Outcomes of the Arterial Switch Operation in Children Less Than 2.5 Kilograms

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Background. **Children with body weight less than 2.5 kg who undergo the arterial switch operation (ASO) represent a challenging group. We sought to determine outcomes of patients with weight less than 2.5 kg at ASO at a single institution.**

Methods. **All patients who underwent an ASO with biventricular repair and weighed less than 2.5 kg at time of surgery were identified from the hospital database and reviewed retrospectively.**

Results. **From 1983 to 2014, 870 patients underwent an ASO with biventricular repair at our institution. At the time of ASO, 31 patients (3.6%, 31 of 870) weighed less than 2.5 kg (mean 2.1; median 2.1; range, 1.1 to 2.4). Twenty-nine patients underwent an ASO for d-transposition of the great arteries, and 2 patients had an ASO for Taussig-Bing anomaly. Mean age at operation was 16 days (median 11; range, 3 to 66). There were 6 hospital deaths (19%, 6 of 31) among patients weighing less than 2.5 kg compared with a hospital mortality of 1.9% (16 of 839) among patients weighing more than 2.5 kg ($p < 0.0001$). Mortality for children weighing 2.0 kg or less was 50% (5 of 10) compared with a mortality of 2.8% (1 of 21) for children weighing more than 2.0 kg but less than 2.5 kg. Four patients (13%, 4 of 31) required reoperation during hospital admission. Follow-up was available for 24 survivors (96%, 24 of 25). Mean follow-up was 13.2 years (median 11.9; range, 6 months to 25 years). There were no late deaths. Two patients (8%, 2 of 24) required late reoperation. No patient had more than mild neoaortic valve regurgitation, and all survivors were in New York Heart Association class I at last follow-up.**

Conclusions. **Early mortality for children weighing less than 2.5 kg undergoing the ASO remains high; however, most of the mortality occurred in children weighing 2.0 kg or less. Long-term outcomes for survivors are excellent.**

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The arterial switch operation (ASO) has excellent early outcomes in the modern era. However, children undergoing the ASO represent a heterogeneous group with challenging subgroups. One of these subgroups includes children with low body weight (LBW) at time of surgery. Although LBW at time of surgery has been associated with poorer outcomes in pediatric cardiac surgery [1–4], it has not been closely studied with regard to the ASO. Therefore, we sought to determine outcomes of patients with weight less than 2.5 kg at time of ASO at a single institution.

Material and Methods

Patients

From 1983 to 2014, 870 patients with transposition of the great arteries (TGA) or Taussig-Bing anomaly underwent an ASO for biventricular repair at the Royal Children's Hospital. Thirty-one patients (3.6%, 31 of 870) weighed less than 2.5 kg at ASO. Mean weight at ASO for the less than 2.5 kg patients was 2.1 kg (median 2.1; range, 1.1 to 2.4). Twenty-nine patients underwent an ASO for TGA, and 2 patients had an ASO for Taussig-Bing anomaly. Mean age at operation was 16 days (median 11; range, 3 to 66). This study was approved by the Royal Children's Hospital Human Research Ethics Committee. All data were collected retrospectively.

Definitions

Early death or reoperation was defined as death or reoperation occurring prior to hospital discharge or within 30 days of ASO. Late death or reoperation was defined as death or reoperation occurring after discharge and more than 30 days after ASO. Reoperation was defined as an operation on the heart or great vessels performed after the ASO excluding exploration for bleeding, wound debridement, mechanical circulatory

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support and pacemaker replacement. Functional status was described according to the New York Heart Association classification.

Statistical Analysis

Data were imported into STATA version 12 (StataCorp, College Station, TX). Continuous variables were reported as a mean or median with an accompanying range. Kaplan-Meier curves were constructed to display freedom from the study's outcomes. Fisher's exact test was used to determine statistical significance in mortality between less than 2.5 kg and greater than 2.5 kg groups.

Results

Early Outcomes

Preoperative and operative data are summarized in Table 1.

EARLY MORTALITY. Overall early mortality was 2.5% (22 of 870) for all ASO patients. There were 6 early deaths (19%, 6 of 31 patients) among patients weighing less than 2.5 kg compared with hospital mortality of 1.9% (16 of 839 patients) among patients more than 2.5 kg ($p < 0.0001$). Of the 6 early deaths among patients less than 2.5 kg, 5 of these patients were 2.0 kg or less at time of ASO, resulting in a hospital mortality of 50% for patients 2.0 kg or less. One of the 21 patients (4.8%) more than 2 kg but less than 2.5 kg died (Tables 2 and 3). Mortality did not improve over time (Table 4). Mean weight at time of ASO was 1.8 kg (median 1.8; range, 1.1 to 2.1) for patients who died, and hospital death occurred at a median 6 days after ASO (mean 27; range, 0 to 112).

Patient 1 was born at 32 weeks' gestation and was operated on day 16 at a weight of 1.8 kg. The patient's postoperative period was complicated by bilateral chylothoraces and superior vena caval obstruction, requiring return to the operating theater. The patient was unable to be weaned from mechanical ventilation, having been become septic and requiring reintubation. The patient died after withdrawal of medical care 34 days after ASO.

Patient 2 was born at 32 weeks' gestation with numerous comorbidities including CHARGE (coloboma of eye, heart defects, atresia of nasal choanae, retardation of growth and/or development, genital and/or urinary abnormalities, and ear abnormalities) syndrome and a single kidney. The patient underwent operation on day 9 at a weight of 1.8 kg. The patient's postoperative period was complicated by recurrent episodes of sepsis and the requirement of several noncardiac operations. After 3 months of hospital admission, the patient had an episode

Table 1. Preoperative and Operative Data

Variables	Patients <2.5 kg (n = 31)	Patients >2.5 kg (n = 839)
Age, weight, and body surface area		
Age at operation, days	11, 16.2 (3–66)	10, 61 (1–4933)
Weight at operation, kg	2.1, 2.1 (1.1–2.4)	3.8, 3.5 (2.6–19)
Body surface area at operation, m^2	0.16, 0.15 (0.1–0.18)	0.21, 0.22 (0.16–0.79)
Previous surgeries		
Previous cardiac surgery	1 (3.2)	38 (4.5)
Previous noncardiac surgery	2 (6.5)	1 (0.1)
Associated anomalies		
Ventricular septal defect	11 (34)	317 (38)
Aortic arch obstruction	3 (9.7)	62 (7.4)
Coarctation of aorta	3 (9.7)	45 (5.4)
Hypoplastic aortic arch	2 (6.5)	31 (3.7)
Interrupted aortic arch	0 (0)	7 (8.3)
LVOTO	0 (0)	23 (2.7)
Coronary artery pattern		
Normal: 1 LAD, Cx; 2 RCA	21 (68)	469 (56)
Anatomy other than 1 LAD, Cx; 2 RCA	10 (32)	370 (44)
Intramural	0 (0)	33 (3.9)
Operative data		
Cardiopulmonary bypass time, minutes	184 (105–364)	169 (37–567)
Aortic cross-clamp time, minutes	96 (48–158)	93 (31–278)
Circulatory arrest time, minutes	8.7 (0–63)	5.7 (0–67)
Circulatory arrest used	14 (45)	455 (54)
Arch repair at time of ASO	2 (6.5)	37 (4.4)
Postoperative mechanical support	3 (9.7)	26 (3.1)

Values are median, mean (range), n (%), or mean (range).

ASO = arterial switch operation; Cx = circumflex artery; LAD = left anterior descending artery; LVOTO = left ventricular outflow tract obstruction; RCA = right coronary artery.