Left-Sided Reoperations After Arterial Switch Operation: A European Multicenter Study

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Background. We sought to report the frequency, types, and outcomes of left-sided reoperations (LSRs) after an arterial switch operation (ASO) for patients with D-transposition of the great arteries (D-TGA) and double-outlet right ventricle (DORV) TGA-type.

Methods. Seventeen centers belonging to the European Congenital Heart Surgeons Association (ECHSA) contributed to data collection. We included 111 patients who underwent LSRs after 7,951 ASOs (1.4%) between January 1975 and December 2010. Original diagnoses included D-TGA (n = 99) and DORV TGA-type (n = 12). Main indications for LSR were neoaortic valve insufficiency (n = 52 [47%]) and coronary artery problems (CAPs) (n = 21 [19%]).

Results. Median age at reoperation was 8.2 years (interquartile range [IQR], 2.9–14 years). Seven patients died early after LSRs (6.3%); 4 patients with D-TGA (5.9%) and 3 patients with DORV TGA-type (25%) ($p = 0.02$). Median age at last follow-up was 16.1 years (IQR, 9.9–21.8 years). Seventeen patients (16%) required another reoperation, which was more frequent in patients with DORV-TGA type (4 of 9 [45%]) than in patients with D-TGA (13 of 95 [14%]). Late death occurred in 4 patients (4 of 104 [3.8%]). The majority of survivors were asymptomatic at last clinical examination (84 of 100 [84%]).

Conclusions. Reoperations for residual LSRs are infrequent but may become necessary late after an ASO, predominantly for neoaortic valve insufficiency and CAPs. Risk at reoperation is not negligible, and DORV TGA-type anatomy, as well as procedures on the coronary arteries, were significantly associated with a higher morbidity and a lower overall survival. Recurrent reoperations after LSRs may be required.

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The arterial switch operation (ASO) is the standard surgical procedure for correction in patients with D-transposition of the great arteries (D-TGA) and double-outlet right ventricle TGA-type (DORV TGA-type) [1]. Despite excellent early- and long-term survival after an ASO [2–7], it is now evident that a percentage of these patients may require additional surgical or hemodynamic maneuvers, which in the majority of cases are for neopulmonary stenosis [2, 5, 8, 9]. Less is known about the frequency, types, and outcomes of reoperations after ASO on the left side of the heart [9–16]. With the aim of obtaining more consistent data on this topic, we embarked on a multicenter study within the European Congenital Heart Surgeons Association (ECHSA).

Patients and Methods

The Clinical Investigation Committee of the University Hospital of Padua, the coordinating center, approved the retrospective review of medical records in accordance with the protection of patient confidentiality and consented to use data for publication; patients were not identified and individual consent was not obtained.

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*Additional members of the European Congenital Heart Surgeons Association (ECHSA) study group appear at the end of this article.

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Abbreviations and Acronyms

ASO = arterial switch operation
CABG = coronary artery bypass grafting
CAP = coronary artery problems
CHD = congenital heart disease
DORV = double-outlet right ventricle
D-TGA = D-transposition of the great arteries
ECHSA = European Congenital Heart Surgeons Association
IQR = interquartile range
LSRs = left-sided reoperations
LVAD = left ventricular assist device
LVOTO = left ventricular outflow tract obstruction
MVR = mitral valve replacement
NYHA = New York Heart Association
PA = pulmonary artery
RVOTO = right ventricular outflow tract obstruction
RV-PA = right ventricle to pulmonary artery

This study is a retrospective evaluation and was conducted on behalf of the ECHSA. We included data relative to the follow-up course and outcome of any patient who required left-sided reoperation (LSR) after ASO for D-TGA and DORV TGA-type between January 1975 and December 2010.

We arbitrarily defined an LSR as any surgical procedure that is necessary for residual or new anatomic/functional problems after a previous ASO on the neoaortic valve, the aortic root, the coronary arteries, and the left ventricular outflow tract (LVOT) (sites of the previous ASO). We excluded (1) patients who underwent reoperation after ASO for isolated right-sided lesions, (2) patients who underwent isolated left-sided procedures on the aortic isthmus and mitral valve, and (3) patients with forms of DORV TGA-type who underwent other types of repair.

Variables analyzed in this study are summarized in Tables 1 to 4. We divided patients with D-TGA into simple forms (with intact ventricular septum) and complex forms (with associated congenital heart disease [CHD]).

The aim of this study was to investigate the frequency, types, and outcomes of LSRs after ASO for D-TGA and DORV TGA-type. Outcomes included postoperative morbidity after LSR, patient survival, need for further reoperation, and clinical status at the last clinical examination. Early mortality was defined as any death occurring within the first 30 days after operation or during hospitalization for a LSR. Any other death after hospital discharge was defined as late mortality.

Statistical Analysis

Continuous variables are expressed as medians, with interquartile range (IQR) as a measure of variability. Comparison between groups was made using the Wilcoxon rank sum or Fisher's exact test if the variables were continuous or dichotomous, respectively. We compared the results of LSRs in patients with D-TGA and DORV TGA-type. A Kaplan-Meier survival analysis stratified by fundamental diagnosis (D-TGA and DORV TGA-type) and by the main diagnosis leading to LSR was performed. The comparison of survival probability among subgroups was performed by means of the log-rank test. The statistical significance was set at a familywise error rate of p less than 0.05. The R statistical package and Harrell's rms libraries were used for analysis.

Results

Patients

Seventeen of the 42 (41%) ECHSA centers initially contacted contributed to data collection. We included in this

Table 1. Demographics and Characteristics Patients Undergoing LSR at ASO

Variable	Total N = 111	D-TGA n = 99	DORV TGA-Type n = 12	p Value
Male sex[a]	89 (80%)	79 (80%)	10 (83%)	1
Prenatal diagnosis[a]	10 (9%)	9 (9%)	1 (8.3%)	1
Bicuspid neoaortic valve[a]	8 (7%)	8 (8%)	. . .	0.6
Rashkind procedure[a]	61 (55%)	58 (59%)	3 (25%)	0.03
PGE-1 infusion[a]	61 (55%)	56 (57%)	5 (42%)	0.3
LVOT surgery at ASO[a]	11 (10%)	9 (9%)	2 (17%)	0.3
Age at ASO, d[b]	12 (6.5–83)	10 (6–76)	41 (8–90)	0.3
Weight at ASO, kg[b]	3.7 (3.2–4.2)	3.7 (3.2–4.3)	3.8 (3.4–3.9)	1
CPB time at ASO, min[b]	187 (149–241)	179 (141–217)	281 (248–300)	0.0003
Cross-clamp time at ASO, min[b]	110 (87–136)	105 (83–131)	169 (139–198)	0.00001
Trapdoor technique[b]	50 (45%)	43 (43%)	7 (58%)	0.4
LeCompte maneuver[b]	97 (87%)	88 (89%)	9 (75%)	0.1

[a] Number of patients and percentage. [b] Median and interquartile range.

ASO = arterial switch operation; CPB = cardiopulmonary bypass; DORV = double-outlet right ventricle; D-TGA = D-transposition of the great arteries; LSR = left-sided reoperation; LVOT = left ventricle outflow tract; PGE-1 = prostaglandin E1.