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Changing Referral Pattern in Off-Pump Coronary Artery Bypass Surgery: A Strategy for Improving Surgical Results

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ABSTRACT

Background: We have previously shown that a less invasive surgical approach (LISA) can reduce mortality and morbidity in coronary artery bypass grafting (CABG). This appears to have led to the referral of increasingly high risk patients for this procedure as compared to patients undergoing traditional CABG. The purpose of this paper is to compare preoperative risk factors and postoperative complications in both LISA and conventional CABG cases using the New York State database.

Methods: From January 1997 to September 1998, 1,993 patients underwent CABG in our institution: 1,384 with CPB (group A) and 609 without CPB (group B). In group B (LISA), a well defined strategy was followed in an effort to prevent hemodynamic instability during coronary exposure, avoid myocardial ischemia, verify graft patency, and use alternative surgical incisions in reoperations.

Results: Analysis of preoperative risk factors using the NYS database showed a significant increase in comorbidities in group B ($p < 0.005$), while at the same time postoperative complications and risk-adjusted mortality were lower (p = NS).

Conclusion: Our data demonstrates that by using the LISA, high risk patients can undergo CABG with equal or lower mortality and morbidity than traditional CABG.

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INTRODUCTION

The feasibility of safe off-pump CABG has been widely demonstrated. Complete myocardial revascularization can now be performed off-pump in the majority of patients needing such a procedure [Bergsland 1998]. The referral pattern for CABG appears to be changing due to availability of LISA surgery. In our institution, patients referred for CABG have shown a gradually increasing mean age and numerous comorbidities present, thus increasing the risks associated with CPB. For this reason LISA may be particularly useful in reducing postoperative complications. In this manuscript, we summarize our strategy for obtaining the best results in off-pump coronary surgery and compare these findings with the New York State Department of Health database for conventional cardiac surgery patients.

MATERIALS AND METHODS

CABG procedures performed from January 1997 to September 1998 were reviewed and statistically compared using the methods developed by New York State Department of Health. Preoperative risk factors, postoperative complications, expected mortality, and risk-adjusted mortality were compared between patients who underwent CABG with (group A) and without (group B) cardiopulmonary bypass (CPB).

Surgical Technique

Approach: Patients referred for LISA in our institution are carefully evaluated in an effort to optimize intraoperative management. Our surgical strategy focuses on maintenance of hemodynamic stability during positioning to expose target coronaries, prevention of myocardial ischemia, assurance of graft patency before chest closure, and use of alternative surgical approaches in certain situations (i.e., reoperations).

Table 1. Preoperative risk factors

	Group A n (%)	Group B n (%)	*p* Value
Previous CABG	64 (4.6)	132 (21.7)	<0.005
Previous AMI	489 (35.3)	358 (58.8)	<0.005
Previous stroke	63 (4.6)	74 (12.2)	<0.005
Aortoiliac disease	31 (2.2)	47 (7.7)	<0.005
Carotid disease	211 (15.2)	153 (25.1)	<0.005
CHF admission	50 (3.6)	66 (10.8)	<0.005
Calcified asc. aorta	16 (1.2)	46 (7.6)	<0.005
Renal failure creat. > 2.5	10 (0.7)	23 (3.8)	<0.005

Table 2. Postoperative complication

	Group A n (%)	Group B n (%)	*p* Value
No complications	1223 (88.4)	548 (90.0)	NS
Stroke	38 (2.7)	13 (2.1)	NS
AMI	25 (1.8)	10 (1.6)	NS
Deep sternal infect	8 (0.6)	4 (0.7)	NS
Bleeding	40 (2.9)	8 (1.3)	NS
Sepsis or endoc	14 (1.0)	4 (0.7)	NS
GI bleeding	13 (0.9)	7 (1.1)	NS
Respiratory failure	38 (2.7)	17 (2.8)	—
Renal failure	13 (0.9)	11 (1.8)	NS

Positioning: One of the crucial issues in LISA surgery is positioning and presentation of the target vessels.

The necessity for exposure of the circumflex and its branches without resultant hemodynamic instability has encouraged us to develop a new technique of exposure and stabilization of the coronary vessels called the single suture technique. A heavy suture is passed through the middle of the oblique sinus of the pericardium after elevation of the heart. The suture is then passed through a double armed vaginal packing, and finally snared down with a rubber tourniquet to prevent sawing effect on the myocardium (see Movie 1 ◎). Different degrees of tension on the suture and the varying position of the two arms of the vaginal packing permit rotation and elevation of the heart, thereby exposing all marginal branches of the circumflex while maintaining stable hemodynamic conditions. Infusion of fluid or a low dose of NeoSynephrine® easily controls initial hypotension. After positioning, a mechanical stabilizer is utilized creating excellent suturing conditions. With this technique, manipulation of the heart does not cause hemodynamic impairment and complete myocardial revascularization can be performed comfortably.

Prevention of myocardial ischemia

Sequence of grafting: The first vessel to bypass is the left anterior descending (LAD), usually using the left internal mammary artery (LIMA). We consider it very important to revascularize the anterior wall and the septum prior to manipulation of the heart. Following LAD grafting, the right coronary artery (RCA) is usually revascularized, followed by the circumflex branches.

Preconditioning: After proximal snaring of the target coronary with a 4-0 pledgeted suture, 3 minutes of ischemic preconditioning are allowed before performing the arteriotomy.

Shunting—local or from the aorta: After the coronary stabilizer is positioned and the target vessel is opened, an intracoronary shunt is placed, the proximal snare is released and the anastomosis is performed with 7-0 continuous prolene suture. The shunt allows coronary blood flow while the anastomosis is performed. Its use should be emphasized especially in those vessels not critically stenosed.

During revascularization of the RCA, heart block and sudden right ventricular failure can occur rapidly by coronary occlusion. We always use an intracoronary or an aorto-coronary shunt after the RC arteriotomy. Placement of a ventricular pace maker wire is routinely performed.

Graft patency verification

In our opinion, intraoperative graft verification should be used for all CABG, and it is certainly of critical importance in LISA. We have standardized our technique of flow measurement and interpretation of the flow curves. Transit time flow measurement (TTFM) is performed at the end of every anastomosis, both with the coronary snared and unsnared. When TTFM are not satisfactory the graft is revised. Since routine use of TTFM was initiated we have recorded more than 1,002 flow values in 464 patients, revising 57 grafts (5.7 %). All the revised anastomoses were found to be stenotic and were always corrected to satisfactory TTFM values. We strongly believe TTFM should be used as a strategic tool to reduce the risks of perioperative myocardial ischemia and postoperative myocardial infarction.

Alternative surgical approaches

The number of patients referred for reoperative off-pump myocardial revascularization is increasing. With the LISA we minimize the operation by avoiding CPB and by using smaller and alternative incisions depending on the vessels to be grafted. We are more prone to graft "culprit" vessels in reoperations than in primary where complete myocardial revascularization is routinely performed.

Left posterior thoracotomy: A left posterolateral thoracotomy gives excellent access to the circumflex and its branches without positioning the heart. The lateral wall of the heart is easily reached and revascularized using the saphenous vein or other conduits proximally anastomosed to the descending thoracic aorta [Grosner 1990]. A medial extension of the incision permits approaching the LAD coronary artery and harvesting the left internal mammary artery whenever available.

Table 3. Mortality rate

Mortality Rate	Group A n (%)	Group B n (%)	*p* Value
Crude	36 (2.6)	17 (2.8)	NS
Expected	2.1	3.8	NS
Risk adj.	3.1	1.9	NS

Subxiphoid incision: Through a subxiphoid access, the diaphragmatic wall of the myocardium may be approached. In this case, the right gastroepiploic artery can be harvested and anastomosed off-pump to the RCA or its distal branches [Akhter 1997].

Median sternotomy or partial median sternotomy that preserve the manubrium remain our main approaches for primary multivessel CABG. Patients with disease limited to the LAD are usually approached through a left anterior small thoracotomy (LAST). In elderly high-risk patients with isolated disease of the LAD, we prefer to perform an "H graft" [Cohn 1998]. In this case, the midportion of the LIMA is harvested through a left anterior small thoracotomy and a saphenous conduit is proximally anastomosed to its lateral wall and distally to the LAD. We found this technique time saving when compared to the classical LAST. It also adds further length to the graft and permits reaching even the more distal portion the LAD.

RESULTS

From January 1997 to September 1998, 1,993 patients were operated on: 1,384 on-pump (group A) and 609 off-pump (group B). An analysis of the preoperative risk factors, as compiled in the NYS database, reflected a significant increase in comorbidities in group B versus group A. This included an increase in the number of reoperations (21.7% versus 4.6 %, $p < 0.005$), previous cerebrovascular accidents (12.2% versus 4.6%, $p < 0.005$), rate of peripheral atherosclerotic disease (aorta and carotids) (7.7% versus 2.2% and 25.1% versus 15.2 %, $p<0.005$), and preoperative congestive heart failure (CHF) (10.8% versus 3.6 %, $p < 0.005$) (see Table 1 ◎). These results are also reflected by an increase in the expected mortality in the B versus A group (3.8% versus 2.1%, p = NS). When analyzing the postoperative complications, there was no significant difference in the two groups (see Table 2 ◎). Risk-adjusted mortality was reduced to 1.9% in B versus 3.1% in group A (p = NS) (see Table 3 ◎).

DISCUSSION

From being a rare operation a few years ago, off-pump CABG is rapidly reaching the main stream of cardiac surgery. In our institution, some surgeons are performing almost 100% of CABG off-pump, while others still use the traditional approach. We see increasingly high-risk patients being referred for LISA surgery while the lower risk patients are offered standard CABG. Our results demonstrate that despite significantly increased comorbidities, both risk-adjusted mortality and complication rates were reduced in the LISA group.

We have previously demonstrated that when a more selected group is referred for LISA, complications are significantly reduced [Bergsland 1998]. The current results therefore strengthen our belief that very few, if any, patient should electively be placed on CPB for CABG.

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REVIEW AND COMMENTARY

1. Editorial Board Member SC389 writes:

I do not feel that the authors can say their data demonstrates off-pump mortality and that the morbidity is less than traditional CABG as it was not statistically significant. Also, their conclusion that very few patients should be done on-pump is not borne out by their data since over twice as many patients were put on-pump as were done off bypass.

I would like to see the average number of grafts and the patients' status (i.e., elective, urgent emergent, salvage) done on and off-pump.

Authors' Response by Giuseppe D'Ancona, MD:

The aim of this study is to show how the referral pattern in off-pump coronary artery surgery has been changing and an increasing number of patients at higher preoperative risk are today treated without the use of the heart lung machine. Despite higher preoperative co-morbidities in the off-pump group, the postoperative complications and deaths are comparable in the two groups.

The number of patients treated without the use of the heart lung machine is lower than the number of patients treated with traditional CABG, simply due to the fact that the number of surgeons that routinely perform off-pump coronary surgery is, in our institution, limited .

There is no difference regarding the patients' status (elective, urgent, emergent, salvage) in the two groups.

The average number of grafts is 3.41 in the group operated on-pump and 2.02 in the off-pump group. The difference is not statistically significant.

2. Editorial Board Member AR11 writes:

Although the authors present data to support their contention that off-pump revascularization is safe and even desireable, I believe their methods and design are faulty. There is no reference to randomization of patients and indeed, looking at the premorbid conditions of each group of patients suggests that patients were selected for entry into either one of the two groups on a non-random basis. The fact that the off-pump group appears "sicker" than the other patients is misleading.

Furthermore, it is unclear if the same surgeon(s) performed all of the procedures or if there were different surgeons for the two groups. Secondly, no mention of the system of stabilization of the heart was made. Is the procedure a "jury-rigged" system, developed at the author's institution or is it one of the commercially available systems (e.g., Medtronic's Octopus)? Next, analysis of the results can also be interpreted to show that the CPB group had no differences in post-op morbidities/mortalities, suggesting that the off-pump technique offers no advantage to the conventional method.

Finally, both for analysis of cost containment and rapidity of discharge, the authors should examine the relative costs of (at least) the materials involved in each of the two groups (pump set-up vs. cost of disposable stabilizer, etc.), as well as the time to discharge post-op.

Authors' Response by Giuseppe D'Ancona, MD:

This is not a randomized study and we believe it is impossible to obtain randomization in such a large population. All the data were collected following a strict database (New York State database). Statistical analysis showed a significantly higher rate of preoperative risk factors in the off-pump group. We believe our results suggest off-pump surgery can be performed safely even in very high risk patients.

The two groups of patients were operated on by two different groups of surgeons. The CTS stabilizer was used for coronary stabilization.

No difference was found in the postoperative length of stay.

We do not have a cost analysis yet although we calculated a savings of $8,000 per patient operated off-pump via a left anterior small thoracotomy instead of using a traditional approach on-pump.