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Incidence of Reoperation in Patients with a History of Arterial Switch Operation: An Eighteen-Year Retrospective Cohort Study

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Abstract

Background: The Arterial Switch Operation (ASO) has been the preferred surgical method for Transposition of great arteries (TGA) since its introduction over 40 years ago. Although initial survival rates have improved significantly, long-term complications often require reoperation.

Methods: In this retrospective cohort study, medical records of 302 patients with TGA, who underwent ASO between 2004 and 2022, were reviewed. Data on demographic and morphological characteristics, surgical reports, and follow-up interventions were collected. Reoperation data, including surgical and catheter-based interventions, were analyzed.

Results: Thirty-seven reoperations were performed on 31 patients, with a reoperation rate of 10.26%. Open surgical interventions included Right Ventricle Outflow Tract Obstruction (RVOTO) relief (3.31%), neo-aortic root and valve surgery (0.66%), ascending aorta replacement (0.33%), VSD closure (0.33%), and pacemaker implantation (2.31%). Catheter-based interventions included balloon angioplasty (1.65%) and stent implantation (1.65%) for RVOTO, with additional procedures for aortic arch stenosis (0.66%) and coronary artery stenosis (0.33%). Residual shunts were treated in 0.99% of cases.

Conclusion: ASO has revolutionized the management of TGA, providing infants a chance at a normal, healthy life. As our understanding of congenital heart defects grows, ASO remains pivotal in enhancing patient outcomes. Despite the average time to reoperation being 4 years, regular follow-up is essential. Gradual complication development necessitates periodic monitoring to prevent escalation requiring surgical intervention.

Key Words: Arterial Switch Operation, Pediatric Heart Disease, Reoperation, Transposition of Great Arteries.

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1- INTRODUCTION

Transposition of great arteries (TGA) is one of the congenital cyanotic heart diseases, which is caused by Ventriculo-Arterial (VA) discordance (1, 2). Prenatal diagnosis is given by fetal echocardiography. The infant's survival at the birth time depends on the mixing of deoxygenated and oxygenated blood through the ductus arteriosus and defect of atrial and ventricular septum (3). In terms of epidemiology, the incidence of the disease is slightly higher in boys. This abnormality may be seen in isolation or together with other malformations such as Ventricular Septal Defect (VSD), Left Ventricle Outflow Tract Obstruction (LVOTO), aortic arch anomaly and systemic venous return disorders that affect the severity and time of symptoms (4).

For more than 40 years, Arterial Switch Operation (ASO) has been introduced as a standard and treatment of choice among patients affected by TGA (5, 6). Due to the low mortality during surgery in recent decades, the investigation and focus on the long-term complications of these patients and the consequences of surgery has been focused (7, 8). The main reasons for re-operation following this procedure included supravalvar pulmonary stenosis, aortic root dilation, neo aortic insufficiency, and coronary artery involvement. (9, 10) The aim of this study is to evaluate outcomes and examine the variables that lead to re-intervention in these patients.

2- MATERIALS AND METHODS

A retrospective cohort study was designed and approved by our institution's board review (IR.IUMS.FMD.REC.1402.217). Medical records of patients with TGA who underwent ASO between 2004 and 2022 in our referral hospital were evaluated and data were extracted and recorded. Patients with TGA were divided into three subgroups, including TGA+ Intact Ventricular Septum (IVS), TGA+ VSD, and Taussig-Bing Anomaly (TBA). Data related to demographic and morphological characteristics as well as surgery reports were collected and recorded from the files. If the patient needed re-operation or angiography following the surgery and during follow-up after the ASO, the relevant reports were recorded.

Re-operation included LVOTO repair and Right Ventricle Outflow Tract Obstruction (RVOTO) repair surgeries; re-interventions using angiography techniques included balloon angioplasty and RVOTO stent and coronary stenosis removal using coronary stents were collected from patients' records. Closing ASD and VSD shunts using open or angiography techniques were also extracted and included in this study. Data related to the need for ablation, atrial and ventricular arrhythmia and the need for cardiac devices such as pacemaker and ICD were collected and recorded. The latter used medical records based on patients' files and regular follow-up visits. Patients with missing data and non-completed files were excluded from this study.

3- RESULTS

302 patients including 204 male (67.5%) and 98 females (32.5%) with a history of TGA who underwent ASO were assessed in order to extract reoperation patients. The frequencies of TGA+IVS, TGA+VSD, and TBA in patients were 156 (51.7%), 124(41.1%) and 22(7.3%), respectively (Table 1).

Thirty seven reoperation interventions were performed on 31 patients between 2004 and 2022. The rate of interventions was 10.26% in our 18-year cohort.

Table-1: The operated patients and reoperation surgeries in each subtype group

Variable	TGA-IVS	TGA+VSD	TBA
Operated Patients	156 (51.7%)	124(41.1%)	22(7.3%)
Reoperations	8 (5.1%)	27 (21.7%)	2 (9%)

Twenty one patients underwent open surgery including ten cases of RVOTO relief (3.31%), 2 cases of Neo aortic root and valve surgery (0.66%), one case of ascending aorta replacement due to pseudo aneurysm (0.33%), one VSD closure (0.33%) and 7 cases with heart block who needed pacemaker application (2.31%) (Table 2).

Among 10 interventions of RVOTO relief, 2 of them were cases due to failure of Angioplasty. Among these 10 patients, 4 cases were TGA-IVS, 5 cases were TGA-VSD and one case was TBA. Other cases with open surgery were all included in the TGA-VSD group (Table 2).

Table-2: Causes and specifications of open reoperation intervention

Type of Surgery	Total	Group		
		TGA-IVS	TGA+VSD	TBA
RVOT Relief	10	4	5	1
Neo aortic valve and root surgery	2	0	2	0
AAO Replacement	1	0	1	0
PPM Implantation	7	0	7	0
VSD Closure	1	0	1	0

(RVOT: Right Ventricle Outflow Tract / AAO: Ascending Aorta / PPM: Permanent Pacemaker / VSD: Ventricular Septal Defect)

Among the patients who underwent right sided angiography reintervention, 5 cases were treated with balloon angioplasty (1.65%) and 5 cases were treated with stent implantation (1.65%). Two cases of aortic arch stenosis (0.66%) and one case of left main coronary artery stenosis (0.33%) were treated through balloon angiography (Table 3).

Three cases (0.99%) with residual shunt were treated with septal occluder (Amplatzer ^{TM}) including two ASD and one VSD closure (Table 3).

According to the type of TGA among patients who underwent angiography intervention on the right side, 8 cases were in the TGA-VSD group (mean time 4 years following index surgery)) and two cases were in the TGA-IVS group (mean time 2.3 years after index surgery). Among patients with left-side angiography intervention, one case was in the TGA-IVS group (3 years after index surgery) and one in the TBA group (2 years after index surgery). All interventions for residual shunt were in the TGA-VSD group (mean time 1.5 years after index surgery) (Table 2).

4- DISCUSSION

Historically, TGA was associated with high mortality rates in infancy. However, the advent of ASO revolutionized the treatment landscape for this condition (1, 3, 11). Numerous studies have demonstrated the efficacy and safety of ASO in treating TGA. Long-term follow-up studies have reported excellent outcomes (5, 12, 13). Despite its success,

ASO remains a complex surgical procedure that requires expertise and specialized facilities. However, advancements in surgical techniques and perioperative care have led to further improvements in outcomes, making ASO the gold standard for treating TGA.

Table-3: Causes and specifications of the catheter intervention

Type of Intervention	Total	Group		
		TGA-IVS	TGA+VSD	TBA
Balloon angioplasty	5	1	4	0
Supra-valvular PS	2	1	1	0
RPA	1	0	1	0
Bilateral PA	2	0	2	0
Stent implantation	5	1	4	0
RPA only	2	1	1	0
LPA only	1	0	1	0
Balloon stent bilateral	1	0	1	0
Bilateral PA	1	0	1	0
Relief arch obstruction	2	1	0	1
PTAC	1	1	0	0
Closure of shunts	3	0	3	0
ASD	2	0	2	0
VSD	1	0	1	0

(PS: Pulmonary Stenosis / RPA: Right Pulmonary Artery / PA: Pulmonary Artery / LPA: Left Pulmonary Artery / PTAC: Percutaneous Trans Luminal Coronary Angioplasty / ASD: Atrial Septal Defect / VSD: Ventricular Septal Defect)

In our cohort, the ASO has shown both successes and challenges, as revealed in the need for reoperation and interventions among 10.26% (31 cases) of patients; some of them need more than one reoperation surgery. Despite the improved prognosis of infants with TGA in recent years, due to the improvement of surgical techniques and prenatal diagnosis of these patients, there is still the need for re-surgery and frequent clinical follow-up of these patients. Our findings are consistent with the 2015 study by Vijayukumar et al. on 32 patients who underwent ASO, where the most common reason for reoperation was right-sided heart pathology, followed by issues with the neoaortic root (14). The 2018 study by Jung et al. investigated the need for re-surgery due to coronary artery stenosis, and the indication for re-surgery in these patients was severe coronary artery stenosis, which was recorded by CTA and coronary angiography in patients with and without symptoms, and recommended long-term follow-up of ASO patients by CTA and coronary angiography (15). In a retrospective 43-year cohort study by Van der Palen et al. in 2021 on 490 patients who underwent ASO surgery, the need for surgery or re-intervention was seen, and the most common cause was RVOTO and then neo-aortic valve regurgitation (9). Re-intervention surgeries were necessary for 10.26% of patients in our series, most often due to RVOTO (3.31%), with various interventions including angioplasty, stent placement, or open cardiac surgeries necessary to resolve these issues.

Different studies were also performed in developing countries (16-18). The studies conducted on patients after ASO by Amoozegar et al., the prevalence of significant arrhythmias was less than 5%, notably lower compared to the Senning and Mustard procedures. Holter monitoring of these patients frequently revealed right bundle branch blocks, necessitating long-term follow-up. In our series, 2.31% of patients required pacemaker implantation due to block, which closely aligns with the findings of the aforementioned study. Our findings were consistent with those of Choi et al., where many patients experienced valvular disorders, primarily mild tricuspid, pulmonary, and mitral valve insufficiency (19).

In this study, closure of residual shunts and interventions for coronary artery stenosis and heart block demonstrated a series of complications that required follow-up medical care. This study emphasizes the complex nature of arterial switch surgery. Further research and advances in management strategies are critical to improve outcomes and minimize complications for patients undergoing this procedure. Nevertheless, limitations such as the retrospective nature of the study emphasize the necessity for future prospective research.

5- CONCLUSION

Arterial switch surgery has transformed the management of transposition of the great arteries, offering infants born with this condition a chance of having a normal, healthy life. As our understanding of congenital heart defects continues to evolve, ASO will likely continue to play a central role in improving outcomes for patients with TGA. While the average time to reoperation for patients who underwent ASO surgery is 4 years, these patients must receive regular follow-up care. Complications tend to develop gradually and should be monitored periodically to address any issues before they escalate to a severity that necessitates surgical intervention.

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