Beating Heart Surgery Reduces Mortality in the Reoperative Bypass Patient

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ABSTRACT

Background: Reoperative coronary artery bypass grafting (redo-CABG) has an increased operative morbidity and mortality compared to patients undergoing primary revascularization. In an effort to reduce the hazards of reoperative CABG, we commenced revascularizing selected patients without cardiopulmonary bypass (CPB) as an alternative to conventional approaches.

Methods: From January 1998 to Dec. 2000, 432 patients underwent reoperative CABG, 153 patients (35%) without the aid of CPB. Treatment groups were compared by means of univariate analysis for preoperative risk factors and postoperative complications. Predicted risk and risk-adjusted mortality were determined by the Society of Thoracic Surgeons risk algorithm.

Results: There was a significant difference in the preoperative predicted risk scores between the two treatment groups (off pump 6.5% vs. on pump 5.4%, p=0.0343). There was a significant difference in the off pump observed mortality

(2.61%) versus the on pump group (9.68%, p=0.0065). Decreased morbidity in the off pump group was evidenced by a reduced need for blood products (25% vs. 67%, p<0.0001), and the incidence of prolonged ventilation (4% vs. 14%, p=0.0032). The off pump group also had shorter hospital stays (6.2 ± 5.96 days vs. 8.0 ± 7.82, p=0.0091). No significant differences between the two groups were seen in the prevalence of perioperative myocardial infarction, stroke, renal failure, or reoperation for bleeding.

Conclusion: Bypass grafting without CPB significantly decreases mortality and morbidity in selected reoperative patients, and should be considered a viable alternative to conventional approaches.

INTRODUCTION

With a growing population of patients having undergone primary coronary artery bypass grafting, reoperations, once exceptional, are increasingly common. Progressive native vessel atherosclerosis and bypass graft attrition, leads to recurrence of ischemic symptoms and consideration for further surgical therapy. Reoperative coronary artery bypass grafting (redo-CABG) has an increased operative morbidity and mortality compared to patients undergoing primary revascularization [Lytle 1987, Verheul 1991, Salomon 1991, Christenson 1997]. Poor left ventricular ejection fraction, older patient age, female gender, and history of arrhythmia have been shown to be significant risk factors for mortality in patients undergoing redo-CABG [He 1995]. Additionally, severe left main stem stenosis, emergent operations, and a short interval between the primary procedure and the reoperation (<1 year) have been described as independent risk factors for mortality in this population [Lytle 1987, Christenson 1996, Christenson 1997].

In an attempt to improve patient survival and to reduce the morbidity of reoperative CABG, we commenced revascularizing selected patients without cardiopulmonary bypass (CPB) as an alternative to conventional approaches.

MATERIAL AND METHODS

Patients

Between January 1998, and December 2000 432 patients underwent redo-coronary artery bypass grafting in a single practice. Over this period, patients undergoing redo-coronary artery bypass grafting accounted for 7.2% of all revascularization procedures performed within the practice. Preoperative, perioperative, and postoperative data were collected using a customized version of the Society of Thoracic Surgeons database. There were 279 patients who underwent revascularization with the aid of cardiopulmonary bypass, and 153 patients that received grafting without the aid of cardiopulmonary bypass (Table 1)

Patients were selected in a nonrandomized manner into the off pump group based on medical co-morbidities which were felt to increase the risk of cardiopulmonary bypass. This group includes the elderly, patients with underlying renal or pulmonary disease, those with prior stroke or significant cerebrovascular disease, and patients with calcified or porcelain aortas

In the off pump cohort there were 109 males (71.24%) and 44 females (28.76%), with a mean age of 64.78 years. The on pump group consisted of 237 males (84.94%) and 42 females (15.05%), with a mean age of 64.35 years. The two groups differed in the higher percentage of females in the off pump group 28.76% versus 15.05% (p=0.0006), and in the number of current smokers in he off pump cohort 22.22% as compared to the on pump group 16.49% (p=0.028). (Table 1)

Both groups were equally matched in the number of patients with previous myocardial infarctions, and coexistent cerebrovascular disease, diabetes, and renal failure. There were equivalent percentages of patients in each cohort with symptoms of congestive heart failure. Patients with hemodynamic instability and cardiogenic shock were excluded from the study population.

Technique

Three different surgical approaches were utilized in performing off pump redo-CABG: median sternotomy, posterolateral thoracotomy and minimally invasive direct coronary artery bypass (MIDCAB). The indication for the performance of a MIDCAB was isolated disease of the left anterior descending artery. A lateral thoracotomy approach was used when circumflex artery distribution disease was the principal indication for revascularization The operative technique for the performance of coronary artery grafting without the aid of cardiopulmonary bypass via MIDCAB and lateral thoracotomy has been previously published in the literature [Allen 197, Boonstra 1997, Coulson 1998].

Median sternotomy was employed for grafting of the right coronary artery and its branches, and all procedures requiring revascularization of more than one arterial bed. Our standard technique is to use an oscillating saw to gain entry into the reoperative chest. Following separation of the heart from the sternum, harvesting of the internal mammary arteries for conduit is performed. Dissection to mobilize the heart is initiated at the junction of the right ventricle and the diaphragm and directed toward the apex and lateral wall of the left ventricle. Exposure of the lateral wall of the left ventricle is facilitated by maintaining the distraction of the sternal edge by the mammary retractor. Stay sutures are sequentially placed into the lateral pericardium and placed on traction to roll the lateral wall of the heart towards the operator. This permits dissection of

adhesions in the circumflex distribution without undo compression of the heart. The Guidant Expose device (Cuppertino, CA.) is used to facilitate dissection of the diaphragmatic surface of the right ventricle and apex of the heart. Throughout the mobilization of the heart, meticulous adherence to a “no touch technique” is maintained in order to avoid embolization of atheromatous material from senile vein grafts. This mirrors our on pump approach for redo-CABG in which old grafts are not routinely divided from the ascending aorta, and are avoided during the conduct of the dissection. Recently, anastomotic connectors have been utilized to eliminate the use of partial occlusion clamps for proximal vein graft anastomosis, thereby reducing dissection and manipulation of the ascending aorta. When indicated, we prefer to initially graft the left anterior descending artery using the left internal mammary artery if available. The proximal anastomoses are subsequently performed prior to the construction of the distal anastomosis. Anesthetic and anticoagulation protocols for off pump bypass surgery have previously been described.

Statistical Analysis

Data are expressed as percentages or as means ± standard deviation. Statistical analysis was performed using the SAS (SAS Institute, Cary, NC) software program. Descriptive data were analyzed using chi-squared test or Fischer’s exact test where appropriate.

RESULTS

The perioperative results of the two groups are shown in Table 2. The off pump group received significantly fewer grafts per patient compared to the on pump cohort, (2.02 vs. 2.97, $p<0.001$). When excluding all single vessel bypasses

from both groups, the average number of grafts performed off pump was 2.86 versus 3.09 on pump. This number just reached significance.

A striking difference was noticed between the groups in the incidence of transfusion requirements. While greater than half of the patients in the on pump group required transfusion of blood or blood products, less than one-third of the off pump cohort received any blood products ($p<0.0001$). This finding was also noted in the subset of patients only receiving multivessel bypass.

Length of stay was significantly shorter in the off pump group as compared to the on pump group for the entire population ($p=0.0091$). However, this number did not reach significance when the patients that received multivessel vessel grafting were examined.

There were no differences noted between the off pump and on pump cohorts with respect to the incidence of perioperative myocardial infarction, or return to the operating room for bleeding. The on pump patients were noticeably more likely to require insertion of an intra-aortic balloon pump either intra-operatively or post-operatively as compared to the off pump group.

The thirty day observed mortality was significantly different between the two groups as a whole and demonstrated a survival benefit for the off pump cohort as compared to the on pump group (2.61% vs. 9.70%, $p=0.0065$). Examining only those patients receiving multivessel grafting reveals that the off pump cohort had a greater predicted risk of mortality (6.49% versus 5.35%) than the on pump patients. Moreover, while the observed mortality between these groups did not quite reach significance, the risk adjusted mortality was significant demonstrating a survival advantage in the off pump cohort (2.94% vs. 9.41%, $p<0.001$).

Complications

Postoperative complications were examined and significant differences were seen between the two groups Table 3. Most prominent was the significantly greater incidence of post-operative atrial fibrillation in the on pump patients as compared to the off pump patients (6.6% vs. 24%, $p<0.001$). In addition, there were distinctly more patients in the on pump group that required prolonged ventilation than in the off pump cohort (3.9% vs. 14.3%, $p=0.0032$). No differences were identified with regards to the incidence of perioperative stroke, renal failure, ventricular arrhythmias, or wound infections.

DISCUSSION

Reoperative coronary artery bypass grafting is a procedure characterized by increased mortality and morbidity when compared to primary operations [Lytle 1987, Verheul 1991, Salomon 1991, Christenson 1997]. With increased experience and technical advances, such as retrograde cardioplegia, a reduction in operative mortality has been observed, but the morbidity of the procedure remains significant [Langenburg 1995, Kron 1997]. These patients are likely to have poorer ejection fractions and a history of previous myocardial infarction, which increases the propensity for complications [Christenson 1997]. Eliminating the detrimental systemic effects of cardiopulmonary bypass provides the means to reduce the morbidity and mortality of reoperative coronary artery bypass.

Reoperative procedures provide several technical challenges that distinguish them from primary operations. These obstacles include (1) sternal reentry, (2) injury to previous grafts or the heart during dissection, (3) quality and availability of conduit, (4) management of diseased but patent vein grafts, (5) myocardial protection, and (6) minimizing blood loss and blood product usage

[Cosgrove 1993]. To be successful, off pump redo-CABG requires meticulous technique, patience and appropriate patient selection.

Problems with sternal reentry can be avoided by use of alternative incisions when isolated revascularization is indicated. A MIDCAB approach provides an opportunity to avoid myocardial or graft injury for isolated lesions of the left anterior descending artery. Likewise, a lateral thoracotomy can demonstrate the posterolateral wall of the left ventricle for redo grafting of the circumflex distribution. These approaches may also reduce the risk of embolization of atheromatous material triggered by repeated lifting and manipulation of the heart. Adhesions from previous procedures reduce the inherent motion of the heart, thereby facilitating the performance of the anastomosis. These approaches provide the option for surgical revascularization to a patient population that might otherwise be denied conventional redo-CABG for isolated disease.

When multivessel revascularization is required, repeat median sternotomy remains the approach of choice. Meticulous technique is required to mobilize the heart from its surrounding adhesions without causing hemodynamic instability or trauma to previous grafts. Our approach has been to fastidiously avoid manipulation or contact with the senile grafts while mobilizing the heart and identifying the intended target vessels. We acknowledge that the increased manipulation required for dissection of the heart during off pump revascularization may increase the risk emboli to the native coronaries.

Maintenance of hemostasis during reoperative coronary artery bypass surgery remains problematic given the obligate dissection required by epicardial scarring, and the increased operative time associated with these procedures. Platelet activation and defunctionalization occurs with exposure of blood to the foreign surface of the extracorporeal circuit. Comparison of platelet counts before

and after bypass shows a striking reduction in absolute numbers [Ray 1984, Jung 1995, Wahba 1996], furthermore, bleeding times as a measure of impaired hemostasis demonstrates a strong linear correlation with the length of time on bypass [Bertolino 1996]. In this study, transfusion requirements were dramatically reduced in the off pump group (25%) as compared to the on pump cohort (67%), and the historical transfusion rates of 50% to 70% in patients undergoing conventional reoperative surgery [Bracey 1995]. These findings dovetail with the work of other investigators also describing a reduction of blood product use in both primary and redo coronary artery bypass procedures [Pfister 1992, Tasdemir 1998 Puskas 1998, Stamou 2001, Dewey 2001].

The significant reduction in postoperative ventilatory time seen in the off pump cohorts explicates the reduction in the pulmonary insult seen by diminishing the release of inflammatory mediators and controlling volume shifts. Moreover, a striking reduction in the rate of postoperative atrial fibrillation was observed in the off pump patients. Reports describing a reduction in the rate of atrial fibrillation with off pump surgery have ascribed this benefit to reduced atrial manipulation, the absence of cardioplegia, and avoidance of extracorporeal circulation [Cohn 1999, Stamou 2000].

The off pump patients realized a discernible mortality benefit as compared to the on pump patients. Risk adjusted mortality was significantly lower for the entire off pump group as compared to the on pump patients (2.1% vs. 9.6%, $p<0.001$), as well as for the subgroup of patients receiving multivessel grafting (2.9% vs. 9.4%, $p<0.001$). There were no statistical differences between the groups in regards to cause of death. We contend these results stem from improved myocardial protection by avoiding the problems of global ischemia and unequal distribution of cardioplegia seen with conventional surgery. Furthermore, while the conduct of off pump surgery might be expected to result

in more episodes of atheromatous embolization and perioperative myocardial infarction, this was not observed in this study. Moreover, significantly fewer intraaortic balloon pumps were required in the perioperative and postoperative period in the off pump patients than the on pump cohort. During the second year of the study, our conversion rate to a conventional procedure with cardiopulmonary bypass from an attempted off pump approach was 3.59%.

This study is weakened by the limitations inherent to retrospective and nonrandomized reviews of single institution data. While acknowledging these limitations, we feel the results of this study are sufficiently compelling to extend the debate regarding the applicability of off pump revascularization for the reoperative patient. We conclude that bypass grafting without CPB decreases mortality and morbidity in reoperative coronary artery bypass patients, but recognize that these inferences could be strengthened and substantiated with larger, prospective multi-institutional studies.

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Table 1. Preoperative Clinical Data

Characteristic	Off Pump (n=153)	On Pump (n=279)	*p* value
Average Age	64.8 – 10.7	64.4 – 9.78	ns
Male	109 (71.24%)	237 (84.95%)	ns
Female	44 (28.76%)	42 (15.05%)	0.0006
Average Ejection Fraction	47.5 – 10.64	46.6 – 11.88	ns
Diabetes	37 (24.18%)	71 (25.45%)	ns
COPD	19 (12.42%	26 (9.32%)	ns
Hypertension	92 (60.13%)	184 (65.95%)	ns
Previous MI	82 (53.59%)	153 (54.84%)	ns
Previous Valve Replacement	5 (3.27%)	6 (2.15%)	ns
Peripheral Vascular Disease	26 (16.99%)	36 (12.90%)	ns
Cerebrovascular Disease	18 (11.76%)	26 (9.32%)	ns
Renal failure	2 (1.31%)	2 (0.72%)	ns
Smoker-Current	34 (22.22%)	46 (16.49%)	0.028
Congestive Heart Failure	19 (12.42%)	34 (12.19%)	ns
Predicted Risk	6.50%	5.40%	0.0343

COPD: Chronic Obstructive Pulmonary Disease; **MI**: myocardial infarction

Table 2.Clinical Outcomes

	All Vessels			Multivessel Only		
Variable	**Off Pump** (n=153)	**On Pump** (n=279)	***p* value**	**Off Pump** (n=84)	**On Pump** (n=263)	***p* valu**
Mortality (%)	2.61%	9.70%	0.0065	3.57%	9.50%	0.08
Risk Adjusted Mortality (%)	2.10%	9.60%	<0.001	2.94%	9.41%	<0.001
Transfusion (%)	24.84%	67.38%	<0.0001	24.84%	67.63%	<0.000
Length of Stay (days)	6.2 – 5.96	8.0 – 7.82	0.0091	7.26 – 7.57	8.04 – 7.98	ns
Perioperative MI (%)	0	2.15%	0.0919	0	2.28%	ns
Reoperation For Bleeding (%)	3.92%	6.45%	ns	3.57%	6.46%	ns
IABP Insertion (%)	0	13.09%	<0.0001	0	13.31%	0.0004
Average Number of Grafts	2.02	2.97	<0.001	2.86	3.09	0.03

MI: myocardial infarction; **IABP**: Intra-Aortic Balloon Pump
ns: not significant

Table 3. Postoperative Complications

	All Vessels			Multivessel Only		
Variable	**Off Pump** (n=153)	**On Pump** (n=279)	***p* value**	**Off Pump** (n=84)	**On Pump** (n=263)	***p* value**
Prolonged Ventilation (%)	3.92%	14.34%	0.0032	3.57%	14.45%	0.0072
Renal Failure (%)	2.61%	5.38%	ns	4.76%	5.32	ns
Septicemia (%)	0.65%	1.79%	ns	1.19%	1.90%	ns
Sternal Infection (%)	0	0.72%	ns	0	0.76%	ns
Stroke (%)	0	1.43%	ns	0	1.52%	ns
Atrial Fibrillation (%)	6.64%	24.01%	<0.001	8.33%	24.71%	0.0013
Cardiac Arrest (%)	1.03%	2.87%	ns	1.19%	1.90%	ns

ns: not significant