Original Article

Aortic Valve Replacement by Ministernotomy in Redo Patients with Previous Left Internal Mammary Artery Patent Grafts

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Objective: Aortic valve surgery with a patent left internal mammary artery (LIMA) on the left anterior descending (LAD) coronary artery is challenging in terms of myocardial protection and graft injury. Minimally invasive techniques may require minimal dissection of adhesions and may eventually decrease the risk of injuries.

Methods: Since 1997, more than 1000 ministernotomies have been performed by our surgical unit. Of these, 16 patients (14 males, 2 females, mean age: 68.7 years) had a patent LIMA graft on LAD. Fourteen underwent native aortic valve replacement, and in 2 a previously implanted prosthesis was replaced. A miniresternotomy was performed using either a "J" (15 patients) or a "reversed-T" method (1 patient).

Results: Cardiopulmonary bypass (CPB) was achieved by either femoral vein (12 patients) or right atrium (4 patients); arterial inflow was achieved either by ascending aorta (12 patients) or by femoral artery (4 patients). Mean CPB time was 119.7 ± 38.1 minutes (range: 50–235). Mean cooling body temperature was 27.4°C. Antegrade cold crystalloid cardioplegia was delivered to all the patients. Mean aortic cross-clamp time was 72 ± 20 minutes (range: 45–125). No damage to LIMA occurred in any of the patients. No intra- or perioperative myocardial infarction (MI) occurred. Neither a conversion to full sternotomy nor a reoperation for bleeding was needed. Mean postoperative bleeding was 426 ± 474 ml (range: 120–1950). A blood transfusion was necessary in 7 patients. Mean postoperative ICU stay was 1.6 ± 1.1 days. Mean postoperative hospital stay was 7.5 ± 2.6 days. Postoperative course was totally uneventful in 10 patients (58.8%). Follow-up was complete for a total of 928 patient/months (range: 11–124), and there were four late deaths, two of which were related to cardiac problems. Nine of the 12 survivors are in NYHA CLASS I·II. Prosthesis-related morbidity did not occur either early or late during follow-up.

Conclusions: This experience may represent the feasibility of an alternative surgical approach to a standard full-length median sternotomy in patients with previous coronary revascularization and with a patent LIMA on the LAD, requiring new surgery on the aortic valve. (Ann Thorac Cardiovasc Surg 2010; 16: 181–186)

Key words: minimally invasive, reoperation, aortic valve replacement

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Introduction

Minimally invasive access, endoscopic, percutaneous, robotic, and endovascular procedures are presently being used to treat heart diseases.[1–3] In 1996, Cosgrove and Sabik introduced their minimally invasive procedure with the aim of reducing perioperative bleeding, structural alteration of the chest, postoperative discomfort, infections, and, eventually, hospital stay.[4] Recently, the ministernotomy approach has appeared to be safe and effective in aortic valve operations,[5] especially in an experienced surgical group, but a final statement regarding its clinical relevance is still being debated.[6,7]

Management of mild aortic valve defects at the time of coronary artery bypass grafting (CABG) surgery has been a source of controversy for cardiac surgeons.[8–11] Furthermore there is increasing evidence of rapid progression of a previous irrelevant pressure gradient across the aortic valve after isolated CABG, prompting the need for aortic valve replacement (AVR).

The estimated risk of catastrophic hemorrhage on sternal reentry is about 0.5% to 1% with an associated mortality rate of 21% . The presence of a coronary graft has been demonstrated to increase this risk by at least 2.5-fold.[12] Moreover, injury of the patent conduit may occur anytime during surgery, this accident ranging from 3.5% to 38% in cases at reoperations.[13,14]

The management of myocardial protection with a patent left internal mammary artery (LIMA) graft may be challenging. Dissection and temporary occlusion of the LIMA during aortic cross-clamping is advisable to reduce any cardioplegia washout from the territory supplied by the graft.[14] Another strategy is to establish moderate-to-deep hypothermia, apply aortic cross-clamping, apply cardioplegia, and leave the LIMA unclamped.[14–15] Limited surgical dissection during a second operation through ministernotomy may reduce the risk of damaging a previously implanted LIMA on the left anterior descending coronary artery (LAD), but it will maintain blood flow through the graft.[15,16]

With this study we present a series of 16 patients with patent LIMA on LAD, treated using ministernotomy during surgery for aortic valve replacement (AVR). This is a retrospective, single-center analysis. We analyze preoperative variables and postoperative outcomes, and we describe the surgical procedure.

Materials and Methods

From March 1997 to June 2007, more than 1,000 minimally invasive partial upper sternotomies (ministernotomies) for aortic valves and ascending aortic diseases were performed at our cardiac surgery unit. Out of this population, the early and late outcomes of 16 patients who had undergone AVR and aortic valve prosthesis replacement after a previous LIMA on LAD graft were retrospectively analyzed. A "J" shape partial upper resternotomy was carried out at the 3rd (10 patients) or 4th (5 patients) right intercostal space. A "T-reversed" partial upper resternotomy was also used in one case. All patients underwent cardiopulmonary bypass (CPB) with systemic hypothermia. Antegrade cold crystalloid potassium cardioplegia was delivered to all patients both into the aortic root and the coronary ostia later on during prosthesis implantation. The selection of valve prosthesis depended on each surgeon preference. A transthoracic echocardiogram (TTE) was routinely performed before patient discharge from the hospital. A clinical routine examination was carried out at the "outpatient clinic" one month after the procedure and subsequently yearly unless the clinical status indicated otherwise. Long-term follow-up information was obtained through questionnaires and telephone calls to all patients.

Patients

The time span since CABG procedure and AVR was 7.7 ± 5.6 years (range: 1–22). One patient had two previous surgical myocardial revascularizations, three and two CABGs, respectively. Surgery for the aortic valve represented the aim of the second cardiac procedure in 15 patients and the third in 1. Reoperative surgery on an aortic valve prosthesis was performed on 2 patients. Preoperative coronary angiography was routinely performed on all patients. The mean number of bypass grafts was 2.5 per patient. A functioning LIMA graft on LAD was present in all cases. One patient had a patent pedicled LIMA graft on LAD and a patent right internal mammary artery as a free graft on the obtuse marginal branch running through the transverse sinus. Three patients had undergone previous percutaneous coronary angioplasty and stent positioning procedures (two on the right coronary artery and one on the circumflex coronary artery).

Preoperative clinical characteristics are listed in Table 1. Eleven patients were in the New York Heart Association (NYHA) functional class III or IV, and left ventricular ejection fraction was severely reduced (≤ 30%) in 4. Preoperative stroke was present in 1 patient who had permanent atrial fibrillation, and another had undergone previous carotid endarterectomy and a femoropopliteal bypass. Thirteen patients were in normal sinus rhythm preoperatively,

and 1 had a pace maker. Three patients had permanent atrial fibrillation. Based on echocardiographic and angiographic examinations, 10 patients also had evidence of mild mitral regurgitation, and combined trivial mitral valve stenosis/regurgitation was present in 1. The tricuspid valve was free of functional abnormality in all patients. Aortic valve pathology showed calcified degeneration in 13 patients and congenital valve disease in 1 (bicuspid aortic valve). In the remaining 2 cases, the reason for surgery was represented by a periprosthetic leak in a patient with a Starr-Edwards valve prosthesis (Edwards Lifesciences, Irvine, Calif.) and a bacterial endocarditis in a patient who previously had a Medtronic Hall prosthesis implant (Medtronic Inc., Minneapolis, Minn.). The European system for cardiac operative risk evaluation (EuroSCORE) ranged from 5 to 11, (mean 8.7 ± 1.7).[17] All procedures were performed on an elective basis.

Table 1. Preoperative state

CHARACTERISTICS	PTS
NYHA class	
I	2
II	3
III	8
IV	3
EF < 30%	4
Atrial fibrillation	3
Redo aortic valve replacement	2 (prosthetic leak)

Procedures

Mediastinal LIMA course and its relationships to the intercostal spaces and sternal wires were carefully studied by selective contrast angiograms, both in anteroposterior and lateral views. The groin was prepared with no incision in patients except in 1 in whom femoral vessels were surgically exposed before miniresternotomy. No CPB was performed before miniresternotomy.

No attempt was made to search the LIMA graft, which in almost all instances was left undisturbed on the left side of the heart. A minimal aorta and right atrium dissection was performed to allow CPB cannulations, aortic cross clamp, and aortotomy. Surgical dissection was mainly performed only on the right side of the surgical incision.

Arterial cannulation sites were the ascending aorta in 12 patients and the femoral artery in 4. Venous cannulation sites were the femoral vein in 12 patients and the right atrium in 4.

In case of femoral vein cannulation, a long standard venous cannula was placed percutaneously by the Seldinger technique into the right atrium under transesophageal echocardiogram (TEE) guidance. The percutaneous insertion of a venous cannula is now our primary choice because it avoids dissection of adhesions and improves visualization in the operative field. In the event of direct right atrium cannulation, a two-stage oval-shaped cannula was employed. Optimal venous drainage was gained by using vacuum assistance in the most recent cases. Femoral artery cannulation was done in 4 patients because of the presence of severe calcified atherosclerotic disease of the aorta. Upon CPB, the patients were cooled down to a mean rectal temperature of 27.4 ± 2.5°C (range 24° to 33°C). Total bypass time was 119.7 ± 38.1 minutes (range 50 to 235), and aortic cross-clamp time was 72 ± 20 minutes (range 45 to 125). In 2 of the 16 patients with patent LIMA, the graft was easily seen, and it was temporarily occluded by a delicate clamp. In 14 patients, the artery was kept sitting undisturbed on the left side of the sternum and left patent. Surgical access to the aortic valve was provided by oblique aortotomy directed toward the noncoronary aortic sinus, paying attention not to damage the proximal SVG anastomosis, if any. Venting of the left ventricle was obtained through the aortic annulus by a sump.

A mechanical valve was used in 9 out of 16 patients (56%) and a biological one in 7 of 16 patients (44%). Implanted prostheses were Medtronic HallTM (Medtronic., Inc., Minneapolis, Minn.) in 8 patients (50%), Starr-Edwards in 1 (6.25%), Carpentier-Edwards Pericardial in 6 (37.5%); and Carpentier-Edwards Perimount Magna in 1 (6.259%). (Edwards Lifesciences, Irvine, Calif.). Concomitant carotid endoarterectomy was performed in 1 patient.

Removing the air from the heart was best achieved by insufflating the lungs, decreasing the venous return on CPB, rotating the operative table upward and on the left side, manually compressing the left chest from the outside, and by examining by TEE for the presence of any air bubbles in the left cardiac cavities. In no instance was CO_2 used. With the patient in a Trendelenburg position, the aorta was then unclamped and the ascending aortic vent turned on. After the aortic cross clamp was released, ventricular fibrillation occurred in 8 patients (50%) and was successfully treated using the external defibrillation pads. When feasible, temporary epicardial pacing wires were placed on the right ventricle surface; otherwise temporary endocavitary pacing leads were positioned through the right internal jugular vein (one patient, 5.9%).

Table 2. Postoperative state

CHARACTERISTICS	MEAN ± SD	RANGE
Packed red cells requirements (units)	0.9 ± 1.2	0–4
Bleeding (ml)	425.8 ± 474.3	120–1950
Mechanical ventilation time (hours)	12.1± 5.1	5–21
ICU stay (days)	1.6 ± 1.1	0.6–5
ICU stay (days)	1.6 ± 1.1	0.6–5
Postoperative hospital stay (days)	7.5 ± 2.6	4–14

Table 3. Postoperative morbidity and mortality

CHARACTERISTICS	PTS
Prolonged mechanical ventilation	1
TIA	1
Uneventful course	14

Table 4. Postoperative follow-up

CHARACTERISTICS	PTS
Late deaths	4
I–II	9
III	3
CCS I	12
Atrial fibrillation	3
Permanent atrial fibrillation	2

Results

Postoperative characteristics are summarized in Table 2. Neither intraoperative deaths nor conversion to full resternotomy were necessary. No patient required surgical revision for bleeding.

Postoperative mortality and morbidity are listed in Table 3. On postoperative day 3, one patient affected by chronic obstructive pulmonary disease (COPD) suffered from acute respiratory distress syndrome because of severe bronchospasm, requiring intensive care unit reentry for 24 hours and mechanical ventilation for 12. Cerebral transient ischemic attack was observed in 1 patient. No electrocardiogram (ECG) changes or postoperative increase of myocardial enzymes indicative of perioperative myocardial infarction were present in any of the patients. Postoperative course was totally uneventful in 14 of the 16 patients. All 16 were discharged from the hospital, and sinus rhythm was present in 12.

Follow-up was 100% complete in the 16 survivors for a total of 928 patient/months (median 58 months, range 11–124). There were 4 late deaths; 2 were due to congestive heart failure at 11 and 52 months, respectively; 1 of lung cancer at 62 months; and 1 at 84 months of unknown reasons. No prosthesis-related morbidity (defined as valve-prosthesis thrombosis, valve-related thromboembolism, anticoagulation-related hemorrhage, early prosthetic valve endocarditis, intrinsic dysfunction, or nonstructural dysfunction such as paravalvular leakage) was referred during the follow-up period. Nine of the 12 survivors are in NYHA I and II, all in Canadian Cardiovascular Score I. New permanent atrial fibrillation occurred in 2 patients. Survival at 1, 5, and 10 years is 91.6%, 83.3% and 75%, respectively.

Discussion

Since its introduction in 1996,[4] minimally invasive access to the aortic valve has become standard practice in many cardiac surgery centers.[5] It has been presumed that smaller surgical incisions lead to earlier respiratory weaning off the ventilator, lower blood transfusion rates, less wound pain, faster postoperative recovery, and shorter hospital stay compared with a full sternotomy.[18] Many of these advantages have been questioned by other authors.[6,7] Reoperative cardiac surgery carries an increased operative risk, which is mostly related to potential damage of cardiac structures, greater bleeding with subsequent transfusion requirements, prolonged operative time, and longer intensive care unit stay. Many of these issues are due to resternotomy, sharp dissection of the diffuse mediastinal, and pericardial adhesions to spread the sternum and gain access to the operative field. To try decreasing these risks, some authors have advocated a limited exposure of cardiac structures.[16,19,20] As others have, we too have become acquainted with this policy applied so far in many redo cases over the past 10 years. The risk of isolated AVR after CABG may be great, and it may due to the older ages of patients requiring operations, the presence of left ventricular hypertrophy, the underlying coronary artery, and graft pathology and heart valve disease. The reported mortality for this kind of procedure ranges from 0% to 16.6% [9–11,15,21] with full resternotomy.

The widespread use of the LIMA and its high patency rate have made it quite common to reoperate in the presence of well-functioning coronary bypass grafts.[22] In these cases, the traditional strategy involves dissecting and clamping the LIMA pedicle prior to starting cardioplegic delivery to avoid myocardial regional warming and "washout" of cardioplegic solution in the territory supplied by the graft. This technique carries a significant

risk of LIMA injury.[22]

To reduce the risk of injury and to avoid regional myocardial rewarming, Byrne and colleagues[15] performed AVR, leaving the graft open using hypothermia at 20°C, a procedure previously described by Lytle and colleagues in 1994.[14] Perioperative myocardial infarction (7%), low cardiac output (14%), and LIMA injury (5%) were reported in this study. In a series of 50 patients reported by Akins et al.,[8] 13 patients underwent AVR leaving the mammary pedicle unclamped. Although there was no mention about cooling temperature of the patients, these authors found no instances of myocardial dysfunction that could be attributed to such a strategy.

An alternative approach that avoids myocardial reperfusion injury resulting from cardioplegic arrest is to perform beating heart AVR with continued use of CPB, antegrade and/or retrograde perfusion, and LIMA unclamped. In a series of 16 patients using this method, Savitt and colleagues reported a mortality rate of 0%.[23]

In our current practice, it is most common not to expose the LIMA and to cool down the body temperature any further if cardiac electrical activity resumes early. In our series, clamping of the mammary pedicle was done in two patients only because it was easily identified.

We didn't observe differences of cardiac enzyme level, such as CKMB or troponin between occlusion and non-occlusion groups of LIMA: From this experience, we believe that during a redo operation we need not occlude the patent LIMA.

In our series of patients, the mean number of bypass grafts was 2.5 per patient. Therefore during dissection on the ascending aorta area, we found patent aorto-coronary vein grafts that needed to be carefully isolated. In effect, with this approach we mainly protect the patent LIMA on the LAD, whose injury we consider a more dangerous complication to deal with.

Unlike other authors,[16] we do not start CPB and cool down the patient before dividing the sternum. There are several reasons to warrant this approach: first of all, a "J" incision toward the third or fourth right intercostal space is very likely to be away from the usual position of the LIMA graft. In a study by Byrne et al.,[19] the reported blood loss during the first 24 hours in the partial hemisternotomy group (55% of the patients with previous CABG) was a median of 360 ml (mean 458 ± 348, range 80–1568), and the packed red blood cells transfused was a median of 2 (mean 3.1 ± 3.0, range 0–9). These data were statistically much lower compared to the conventional full sternotomy group (53% previous CABG patients), which was 5.7 times more likely to have high blood loss and 3.6 times more likely to require transfusion of more than 5 units of blood.

As described above, the LIMA pathway was carefully studied at the selective angiogram; its position is usually near the pulmonary artery, but also quite close to the inferior surface of the left hemisternum. A lateral view of this artery at the selective angiogram is usually very helpful, as suggested by others.[24]

The overall early and late mortality reported by Byrne and colleagues[16] in a series of 34 patients (21 with previous CABG) who underwent AVR or aortic valve rereplacement after previous cardiac surgery through partial upper resternotomy was 5.9% and 6%, respectively. In another study by the same author, the overall hospitality mortality of 94 patients who underwent aortic valve surgery (18 patients through upper hemisternotomy, 19%) after previous CABG with functioning internal mammary artery graft was 6.4%.[15]

Percutaneous AVR represents an emerging alternative therapy for high-risk patients with severe symptomatic aortic valve stenosis. Sixteen patients (18.6%) from the overall population (86 patients) who had undergone prior CABG were treated with this technique by Grube and colleagues.[1]

Study limitation: The authors understand the retrospective nature of this study, the single-center experience and the limited number of study patients.

In conclusion, even with the underlined study limitations, the authors agree with others[5] that ministernotomy in aortic valve operations with a patent LIMA graft may be considered as an alternative surgical approach to longitudinal total sternotomy. Further randomized group studies with a larger number of patients would be of help to better define the utility of this approach.

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