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Conversion of Endoscopic, Robotically Assisted Coronary Bypass: Incidence, Risk Factors, and Outcome

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ABSTRACT

Background: The clinical and financial consequences of conversion from endoscopic (robotically assisted) atraumatic coronary artery bypass (EndoACAB) to sternotomy (converted EndoACAB) have not been previously reported. This study sought to identify the incidence, causes, predictive factors, and adverse consequences of converted EndoACAB.

Methods: Between June 1996 and June 2003, 509 patients underwent EndoACAB, and an additional 20 EndoACAB patients underwent converted EndoACAB. Data from the patients requiring conversion to sternotomy were retrospectively reviewed using multivariate regression and computer matched with data from a cohort of patients who underwent primary sternotomy (SternCAB).

Results: The overall rate of conversion was 3.8% (20/509). Causes were: inability to expose the target vessel(s) (9), unsuitable internal mammary artery (7), intrathoracic bleeding (2), and hemodynamic instability (2). There were no statistical differences in mortality or major morbidity between converted EndoACAB patients versus the computer-matched SternCAB patients (P = not significant). Hospital costs for the converted EndoACAB patients were higher than for the successful EndoACAB patients, but not higher than the computer-matched SternCAB patients.

Conclusions: The incidence of conversion of EndoACAB patients to sternotomy was low and often occurred under elective circumstances. The clinical and economic consequences of conversion were minimal.

INTRODUCTION

Conversion to sternotomy is occasionally necessary during the performance of a minimally invasive coronary artery bypass procedure. The recent prevalence of conversion to full sternotomy is reported to be between 0.9% and 22.2% [Detter 2001, Dogan 2002, Kappert 2001] and varies with the type of procedure performed (lower hemisternotomy, 6- to 9-cm anterior thoracotomy, 3- to 5-cm non–rib-spreading thoracotomy, totally endoscopic on pump, totally endoscopic off pump). The goal of this study was to assess the clinical and economic outcomes of patients receiving sternotomy after an unsuccessful endoscopic atraumatic coronary artery bypass (EndoACAB). We compared these outcomes with patients having primary sternotomy.

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MATERIALS AND METHODS

Patients

Over the 7-year period between June 1996 and June 2003, 1874 consecutive patients underwent isolated, first-time, elective coronary bypass performed by a single surgeon (T.A.V.) at the Pensacola Heart Institute. A total of 509 patients underwent the EndoACAB procedure, and 1365 patients underwent coronary bypass through a sternotomy (SternCAB). An additional 20 patients (3.8%) underwent intraoperative conversion from EndoACAB to sternotomy (converted EndoACAB), with 18 patients undergoing grafting off-pump and 2 patients on-pump. A summary of the patient characteristics is provided in Table 1. In addition to the total EndoACAB patient group (509), there were 16 patients for whom the internal mammary artery (IMA) harvest was aborted because of extensive pleural adhesions (6), excessive external and internal thoracic adiposity (5), mechanical ventilation problems (3), and video equipment failure (2). These patients were not included in this report.

Definition of Terms

EndoACAB: Coronary artery revascularization using thoracoscopic IMA harvesting and off-pump grafting through a muscle-sparing, non–rib-spreading thoracotomy.

Converted EndoACAB: Procedure that begins as an EndoACAB and requires conversion to sternotomy intraoperatively.

SternCAB: Coronary artery bypass performed through a sternotomy either with or without the use of cardiopulmonary bypass (CPB).

Data Collection and Statistical Analysis

Patient data and results were collected and analyzed according to the guidelines of the Society of Thoracic

Table 1. Patient Variables*

Variable	Converted EndoACAB	Successful EndoACAB	*P*
No. of patients	20	509	
Mean age, y	62.2	64.5	NS
Male:female	1.8:1	2.1:1	NS
Hypertension, %	40.0	42.2	NS
Diabetes, %	20.0	22.5	NS
PVD, %	15.0	12.7	NS
COPD, %	25.0	26.8	NS
CRF, %	10.0	8.6	NS
Mean LVEF, %	50.2	53.4	NS
NYHA class	2.3	2.2	NS
No. of grafts	1.40 ± .59	1.12 ± .31	0.04

*EndoACAB indicates endoscopic atraumatic coronary artery bypass; NS, not significant; PVD, peripheral vascular disease; COPD, chronic obstructive pulmonary disease; CRF, chronic renal failure; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association.

Table 2. Reasons for Conversion to Sternotomy

Reasons for Conversion	Urgency	n
Inadequate exposure	Elective	
Intramyocardial left anterior descending artery		6
Right coronary artery not graftable		3
Unsuitable internal mammary artery	Elective	
Internal mammary artery <1.5 mm		4
Internal mammary artery <20 mL/min		3
Bleeding	Elective	
Subclavian vein injury		1
Internal mammary artery injury		1
Hemodynamic instability	Urgent	
Ischemia		1
Ventricular tachycardia		1
Total		20

Surgeons National Cardiac Surgery Database. Patient characteristics and outcomes for the 2 groups (EndoACAB and converted EndoACAB patients) were compared using the chi-squared analysis or Fischer exact test for categorical and the Student *t* test for continuous variables. Results are reported as the mean ± SD. The patients requiring conversion to sternotomy (converted EndoACAB) were computer matched to a cohort of patients who underwent primary sternotomy (SternCAB). Statistical significance was defined as a *P* value of less than 0.05.

Surgical Technique

The technical details of the EndoACAB procedure have been previously described in detail [Vassiliades 2001]. In brief, the technique consisted of single or bilateral, robotically assisted (AESOP; Computer Motion, Goleta, CA, USA), thoracoscopic IMA harvesting followed by thoracoscopic pericardiotomy for target vessel identification. Directed by the endoscopic information, a 5- to 6-cm incision was made followed by a muscle-sparing (pectoralis major), non–rib-spreading opening in the thoracic cavity. Through the natural width of the interspace (mean, 18 mm), the off-pump direct vision anastomoses were performed. In the case of multiple grafts, the heart was positioned under the incision with a port-based suction positioner and stabilizer. Graft patency was assessed routinely with the transit-time flow measurement technique (Medtronic, Minneapolis, MN, USA).

RESULTS

Eighteen (90%) of the 20 required conversions to sternotomy were done under elective situations. The most common reason for conversion was an inability to find a deep intramyocardial left anterior descending artery (LAD) or an adequate location on a very diseased right coronary artery (Table 2). One of these patients had an intraseptal LAD, and elective CPB and cardioplegic arrest were required to perform the graft. In 7 patients the LIMA was felt to be an unsuitable conduit for in situ grafting because of size and/or flow. Two patients required conversion to sternotomy because of technical misadventures resulting in an injury to an important structure: one LIMA (in the first interspace) and one left subclavian vein. Bleeding in both situations was controlled with an endoscopic grasper while the sternotomy was performed, thereby avoiding significant blood loss or any adverse hemodynamic effects. Of the entire series of EndoACAB surgeries performed (509), the IMA was injured in approximately 9 additional cases, but in these cases conversion to sternotomy was not necessary. In these patients, either (*a*) the injury to the LIMA was repaired by a segmental excision followed by end-to end anastomoses (4), (*b*) the injured portion was discarded because of its distal location on the LIMA (3), or (*c*) an alternative conduit was used to perform a subclavian-to-LAD bypass using an additional infraclavicular incision (2). The technique of externalizing the LIMA in the second interspace and then replacing it into the pleural cavity for anastomosis to the LAD through the third interspace was also employed as one method for construction of Y grafts to the LIMA.

Two patients underwent urgent conversions because of hemodynamic problems. One patient developed significant anterior and inferior wall ischemia that did not respond to intracoronary shunting. This patient underwent conversion to sternotomy and grafting on-pump with the heart beating. A second patient had numerous episodes of sustained ventricular tachycardia and underwent conversion to sternotomy with the plan to graft on CPB. However, the arrhythmias ceased and the LAD was grafted off-pump.

All 20 patients who underwent converted EndoACAB were matched 1:1 with 20 patients from the SternCAB group. The variables matched between the 2 groups were age ± 3 years, sex, body mass index, left ventricular function (>50%, 30%-50%, <30%), coronary arteries grafted, presence of chronic obstructive pulmonary disease, diabetes, peripheral vascular disease, hypertension, and renal insufficiency. The clinical outcomes of the 2 groups are compared in Table 3.

Table 3. Comparison of Data from Converted EndoACAB Patients and Primary SternCAB Patients*

Variable	Converted EndoACAB	Primary SternCAB	*P*
No. of patients	20	20	
Follow-up	100%	100%	
Mean follow-up, mo	28.1 ± 16.6	33.4 ± 18.3	
30-Day mortality	0	0	NS
Hospital length of stay, d	5.15	5.25	NS
ICU length of stay, d	1.5	1.7	NS
Atrial fibrillation	4 (20%)	5 (25%)	NS
Bleeding	0	0	NS
Transfusion	3 (15%)	4 (20%)	NS
Myocardial infarction	0	0	NS
Neurological event	0	0	NS
Wound complication	0	0	NS
Hospital cost	1.3 X	1.2 X	NS

*EndoACAB indicates endoscopic atraumatic coronary artery bypass; SternCAB, CAB with sternotomy; NS, not significant; X, mean hospital cost of a successful EndoACAB.

DISCUSSION

Because the EndoACAB procedure does not violate the skeletal aspects of the thoracic cage, an elective conversion to sternotomy does not impart significant patient trauma beyond that of primary sternotomy. In contrast, the more traumatic classic MIDCAB (minimally invasive direct coronary artery bypass) and LAST (left anterior small thoracotomy) procedures [Calafiore 1996], which rely on chest wall elevation and rib spreading, cause considerably more trauma to the patient even when conversion to sternotomy is not needed [Bucerius 2002]. Therefore, the fundamental procedural differences between the EndoACAB procedure and its procedural ancestors account for the negligible clinical effects of conversion to sternotomy. Patients who underwent required intraoperative conversion to a full sternotomy (converted EndoACAB group) had outcomes similar to those of the matched sternotomy patients (SternCAB group) because all but one of these conversions were performed electively. Only one patient underwent conversion because of hemodynamic reasons that might have directly impacted clinical outcome.

For the purposes of cost comparison, the in-hospital cost of a successfully completed EndoACAB procedure was designated as X. During the same time period, patients who underwent a primary sternotomy for an elective CAB graft had an average in-hospital cost of 20% higher than the EndoACAB procedure (1.2 X). For the 20 EndoACAB patients converted to sternotomy, the increased hospital costs were attributed to the additional disposable costs during the operation, either sternotomy off-pump or on-pump equipment. Overall, the converted EndoACAB patients cost the hospital 30% more than the successful EndoACAB patients (P = .02) but not a statistically significant amount more than the primary sternotomy patients.

Most of the patients requiring conversion to sternotomy might have been identified from the preoperative angiogram. Nine patients were converted because of target vessel anatomy (intramyocardial LAD or calcified right coronary artery) and 7 patients because of a small LIMA. In contrast, only 20% of the converted patients (4/20) underwent sternotomy because of unpredictable intraoperative events such as technical misadventures or cardiac ischemia. Results of the computer-matched comparison between converted EndoACAB patients and primary sternotomy patients revealed a significant difference between the numbers of grafts performed. Four of the 20 converted patients required 2 or 3 grafts, making the procedure more difficult to complete as an EndoACAB. With the recent introduction of endoscopic cardiac positioners [Vassiliades 2003], the performance of multiple grafts through a single non–rib-spreading opening in the chest may become more straightforward.

In summary, the EndoACAB procedure can be performed with a low sternotomy conversion rate (compared to the totally endoscopic technique) because many of the steps of the procedure are performed under direct vision. In addition, when conversion is necessary, the resultant clinical and economic effects to the patient and the hospital are minimal, making the operation attractive for a new minimally invasive revascularization program.

REFERENCES

Bucerius J, Metz S, Walther T, et al. 2002. Endoscopic internal thoracic artery dissection leads to significant reduction of pain after minimally invasive direct coronary artery bypass graft surgery. Ann Thorac Surg 73:1180-4.

Calafiore A, Giammarco GD, Teodori G, et al. 1996. Left anterior descending coronary artery grafting via left anterior small thoracotomy without cardiopulmonary bypass. Ann Thorac Surg 61:1658-63.

Detter C, Reichenspurner H, Boehm D, et al. 2001. Single vessel revascularization with beating heart techniques—minithoracotomy or sternotomy? Eur J Cardiothorac Surg 19:464-70.

Dogan S, Aybek T, Andressen E, et al. 2002. Totally endoscopic coronary artery bypass grafting on cardiopulmonary bypass with robotically enhanced telemanipulation: report of forty-five cases. J Thorac Cardiovasc Surg 123:1125-31.

Kappert U, Schneider J, Cichon R, et al. 2001. Development of robotic enhanced endoscopic surgery for the treatment of coronary artery disease. Circulation 104:102-7.

Vassiliades T. 2001. Atraumatic coronary artery bypass: technique and outcomes. Heart Surg Forum 4:331-4.

Vassiliades T. 2003. Multi-vessel, all-arterial, off-pump surgical revascularization without disruption of the thoracic skeleton. Heart Surg Forum. In press.