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Alternative Approaches in Off-Pump Redo Coronary Artery Bypass Grafting

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ABSTRACT

Background: The recent development of off-pump and minimally invasive techniques in coronary artery bypass grafting (CABG) has provided the surgeon with multiple options in performing redo revascularization procedures.

Methods: We retrospectively analyzed our early results in off-pump redo CABG procedures. Between January 1998 and January 2000, we performed 55 off-pump redo CABG procedures: 25 through a full sternotomy, 21 through a left posterolateral thoracotomy, 5 using a lower hemi-sternotomy and 4 using a mini anterior thoracotomy with thoracoscopic internal mammary artery harvesting. The mean age of this group was 67.7 years (range 37–85). The mean number of grafts performed in earlier operations was 2.7 (range 1–6) with 51% of grafts still partially or fully open at the time of re-operation. Twenty-six patients (47.3%) had a functioning left internal mammary artery graft to left anterior descending. Preoperative clinical severity scoring predicted a mortality of 9% and morbidity of 30%.

Results: There were no operative or thirty-day infarctions or deaths. Morbidity included pulmonary complications (8), renal failure (1) and bleeding (1) for a total complication rate of 18.9%. The average number of grafts performed was 2.7 (range 1–5) for sternotomy patients and 1.4 (range 1–3) for thoracotomy patients.

Conclusions: By employing alternative approaches in performing off-pump redo CABG procedures, the surgeon can often avoid injury to pre-existing patent internal mammary grafts as well as the morbidity associated with the use of cardiopulmonary bypass.

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INTRODUCTION

With the advent of new technology and improved surgical techniques, off-pump coronary artery bypass grafting (CABG) has gained wider acceptance among cardiac surgeons. In fact, many surgeons have transitioned their practice to include a majority of first-time CABG procedures without the use of cardiopulmonary bypass (CPB). The advantages and role of off-pump techniques in coronary re-operations, however, remains less well defined. The present report outlines our experience with off-pump re-operative CABG employing a variety of approaches.

MATERIALS AND METHODS

From January 1998 to January 2000, 55 patients underwent off-pump redo CABG. These patients represent 8.2% of the off-pump CABG procedures (651 patients) and 39.2% of all redo CABG procedures (170 patients) performed during this period. The clinical characteristics of the patients are summarized in Table 1 (◉). Six patients had undergone two previous CABG procedures and ten patients had previous catheter-based intervention since their last CABG procedure. The mean number of grafts performed in earlier operations was 2.7 (range 1–6) with 51% of grafts still partially or fully open at the time of re-operation. Twenty-six patients (47.3%) had a functioning left internal mammary artery (LIMA) graft to left anterior descending (LAD). The mean time from the previous CABG procedure was 8.1 years (range 2–24). The mean preoperative risk score for the entire group was 6.3 (range 3–16) [Higgins 1992]. This translated to an average risk-adjusted predicted mortality of 9% and postoperative morbidity of 30%.

Surgical Technique

Left thoracotomy technique: Saphenous vein and/or radial artery harvesting was performed in the supine position. The patient was then turned to a right lateral decubitus

Table 1. Patient Characteristics

Variable	Value (range)
Male/female	42/13
Age	mean 67.8 (37–85)
NYHA class	mean 3.0 (1–4)
Pre-operative EF	mean 47.8 (15–65)

position. A standard left thoracotomy approach was performed in 21 patients. Single-lung ventilation was used in all patients. The hips are slightly rotated to allow exposure of the left femoral vessels should CPB be necessary. The inferior pulmonary ligament was mobilized and the lung was retracted cephalad. Access to the posterolateral, obtuse marginal, ramus intermedius, and diagonal coronary arteries was accomplished. After full heparinization, coronary occlusion and cardiac stabilization was performed with the OPCAB Elite system (Genzyme Corporation, Cambridge, MA). All anastomoses were performed off-pump. The proximal anastomoses were placed to the descending aorta or left subclavian artery. The course of the graft to the aorta is determined by how far distally on the coronary artery the graft is constructed. Grafts to the circumflex in the atrio-ventricular groove or very proximal on the ramus intermedius or obtuse marginal are best placed in a straight line to the aorta. However, if the graft is more distal on the coronary artery, the graft should take a slow curved course to the inferior pulmonary ligament and then back up to the higher descending aorta. Grafts placed in this manner, in both situations, will then avoid kinking with left lung re-inflation.

MIDCAB technique: The minimally invasive direct coronary artery bypass (MIDCAB) technique employed in these four patients consisted of single-lung ventilation and carbon dioxide insufflation. The LIMA was then harvested as a pedicled graft using the electrocautery on a low setting. A total of three small stab wounds were used for the harvest of the internal mammary artery (IMA). A 5.5mm port (Genzyme Surgical Products, Cambridge, MA) was used for the 5mm scope placed in the fifth intercostal space along the anterior axillary line. A small stab wound was used for the cautery and was placed in the third intercostal space along the anterior axillary line. Another stab wound was used for a grasper and was placed in the seventh intercostal space along the nipple line. Control of the thoracoscope was accomplished using a voice-activated robotic arm (AESOP®, Computer Motion, Inc., Goleta, CA). The IMA was harvested from its subclavian artery origin to the sixth rib. After completion of the IMA harvesting phase, the pericardium was opened and the LAD was identified. A long spinal needle was passed through the chest wall and the endoscopic view determined the ideal incision location. A 5cm incision was then performed and the chest was entered most commonly through the fourth intercostal space. The patient was then heparinized to an activated clotting time greater than 400. After full heparinization, coronary occlusion and cardiac stabilization were performed with a mini-thoracotomy retractor and stabilizer platform system (Genzyme Corporation, Cambridge, MA). All LIMA to LAD anastomoses were performed off-pump.

Median sternotomy technique: These 30 patients underwent standard redo sternotomy (25) or a lower hemisternotomy (5). The five lower sternotomy patients underwent harvesting of the right gastroepiploic artery via a mini-laparotomy. An anastomosis was then performed off-pump to the right coronary artery (RCA) or posterior descending coronary artery (PDA) using the off-pump coronary artery bypass (OPCAB) system (Genzyme Corporation, Cambridge, MA). The grafts were placed only to highly stenotic or totally occluded coronaries. After all the pericardial adhesions were divided, full sternotomy patients underwent an off-pump coronary artery bypass in the same fashion as first time CAB patients. Patients with patent internal mammary grafts had the pedicle carefully dissected enough for safe retraction of the apex into the right pleural space. Diseased, but patent vein grafts, were dissected out utilizing a "no touch" technique. Often the patient was heparinized prior to dissection of these atheromatous vein grafts. The OPCAB Elite system (Genzyme Corporation, Cambridge, MA) was utilized in all cases. Free grafts were perfused immediately after distal anastomoses by connecting them to a 9 Fr cardioplegia cannula and multidelivery manifold system (Medtronic, Grand Rapids, MI). This same system also functioned as an aortic-coronary shunt in selected cases of ischemia. A soft plastic 2mm olive tip (DLP®, Medtronic, Grand Rapids, MI) was inserted through the coronary arteriotomy to supply distal perfusion. Aortic manipulation was avoided when it was diseased or where there were patent old vein grafts. When possible, the new vein graft was often sewn end-to-end to the very proximal, biologically privileged stump of the old vein graft. Perfusion of the target coronary artery was accomplished by cannulating a side branch of the new graft with a 2mm perfusion catheter coming off the aortic perfusion manifold. A soft bulldog clamp is then placed between it and the proximal end and the coronary is perfused during the proximal anastomoses. Old grafts were divided after the new graft was completed and while blood was still flowing through them. The ends were then over sewn. This technique avoids embolization that might occur by ligating an intact graft.

Full system heparinization followed by complete reversal with protamine was performed in all patients. All patients were administered aspirin, both prior to operation and in the intensive care unit (ICU) two hours post-operatively.

RESULTS

There was no operative or thirty-day mortality. There were no post-operative myocardial infarctions as assessed by electrocardiogram, cardiac enzymes and troponin levels. There were no clinically apparent neurological complications. The average length of stay in the ICU was 22.7 hours and the total post-operative length of stay was 4.4 days. Ten patients suffered post-operative complications

within the first thirty days (18.1%). These included pulmonary complication (8), renal failure (1), and re-exploration for bleeding (1). The pulmonary complications consisted of prolonged atelectasis (6), pneumonia (1), and pulmonary embolism (1). Of the entire study group, four patients were readmitted during the first thirty days (7.3%). Thirteen patients (23.6%) required a blood transfusion. The post-operative atrial fibrillation rate was 27.2%. During the thirty-day follow-up period, no patients required re-intervention for graft failure or recurrent angina. There were no wound infections.

Left thoracotomy patients: The mean number of grafts performed in this group was 1.4 (range 1–3). Coronary arteries grafted from this approach consisted of ramus intermedius, obtuse marginal, main circumflex in the atrio-ventricular groove, and posterior ventricular branches of the right coronary artery. Seventeen of 21 patients undergoing this operation were extubated in the operating room (80.9%). All remaining patients were extubated within eight hours. Post-operative complications in this group consisted of three patients with prolonged atelectasis in the left lung requiring home oxygen at discharge.

MIDCAB patients: LIMA to LAD anastomoses was performed in these four patients. All patients were extubated in the operating room. For these four patients, mean length of stay in the ICU and total post-operatively was 13.7 hours and 3.0 days respectively. Post-operative complications in this group consisted of one patient with a right-sided pneumonia following a difficult intubation and dual-lumen tube placement.

Sternotomy patients: The mean number of grafts performed in this group of 30 patients was 2.7 (range 1–5). Conduits used for these patients consisted of 24 arterial (29.6%) and 57 (70.4%) venous for a total of 81 grafts. Eighteen of the 25 patients undergoing full sternotomy (72%) received at least one graft to the circumflex system. Eight (26.7%) patients were extubated in the operating room with the remainder having a mean extubation time of 9.7 hours (range 3–48 hours). The mean post-operative length of stay in the hospital was 4.53 days. Post-operative complications in this group consisted of four patients with prolonged left lower lobe atelectasis requiring home oxygen at discharge. One patient with a pre-operative creatinine level of 3.5 developed complete renal failure requiring permanent hemodialysis. An additional patient was admitted 11 days following operation with a pulmonary embolism. This patient responded well to standard anticoagulation and did not require supportive ventilation. Finally, one patient was returned to the operating room for bleeding from the chest wall. He did well thereafter and was discharged on post-operative day four.

DISCUSSION

Total surgical revascularization performed on the beating heart continues to gain widespread acceptance [Fanning 1993, Mohr, 1997]. Significant improvements in both technique and technology have rendered it possible to perform elective, off-pump first time CABG in a large majority of patients. However, performing off-pump redo CABG procedures can present many additional concerns and technical challenges [He 1995]. These include: (1) re-entry, (2) pericardial adhesions, (3) intact mammary grafts, and (4) patent but diseased vein grafts [Cosgrove 1993]. The surgeon has a number of options available to handle these challenges. Patients with disease limited to the LAD and an unused LIMA are candidates for a thoracoscopic LIMA harvest and LIMA to LAD anastomoses through a small anterior thoracotomy. When the LIMA is not available, a saphenous vein or radial artery graft can be taken from the axillary artery to the LAD through the bed of the second costal cartilage. Patients with disease limited to the circumflex system are candidates for a graft placed from the descending aorta to the obtuse marginal or main circumflex via a left posterolateral thoracotomy. Isolated RCA and PDA disease can be bypassed using a right gastroepiploic artery brought through the diaphragm. Frequently this can be performed using a lower hemi-sternotomy and avoids internal mammary grafts.

Patients with totally occluded grafts and no functioning mammary grafts can be the safest patients to undergo an off-pump re-operative bypass procedure. All pericardial adhesions are completely dissected and the remainder of the operation is carried out as a primary off-pump CABG. This includes placement of the deep pericardial stitches between the left inferior pulmonary vein and inferior vena cava as well as performing a right lateral pericardiotomy.

Patients with two or three vessel diseases who require a redo-sternotomy and have patent mammary grafts and/or patent and diseased vein grafts are often the most challenging to perform off-pump. In our series, 42.7% of the patients had patent internal mammary grafts and 51% had patent, often diseased, vein grafts. Frequently the intact IMA can be difficult to dissect out of the mediastinum. Even if this is accomplished, there is no guarantee that there will be sufficient length to allow retraction of the heart for bypassing the lateral and posterior coronary arteries. Cardiopulmonary bypass often decompresses the heart enough so as to make this less problematic. Often the bypass can than be accomplished on the beating heart while on cardiopulmonary bypass without the need for cardioplegic arrest.

The risk of coronary artery embolization caused by manipulation of patent but heavily diseased grafts is a concern in redo CABG procedures—performed off or on the pump. Theoretically, this risk is higher in off-pump surgery because of continued flow at systemic pressure through the grafts during mobilization, positioning and stabilization of the heart. A very careful "no touch" technique is essential. We believe the highest risk patient may be the one with recent clot formation in an old vein graft. In our practice, evidence of fresh thrombus was a

contraindication for off-pump CABG if it required dissection near the graft itself. Additionally, one must also approach coronary occlusion without manipulation of the old diseased vein graft.

Our philosophical approach in performing re-operative coronary artery bypass surgery involves consideration of the following: (1) total myocardial revascularization, (2) alternative incisions to median sternotomy, (3) avoiding cardiopulmonary bypass, (4) protecting intact mammary grafts, and (5) avoiding manipulation of patent, diseased vein grafts. This series provides further evidence of the benefit of an individualized approach to performing re-operative CABG. By avoiding the use of cardiopulmonary bypass and using alternate incisions to avoid intact mammary grafts and diseased vein grafts, the surgeon can lessen the risk of re-operative coronary surgery.

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