ORIGINAL ARTICLE

Replacement of the Ascending Aorta for Severe Atherosclerosis During Coronary Artery Bypass Surgery

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ABSTRACT ***Background and Aim*: In the present study, we investigated the benefit of ascending aorta replacement in patients with severe aortic atherosclerosis who undergo coronary artery bypass surgery (CABG). *Methods*: From January 2001 to April 2011, 3842 patients underwent CABG and in 36 of these patients (31 male, 5 female) the ascending aorta was replaced due to severe atherosclerosis. Total circulatory arrest was used in 22 patients (61%). The patients were followed for 69 ± 36 months (1–133 months) and compared to a control group of patients. The control group consisted of patients who underwent CABG with or without a concomitant procedure (n = 3806). *Results*: For the study group, the mean additive and logistic Euroscores of the patients were nine and 20, respectively. One stroke (2.8%) was observed and this patient died in the early postoperative period. There were a total of four confirmed deaths (12%) at any time point over the length of the follow-up among the patients who were discharged from the hospital. Two of them died of malignancy (lung and gastric tumors) and the other two from cardiac reasons. No patients had a stroke during follow-up. For the control group the mean age was 61 ± 1, the stroke rate was 0.6%, and the mortality rate was 0.96%, and the mean logistic and additive Euroscores were 3.7 ± 4.4, and 3.5 ± 2.5, respectively. *Conclusions*: Replacement of highly calcified ascending aortas during CABG can be safely performed in selected patients with good long-term outcomes.** doi: 10.1111/j.1540-8191.2012.01510.x *(J Card Surg 2012;27:538-542)*

INTRODUCTION

Severe atherosclerosis of the ascending aorta or aortic arch is associated with increased risk of perioperative stroke and the early mortality rate may be as high as 14.6%.[1–6] Several techniques such as off-pump CABG and the "no-touch" technique have been used in order to reduce the risk of procedure-related stroke and mortality.[7–10] However, these techniques do not eliminate the risk of late stroke.[11] Alternatively, a radical surgical approach including the replacement of the ascending aorta has also been suggested.[4] Although this method was associated with relatively higher perioperative mortality, it showed promising results regarding late stroke. Guidelines advise replacing the ascending aorta, if it exceeds 45 mm in diameter, during cardiac surgery in order to avoid future complications.[12] However, there is still no clear guidance as to the optimal surgical approach for patients needing coronary surgery and suffering from atherosclerosis of the ascending aorta. Therefore, we reviewed our experience with replacing the aorta in patients with severe aortic atherosclerotic disease undergoing coronary artery bypass grafting (CABG).

PATIENTS AND METHODS

From January 2001 to April 2011, 3842 patients underwent CABG, and in 36 (0.9%) (31 male, 5 female) the ascending aorta was replaced due to severe atherosclerosis (study group). A control group consisted of patients who underwent CABG with or without a concomitant cardiac procedure (n = 3806).

Conflict of interest: There is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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TABLE 1
Patient Demographics

Demographics	Control Group n = 3806	Study Group n = 36	p Value
Age (years)	61.0 ± 1.0	64.7 ± 8.4	0.01
Preop creatinine (mg/dl)	0.94 ± 0.3	1.18 ± 0.7	0.001
Pre op hematocrit (%)	41.0 ± 4.8	40.7 ± 5.6	0.75
Additive Euroscore	3.5 ± 2.5	9.0 ± 3.0	0.00
Logistic Euroscore	3.7 ± 4.4	20.6 ± 15.0	0.00
	n(%)	n (%)	
Diabetes mellitus	1049 (27.6%)	7 (19%)	0.08
Hypertension	2088 (55.0%)	22 (61%)	0.45
Chronic renal failure	13 (0.3%)	1 (2.8%)	0.002
COPD	572 (15%)	10 (28%)	0.03
Peripheral vascular disease	274 (7.2%)	5 (14%)	0.12
EF < 50%	1161 (30.5%)	12 (33%)	0.48

COPD: chronic obstructive pulmonary disease; EF: ejection fraction.

TABLE 2
Early Postoperative Outcomes

Outcomes	Control Group (n = 3806) n (%)	Study Group n = (36) n (%)	p Value
Intraaortic balloon pump usage	39 (1)	2 (5.6)	0.07
Atrial fibrillation	798 (23)	12 (33)	0.09
Reoperation for bleeding	70 (1.8)	4 (11.1)	0.005
Stroke	23 (0.6)	1 (2.8)	0.000
Acute renal failure	16 (0.4)	1 (2.8)	0.05
Reintubation	49 (1.3)	2 (5.6)	0.08
Inotropic support	201 (5.3)	9 (25)	0.000
ICU readmission	89 (2.3)	3 (8.3)	0.05
Hospital readmission	131 (3.4)	1 (2.9)	1.00
Mortality	37 (1)	1 (2.8)	0.05
CPB time (min)	57.4 ± 19.9	96.5 ± 29.9	0.00
CC time (min)	32.5 ± 12.5	70.1 ± 24.9	0.00
Blood transfusion (units/patient)	0.55 ± 1.2	1.75 ± 2.4	0.006
Total drainage (mL)	612 ± 341	711.4 ± 502.5	0.08
Time to extubation (hours)	6.4 ± 17.0	9.0 ± 5.3	0.01

ICU: intensive care unit; CPB: cardiopulmonary bypass; CC: cross clamp.

The demographic data and perioperative outcomes are presented in Tables 1–2. Mean follow-up was 69 ± 36 months (1–133). All patients had carotid imaging before the procedure and patients with concomitant carotid surgery were excluded.

Institutional informed consent was obtained. The operative strategy was planned after routine assessment of the ascending aorta by digital palpation. In case of suspected aortic atherosclerosis, epiaortic ultrasonography and transesophageal echocardiography (TEE) was performed. The decision for replacing the aorta was based on the presence of severe atherosclerosis. Severe atherosclerosis was defined as an area of thickening of greater than 5 mm in one or more segments and the presence of one or more of the following: marked calcification, protruding or mobile atheroma, ulcerated plaques, thrombi, or circumferential involvement of most or all of the ascending aorta.[1]

In patients without involvement of the distal ascending aorta (n = 14, 39%) the arch was selected for arterial cannulation and the aorta was clamped just below the innominate artery. The right atrium was cannulated directly for venous drainage, whereas bicaval cannulation was used in concomitant mitral valve surgery. Mild hypothermic cardiopulmonary bypass at a flow of 2.4 L/m^2 or greater, and myocardial protection with antegrade and (or) retrograde tepid blood cardioplegia (29–30 °C) was used. Total circulatory arrest (TCA) was not necessary for these patients. In patients with distal aortic involvement (n = 22, 61%), the axillary or brachial artery was selected for arterial cannulation. The aorta was not clamped and deep hypothermic circulatory arrest was instituted. These patients were cooled to 18 °C and antegrade low flow cerebral perfusion (8–10 mL/kg per min) was continued throughout the TCA period. The aortic arch was carefully inspected and mechanically debrided if necessary. Typically the entire ascending aorta above the sinuses of Valsalva to the proximal aortic arch was replaced with a Dacron graft. In severe aortic arch atherosclerosis the arch was replaced with a trifurcated graft. Bypass conduits included left internal thoracic artery and vein grafts.

Perioperative or late stroke was confirmed by cerebral CT/MRI scan and defined as a prolonged (>24 hours) or permanent neurologic deficit not present preoperatively and persisting before or after hospital discharge. Patients were treated with lifelong acetylsalicylic acid (ASA). After 2010, clopidogrel was added to ASA therapy for 3 months following CABG. In cases of atrial fibrillation or concomitant mechanical valve replacement, coumadin was prescribed in combination with ASA.

Data Analysis

Clinical, procedural, and postoperative data were prospectively recorded into an institutional database and retrieved for this retrospective review. Mortality was defined as deaths occurring at any time during the hospital stay and anywhere during the first 30 days after the operation. The follow-up was complete with a final telephone contact with the all patients and the families of the patients that have died.

Results were expressed as mean ± standard deviation. Kaplan-Meier survival analysis was used to describe the time to the first event (neurologic events and all-cause mortality). Data were analyzed with the PASW Statistics 18 version 18.0 statistical program (SPSS Inc, Chicago, IL, USA).

RESULTS

In the study group, the mean additive and logistic Euroscores of the patients were 9 ± 2.8 and 20 ± 15.0, respectively. Complete revascularization was achieved in

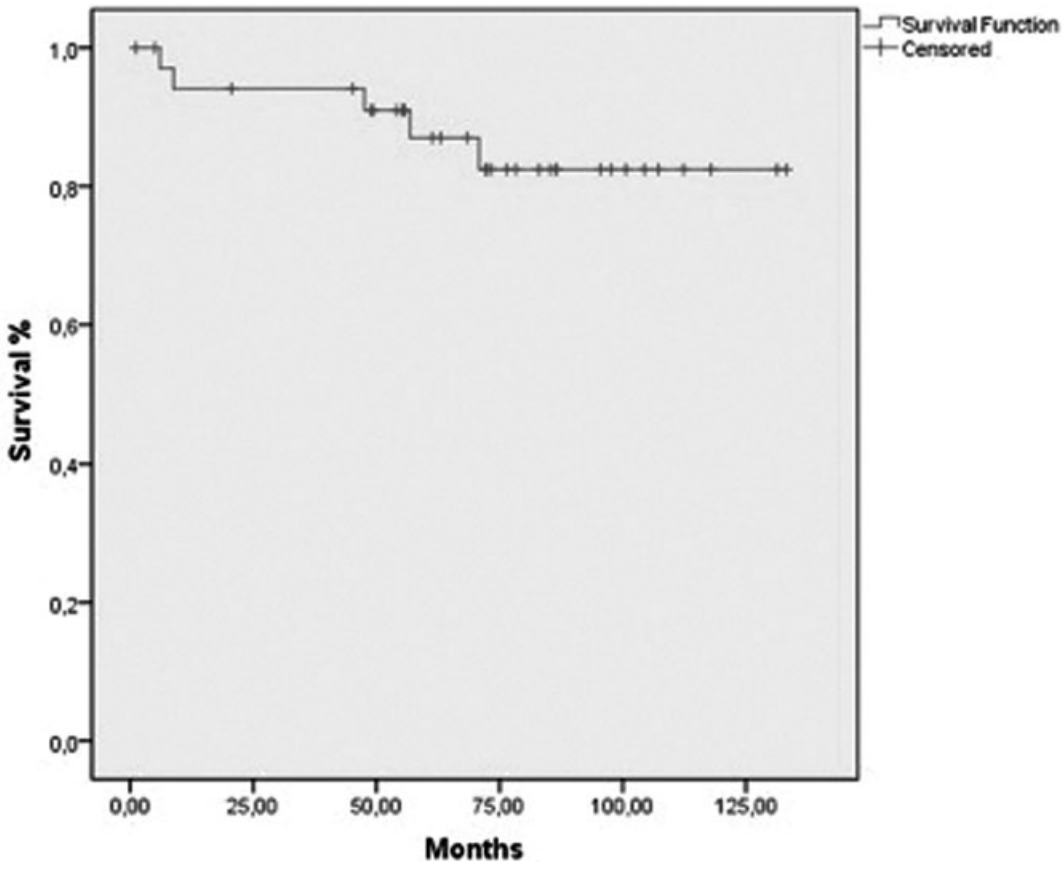

Figure 1. *Kaplan-Meier analysis of survival in study group.*

all patients and the number of mean distal by-pass was 3.4 (range 1–6). Five patients (14%) had concomitant procedures including aortic valve replacement (two patients), Bentall procedure plus mitral valve replacement (one patient), and mitral valve repair (two patients). TCA was necessary in 22 patients (61%). Mean duration of CPB and TCA was 97 ± 30 and 15.7 minutes, respectively. The replaced segment of the aorta was ascending in 30 patients, ascending + arch in five, and root + ascending in one patient. One stroke (2.7%) was observed and this patient died. Hospital mortality was related to multiorgan failure and the logistic Euroscore of this patient was 32%.

In the control group the concomitant procedures were aortic valve replacement (n = 138), aortic valve repair (n = 6), mitral valve replacement (n = 56), mitral valve repair (n = 134), tricuspid valve repair (n = 25), ascending aorta replacement (n = 64), total aortic arch replacement (n = 11), aortic root replacement (n = 20) via Bentall procedure, left ventricular aneurysm repair (n = 58), atrial septal defect closure (n = 3), carotid enderterectomy (n = 41), and peripheral bypass (n = 5).

For the control group the mean age was 61 ± 1, the stroke rate was 0.6%, and the mortality rate was 0.96%, whereas the mean logistic and additive Euroscore were 3.7 ± 4.4, and 3.5 ± 2.5, respectively.

Mean follow-up duration of the study group was 96 months (1–133 months). There were a total of four confirmed deaths (12%) at any time point over the length of the follow-up among the patients who were discharged from the hospital. Two of them died of malignancy (lung and gastric tumors) and the other two from cardiac reasons. The Kaplan-Meier survival analysis is shown in Figure 1. No neurological event was observed during the follow-up period.

All patients who underwent replacement of the ascending aorta had carotid Doppler studies preoperatively. None of them had severe carotid stenosis (>70%) that needed an intervention. In two of these patients the lesions progressed with time and they underwent carotid stenting at two and four years after surgery.

DISCUSSION

The overall incidence of complications after CABG has decreased; however, the incidence of major neurological complications, such as stroke, remains relatively unchanged.[13] Several reports have documented the role of the atherosclerotic aorta as a precursor of brain embolism during cardiac procedures mainly resulting from manipulation of the diseased aorta.[1–4] Although many techniques have been described to overcome the risks of manipulating an atherosclerotic aorta during coronary surgery, the optimal approach to this pathology is still uncertain. Moving cannulations and cross-clamping away from the involved sites may suffice if the disease is well localized. Isolated

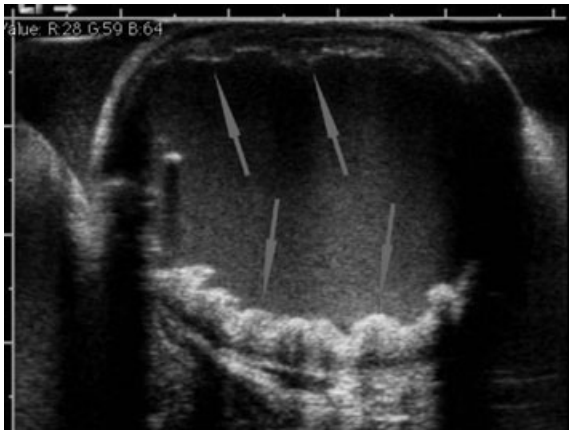

Figure 2. *Epiaortic ultrasonography showing ascending aorta. Arrows show atherosclerotic plaques.*

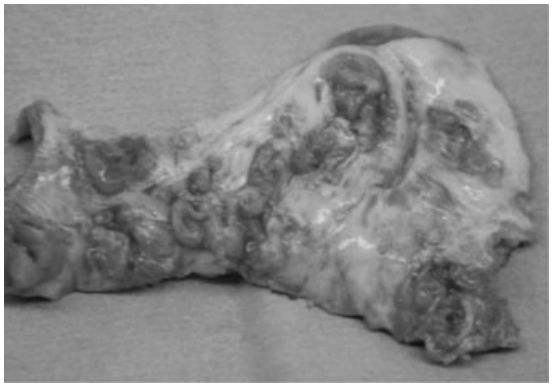

Figure 3. *The appearance of excised atherosclerotic ascending aorta.*

revascularization can be performed without CPB, or at least without cross-clamping, while using in situ arterial grafts (LIMA, RIMA).[14] Arterial composite grafts (T or Y grafting) with or without sequential grafting techniques can increase the number of distal coronary anastomosis with a limited number of grafts, avoiding a proximal aortic anastomosis.[15] However, there are concerns regarding the total dependence of the coronary bypass flow on the flow of one in situ arterial graft and the possibility that a technical error may result in compromised flow in one or both limbs of the composite grafts. For a small subgroup of patients with complex disease, a tailored invasive approach such as hybrid coronary artery revascularization which is a combination of LIMA bypass grafting to the LAD combined with PCI to other coronary arteries may be an other option for this group of patients.[16]

An atherosclerotic aorta may not be anticipated before surgery. This may force the surgeon to operate on a beating heart. Moreover, a significant number of these patients may require concomittant intracardiac procedures, which are not possible to perform with an off-pump technique.

On the other hand, leaving an atherosclerotic aorta behind exposes the patient to a lifetime risk of stroke (Figs 2–3). There is a strong relationship between atherosclerosis of the thoracic aorta and stroke.[17–20] In recent a study, Mazighi et al. reported a review of 500 consecutive autopsies in patients with neurological diseases and ulcerated plaques were documented in the aortic arch in 26% of patients who died from stroke and 5% of who died from other neurological diseases.[5] Plaques were seen in 61% patients who died from cerebral infarction of unknown etiology as compared to only 22% of patients with an identifiable cause of ischemic stroke ($p < 0.001$). In another autopsy study, Khatibzadeh et al. found 36 cases with pathological evidence of cerebral infarction at 120 consecutive hospital autopsies (30%) and complex plaques at the arch were shown to be associated with stroke.[18] The largest studies comparing plaque thickness, morphology, and embolic risk is the French Study of Aortic Plaque in Stroke (FSAPS) in which 331 consecutive stroke patients aged >60 years were followed for 2–4 years.[19] In that study, all patients had an initial TEE to assess the presence of atherosclerotic plaques in ascending aorta. After adjustment for the presence of carotid stenosis, atrial fibrillation, peripheral arterial disease, and plaque thickness >4 mm were independent predictors of both recurrent stroke and a new arterial vascular event. In a recent study involving 862 patients, it has been shown that the extent of the aortic atherosclerotic burden determined by pre-operative multidetector-row computed tomographic angiography is independently associated with increased long-term mortality in patients following surgery although the exact reason for the deaths was not reported.[20]

In a prospective, long-term follow-up study of 1,957 patients who underwent cardiac surgery, Dávila-Román and colleagues have reported that atherosclerosis of the ascending aorta was an independent predictor of neurologic events and of all-cause mortality. They also showed that there was more than 1.5-fold increase in the incidence of both neurologic events and mortality as the severity of atherosclerosis increased from normal-mild to moderate, and a greater than threefold increase in the incidence of both as the severity of atherosclerosis increased from normal-mild to severe.[17] In another prospective study, van der Linden and colleagues assessed the extent and location of atherosclerosis in the ascending aorta and arch intraoperatively with epiaortic ultrasound and TEE in 611 consecutive patients undergoing CABG and followed them for 5.5 years. They found that five-year stroke-free survival rate for patients with severe atherosclerosis of the ascending aorta was severely decreased compared to the patients without aortic disease, 65% vs 95%, respectively. They also showed that atherosclerosis in the middle and distal part of the ascending aorta, just before the origin of the innominate artery and especially on the left side, is mainly responsible for the association with late stroke.[11]

Rokkas and Kouchoukos have suggested a radical surgical approach including the replacement of the ascending aorta.[4] In 81 patients with a mean age of 71 years they performed a partial (5) or complete (75) replacement of the ascending aorta and atherectomy using hypothermic circulatory arrest with a stroke rate

of only 4.9%. In this series, 34 patients had replacement of the aortic arch, 19 had a valve replacement, and six had carotid endarterectomy. Although this method was associated with relatively higher perioperative mortality (8.6%), the incidence of neurological events was decreased. However, long-term survival has been disappointing with a 3-year survival rate of 40%, which was primarily related to generalized atherosclerosis.

Currently, there are no data supporting the widespread use of surgical endarterectomy of the ascending aorta or aortic arch in patients with recurrent embolism despite anticoagulation. In large clinical series it has been shown that surgical endarterectomy of the ascending aorta and aortic arch is associated with an increased risk of extensive intraoperative cerebral infarction. Stern and colleagues reported the early results of 268 patients with aortic arch atheromas with and without endarterectomy and in this study the stroke rate was as high as 34.9%.[21]

In our study, early stroke was observed in one patient (2.8%), which is relatively low, taking into consideration the severity of the disease. The possible reasons for fewer strokes in our patient group may be the application of antegrade cerebral perfusion, and shorter duration of cross clamp, CPB and TCA times. The lack of any stroke during the follow-up period supports our hypothesis, although in a limited number of patients. However, two patients had carotid artery intervention at the follow-up. These data also show that atherosclerosis is a progressive disease and these patients should be monitored closely.

One of the limitations of this study was that epiaortic ultrasonography was used only in patients with suspected atherosclerosis of the aorta, and it is likely that the severity and the extent of ascending aortic atherosclerosis were underestimated in the remaining patients. Another limitation was the relatively small number of the patients, which precluded multivariable analysis with adjustments for possible differences among the patients in various subgroups. Nevertheless, our study has shown that replacement of the heavily calcified ascending aorta can be performed in selected CABG patients with good long-term outcomes.

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