Aortic root and valve surgery after arterial switch operation

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Between May 1983 and January 2009, 720 arterial switch operations (ASOs) were performed at the Royal Children's Hospital, Melbourne, Australia (Figure 1). Of those, 618 (85.8%) patients had simple transposition of the great arteries (d-TGA), 57 (9.2%) had Taussig-Bing anomaly, 21 (3.0%) had congenitally corrected transposition of the great arteries, 5 (0.7%) had Mustard procedures converted to ASO, 10 (1.4%) had Senning procedures converted to ASO, and the remaining 9 (1.3%) had ASO as part of uni-ventricular repair.

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Of these 720 patients, 15 (2.1%) underwent surgery on the neo-aortic root or neo-aortic valve after ASO. Surgery occurred at a mean 8.8 years (median, 9.1 years; range, 7 months to 16.8 years) after ASO. Freedom from neo-aortic root or valve surgery was 99.5% (95% confidence interval [CI], 98.5%-99.9%), 99.3% (95% CI, 98.2%-99.7%), 98.3% (95% CI, 96.6%-99.1%), 96.7% (95% CI, 94.0%-98.2%), and 94.6% (95% CI, 90.6%-97.0%) at 1, 5, 10, 15, and 20 years, respectively, after ASO. Ten of 15 patients (1.6%) had primary ASO for d-TGA, 2 (20%) had conversion to ASO after Senning procedure, 1 (20%) had conversion to ASO after Mustard procedure, 1 (4.8%) had double switch for congenitally corrected transposition of the great arteries, and 1 (11.1%) had ASO for transposition of the great arteries with univentricular physiology.

Further analysis of patients undergoing ASO for d-TGA (n = 618) demonstrated that aortic surgery was rare in patients with intact ventricular septum (n = 408) with (0%, 0/10) or without (1.0%, 3/398) aortic arch obstruction (AAO), but more frequent in those with ventricular septal

FIGURE 1. Flow chart demonstrating distribution of aortic root and valve surgery in subgroups of patients after arterial switch operation (ASO). TBA, Taussig-Bing anomaly; TGA, transposition of great arteries; d-TGA, simple transposition of great arteries; l-TGA, congenitally corrected transposition of great arteries.

TABLE 1. Characteristics of patients requiring aortic root or aortic valve surgery after arterial switch operation

Patient no.	Anomaly	Age at ASO (y)	Repair	Aortic surgery	Age at first aortic (y) reoperation	Time since ASO (y)
1	TGA, VSD	6*	ASO	AVR Bentall	11.5	11 14.5
2	TGA, VSD	14	Mustard to ASO	AVR	19.4	5.4
3	l-TGA, VSD	3	Double switch	AVR	19.8	16.5
4	TGA, IVS	7†	ASO	Bentall	16.8	16.8
5	TGA, VSD	10	Senning to ASO	AVR	22.4	12.3
6	TGA, IVS	21†	ASO	Bentall	15.4	15.4
7‡	TGA, IVS	10†	ASO	Ross AVR	4	4 5
8	TGA, VSD	7	ASO	VSAAR and AoV repair	17.4	10.5
9	TGA, VSD	5†	ASO	AoV repair	6.3	6.3
10	TGA, VSD	4†	ASO	AoV repair	7*	7*
11	TGA, IVS, COA	8†	ASO	AoV repair	9.1	9.1
12	TGA, VSD	5	Senning to ASO	AoV repair AVR AVR	5 years	9† 20† 5
13	TGA, VSD, IAA	2†	ASO	AVR	8.9	8.9
14	TGA, VSD	2*	ASO	AoV repair	11*	8*
15	TGA, VSD, TA, IAA	16†	ASO	VSAAR	15	15

TGA, Transposition of great arteries; VSD, ventricular septal defect; ASO, arterial switch operation; AVR, aortic valve replacement; *Bentall*, aortic root replacement with composite graft; *l-TGA*, congenitally corrected TGA; IVS, intact interventricular septum; VSAAR, valve-sparing aortic root replacement; AoV, aortic valve; COA, coarctation of the aorta; IAA, interrupted aortic arch, TA, tricuspid atresia. *Months. †days. ‡deceased.

defect (n = 210) with (7.1%, 2/28) and without (2.2%, 4/182) AAO. Ventricular septal defect was not a risk factor for aortic reoperation in this subgroup.

There were 19 surgeries in the 15 patients. There were 8 neo-aortic valve replacements, 5 neo-aortic valve repairs, 3 Bentall procedures, 1 Ross procedure, 1 valve-sparing neo-aortic root replacement, and 1 valve-sparing neo-aortic root replacement with concomitant neo-aortic valve repair. Table 1 summarizes the patients and the operations performed.

One of the 15 patients (6.7%) died during surgery on the neo-aortic root or valve following ASO. This patient had undergone an ASO and concomitant neo-aortic valvotomy for TGA at age 10 days. At age 4 years, a Ross procedure was performed because of progressive neo-aortic regurgitation. The patient again developed severe neo-aortic regurgitation and underwent a neo-aortic valve replacement 1 year later. The patient was put on extracorporeal membrane oxygenation on postoperative day 1, but died 2 days later of cerebral hemorrhage that was confirmed at autopsy.

Follow-up was obtained for all 15 patients. Mean follow-up time was 14.5 years (median, 16.3 years; range, 4.4-25.5 years) after ASO and a mean 5.7 years (median, 4.3 years; range, 1 month-15.3 years) after surgery on the neo-aortic root or valve.

Age at time of ASO >12 months was the only risk factor for aortic reoperation on logistic regression

multivariate analysis (odds ratio, 9.6; 95% CI, 3.1-29.5; $P < .001$).

DISCUSSION

Despite concern for the neo-aortic root function after ASO, reintervention rates on the root or valve remain low.¹⁻⁵ Incidence of aortic valve surgery is estimated at 2% to 2.5% at 10 years.^{1,2} We demonstrated that patients with Taussig-Bing anomaly have higher rates of moderate or worse aortic regurgitation as compared with patients with transposition of the great arteries.⁴ However, none of our 57 patients required neo-aortic reoperation. ASO performed as a primary operation for biventricular repair was associated with low incidence of aortic valve or root reoperations, but it was much higher following ASO done for other conditions, especially after conversion of atrial switch operations to ASO. Those patients underwent the ASO at older age. Thus, it is not surprising that children who underwent ASO at age ≥ 1 year were at increased risk for aortic root or valve reoperation. It appears that aortic valve or root surgery would be required more often in those who underwent concomitant repair of AAO at the time of the ASO, especially those with interrupted aortic arch.³ Although aortic surgery was more frequent in patient with AAO, this did not reach statistical significance, likely due to small number of aortic reoperations in this subgroup.

CONCLUSIONS

Surgery on the neo-aortic root or valve is rare after ASO and is required predominantly in children older than age 1 year at the time of ASO, particularly those who underwent conversion of the atrial switch.

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