Reoperation After Arterial Switch: A 27-Year Experience

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Background. **The long-term outcome and spectrum of reoperation after the arterial switch operation (ASO) has not been fully defined, and there are limited data in the literature. We reviewed our institutional experience with reoperation(s) after ASO.**

Methods. **Between January 1984 and January 2012, 32 patients (23 male) underwent reoperation(s) after ASO. Anatomy included simple transposition of the great arteries in 14, complex transposition of the great arteries in 14, and Taussig-Bing in 4. Mean age was 6.7 ± 1.4 years at first operation and 10.8 ± 13.4 years at the second operation. Isolated pathology was present in 11 (34.3%) and multiple pathologies in 21 (65.6%). Abnormalities at first reoperation were right-sided pathology in 18 (56.3%), left-sided pathology in 10 (31%), coronary artery in 3 (9%), mitral valve in 3 (9%), residual ventricular septal defect in 4 (12.5%), and recoarctation in 2 (6.3%). It was the second reoperation in 12 and the third reoperation in 3 patients.**

Results. **The first reoperation included pulmonary artery patch plasty in 18, aortic valve operation in 8 (4 valve replacement, 3 root replacement, and 1 repair), pulmonary valve replacement in 4, coronary artery bypass grafting in 3, and mitral valve repair in 3. Multiple reoperations occurred in 15 patients, comprising right-sided procedures (11), left-sided (2), and other (2). Pulmonary artery reconstruction occurred earlier than neoaortic intervention (5.4 ± 6.8 vs 13.8 ± 7.7 years, $p < 0.001$). There were 2 early deaths (6.2%); both patients had complex transposition of the great arteries and both were at early reoperation after ASO. Median follow-up was 14.5 years (maximum, 27 years). There were no late deaths. Freedom from reoperation at 1, 5, and 15 years was 88%, 78%, and 41%, respectively.**

Conclusions. **The most common indication for reoperation after ASO is right-sided pathology, followed by neoaortic root pathology. Late survival after ASO is excellent and risk of late reoperation is low. Life-long medical surveillance is required.**

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Arterial switch operation (ASO) is the standard treatment approach with transposition of the great arteries (TGA) since its introduction in 1975 [1] and modifications by others to make it as anatomic as possible [2–4], The ASO places the pulmonary valve (PV) as a neoaortic valve, and with the Lecompte maneuver, both branch pulmonary arteries (PAs) are anterior to the aorta, exposing them to constant stretch and potential compression during somatic growth. These atypical anatomic factors can influence the long-term outcome and potential need for reoperation after ASO. There are few reports on the late results and the need of reoperation after ASO [5–10]. The purpose of this study is to review our experience with reoperation after ASO and examine long-term outcome after the reoperation.

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Patients and Methods

The Mayo Clinic Institutional Review Board approved the study and all patients or their families gave written informed consent. Between January 1, 1984, and January 1, 2012, 32 patients (23 males) who had undergone ASO and needed reoperation in our institution were retrospectively analyzed. Multiple reoperation(s) were performed in 15 of the 32 patients (second time in 12, third time in 3). During this time interval, 182 ASOs were performed at our institution, with 20 (10.9%) requiring reoperation, and 12 patients (37.5%) underwent ASO elsewhere and were referred to us for reoperation. The ASO was performed in 21 patients (65.6%) before 2000. Patient data were obtained from the medical record and cardiac surgery database.

TGA Anatomy

Transposition anatomy included simple TGA (intact ventricular septum) in 14 (44%), complex TGA (ventricular septal defect and arch or other intracardiac anomaly) in 14 (44%), and Taussig-Bing in 4 (12%; Table 1). On the basis of the Gittenberger-de Groot coronary classification

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Abbreviations and Acronyms

1L-2C×R = circumflex coronary artery arising from the right coronary artery
1RLC× = single left coronary artery
2LC×R = single right coronary artery
AR = aortic regurgitation
ASO = arterial switch operation
AVR = aortic valve replacement
AVSD = atrioventricular septal defect
BT = Blalock-Taussig
CABG = coronary artery bypass grafting
Cx = circumflex artery
ECMO = extracorporeal membrane oxygenation
IAA = interrupted aortic arch
ICD = internal cardio defibrillator
L = left
LAD = left anterior descending
LIMA = left internal mammary artery
LPA = left pulmonary artery
LVOT = left ventricular outflow tract
MAPCA = major aortopulmonary collateral arteries
MR = mitral regurgitation
PA = pulmonary artery
PR = pulmonary regurgitation
PV = pulmonary valve
pts = patients
PVR = pulmonary valve replacement
R = right
RIMA = right internal mammary artery
RPA = right pulmonary artery
SVC = superior vena cava
SVPS = supravalvar pulmonary stenosis
TGA = transposition of great arteries
VSD = ventricular septal defect

[11], normal coronary artery anatomy (1LCx- 2R, LAD and circumflex arising from sinus 1, right coronary artery arising from sinus 2) was seen in 24 patients (75%) and abnormal in 8 (25%) patients; including 1L-2CxR (circumflex coronary artery arising from the right coronary artery) in 6 patients (18.8%), single right coronary artery in 1 (2LCxR, 3.1%), and intramural single left coronary artery in 1 (1RLCx, 3.1%). Palliative procedures were done in 19 patients (59%) before ASO; atrial septostomy was most common (n = 13). ASO was performed in the neonatal period in 23 patients (72%). All patients had the Lecompte maneuver during ASO.

Reoperation

Early reoperation was defined as operation within 30 days and late reoperation after 30 days of ASO. Demographic data and pathology are summarized in Table 2. Patients with simple TGA (mean age, 5.9 ± 2.1 years) needed their first reoperation earlier than patients with complex TGA (7.0 ± 0.2 years) or Taussig-Bing (8.4 ± 12.2 years; $p = 0.6$).

Indications for late reoperation for great artery or valve abnormalities included peak-to-peak gradient across the right ventricular (RV) outflow tract of > 50 mm Hg, RV-to-left ventricular (LV) pressure ratio > 0.7, or lesser degrees with symptoms; evidence of RV enlargement with severe pulmonary regurgitation (PR); symptomatic patients with severe neoaortic regurgitation (neo-AR) or asymptomatic patients with moderate-severe neo-AR and LV dilatation or dysfunction; aortic root diameter of > 45 mm with mild-moderate neo-AR, or aortic root > 5 cm with mild neo-AR if planning valve-sparing root replacement.

Right-Sided Reoperation

Right-sided reoperation involved the main and branch PA stenosis (supravalvar pulmonary stenosis [SVPS]), PV, or RV infundibulum. Right-sided pathology was the most common indication for first time reoperation (n = 18 [56.3%]). Combinations of right-sided lesions were seen in 17 patients; SVPS was most common. The mean gradient across the SVPS was 55.2 ± 19.1 mm Hg. PV lesions (n = 7) included pulmonic stenosis in 5, PR in 2, and infundibular stenosis in 2 other patients. Right-sided lesions were similar between simple and complex TGA ($p = 0.2$). Among the 12 patients who needed a second reoperation, SVPS occurred in 5 (recurrent in 2), and PR in 3. Three patients needed a third reoperation (2 SVPS, 1 PR).

Left-Sided Reoperation

Left-sided reoperation involved the subaortic, neoaortic valve, aortic root, and supravalvar ascending aorta. Left-sided pathology was the next common indication for first reoperation (n = 10 [31%]) after ASO, and the aortic valve was the most common site. Isolated AR occurred in 5 patients and a dilated neoaortic root with AR in 3 patients. Supravalvular aortic stenosis and subaortic stenosis were seen in 1 patient each. Aortic root and aortic valve pathology occurred in 5 patients with complex TGA and in 3 with simple TGA. Three of the 10 patients had abnormal coronary anatomy (2 IL-2RCx, 1 1RLCx). A second reoperation was required in 2 patients, one each for aortic valve and aortic root pathology. None of the patients with left-sided abnormalities needed a third reoperation.

Coronary Artery Lesion Needing Reoperation

Three patients underwent coronary bypass grafting after ASO. Two patients had ostial left main stenosis and 1 patient had an occluded right coronary artery. Two of the 3 patients had abnormal coronary artery anatomy. Early coronary artery stenosis occurred in 1 patient with an intramural left main artery and required early reoperation, and the other late coronary artery stenosis developed in 2 patients at a mean interval of 7.5 years after ASO.

Comparison Between Right-Sided and Left-Sided Lesions During First Reoperation

Right-sided pathology was the most common indication for the first reoperation and was seen in 56% patients. The mean age at presentation for right-sided pathology was 5.4 ± 6.8 years and was 13.8 ± 7.7 years for left-sided pathology (31%; $p < 0.001$). The interval between ASO and reoperation was 5.1 ± 13.8 years for right-sided and 13.3 ± 7.1 years for left-sided ($p = 0.0017$). SVPS was the