Routine Off-Pump Coronary Bypass Is Safe in Reoperations

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ABSTRACT

Background: Reoperations for coronary artery bypass grafting (CABG) on cardiopulmonary bypass (CPB) are known to carry a high morbidity and mortality, particularly in patients with patent internal mammary artery (IMA) grafts to the left anterior descending artery. Since early 1999, we have evaluated the feasibility and potential benefits of routine off-pump surgery (OPCAB) on 50 consecutive patients on their first (43), second (6), or third (1) reoperation.

Methods: Various incisions, at times combined, were used including: resternotomy (Re-ST) (15), left posterolateral thoracotomy (24), small left anterior thoracotomy (12) and xyphoid (8). Conduits used included: IMA (20), Radial artery (30), saphenous vein graft (61) and gastroepiploic artery (4). Arterial inflow was from the ascending aorta in Re-ST and right parasternal incisions, the right or left subclavian artery, the descending aorta or L.SCA (in LPLT) and occasionally from a patent IMA graft, the hood of a patent vein graft or even an adjoining patent coronary artery.

Results: There was 1 conversion to CPB during performance of a final proximal anastomosis to the ascending aorta. There was 1 sudden death at one week in an obese patient on his third reoperation, presumably from a massive pulmonary embolism. Morbidity and mortality were otherwise markedly reduced in comparison to the published series of reoperative CABG on CPB. There were no strokes, no re-exploration for bleeding, no perioperative MI, 1dialysis in a patient with prior severe renal insufficiency, one tracheotomy for respiratory failure in a patient with prior severe chronic obstructive pulmonary disease (26%) with new onset atrial fibrillation.

Conclusion: Reoperative OPCAB through alternative approaches has several advantages over traditional on-pump resternotomy:1) it avoids injury to a patent IMA graft, 2) it avoids dissection of adhesions thus preventing post operative bleeding, 3) it reduces significantly the morbidity and mortality seen with the more traditional approach, 4) it allows complete revascularization while significantly reducing length of stay and probably cost. Our results indicate that OPCAB can be safely done, or at least attempted, routinely in all patients undergoing reoperation.

INTRODUCTION

Conventional redo CABG on CPB carries a significant morbidity and mortality ([Loop 1990, Lytle 1997, He 1999] particularly in the presence of a pre-existing patent IMA to LAD graft which may be traumatized during re-entry [Gillinov 1999]. In our Institution, after a 2-year learning period, (for both the surgeon and the anesthesiologist) all first time CABG operations are done on the beating heart (IFT). It was a natural progression to extend our experience with OPCAB to redo CABG. Thus, .in January 1999 we felt comfortable enough to initiate a prospective evaluation of 50 consecutive such patients to: 1) assess the technical feasibility of complete off-pump revascularization using alternative approaches, and 2) evaluate the overall immediate results associated with this procedure compared to traditional on-pump surgery.

MATERIALS AND METHODS

Between January 1999 and May 2001, 50 consecutive patients underwent off-pump redo CABG. This represented 11% of our total series of OPCAB procedures (450) .Age ranged from 43 to 87 years (mean 76.5) .32were males (64%) and 18 females (36%). 43 had undergone 1 previous CABG, 6 had undergone 2 and 1 had undergone 3 such procedures.28 (56%) had a patent IMA graft to the LAD, 1had a patent IMA to the ramus intermedius and 3 a patent IMA to the first diagonal branch of the LAD.36% of all previously created vein grafts were partially patent and 18 patients had undergone at least one prior angioplasty or stenting of a vein graft or native vessel. Mean time from the prior CABG procedure was 10 years (range 2.5 to 18 years). Risk factors were common, including Diabetes mellitus (21 patients-42%), hypertension (25-50%), COPD (12-24%), chronic renal insufficiency (11-22%), prior CVA (4-8%), and ejection fraction less than 35% (29-58%).

Surgical Techniques

All patients were heparinized to maintain ACT around 400.CTS retractor system (CardioThoracic Systems Inc, Cupertino, CAL), stabilizer set and lift set were used mostly, though occasionally the Medtronic Octopus apparatus (Medtronic Cardiac Surgical Products, Grand Rapids, MI) was utilized. Single-lung ventilation was the norm whenever the incision was not a Re-ST.4 approaches, isolated or in combination, were used depending on the targets needing revascularization and the arterial inflow:

1.Re Sternotomy was accomplished in 15 patients (30%) using a Stryker oscillating saw (Stryker Instruments, Kalamazoo, MI). This was invariably a full sternotomy. Re-ST was reserved to patients in need of revascularization of the right coronary artery (RCA), LAD and circumflex (CX) branches and who did not have a patent IMA –LAD graft. After taking down 1 or 2 IMAs as necessary, adhesions were carefully dissected around the aorta and right atrium first and then progressively around the entire heart. Because of the need to revascularize the CX branches in 14 of these 15 patients and the usual presence of extensive adhesions and fibrous scarring around a patent IMA to LAD graft preventing satisfactory exposure of these targets, this approach was not used in the presence of a patent IMA graft. All distal anastomoses were done using our standard OPCAB technique: simple immobilization of the target vessel using the stabilizer set without sling occlusion, arteriotomy, insertion of temporary shunt (Flo-Thru, Bio-Vascular Inc) or stent (Flo-Rester, Bio-Vascular Inc), anastomosis using a CO^2 blower, removal of the shunt and completion of the suture line if necessary for hemostasis then knot tying. The LAD was first perfused with the IMA when feasible, but no effort was made to systematically perfuse other grafts immediately after the distal anastomosis was completed. No adjunctive aorto-coronary shunts were used for this purpose. Proximal anastomoses were done to the ascending aorta, or, when diseased, to the IMA itself or to the hood of an old patent vein graft. Old grafts were left intact and were never divided whether still patent or occluded.

2.A Standard Left Posterolateral Thoracotomy, entering the chest in the fifth or sixth intercostals space, was performed after harvesting saphenous vein grafts, radial arteries and GEA in the supine position and using single lung ventilation (24 cases-48%). This was our favorite exposure in the presence of a functioning IMA-LAD graft. The femoral vessels were not exposed. The inferior pulmonary ligament was divided and just enough adhesions between the lung and the pericardium were taken down in order to avoid postoperative air leaks. Longitudinal pericardiotomy behind the phrenic nerve generally provided excellent exposure of the entire CX system and frequently of the distal branches of the RCA (posterolateral and less often the PDA). Exposure of the diagonal branch of the LAD, the distal LAD and the IMA graft was achieved by incising the pericardium anterior to the phrenic nerve and up to the "point of entry"of the IMA graft or as high as feasible. Target vessel identification was greatly facilitated by following the course of old vein grafts. Stabilization of the target vessels was ensured by the use of the CTS retractor (CardioThoracic Systems, Inc.Cupertino, CA) instead of the usual thoracotomy retractor. Because careful planning of the course of the grafts from the Descending aorta (Des-Ao) to the target vessel/s is crucial to avoid kinking, we have not hesitated, when deemed necessary, to perform the proximal anastomosis first. The distal Des-Ao was used as the inflow for distal CX grafts, while the proximal Des-Ao (above the hilum) was a more appropriate site of inflow in the case of ramus or very proximal CX grafts. A metal marker ring was always placed around the proximal anastomosis for further reference should the need arise to assess graft patency by angiography. A 0.5% Marcaine was infiltrated in the adjoining intercostal spaces prior to closure, and more recently an indwelling intrapleural catheter connected to a morphine or marcaine pump has been left in place for 2-3 days postoperatively.

3.MIDCAB technique (12 cases-24%) was performed in the following fashion: through a 4 " incision in the 4th intercostals space careful dissection of the skeletonized IMA was done with low current electrocauthery and fine clips from its origin to the 6th intercostal space under direct vision and using the CTS Lift set (CardioThoracic Systems, Inc.Cupertino, CA) assisted with intracavitary lighting and single-lung ventilation. After switching to a CTS Stabilizer set (CardioThoracic Systems, Inc.Cupertino, CAL) the pericardium was incised to expose the LAD and Diagonal. Deep pericardial sutures or a small laparotomy sponge placed behind the apex of the heart allowed satisfactory exposure. When necessary to bypass both the LAD and a Diagonal branch, major consideration was given to the proximity of the 2 vessel. If the vessels were separated by an acute angle, the IMA was anastomosed to both in a sequential fashion. If they were farther apart, it was necessary to "Y" the IMA or interpose a segment of radial artery. On 4 occasions, when a free graft was used (radial artery or saphenous vein), the MIDCAB incision was supplemented with a left subclavicular incision to provide arterial inflow from the axillary artery.

4.Xyphoid-Upper abdominal incision (8cases-16%) was always performed in combination with another approach (MIDCAB in3, and LPLT in5) .After harvesting the GEA (4), the xyphoid was excised in its totality and up to one inch of lower sternum was removed with the Stryker saw as an inverted V in patients with a narrow lower sternal angle. This allowed excellent exposure of the RCA and its branches, thus avoiding the need to reopen the entire sternum. Three maneuvers were very helpful in exposing the deep seated vessels: 1) elevation of the lower sternal edge with a Rultract type retractor (Rultract, Inc., Cleveland, Ohio) while keeping anterior adhesions intact, 2) deep retraction sutures on the diaphragm exiting through the abdominal wall rather than through the incision itself, and 3) steep Trendelenburg position of the patient Extra long forceps and needle holders facilitated performance of the distal anastomoses.

Heparin was partially reversed in all patients. Temporary pacing wires were seldom used .The chest cavity was drained using 2 Blake silicone drains (Gish Biomedical, Irvine, CA). Simultaneous procedures included:1 carotid endarterctomy in a patient with critical internal carotid stenosis and an occluded contralateral carotid, and 2 extended LAD endarterectomies on patients with patent IMA grafts but extensive disease distally precluding simple grafting. Graft flows were measured in the more recent 12 patients using the Butterfly Flowmeter (Medi-Stim AS, c/o Medtronic Inc., Minneapolis, MN). Routine administration of Aspirin, Plavix and subcutaneous Lovenox postoperatively was used to counteract the hypercoagulable state described in OPCAB surgery [Mariani1999]. Hybrid procedure (balloon angioplasty-stenting of a CX branch) was done in an elderly gentleman 24 hours after a MIDCAB (LIMA to LAD graft)
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RESULTS

There was 1 conversion to CPB, ironically during performance of the final proximal anastomosis of a vein graft to the ascending aorta in a patient undergoing Re-ST and three vessel grafting. Presumably there was partial occlusion of a vital patent old vein graft to the ramus resulting in intractable ventricular fibrillation. CPB was instituted for 15 minutes after which the patient resumed excellent hemodynamics and subsequently had an uneventful recovery.

There was 1 sudden death on the 7th postoperative day in a 43 year old obese (270lbs) patient with COPD on his 3rd reoperation for CABG. The left IMA had been harvested without difficulty through a MIDCAB incision, however we were unable to identify with certitude the LAD which was buried in fat. We resorted to a tertiary Re-ST which then allowed identification of the LAD. The anastomosis between LIMA and LAD was then carried out as planned through the MIDCAB incision to avoid further dissection of adhesions and injury to the heart. Excellent flows were measured. His recovery was relatively uneventful, though extubation was delayed for 24 hours. He succumbed suddenly on day 7 after a respiratory arrest sustained while in the step-down unit, presumably as a result of a massive pulmonary embolism. Autopsy was not obtained.

There were no instances of perioperative MI either by EKG, cardiac enzymes or troponin levels. There were no documented strokes.42 patients (85%) were extubated within 8 hours of completion of surgery. Total postoperative length of stay averaged 4.5 days (3-9 days) .Prolonged ventilation leading to tracheotomy was necessary in a patient with severe COPD. This same patient, with preoperative creatinine of 3.2 required permanent hemodialysis. There were three readmissions for shortness of breath and pleural effusions resolving after thoracentesis. One patient had a documented episode of pulmonary embolism. New onset atrial fibrillation occurred in 13 patients (26%), while 3 had chronic atrial.fibrillation. There were no instances of reexploration for bleeding and transfusions were limited to elderly patients with Hemoglobin less than 8or Hematocrit less than 24%.There were no wound infections. On follow-up, only 1 symptomatic patient so far has required restudy; his sequential radial artery graft to 2 branches of the CX artery originating from the Desc-AO was widely patent.

In this series, Re-ST allowed total revascularization (1-6grafts) using any conduit. Successful grafting of CX artery branches was achieved in 14 of 15 patients in this group. However severe pulmonary hypertension and/or cardiomegaly, pronounced chest wall deformities, previous radiation therapy or mediastinitis precluded use of this approach.

LPLT allowed exposure of the CX artery branches primarily. It also was used for simultaneous grafting of the distal LAD (beyond a patent or diseased IMA), diagonal branches, ramus arteriosus, and frequently distal branches of the RCA. On three occasions a vein graft was first anastomosed to the posterior descending branch (PDA) of the RCA through a xyphoid approach, then tunneled to the left chest and anastomosed to the Desc-AO after re-positioning and draping the patient for a LPLT.

MIDCAB was used exclusively for revascularization of the LAD and diagonal branches. It was combined with a subclavicular incision [Coulson1997] to provide arterial inflow in cases where a free graft was necessary (3) .An H-Graft [Cohn 1998] was used in 2 elderly patients.

XY was performed primarily for exposure of the RCA and its branches and harvesting of a GEA. It was never isolated as, with the exception of the in situ GEA (4), it does not by itself provide a source of arterial inflow. This was provided instead by the Desc-AO (3) and the R. SCA (with the vein graft routed intrapleurally) (1). Immobilization of the target vessel was less satisfactory with this approach irrespective of the type of device used because of the absence of a bony support However it was greatly facilitated by keeping division of adhesions to a minimum and lifting the lower sternum with a Rultract type of retractor (Rultract Inc, Cleveland, OH).

DISCUSSION

CPB has been known to have deleterious effects on patients undergoing CABG surgery, particularly in the presence of significant comorbid conditions. For this reason OPCAB was popularized by Buffolo[Buffolo1996] and Benetti [Benetti1991]and shown, though not conclusively yet, to reduce morbidity, mortality and cost of this procedure. At our Institution and after a two-year learning period, we have been able to adopt OPCAB exclusively for isolated primary coronary revascularization with a negligible conversion rate and mortality less than 1% in all comers (IFT). More recently, it became evident that if the same technique could be applied to the more complex reoperations for CABG, their significant associated morbidity and mortality could also be markedly reduced. Like our vascular surgery colleagues who avoid areas of scarring –or infection- by approaching their target vessels “extra-anatomically”, we utilized alternative strategically placed incisions aimed at: 1) avoiding sternal re-entry problems (IMA injury, myocardial tears, lysis of dense adhesions, sternal wound infection), 2) obtaining adequate exposure of all target vessels and3) ensuring a good source of arterial inflow. Our limited experience with 50 consecutive cases centered on the following guidelines:

1) Patients with a patent IMA-LAD graft are the ones to benefit the most from alternative "extra-anatomic" incisions (LPLT, MIDCAB or XY or a combination) particularly when a CX artery branch needs revascularization. Re-ST in such patients does not usually provide adequate exposure of the lateral wall of the heart, as retraction is severely limited by the fixed and shortened IMA pedicle (The same limitation theoretically exists in reoperation with a patent GEA to any target vessel). Endarterectomy of the distal LAD in patients with progression of disease beyond a patent IMA or vein graft can be safely done through a LPLT or a Re-ST respectively without any adjunct other than the use of a Florester (Flo-Rester, Bio-Vascular, Inc).

2) In the absence of a patent IMA-LAD graft and in patients requiring multiple vessels revascularization involving RCA, LAD and CX branches, Re-ST provides excellent exposure in addition to allowing harvesting of one or two IMAs. Traditional precautions need to be exercised, particularly avoiding manipulation of old but patent vein grafts and finding the correct plane of dissection to avoid myocardial injury. Complete dissection of the heart all around, wide incision of the right pleura, placement of deep pericardial retraction sutures and Trendelenburg position, all facilitate performance of an operation that should be similar in simplicity to a primary OPCAB.

3) When a single or a double bypass needs to be done, there are multiple potential strategies that do not necessitate Re-ST. In the case of the RCA, it is generally accepted that, because of progression of disease in the main artery, its branches (the PDA and the Postero-lateral) are better suited for bypass. These branches can be easily exposed through a XY- upper abdominal approach. Through this incision, the GEA can be harvested and used in-situ. If instead a free graft is used, arterial inflow can be provided by the R.SCA (subclavicular incision) or the ascending aorta (right parasternal incision) .The graft can also be tunneled to the left chest and connected to the Desc-AO through a separate LPLT incision in patients who need simultaneous X revascularization. In the case of the CX artery branches their exposure is simplified by a traditional LPLT approach, particularly in the presence of a patent IMA graft. Inflow is readily provided by the Desc-AO, below or above the hilum depending on the best course of the graft and the presence of calcification in the aorta. The left subclavian artery, proximal to the origin of the IMA, can be used in case of calcification of the Des-AO.A short period of temporary clamping of the SCA and EKG observation is advisable in that case.

4) The MIDCAB incision provides excellent exposure of the LAD and its diagonal branches, even in the presence of a patent IMA-LAD graft. It allows easy harvesting of the IMA, and in cases where a free graft is used it can be combined with a small subclavicular incision to access the L.SCA .

5) Frequently the combination of a MIDCAB or a LPLT incision with a XY and/or a subclavicular incision will allow total "extra-anatomic" revascularization of all targeted vessels. In these cases sources of arterial inflow are readily available and include: the right and left SCA through appropriate small subclavicular incisions, the ascending aorta through a small right parasternal incision, and the Des-Ao or L.SCA in LPLT. The hood of an old vein graft, a patent IMA graft and an adjoining patent

coronary artery branch can also be used as a source of arterial inflow.

Last but not least, good anesthesia has proved to be crucial for the success of OPCAB surgery. It is even more crucial in redo OPCAB surgery, a generally more challenging operation which can turn into a frustrating experience if hemodynamic instability is not anticipated and treated appropriately. Continuous communication between anesthesiologist and surgeon allows smooth progression of the procedure without unnecessary delays and conversion to CPB. Volume management, particularly reinfusing shed blood, saved with the cell saver, in elderly patients is paramount. Appropriate pharmacological intervention to stabilize blood pressure, particularly during performance of the distal CX grafts, is accomplished with the use of norepinephrine and neosynephrin and/or nitroglycerine. When atrial fibrillation occurs during cardiac manipulation, cardioversion is done and the procedure resumed. Calcium channel blockers are routinely administered throughout the procedure when radial artery grafts are used.

By following these guidelines we were able to eliminate almost completely the morbidity and mortality associated with CPB. Length of hospitalization and cost were also markedly reduced. Thus we are of the opinion that, with proper planning and execution, re-operative OPCAB should be no more difficult to achieve technically than primary OPCAB, and should be at least attempted routinely by surgeons who have mastered beating heart surgery techniques. Most importantly it should achieve complete revascularization rather than be limited to the “culprit”vessel.

CONCLUSION

Redo CABG operations can be safely performed on a routine basis using traditional OPCAB techniques, provided “extra-anatomic” incisions are carefully planned to allow optimal arterial inflow and target vessel exposure and ensure complete revascularization .The early results in our small series of re-operative OPCAB are extremely encouraging and we have no reason to believe that the long term results will be less good than in primary OPCAB procedures.

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