Early results of Bentall aortic root replacement for ascending aortic aneurism

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Abstract

Aim: The aim of this study was twofold: i) to assess the early and long-term outcomes in patients undergoing aortic root replacement (ARR) with a composite graft (CG) and; ii) to identify the predictors for poor overall survival in this group of patients.
Methods: Between March 2006 and September 2014, 48 patients underwent ARR with a CG. Mean age was 51±12 years (range: 26-77 years). Atherosclerotic aneurysm was the most frequent cause of aortic disease with 38 (76.8%) patients, followed by type A acute aortic dissection (10, or 20.3%). Marfan's syndrome was present in 2 (4.2%) patients. Duration of follow-up ranged from 38±29 months.
Results: The overall hospital mortality was 3 (6.3%) patients. One of the fatal cases had a cerebrovascular accident, one died from postoperative acute myocardial infarction and one from postoperative bleeding. The most frequently found complication resulted to be atrial fibrilation in 11 (22.9%) patients, renal failure in 6 (12%) patients and bleeding in 5 (10.4%) patients. The incidence of perioperative myocardial infarction, neurological complications, respiratory complications, renal failure and coagulopathy incidence were significantly higher in patients with cardiopulmonary bypass (CPB) time 155 min, CA 25 min, and total aortic arch replacement. Survival rate in patients with aortic dissection was significantly lower compared to non-dissection counterparts (P=0.022). The multivariate analysis revealed the aortic dissection (P=0.03), age >65 years (P=0.014), associated coronary artery disease (P=0.002), and total arch reconstruction (P=0.003) as strong predictors for poor overall survival in patients undergoing ARR.
Conclusions: The ARR with a CG offers acceptable early and long-term outcome. The predictors for poor overall survival in patients undergoing ARR seems to be preoperative aortic dissection extended into the aortic arch, older age, depressed left ventricular function and associated coronary artery disease.

Keywords: aortic root replacement, composite graft, long-term results, predictors.

Introduction

The surgical reconstruction of the aortic root with a conduit valve/composite graft (CG) was firstly described by Bentall and DeBono (1) in 1968 and subsequently modified procedures were reported by Cabrol et al. (2) and Kouchoukos et al. (3). In the last decade, different new conservative surgical procedures of the aortic root have been successfully employed in patients with normal aortic valve (4,5). Previous conservative methods of aortic root repair, such as aneurysm banding, plication, and supracoronary aortic replacement, were characterized by partial removal of diseased aortic tissue. The conservative surgery remains the best alternative procedure since the native aortic valve is not removed; however, it should not be employed in cases when the disease involves the aortic valve, annulus and sinuses of Valsalva. Various studies have shown that the Bentall's technique is a safe and lasting procedure (6,7). Nonetheless, predictors for early and late death are not well-defined (8,9).

The aim of this study was twofold: i) to assess the early and long-term outcome in patients undergoing aortic root replacement (ARR) with a CG according to the Bentall's technique and; ii) to identify the predictors for poor overall survival in this group of patients.

Methods

Between March 2006 and September 2014, 48 patients underwent ARR with a CG according to the Bentall's technique. All patients undergoing Cabrol's procedure and ARR with homografts were not included in the study. Data were collected retrospectively from the operative records and hospital charts.

Patients' characteristics

Mean age of the patients included in this study was 50.9±11.7 years (range: 26-77 years). The atherosclerotic aneurysm was the most frequent cause of aortic disease in this series with 38 (76.8%) patients, followed by type A acute aortic dissection 10 (20.3%). Marfan's syndrome was present in 2 (4.2%) patients. All patients presented moderate to severe aortic valve regurgitation. The preoperative data are presented in Table 1.

Table 1. Preoperative characteristics

Variables	Number (%)
Patients	48
Male	39 (81.3%)
Female	8 (16.7%)
Mean age	50.9±11.7
Mean NYHA functional class	2.1±0.78
Mitral valve insufficiency	2 (4.2%)
Hypertension	23 (47.9%)
Marfan syndrome	2 (4.2%)
Coronary artery disease	2 (4.2%)
Chronic obstructive pulmonary disease	0 (0.0%)
Cerebrovascular disease	1 (3.6%)
Type of aortic pathology	
Acute type A dissection	10 (20.3%)
Atherosclerotic aneurysm	38 (76.8%)
Infective aneurysm	0 (0.0%)
Emergency/urgency	10 (20.3%)
Reoperation	2 (2.1%)

Anaesthesia and CPB

Anaesthesia consisted of propofol (3 mg/kg/h) combined with fentanyl 20-30 mcg/kg and pancuronium 0.1 mg kg. Femoral arterial cannulation was performed in patients with aortic dissection, ascending aorta aneurysm extending to aortic arch, and emergency status. In patients with severe atherosclerotic disease of the abdominal aorta or femoral arteries, the axillary cannulation was employed as previously described (10,11). In other patients, the CPB was instituted using ascending aortic cannulation and a two-stage venous cannulation in the right atrium. Intermittent antegrade cold blood cardioplegia and moderate hypothermia in most patients, whereas deep hypothermia was applied in some patients.

Surgical technique

All patients underwent longitudinal median sternotomy. After clamping the ascending aorta, a longitudinal aortotomy was made and extended into the non-coronary sinus of Valsalva, away from the right coronary ostium. The CG (valve conduit) was sewn to the aortic annulus with a series of pledgeted matters sutures with 2-0 Ethibond. The 'Modified Bentall technique' with Button Technique for coronary reimplantation, consisting of an end-to-side anastomosis of the coronary arteries to the CG, was employed in all patients (12,13).

Then, the distal ascending aorta was transected and anastomosed to the CG with continuous 3/0-4/0 Prolene suture and in most cases reinforced by a strip of teflon felt placed outside of the aorta. When deep hypothermic circulatory arrest was needed, we applied a retrograde selective cerebral perfusion, via the superior vena cava, or antegrade, via the brachiocephalic trunk (14). Six patients necessitating proximal aortic arch reconstruction or total aortic arch replacement underwent deep hypothermic arrest. The anterograde selective cerebral perfusion was performed in two patients. All the three patients undergoing proximal aortic arch reconstruction underwent retrograde cerebral perfusion. Open technique was performed for distal anastomoses under hypothermia at 16-18C (15,16). In patients undergoing ARR, a long tongue of the CG was cut to allow tangential replacement of the aortic arch along its lesser curvature.

Two patients presenting mitral valve regurgitation grade III-IV underwent concomitant mitral valve surgery, prior initiating the aortic root replacement. One patient underwent mitral valve replacement and one mitral valve reconstruction procedures. One patient with coronary artery disease (CAD) underwent concomitant coronary revascularization. The distal anastomoses of the vein grafts to the coronary arteries were performed prior initiating the ARR and at the end of the procedure were implanted to the aortic graft. One patient with preoperative aortic dissection presented dissection extension to the coronary ostiums, requiring coronary artery bypass grafting.

All the intraoperative data are provided in Table 2.

Postoperative data

Perioperative myocardial infarction, low cardiac output incidence, intensive care unit stay, complications and early death were determined (Table 2).

Associative procedures

Six patients underwent CABG x 3-4 as associative procedures, two patients underwent Bentall + MV repair, two other patients required total arch replacement, three patients underwent hemiarch procedure and one of them elephant trunk.

Follow-up

Survival status was determined by contacting all patients or, subsequently, by telephone. Clinical follow-up data were obtained by means of direct contact with the patients, parents, their referring cardiologist and family physicians. Duration of follow-up was 38±29 months. The first control visit was performed within one month after surgery. All the contacted survivors underwent transthoracic color flow doppler ecocardiography.

Table 2. Operative and early postoperative data

Variables	Number (%)	Range
Cardiopulmonary bypass time (min)	155.2±57.4	(128-217)
Aortic cross clamping time (min)	142.4±54.1	(112-172)
Deep hypothermic circulatory arrest (min)	24.4±6.2	(18-45)
Ascending aorta and proximal aortic arch replacement	3 (6.25%)	
Ascending aorta and aortic arch	2 (4.2%)	
Elephant trunk	1 (2.1%)	
Mitral valve repair or replacement	2 (4.2%)	
Coronary artery bypass grafting $1 vessel	2 (4.2%)	
Left internal mammary artery	0 (0%)	
Perioperative myocardial infarction	1 (2.1%)	
Transfusions	47 (97.9%)	
Reintubation	5 (10.4%)	
Low cardiac output	3 (6.25%)	
Arrhythmias	16 (33.3%)	
Renal failure	6 (12.5%)	
Respiratory complications	3 (6.25%)	
Gastrointestinal complications	2 (4.2%)	
Neurological complications	5 (10.4%)	
Sepsis	2 (4.2%)	
Deep sternal wound infection	5 (10.4%)	
Reoperation for bleeding	5 (10.4%)	
Hospital death	3 (6.25%)	
Mean intensive care unit stay (days)	4.04±3.8	
Mean hospital stay (days)	16.65±6.5	

Statistical analysis

Group statistics were expressed as mean values ± SD. The generalized Wilcoxon test was performed for the statistical analysis between the groups. Fisher's exact test was used for comparison of categorical variables. The relationship between preoperative and postoperative variables within the same group was assessed by the McNemar test. The univariate analysis was performed to identify risk factors for early and overall mortality. The multivariate logistic regression model was employed for the early mortality analysis. The multivariate Cox regression analysis was performed to determine independent variables associated with overall death rate during follow-up. Long-term survival rates were calculated using the Kaplan-Meier method and statistical significance was calculated by the log-rank test. A p-value of ≤ 0.05 was considered as statistically significant in all cases.

Results

The overall hospital mortality was 3 (6.3%) patients. Preoperatively, ten patients had aortic dissection.

The postoperative morbidity is presented in Table 2. The most frequently found complication resulted to be arrythmias in 16 (33.3%) patients. Five patients

(10.4%) experienced postoperative neurological complication (four of them with cerebral edema and one of them coma).
One patient underwent reoperation within the first postoperative day, due to bleeding. In this case hemostasis is established.
The multivariate analysis between survived patients and deaths revealed the aortic dissection, CA>40 as strong predictors of in-hospital mortality (Table 3). The incidence of perioperative myocardial infarction, neurological complications, respiratory complications, renal failure and coagulopathy incidence were significantly higher in patients with CPB time >170 min, CA >40 min, and total aortic arch replacement.

Table 3. Predictors for poor early postoperative survival

Variables	Death (n=3)	Survivors (n=45)
Acute type A dissection	2 (66.7%)	8 (17.8%)
NYHA class	3±0.5	2.1±0.7
Emergency/urgency	2 (66.7%)	8 (17.8%)
Reoperation	0 (0%)	1 (2.1%)
Coronary artery disease	2 (66.7%)	0 (-)

Within the first year after surgery, all survivors were contacted. The postoperative echo colour Doppler echocardiography or computed tomography did not reveal left-to-right shunt at the right atrial level and no pseudoaneurysm at the suture lines in 45 survivors within 1 year after surgery.
A complete follow-up was performed in 45 survivors. The actuarial survival at 1 year and 3 years was 92% and 86%, whereas the survival rate without reoperation was 89%, 82% and 78%. The statistical analysis demonstrated a significantly lower survival rate in patients with aortic dissection versus patients undergoing ARR not due to aortic dissection. One patient with aortic dissection underwent coronary revascularization who died postoperatively from a cerebrovascular accident.
One patient died from postoperative bleeding and the other patient who underwent Bentall procedure for acute aortic dissection died from acute myocardial infarction.
The multivariate analysis revealed the aortic dissection, associated CAD, and total arch reconstruction as strong predictors for poor overall survival in patients undergoing ARR (Table 4).

Table 4. Echocardiography data

	Pre-op	Post-op	P	Follow-up	P
TDD	57.2±2 4.4	56.4±30.7	0.82	52±14	0.037
TSD	38.5±12.5	37.7±18.8	0.67	34±10	0.002
EF	53.3±11.2	54±28	0.79	56±23	0.231
Aortic regurgitation	3±1.2	1.1±0.3	0.001	1±0.5	0.001

Echocardiographic measurements

ECG control subjects showed a postoperative reduction in mean end-systolic dimensions (upon hospital discharge: 37.7 ± 18.8 mm; at the end of the follow-up period: 34± 10 mm; vs. preoperatively: 38.5±12.5 mm; p=0.02 and p=0.01, respectively) and end-diastolic dimensions (upon hospital discharge: 56.4±30.7 mm; at the end of the follow-up period: 52±14 mm; vs. preoperatively: 57.3±24.4 mm; p=0.03 and p=0.02, respectively).

Mean ejection fraction (upon hospital discharge: 54±28; at the end of the follow-up: 56±23; vs. preoperatively: 53.3±11.22), a difference which was not statistically significant.

Mean aortic root diameter was 3.1 cm upon hospital discharge and 3.2 cm at the end of the follow-up period. Upon hospital discharge, mean aortic insufficiency was estimated 1.1±0.3 vs. preoperatively 3.0±1.2. At the end of the follow-up period, aortic insufficiency was 1±0.

Discussion

In this reported series of patients, the presence of aortic dissection and a long circulatory arrest were strong predictors of early death. Also, strong predictors for an operation with negative feedback were aortic dissection, total arch replacement, chronic renal failure and patients who underwent associative procedures alike. The multivariate analysis revealed the presence of preoperative aortic dissection, chronic renal failure, total aortic arch replacement and long circulatory arrest as strong predictors for overall survival.

The introduction of ARR with a CG according to the classic and modified Bentall's techniques improved significantly the postoperative outcome, providing satisfactory early and long-term results, especially in patients with aortic dissection (17,18). When the aortic valve and annulus are normal, the conservative techniques of the aortic valve suggested by David et al. (4) and Yacoub et al. (5) are indicated. The mid-term outcome in patients with aortic disease including the aortic annulus, undergoing aortic root surgery with Valsalva sinuses preservation, were unsatisfactory due to recurrent aneurysmal formation of the proximal aorta side, needing re-operations. The alternative may be the ARR using an aortic homograft or pulmonary autograft with acceptable long-term results, but unfortunately such materials are not available in any cardiac surgical center.

In such cases, the ARR with a valve conduit (CG) should be taken into consideration. However, such an alternative includes the replacement of the aortic valve with a valve prosthesis, associated with a series of possible postoperative complications such as thrombosis, endocarditis and haemorrhage.

Complete ARR with a CG has a number of advantages: first, all diseased aortic tissue is eliminated from the aortic root; and second, the operation is conceptually simple, well codified and easily reproducible technique (19). The main complication of such a technique may be a false aneurysm at the coronary artery re-implantation sites, due to coronary detachment from the CG, or obstruction and thrombosis when the Cabrol technique is employed (20,21).

The coronary ostium detachment from the CG is mainly due to tension between the graft and the coronary artery, probably related to less mobilization of the coronary artery. Other authors reported some modifications of the Bentall's technique by creating a fistula from the perigraft space to the right atrium, which would reduce the bleeding and late false aneurysm incidence (22,23). However, we do believe that a 'generous' mobilization of the coronary arteries would be enough to reduce significantly the risk for coronary detachment from the coronary ostiums. Initially we believed that in cases undergoing ARR according to the Bentall's technique (side-to-side anastomosis), wrapping the aneurysmal sack around the prosthesis (inclusion technique) may reduce further the tension between the graft and coronary artery and also may prevent the catastrophic consequences secondary to coronary detachment. However, the outcome did not justify such a hypothesis.

Overall hospital mortality was 6.3%, similar to the reported series of patients undergoing this surgical procedure.

The early postoperative morbidity resulted to be high in this series of patients, due to a high presence of associated CAD and patients with depressed left ventricular function demonstrated by a low preoperative LVEf. We observed that the postoperative morbidity was strongly correlated with a long CPB time, long circulatory arrest and extended surgical procedure to the aortic arch. The strong correlation between the postoperative renal failure incidence and prolonged circulatory arrest time and total aortic arch replacement is probably related with longer CPB time that these procedures require.

In the reported series of patients, presence of aortic dissection, aneurysm rupture into pleura or pericardium, emergency status, previous cardiac intervention, associated CAD, were strong predictors of early death. The multivariate analysis revealed the presence of preoperative aortic dissection, concomitant CAD, total aortic arch replacement, as strong predictors for overall survival. Such predictors seem to be similar to the findings of Gott et al. (24,25), although with some differences. In reported study strong predictors for poor early and late survival resulted to be poor NYHA functional class, non-Marfan status, preoperative dissection and male gender.

The echo colour Doppler revealed optimal results of the employed surgical procedures in all patients. With growing of the population undergoing cardiac surgery, the CAD is the most frequently found associated pathology in patients with aortic diseases. We do believe, that all patients >50 years old, undergoing elective ARR, or when the conditions can permit it, should undergo preoperative coronary angiography examination. This strategy will decrease significantly the perioperative mortality due to myocardial infarction and low cardiac output in this group of patients.

The high early and late mortality rate in patients with preoperative aortic dissection is closely related to the complex type of aortic disease leading to complex surgical procedure, poor perioperative hemodynamic, emergency status, presence of acute myocardial infarction due to dissected coronary sinuses, and repetitive aortic dissection. This was demonstrated in our study by a significantly lower actuarial survival in patients with preoperative dissection versus patients with non-aortic dissection undergoing ARR with CG.

In different reported series, prosthetic endocarditis is the most common late complication of CG replacement and occurs in 4%-5% of the patients followed for a period of 14-17 years.

We may conclude that the ARR with a CG is an alternative technique to the aortic replacement with biological materials, offering acceptable early and long-term outcome. The long-term outcomes demonstrate a low valve prosthesis related morbidity. The predictors for poor overall survival in patients undergoing ARR seems to be preoperative aortic dissection extended into the aortic arch and associated CAD.

Conflicts of interest: None declared.

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