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Posterior Thoracotomy for Reoperative Coronary Artery Bypass Grafting without Cardiopulmonary Bypass: Perioperative Results

Dr. D'Ancona

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Giuseppe D'Ancona, MD, Hratch Karamanoukian, MD, Thomas Lajos, MD, Marco Ricci, MD, Jacob Bergsland, MD, Tomas Salerno, MD

Division of Cardiothoracic Surgery and the Center for Minimally Invasive Cardiac Surgery, Kaleida Health—Buffalo General Hospital Site and SUNY at Buffalo, Buffalo, New York

ABSTRACT

Background: This retrospective study evaluates morbidity and mortality of reoperative coronary artery bypass grafting (CABG) without cardiopulmonary bypass (CPB) using a posterior thoracotomy to revascularize the lateral aspect of the heart.

Methods: From January 1995 to July 1999, reoperative CABG without CPB was performed on 67 selected patients using a left posterior thoracotomy approach. Preoperative risk factors, postoperative mortality, and major complications were derived from the New York State database.

Results: All patients were operated on without CPB. A total of 1.3 grafts per patient were performed. Freedom from major complications was 95.5%. There were no postoperative cerebro-vascular accidents (CVA) or new neurological deficits. Two patients (3%) had a perioperative acute myocardial infarction. The actual mortality rate was 4.5% (3/67), the expected mortality was 5.1% and the calculated risk adjusted mortality was 2.1%.

Conclusions: Reoperative CABG without CPB to revascularize selected coronary artery targets can be safely performed using a posterior thoracotomy approach.

INTRODUCTION

Alternative surgical strategies have evolved over the last few years to decrease the risks of reoperative coronary artery bypass grafting (CABG). Use of different surgical incisions to avoid sternal reentry [Knight 1987, Grandjbakhch 1989, Grosner 1990], minimization of graft and aortic manipulation to decrease the possibility of embolism ("no-touch" technique) [Savage 1994], and amelioration of the methods of myocardial protection to limit the ischemic damage [Buckberg 1989] have all been included in the surgical armamentarium of reoperative CABG. Avoidance of cardiopulmonary bypass (CPB) has been recently introduced and added as a strategy to limit the invasiveness of primary CABG [Calafiore 1996, Bergsland 1998] and its advantages have been particularly emphasized in patients at high risk for conventional CABG [D'Ancona 1999b]. This technique has been proposed as a safe alternative in reoperations, especially when associated with alternative surgical approaches to revascularize target areas of myocardium [Grandjean 1996, Akhter 1997, Boonstra 1997, Fonger 1997]. We herein report our experience with off-CPB reoperative CABG using a left postero-lateral thoracotomy to revascularize the lateral aspect of the myocardium.

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Address correspondence and reprint requests to: Hratch Karamanoukian, MD, Kaleida Health—Buffalo General Hospital Site, 100 High Street, Buffalo, New York 14203,Phone: (716) 859-1080, Fax: (716) 859-4697, Email: lisbon5@yahoo.com

MATERIALS AND METHODS

Reoperative CABG without CPB via a left posterior thoracotomy was performed on 67 selected patients from January 1995 to July 1999. This surgical approach was adopted in cases of recurrent coronary artery disease (CAD) limited to the lateral wall of the heart.

Surgical technique

We started to use this approach for reoperative CABG in 1971 utilizing femoral cannulation for CPB [Grosner 1990]. In the last several years, CPB has been avoided in the majority of cases. After induction with general anesthesia and double lumen endotracheal intubation, the patient was

Table 1. Demographics and preoperative risk factors in 67 reoperative CABGs cases, off-CPB

	N	%
Total Patients	67	100
Male/Female	60/7	89.6/10.4
Age	65.4 (47–80)	
EF	46.6% (22–72)	
Elective	38	56.7
Urgent	27	40.3
Emergent	2	3
CCS class (I,II,III,IV)	1, 0, 21, 45	1.5, 0, 31.3, 67.2
Preop AMI	57	85.1
Preop Stroke	11	16.4
Calcified Asc Aorta	1	1.5
Diabetes Mellitus	16	23.9
Hypertension	50	74.6
COPD	23	34.3
CHF	9	13.4
CRF (Creat >2.5)	1	1.5
Dialysis	1	1.5
Preop IABP	1	1.5
Preop IV NTG	21	31.3

AMI = acute myocardial infarction, EF = ejection fraction, COPD = chronic obstructive lung disease, CHF = congestive heart failure, CRF = chronic renal failure, IABP = intra-aortic balloon pump, IVNTG = intravenous nitroglycerin

positioned for a standard left posterolateral thoracotomy. An incision was then made 4 cm below the tip of the scapula towards the left mid-axillary line and was extended posteriorly towards the spine. The chest was entered through the 6th intercostal space after dividing the latissimus dorsi muscle and opening the thoracic fascia. The left lung was collapsed and the pericardium was opened posterior to the phrenic nerve. This exposure provided access to all obtuse marginal (OM) branches of the circumflex system and posterolateral coronary artery (PLA) branches.

After lysis of the adhesions, the target site had been selected on either the native coronary or the hood of an old graft. Intravenous heparin was administered. The coronary stabilizer platform (CTS, Cupertino, CA) was positioned and proximal snaring of the coronary artery was achieved with a 4-0 Prolene® pledgetted suture. After 3 minutes of ischemic preconditioning, the target vessel was opened. An appropriate size intracoronary shunt was placed within the vessel and the snare was released to prevent further myocardial ischemia. Distal anastomoses were performed with 7-0 Prolene® running suture using a blower-aerosolizer to improve visibility during the procedure. The graft was then anastomosed proximally to the partially clamped descending thoracic aorta. Transit time flow measurement (TTFM) was used to confirm graft patency. Flow curves and flow values were recorded in the flowmeter hardware (Medistim Butterfly, Medistim, Oslo, Norway).

If combined revascularization of the left anterior descending (LAD) and circumflex coronary artery territory was needed, the incision was extended anteriorly, gaining access to the anterior aspect of the heart. In this case harvesting of the left internal mammary artery, whenever available, was performed, and the conduit was used to revascularize either the LAD or the OM branches.

Data collection and statistical analysis

All data regarding this group of patients were entered in the New York State Database and retrospectively analyzed. Operative priority was defined as emergent when severity and distribution of CAD, along with hemodynamic instability, mandated immediate surgery.

In regard to perioperative outcomes, perioperative stroke was defined as any new neurologic event lasting more than 24 hours after the operation. Perioperative acute myocardial infarction (AMI) was defined as an abnormal elevation of cardiac enzymes (CK-MB, troponin-T) accompanied or not by 12 lead EKG changes. Respiratory failure was defined as the need for ventilatory support for 48 hours or more, postoperatively. The absence of any postoperative complication was referred to as "freedom from complications". Actual mortality was defined as in-hospital within 30 days from the operation. Expected mortality rate reflected preoperative risk factors. Risk-adjusted mortality rate was calculated by dividing the actual mortality by the expected mortality and multiplying the result by the New York State mortality rate.

RESULTS

Demographic data are summarized in Table 1 (◎). Mean age was 65.4 years (range: 47–80 years). There were 60 males (89.6%) and 7 females (10.4%). All patients had undergone at least one operation for CAD, 6 patients (9%) had already been operated on twice and two patients (3%) three times. A total of 1.3 grafts per patient were performed. Data regarding the type of conduits used and the target coronary arteries are summarized in Table 2 (◎).

There were no conversions to CPB or to median sternotomy. Mortality and morbidity rates are reported in Table 3 (◎). No strokes or postoperative neurological deficits were reported. Two patients (3%) developed a postoperative AMI. Freedom from complications was 95.5%. Average hospitalization after surgery was 8 days. Actual mortality was 4.5% (3/67), expected mortality was 5.1% and risk-adjusted mortality was 2.1%. Two patients (3%) died from left ventricular failure and in one case (1.5%) respiratory failure occurred accompanied by acute pancreatitis and sepsis. Intraoperative TTFM was adopted to document patency in 43 grafts. Flows were measured with and without proximal snaring of the native coronary artery and all grafts tested were patent by TTFM.

DISCUSSION

The referral pattern for CABG has been changing including an increasing number of high-risk patients. In

Table 2. Number of anastomoses with relative conduits used in 67 reoperative CABGs cases off-CPB

	LAD	Circumflex (or OM)	Total
LIMA	2	2	4
SVG	0	83	83
Total	2	85	87

LAD = left anterior descending, OM = obtuse marginal branches of the circumflex system, LIMA = left internal mammary artery, SVG = saphenous vein graft

Table 3. Postoperative morbidity and mortality in 67 reoperative CABGs off-CPB

	N	%
Number grafts/pt	1.3	
Freedom from complications	64	95.5
Stroke	0	0
Transmural MI	2	3
Wound infections	0	0
Renal failure	1	1.5
Respiratory failure	1	1.5
Sepsis	1	1.5
Reoperation for bleeding	0	0
In-hospital stay (days)	8	
Actual mortality	3	4.5
Expected mortality		5.1
Risk-adjusted mortality		2.1

MI = myocardial infarction.

this regard, it has been estimated that 17% of the patients, previously submitted for CABG, will need re-operation within 12 years [He 1995]. To circumvent the deleterious complications of reoperative CABG, attention has been focused on alternative surgical strategies aimed at improving myocardial protection and at reducing manipulation of the heart, aorta, and old grafts. Appropriate use of antegrade and retrograde cardioplegia in re-operations has, for example, been shown to reduce mortality to levels as low as 3.4% [Lytle 1987]. Similarly, the use of a variety of surgical techniques, such as "no-touch" dissection and single aortic cross-clamping, has been shown to decrease operative mortality [Salerno 1982, Savage 1994].

Although the above-mentioned techniques have decreased the risks of reoperative CABG, the complications related to the use of CPB are still present, especially whenever long perfusion periods are required during reoperations. Long CPB time has been identified as the most powerful independent predictor of mortality after reoperative CABG [He 1995]. In this regard, avoidance of CPB may be proposed as a valuable alternative to treat recurrent CAD.

To further contain the risks of this already highly compromised population, use of alternative surgical approaches can be suggested to revascularize, off-CPB, limited areas of the myocardium avoiding the hazards of resternotomy and limiting manipulation on the ascending aorta, heart, and old grafts. Different approaches have been proposed to achieve an off-CPB revascularization of target coronary artery branches in the setting of reoperative CABG. Boonstra et al. [Boonstra 1997] first suggested the use of a left anterior small thoracotomy (LAST) with anastomosis of the left internal mammary artery (LIMA) to the LAD to treat recurrent CAD involving the LAD. Grandjean et al. proposed a subxiphoid approach with harvesting of the right gastroepiploic artery (RGEA) to reach, off-CPB, isolated lesions of the right coronary artery (RCA) system [Grandjean 1996]. Revascularization of recurrent isolated lesions of the circumflex system can be achieved via a left postero-lateral thoracotomy. This approach was first performed using the femoral vessels for institution of CPB [Knight 1987, Grandjbakhch 1989, Grosner 1990], and only later the same conceptual framework was adopted without CPB [Fonger 1997, Baumgartner 1999].

Even if the advantages offered by these alternative surgical approaches seem to be intuitively evident, there is still a limited number of comparative studies with traditional reoperative coronary artery surgery. Miyaji et al. [Miyaji 1999] demonstrated similar results between primary and reoperative CABG performed off-CPB. Allen et al. [Allen 1997] showed a significant decrease in the rate of atrial fibrillation, number of transfusions and ICU length of stay when comparing a group of patients reoperated upon via LAST with a group of conventional redo operations with disease limited to the LAD.

Absence of strokes, low rate of periopeartive AMI (3%) and high rate of freedom from complications (95.5%), have been reported in our experience with reoperative CABG off-CPB via left thoracotomy. These results are very encouraging and are similar to those proposed for larger groups operated on with conventional CPB and via median sternotomy [Lytle 1987, Loop 1990, Aranki 1994, Savage 1994]. Operative mortality in reoperative CABG varies between 3.4% and 12.5% with a median of 8% [He 1995]. In our experience, a rate of 4.5% reflects the results published by other authors using conventional surgical techniques on CPB [Lytle 1987, Loop 1990, Aranki 1994, Savage 1994, He 1995].

The feasibility of reoperative CABG off-pump via median sternotomy is not well documented, and exposure of the lateral coronary artery branches, i.e. circumflex system, can be troublesome if meticulous lysis of the pericardial adhesions is not performed before using the modern techniques of elevation and stabilization of the heart.

Revascularization of the lateral vessels of the heart without CPB through median sternotomy has been made easier since the introduction of the "single suture" technique in the oblique sinus of the pericardium [Karamanoukian 1999] in conjunction with modern stabilization systems. Despite that, a posterior-thoracotomy approach can result in better and safer coronary exposure in patients with recurrent CAD, extended and limited to the circumflex coronary system.

In our experience a total number of 1.3 grafts per patient, as above reported, appears to be very reductive. It has to be emphasized that all patients referred for this procedure had limited CAD localized to the lateral aspect of the heart and complete myocardial revascularization was performed in all cases.

Lack of clinical and angiographic follow-up is an important limitation of our study and, for this reason we have limited our discussion to the intraoperative and perioperative results. Partial documentation of intraoperative graft patency was obtained via TTFMs in 41 grafts. This technology has been demonstrated to be particularly useful to detect, and eventually correct, critical anastomotic lesions [Cerrito 1999, D'Ancona 1999a, D'Ancona (in press)].

In conclusion, our results indicate that reoperative CABG for CAD, extended and limited to the circumflex system, can be safely performed via a left posterior thoracotomy without CPB, limiting postoperative morbidity and mortality. Extensive dissection and manipulation of the heart and old grafts can be avoided thereby minimizing the risks for embolism and achieving revascularization of culprit coronary lesions. Median sternotomy or other surgical approaches should be, on the contrary, performed if the CAD is not limited to the circumflex system aiming always to a complete myocardial revascularization. Acquisition of enough confidence with the modern techniques of coronary exposure, stabilization and shunting, as used during primary operations off-CPB, is mandatory before performing this operation as a redo. Clinical and angiographic follow-up in prospective randomized studies are necessary to better define limits and indications of this very promising technique.

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REVIEW AND COMMENTARY

1. Editorial Board Member L023 writes

This is a nicely written paper, with a sufficient number of patients, albeit without medium or long-term follow-up of an approach to redo revascularization.

a) The author should comment on whether all patients had "total revascularization" redo surgery or only major target vessels revascularized with this approach. Their indications for selecting this approach should also be more fully discussed.

b) Their statistics in terms of the % number of redo cases that this cohort formed would also be of interest, as the number of redo cases approached by other minimally invasive/off-pump approaches.

Author(s)' Response by Giuseppe D'Ancona, MD

a) All patients had complete myocardial revascularization. Coronary artery branches that at angiography were determined to have very poor quality and to be bad surgical targets were not revascularized. This approach was chosen only for patients with coronary artery disease limited to the marginal branches. If other coronaries were amenable to surgical treatment, a median sternotomy was preferred.

b) In the same period of time, a total of 274 patients underwent reoperative CABG off-CPB and 307 on-CPB. In the off-CPB group, 122 patients had a median sternotomy (44.5%), and the remaining patients were treated with alternative surgical approaches (posterior thoracotomy, LAST-RAST, subxiphoid with RGEA).

2. Editorial Board Member EE455 writes:

The lateral thoracotomy approach should become standard for this peculiar and marginal group of patients presented with isolated lateral lesions and patent grafts or native vessels on the anterior and inferior walls.

a) The operative results are not reported. Neither the graft patency, which is discussed by the authors, nor the effects on angina recurrence.

b)The authors assess that this approach is feasible with results as good as those provided by median sternotomy. In my experience, the PT approach is much easier technically, thus faster than sternotomy. It requires less dissection of the pericardial adhesions and less blood loss are to be expected in this very marginal group of patients. I think the advantages should be stressed.

c) We have combined this approach with TMLR on the anterior aspect of the heart in four cases. Do the authors have an opinion on this type of hybrid approach, which increases the potential indications to patients with antero-lateral viability not due to complete classical revascularization?

d) Conversion to sternotomy, which has not happened in the cohort, would be very difficult in this position. In case of emergency, CPB should be instituted through a groin incision, thus mandating a preoperative assessment of the ilio femoral vasculature. This point might be highlighted.

Author(s)' Response by Giuseppe D'Ancona, MD

a) As already specified by the title ("perioperative results") and discussed in the manuscript, we are perfectly conscious of the limitations of the study and the lack of angiographic and clinical follow-up.

b) It is obvious that avoidance of resternotomy can decrease the risks of injury on vital structures and reduce manipulation of the heart, old grafts and large vessels. On the other hand, the PT approach can be extremely difficult and adequate exposure and stabilization of the coronary targets can be very troublesome. We suggest adopting this approach only after having acquired enough experience with off-CPB primary operations.

c) We do not have experience with TMLR and the clinical applicability of this technology is still very controversial.

d) Conversion to sternotomy is almost always not necessary and femoral vessels can be cannulated for CPB. We do not routinely perform perioperative assessment of the groin vessels. This is a very good point, probably applicable to all reoperative CABG patients

3. Editorial Board Member EK34 writes

This is a nice relatively large series of a highly selected group. The data should be a gold-standard for this patient group. The author must use the STS definition of mortality — "all deaths occurring during the hospitalization in which the operation was performed. Those deaths occurring after hospitalization but within 30 days of the procedure....Those deaths occurring after 30 days that are clearly related to the surgical procedure will also be counted as operative mortality".

Author(s)' Response by Giuseppe D'Ancona, MD:

We have not yet reviewed our follow-up data for this group of patients. We can only consider the in-hospital mortality and, for this reason, the STS definition of mortality is not applicable in this particular case.

4. Editorial Board Member AR11 writes:

The authors need to detail the information on their patient group (from how big an overall group of revascularization patients were they selected; 67 patients in a 4.5 year interval doesn't sound like very many). Comparison data to other reops in their institution might be helpful, and certainly interesting, for the reader.

Author(s)' Response by Giuseppe D'Ancona, MD

A total of 274 patients underwent off-CPB reoperative CABG in the same period of time. Different surgical approaches were used on the basis of the extension of the coronary artery disease. A total of 307 patients were reop-

erated on using CPB. A lower incidence of postoperative CVA was recorded in the off-CPB group together with a higher rate of freedom from major complications.

5. Editorial Board Member MN393 writes

This is an innovative approach for re-op surgery where access to the descending thoracic aorta is required. A more anterior approach – muscle-sparing – is better if LIMA or LIMA-radial grafts are used.

Author(s)' Response by Giuseppe D'Ancona, MD

A more anterior incision facilitates harvesting of the LIMA. In this case, revascularization of the circumflex territory with the pedicled LIMA can be achieved only after having extended the incision posteriorly to gain adequate surgical exposure.

Reviewer MN393 responds

My point was that a true posterolateral thoracotomy is only necessary for access to the descending thoracic aorta for a proximal graft anastomosis. An anterolateral thoracotomy - from the nipple to the anterior border of the latissimus dorsi - is muscle-sparing and gives excellent exposure of both the left IMA and anterolateral coronaries (LAD, diagonals, OM1). The distalcircumflex branches are also easily reachable in a primary operation, although a slightly more posterior extension of the thoracotomy may sometimes be necessary in a re-op setting if the mediastinum is immobile.

This is not just idle theory - I have used this approach in primary operations (LIMA-radial Y-grafts) and in re-operations (LIMA-radial Y-grafts, radial grafts from a patent LIMA graft and radial coronary-coronary grafts).

6. Editorial Board Member GX21 writes:

The authors state that the observed mortality was 4.5% and the expected mortality was 5.1%. Thus, they did a bit better than average. The relative risk or risk ratio was 4.5/5.1 = 88%, where anything less than 100% is better than expected. But they then multiply this by the observed mortality for New York to get a "risk-adjusted mortality" of 2.1%. It is this latter calculation and statistic that I think is unnecessary. The interpretation of this last statistic is that if they did this operation on a cross-section of patients, such as are represented in the New York patients, than their operation mortality would be 2.1%. But they will not do this, since only a subset of patients is candidates. That subset had an expected mortality of 5.1%. This is the number that pertains to the subset of patients undergoing this new procedure, not the 2.1%, which may be misleading.

Author(s)' Response by Giuseppe D'Ancona, MD:

Although it may seem that the New York State Risk Adjustment is not necessary, the truth of the matter is that we practice in New York State and this adjustment is a must for public reporting. The group of patients analyzed in this article is included in the larger population of patients operated on in New York State and therefore, the risk adjustment is not erroneous or misinterpreted.