Midterm outcomes of myocardial revascularization in children

Nicola Viola, MD, Abdullah A. Alghamdi, MD, Osman O. Al-Radi, MD, John G. Coles, MD, Glen S. Van Arsdell, MD, and Christopher A. Caldarone, MD

Objective: Pediatric coronary artery bypass grafting is uncommon. Small target vessels and appropriate conduit choice are the main technical challenges.

Methods: Fourteen patients undergoing coronary artery bypass grafting from January 1986 to December 2008 were retrospectively reviewed.

Results: Median age was 10 years (range, 3–15 years); median weight was 36 kg (range, 12–71 kg). Indications included symptoms or evidence of inducible ischemia and angiographically documented coronary stenosis. Diagnoses included Kawasaki disease (5/14), anomalous left coronary artery originating from the pulmonary artery (2/14), previous stent implant (1/14), and metabolic disease (3/14). The remaining 3 patients had coronary stenosis after other cardiac operations. Preoperatively 5 patients (45%) had no symptoms and 9 (64%) had positive stress test. Single-vessel disease was demonstrated in 2 (14%), double-vessel disease in 7 (50%), triple-vessel disease in 1 (7%), and left main coronary artery involvement in 4 (29%). With standard cardiopulmonary bypass, 18 (81%) in situ internal thoracic arteries and 4 (19%) long saphenous veins were grafted. There was 1 early reoperation for graft failure. All patients survived to hospital discharge. Follow-up angiography was performed in 5 patients (36%; median, 2 years; range, 1 day–10 years), and 1 (7%) required late balloon dilatation. Median follow-up was 3.3 years (1 month–10 years), and 12 patients had no symptoms. There was 1 late death of noncardiac cause.

Conclusions: Pediatric coronary artery bypass grafting can be performed for a wide range of indications. Midterm results are excellent. Preoperative stress testing can detect silent myocardial ischemia. (J Thorac Cardiovasc Surg 2010;139:333-8)

Coronary artery bypass grafting (CABG) in the pediatric age group is uncommon. Kawasaki disease and anomalous origin of the coronary arteries remain the most frequent indications. In the first reported cases, an autologous saphenous vein graft (SVG) was used in the treatment of anomalous left coronary artery originating from the pulmonary artery (ALCAPA).[1] In 1976, Kitamura and colleagues[2] reported successful double aortocoronary bypass grafting in a 4-year-old child with Kawasaki disease (mucocutaneous lymph node syndrome).[2] Since the mid 1980s, the use of the internal thoracic artery (ITA) for the treatment of Kawasaki disease and anomalous left coronary artery has been introduced and widely adopted.[3] More recently, percutaneous myocardial revascularization has been adopted in the pediatric population with coronary artery disease.[4,5] The latest developments in these challenging operations include other arterial conduits, such as bilateral ITAs and gastroepiploic artery, and minimally invasive approaches. We report our institutional experience with CABG in pediatric patients.

MATERIALS AND METHODS

Population

After institutional ethics board approval was obtained, the records of all pediatric cardiac patients who underwent CABG from January 1982 to December 2008 were evaluated. Fourteen patients were identified, and their characteristics are shown in Table 1.

The median age at the time of surgery was 10 years (range, 2.5–14.5 years). Five patients (36%) were female. The median weight and height were 36.36 kg (range, 12.2–71 kg) and 137.55 cm (range, 88–156 cm), respectively.

Preoperative diagnoses included Kawasaki disease in 5 patients (36%), Takayasu disease in 1 (7%), and ALCAPA in 2 (14%). Three patients (28%) had coronary stenosis after previous surgical interventions: 1 patient had significant right coronary artery (RCA) stenosis caused by scar retraction from a previous atriotomy for closure of an atrial septal defect, 1 had severe left main coronary artery stenosis caused by compression after a Konno-type root replacement, and 1 had severe left main coronary artery stenosis develop after patch enlargement of a single coronary with ostial stenosis. One patient underwent percutaneous transluminal coronary angioplasty (PTCA) to the RCA, which resulted in acute dissection requiring surgical grafting. Of the remaining 2 (14%), 1 had progeria-related coronary disease and the second had familial hypercholesterolemia (Table 1).

Clinical examinations for symptoms were recorded for 12 of 14 patients. Of those, 5 had no symptoms, 3 were in Canadian Cardiovascular Society class II, and 4 were in class III. The last group reported shortness of breath and angina. Preoperative stress testing revealed reversible ischemia in 9 patients and normal results in 2 (Figure 1). In 1 child with Kawasaki disease, the preoperative rest electrocardiogram showed Q waves in the inferior

From The Labatt Family Heart Centre, The Hospital for Sick Children and the University of Toronto, Ontario, Canada.

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Address for reprints: Christopher A. Caldarone, The Hospital for Sick Children, 555 University Ave, Suite 1525, Toronto, ON, M5G 1X8, Ontario, Canada (E-mail: chris.caldarone@sickkids.ca).

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Abbreviations and Acronyms

ALCAPA = anomalous left coronary artery from pulmonary artery
CABG = coronary artery bypass grafting
ITA = internal thoracic artery
LAD = left anterior descending coronary artery
PTCA = percutaneous transluminal coronary angioplasty
RCA = right coronary artery
SVG = saphenous vein graft

leads, consistent with the history of an old myocardial infarction. Preoperative echocardiography was performed in all cases: 2 patients had mildly decreased left ventricular systolic function, and the remaining 12 had left ventricular ejection fraction greater than 50%. The diagnostic angiograms showed single-vessel disease in 4 patients, double-vessel disease in 5, triple-vessel disease in 1, and involvement of the left main coronary artery in 4. All patients with Kawasaki disease had multiple stenoses and documented aneurysms on previous angiograms.

Surgical Technique

For surgical access, median sternotomy was used. The ITAs were harvested as pedicles in most cases. In a minority of cases, a proximal long SVG. All patients underwent mildly hypothermic or normothermic cardiopulmonary bypass and cold blood cardioplegia delivered through the aortic root. All ITAs were used as in situ grafts. Distal anastomoses were performed under a surgical microscope with interrupted sutures of 10/0 Prolene (Ethicon, Inc, Somerville, NJ) in 1 case of Kawasaki coronaropathy. In all other cases, the distal anastomoses were performed with running 8-0 Prolene sutures. Proximal anastomosis of SVGs to the ascending aorta were with a single-clamp technique with running 7-0 Prolene sutures.

Statistical Methods

A statistical software package (SAS version 9.1; SAS Institute, Inc, Cary, NC) was used for all statistical analyses. Individual patients' data were tabulated where appropriate. Categoric data were summarized as frequencies and percentages, and continuous variables were summarized as mean, medians, and SDs. Kaplan–Meier statistics were used to perform survival curves for the entire cohort. Categoric variables were compared with the χ^2 test, and continuous variables were compared with the Student t test. Analysis of variance was used to compare height, weight, and left ventricular ejection fraction before the operation and at last follow-up.

RESULTS

Median crossclamp and cardiopulmonary bypass times were 96.5 minutes (25–224 minutes), and 113 minutes (34–255 minutes), respectively. Seven patients (50%) received 1 graft, 6 (43%) received 2 grafts, and 1 (7%) received 3 grafts, for a total of 22 grafts and a mean of 1.5 grafts per patient. Of those, 18 grafts (82%) were arterial and 4 (18%) were SVGs.

Five patients (36%) underwent associated procedures. Patient 2, an 8-year-old boy, had severe familial hyperlipidemia and atherosclerosis of the aortic root and underwent unroofing and patch repair of the proximal RCA, as did patient 4, a 13-year-old girl with Takeyasu arteritis. Patient 8 required unroofing of the midportion of the left anterior descending coronary artery (LAD) and division of severe muscle bands. Patient 10, a 9-year-girl with Kabuki syndrome, underwent a complex fifth-time reoperation, during which an aortic pseudoaneurysm was repaired with the Bentall procedure and the mitral valve was repaired. Patient 13 underwent resection of the subaortic membrane (Table 2).

The median stay in the intensive care unit for the entire cohort was 43.5 hours (range, 12–192 hours), and the overall median hospital stay was 8.9 days (range, 3–24 days). After exclusion of patient 10, who underwent a far more complex operation and was in congestive heart failure before the operation as a result of pulmonary hypertension and right ventricular failure, the median intensive care unit stay was 24 hours and the median hospital stay was 5 days.

Clinical follow-up was recorded for 13 patients, with a median interval to follow-up of 3.25 years (range, 1 month–10 years). Clinical follow-up and echocardiography were completed for 13 patients (93%). Patient 4, who was admitted through a charitable program for overseas patients, returned to the country of origin 2 months after the procedure and was unavailable for follow-up.

There were no perioperative deaths. There was 1 late death (7%). Patient 1 died 2 years after the operation of noncardiac complications related to progeria.

Three patients had significant complications in the immediate postoperative period. Patient 4 had inferior wall ischemia and hemodynamic instability develop on postoperative day 1 after left ITA to LAD and diagonal artery branch 1 and patch ostioplasty of the RCA. An emergency angiogram on the same day revealed severe RCA stenosis distal to the site of the repair. The lesion was deemed not amenable to percutaneous treatment, so emergency SVG placement to the RCA was performed on the same day, with complete resolution of the ischemic changes. The subsequent postoperative course remained uneventful, and echocardiography at discharge showed mild inferior hypokinesis. Two patients (14%) had significant postoperative arrhythmias. Patient 4 had ventricular tachycardia in association with the acute ischemic event. Patient 2 had atrial fibrillation, which resolved with antiarrhythmic medical treatment. Patient 10 had severe respiratory failure develop, necessitating reintubation and prolonged intensive care unit and hospital stays because of the underlying condition of pulmonary hypertension and reduced right ventricular function.

Five patients (35.7%) underwent coronary angiography in the postoperative period (median interval, 3.3 years; range, 1 month–3.5 years) for clinical and echocardiography indications. Patient 1 had a diagnosis of recurrent angina made 12 months after surgery: coronary angiography showed severe stenosis at the site of the distal anastomosis of SVG to the circumflex artery. PTCA was performed with immediate clinical improvement. A second routine