (minutes); mean [SD]	213.3 [58.1]	215.8 [61.3]	186.5 [32.9]	252.8 [60.4]	<0.01
AOX duration (minutes); mean [SD]	101.9 [50.0]	96.4 [39.0]	96.4 [53.0]	139.3 [43.9]	0.02

VSD=ventricular septal defects; ASD=atrial septal defects; ECMO=extracorporeal membrane oxygenator; CPB=cardiopulmonary bypass; AOX=aortic cross-clamping; SD=standard deviation; IQR=interquartile range

Table 3. Postoperative complications and their impact on 90-day mortality

Complications	Incidence n (%)	90-day mortality (%)	90-day mortality Odds ratio (95% CI)	p-value*
Overall complications	60 (76.9)	41.7	5.71 (1.20 to 27.11)	0.03
Overall cardiac complications	24 (30.8)	50.0	2.60 (0.95 to 7.04)	0.06
Valvular complications**	10 (12.8)	70.0	5.60 (1.31 to 23.86)	0.03
Cardiac arrhythmia	5 (6.41)	40.0	1.28 (0.20 to 8.17)	1.00
Low cardiac output	5 (6.41)	60.0	3.06 (0.47 to 19.56)	0.24
Pulmonary hypertension	14 (18.2)	50.0	2.15 (0.66 to 6.96)	0.20
Infection	12 (15.4)	50.0	2.14 (0.62 to 7.44)	0.23
Bleeding	10 (12.8)	60.0	3.35 (0.86 to 13.16)	0.08
Chylothorax	8 (10.3)	25.0	0.60 (0.11 to 3.20)	0.55
Persisting hypotension	4 (5.1)	100	NA	<0.01
Diaphragmatic paralysis	4 (5.1)	25.0	0.62 (0.06 to 6.22)	0.68
Others	14 (18.0)	21.4	0.45 (0.11 to 1.79)	0.26
Re-operation	22 (28.6)	36.4	1.09 (0.39 to 3.04)	0.88

CI=confidence intervals; NA=not available

* p-value of univariable logistic regression, ** Valvular complications included major vessel thrombosis

statistically significant. Moreover, patients who had undergone a pre-ASO intervention had significantly better survival rates than those who did not (Figure 2).

Discussion

The authors reviewed the early experience of a university hospital in Southern Thailand in performing

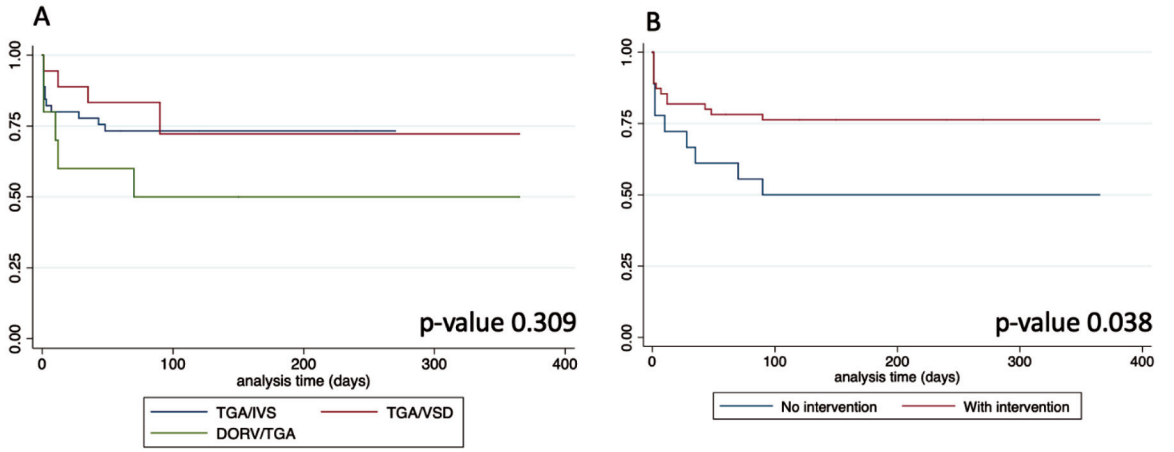

Figure 2. Survival probability of patients with transposition of great vessels (TGA) having undergone an arterial switch operation. (A) Comparison among the types of TGA. (B) Comparison between patients who had received preoperative intervention and those who did not.

TGA/IVS: TGA with intact ventricular septum; TGA/VSD: TGA with ventricular septal defects; DORV/TGA: Taussig-Bing anomaly

ASO and analyzed the factors associated with 90-day survival. Additionally, the authors compared three anatomical subtypes of dextro-transposition of TGA, including TGA/IVS, TGA/VSD, and DORV/TGA. It was found that the survival of patients with TGA having undergone ASO improved with the learning curve.

The goal of ASO is to restore normal circulation by moving the aorta and pulmonary artery to the left and right ventricles, respectively. This involves re-implanting the coronary arteries into the new aorta and ensuring proper alignment of the great vessels[4]. Although ASO has significantly improved outcomes in patients with TGA, it is a complex surgery with potential risks. Timely surgery before an infant develops right-sided cardiac failure is a major challenge. Preparing for an operation requires accurate anatomical evaluation and maintenance of oxygenation of blood pumped from the right ventricle to the aorta by keeping the congenital shunts open. In the present study, patients with TGA/IVS underwent surgery with greater urgency because the ductus arteriosus was the only channel that allowed oxygenated blood to be mixed. Although preoperative oxygen saturation levels were not significantly different among the three groups, the dispersion in terms of standard deviation was the highest in the TGA/IVS group. It was also found that pre-ASO interventions, primarily BAS, were performed more frequently in this group. Moreover, the authors observed an increasing trend in performing interventions and the 90-day survival rates over time. Recent studies have also reported the feasibility of performing BAS under echocardiography in neonatal intensive care units[12,13].

The present study's survival outcome of 65% remains poorer compared to that in a high-volume center in Vietnam, which reported a survival rate of approximately 90%[11]. However, survival rates improved over time, reaching over 70% after 2019 and 90% after 2022. Currently, early mortality rates after ASO in developed countries are less than 5%[14,15]. The present data showed that the improvement in 90-day survival resulted from the improvement in postoperative care, as operative deaths did not change. The data suggest that collective experience and the quality of perioperative intensive care are essential parts of the learning curve for ASO. Modified ultrafiltration after cardiopulmonary bypass aims to reduce excess fluid and inflammatory mediators released during surgery, thereby improving hemostasis[16]. The authors' institute began employing this technique after 2019, and the procedure has become routine since 2022. Although the present study did not demonstrate a statistically significant difference in 90-day survival between patients having undergone ultrafiltration and those who did not, there was a higher percentage of survival (90.9%) in the ultrafiltration group, compared with 61.1% in the other group. Similar to previous studies, the present study cohort had the highest survival among the three groups, although their operative survival rates were comparable[11,17]. The complexity of this anomaly might explain this finding.

In the present study, five out of ten patients in the DORV/TGA group developed pulmonary hypertension, and four patients did not survive. Older age at the time of surgery in this group might have led to pulmonary vascular remodeling and persistent hypertension after definitive surgery[18]. A recent study emphasized that the timing of ASO significantly affects patient outcomes, as an older surgical age has been identified as an independent risk factor for late right ventricular outflow tract obstruction as well as late reintervention[19]. Another study found that the median age at surgery was eight days, and that patients who underwent surgery beyond 28 days had longer intensive care unit and hospital stays[15]. Although the present study did not find a direct association between age at surgery and outcomes, the poorer survival rate in the DORV/TGA group suggests early surgery.

One limitation of the study was the lack of long-term follow-up data in all cases. Although uncommon, late complications can occur, particularly pulmonary artery stenosis and aortic valve regurgitation, secondary to aortic root dilatation[20].

Limitations

1. The retrospective study design relies on the completeness and accuracy of electronic medical records, which may result in missing or misclassified data.

2. The present study was conducted at a single tertiary referral center, which may limit the generalizability of the findings to other institutions or healthcare systems with different resources or patient populations.

3. The small sample size of neonates with transposition of the great vessels may have reduced the statistical power and precision of effect estimates, particularly for subgroup analyses.

4. Potential confounding factors, including variations in surgical techniques, surgeon experience, and perioperative management strategies over time, could not be fully adjusted for in the analysis.

5. The use of univariate logistic regression does not account for interactions or the combined influence of multiple risk factors on 90-day mortality.

6. Long-term outcomes beyond 90 days, including neurodevelopmental status, functional outcomes, and late reinterventions, were not evaluated.

7. Changes in preoperative and postoperative care protocols over the 15-year study period may have influenced outcomes; however, they were not independently analyzed.

Conclusion

In the present study, the authors reviewed the institutional experience of performing ASO in infants with congenital TGA and found that the early outcome was poor but improved with the learning curve. Improvement in perioperative care, especially pre-ASO intervention and postoperative care of pulmonary hypertension, might be the key to improving the survival outcomes in these patients.

What is already known about this topic?

The d-TGA is the second most common cyanotic congenital heart defect in infants and requires surgical correction for survival. The ASO is the standard treatment, achieving survival rates above 90% in high-volume centers. Surgical outcomes can differ depending on the anatomical subtype, such as TGA/IVS, TGA/VSD, or DORV/TGA, as well as perioperative management and timing of surgery. However, data from developing countries remains scarce, and reported survival rates are lower than those from high-resource settings.

What does this study add?

This study presents the first 15-year institutional review of ASOs for TGA in Southern Thailand. It shows a clear improvement in survival over time, reflecting the impact of growing surgical experience and advancements in perioperative care. The findings identify valvular complications and pulmonary hypertension as key predictors of early mortality, while highlighting the survival benefits of preoperative interventions, such as BAS. Overall, the study underscores the importance of early surgery and institutional learning in achieving better outcomes, even within resource-limited healthcare settings.

Authors' contributions

SK: Conceptualization and study design, data acquisition, data analysis, and interpretation, drafting of the manuscript, and final approval of the version to be published. PD: Clinical data acquisition, conceptualization, and study design, drafting of the manuscript, and final approval of the version to be published. SS: Data and statistical analysis, interpretation of results, critical revision of the manuscript for important intellectual content, and final approval of the version to be published. PR, PB, and VC: Data acquisition, data interpretation, manuscript revision, final approval of the version to

be published. All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request. The data is not publicly available due to privacy or ethical restrictions.

Ethics approval and consent to participate

Ethical approval for this study was obtained from the Human Research Ethics Committee, Faculty of Medicine, Prince of Songkla University; under protocol number REC.65-443-10-1.

Clinical trial registration

This study is a retrospective medical record review and was not prospectively registered as a clinical trial.

Use of artificial intelligence

During the preparation of this work, the authors used Google Gemini to improve the English language and readability. After using this tool, the authors reviewed and edited the content as needed and are taking full responsibility for the content of the publication.

Conflicts of interest

The authors declare no conflict of interest.

References

1. Yarrow S, Russell R. Transposition of the great vessels: a series of three cases with a review of the literature. Int J Obstet Anesth 2000;9:179-85.
2. Bernier PL, Stefanescu A, Samoukovic G, Tchervenkov CI. The challenge of congenital heart disease worldwide: epidemiologic and demographic facts. Semin Thorac Cardiovasc Surg Pediatr Card Surg Annu 2010;13:26-34.
3. Canfield MA, Ramadhani TA, Yuskiv N, Davidoff MJ, Petrini JR, Hobbs CA, et al., reported. Improved national prevalence estimates for 18 selected major birth defects--United States, 1999-2001. MMWR Morb Mortal Wkly Rep 2006;54:1301-5.
4. Jacobs JP, Jacobs ML, Mavroudis C, Chai PJ, Tchervenkov CI, Lacour-Gayet FG, et al. Transposition of the great arteries: lessons learned about patterns of practice and outcomes from the congenital heart surgery database of the society of thoracic surgeons. World J Pediatr Congenit Heart Surg 2011;2:19-31.
5. Silversides CK, Roche SL. Congenitally corrected transposition of the great arteries: Untangling the mechanisms of right ventricular dysfunction. JACC Cardiovasc Imaging 2022;15:575-7.
6. Zhang Y, Li Y, Ma Y, Wei Y, He F, Zhu Y, et al. Case report: Surgical repair of congenitally corrected transposition of the great arteries with the guidance of three-dimensional printing. Front Cardiovasc Med 2022;9:1101929. doi: 10.3389/fcvm.2022.1101929.
7. Tobler D, Williams WG, Jegatheeswaran A, Van Arsdell GS, McCrindle BW, Greutmann M, et al. Cardiac outcomes in young adult survivors of the arterial switch operation for transposition of the great arteries. J Am Coll Cardiol 2010;56:58-64.
8. Konstantinov IE, Alexi-Meskishvili VV, Williams WG, Freedom RM, Van Praagh R. Atrial switch operation: past, present, and future. Ann Thorac Surg 2004;77:2250-8.
9. Talwar S, Nair VV, Choudhary SK, Airan B. Atrial switch operation in the current era: modifications and pitfalls. World J Pediatr Congenit Heart Surg 2012;3:96-103.
10. Broberg CS, van Dissel A, Minnier J, Aboulhosn J, Kauling RM, Ginde S, et al. Long-term outcomes after atrial switch operation for transposition of the great arteries. J Am Coll Cardiol 2022;80:951-63.
11. Nguyen MT, Doan AV, Tran VQ, Mai DD, Nguyen UH, Nguyen TLT. The arterial switch operation in the developing world: Risk factors and current outcomes. Ann Thorac Surg 2024;117:543-9.
12. Cirstoveanu C, Georgescu C, Bizubac M, Heriseanu C, Vasile CM, Margarint I, et al. Impact of bedside balloon atrial septostomy in neonates with transposition of the great arteries in a neonatal intensive care unit in Romania. Life (Basel) 2023;13:997. doi: 10.3390/life13040997.
13. Weeda JA, Bokenkamp-Gramann R, Straver BB, Rammeloo L, Hahurij ND, Bertels RA, et al. Balloon atrial septostomy for transposition of the great arteries: Safety and experience with the Z-5 balloon catheter. Catheter Cardiovasc Interv 2024;103:308-16.
14. Jonas K, Jakutis V, Sudikienė R, Lebetkevičius V, Baliulis G, Tarutis V. Early and late outcomes after arterial switch operation: A 40-year journey in a single low case volume center. Medicina (Kaunas) 2021;57:906. doi: 10.3390/medicina57090906.
15. Drury NE, Mussa S, Stickley J, Stumper O, Crucean A, Dhillon R, et al. Outcomes of the arterial switch for transposition during infancy using a standardized approach over 30 years. Interdiscip Cardiovasc Thorac Surg 2023;3:ivad070. doi: 10.1093/icvts/ivad0706.
16. Palanzo DA, Wise RK, Woitas KR, Ündar A, Clark JB, Myers JL. Safety and utility of modified ultrafiltration in pediatric cardiac surgery. Perfusion 2023;38:150-5.
17. Shim MS, Jun TG, Yang JH, Park PW, Kang IS, Huh J, et al. Current expectations of the arterial switch operation in a small volume center: a 20-year, single-

center experience. J Cardiothorac Surg 2016;11:34. doi: 10.1186/s13019-016-0428-9.
18. Xiao Y, Zhang P, Su W, Dong N. Early and mid-term follow-up of patients receiving arterial switch operation: a single-center experience. J Thorac Dis 2018;10:732-9.
19. Wang Z, Kai M, Li S. Long-term outcomes after the arterial switch operation. Cardiol Young 2024;34:1670-82.
20. Fricke TA, Bulstra AE, Naimo PS, Bullock A, Robertson T, d'Udekem Y, et al. Excellent long-term outcomes of the arterial switch operation in patients with intramural coronary arteries. Ann Thorac Surg 2016;101:725-9.