The Heart Surgery Forum #2001-7114
4 (3):231–237, 2001

Online address: www.hsforum.com/vol4/issue3/2001-7114.html

Does Off-Pump Coronary Artery Bypass Surgery Reduce Mortality in High Risk Patients?

Dr. Akpınar

(#2001-7114 … August 3, 2001)

Belhhan Akpınar, MD,[1] Mustafa Guden, MD,[1] Ilhan Sanisoglu, MD,[1]
Ertan Sagbas, MD,[1] Barıs Çaynak, MD,[1] Zehra Bayramoglu, MD,[1] Osman Bayındır, MD[2]

[1]Department of Cardiac Surgery
[2]Department of Anesthesia
Kadir Has University Medical Faculty, Florence Nightingale Hospital Istanbul-Turkey

ABSTRACT

Background: The aim of this retrospective study was to compare outcome in two groups of patients who were classified according to their risk groups and underwent coronary revascularization with or without cardiopulmonary bypass.

Material and Methods: Between January 1996 and July 2000, 480 cases that underwent coronary artery bypass surgery (CABG) were included in a retrospective nonrandomized manner for study. Group 1 included 210 patients who were revascularized using off-pump techniques. Octopus 2 and 3 (Medtronic, Inc., Minneapolis, MN) were used for tissue stabilization. Group 2 included 270 cases who underwent CABG using CPB.

Emergency cases, combined operations, reoperations, and patients in cardiogenic shock were excluded. Demographic variables were comparable between two the groups. Using the Allegheny Clinic Risk Scoring Scale [Magovern 1996], patients in both groups were scored as low, moderate, and high risk. In Group 1, 37 % of patients consisted of high risk patients while Group 2 had 14% ($p < 0.05$).

Student's t-test and chi-square test were used for statistical analysis and alfa < 0.05 was considered significant.

Results: Mortality was 1.4% in Group 1 and 1.5% in Group 2 (p = ns). Mean anastomosis per patient was 2.6 ± 0.6 in Group 1 and 3.2 ± 0.5 in Group 2 ($p < 0.05$). Patients in Group 1 needed less blood transfusions and less inotropic support postoperatively ($p < 0.05$). There were also fewer minor neurological events ($p < 0.05$) and pulmonary complications (Type 2) in Group 1. Atrial fibrillation rate, infection, and major neurological deficit (Type 1) were similar in both groups.

Mortality was less among Group 1 high risk patients (3.9 %) in comparison to Group 2 high risk patients (7.9 %), but this did not reach statistical significance.

Conclusions: In low or moderate risk patients, CABG can be performed safely with or without CPB. In high risk patients with several comorbidities, off-pump CABG seems to be a safe and efficient method that can improve outcome .

Submitted July 25, 2001; accepted August 3, 2001.

Address correspondence and reprint requests to: Belhhan Akpınar, MD, Associate Professor, Dept. Of Cardiac Surgery, Florence Nightingale Hospital, Abide'i Hurriyet Cad. No:280 Sisli, Istanbul-Turkey, Phone: 090 212 2398790, Fax: 090 212 2398791, Email: belh@turk.net

INTRODUCTION

With the increasing use of endovascular technologies and the advancing age of patients, surgical candidates are appearing with more co-morbidities. These co-morbidities can complicate cardiac procedures that use cardiopulmonary bypass (CPB), which itself can cause stroke, immunosupression, and systemic inflamatory response [Edmunds 1995, Czerny 2000]. Eliminating CPB theoretically should reduce, if not overall prevent, some of these complications. Although clinical studies comparing outcomes of off-pump coronary revascularization (OPCAB) and coronary bypass with CPB have reported that patients who were revascularized using off-pump techniques may gain certain benefits, major advantages in terms of atrial fibrillation, cost savings, and mortality could not be shown [Taggart 1999, Hart 2000, Kshettry 2000]. One of the reasons for this may be that in most studies no comparison was made between patients with similar high risks who underwent CABG surgery using off and on pump techniques. The aim of the following study was to compare outcome in two groups of patients who were classified according to their risk groups and operated on by two different surgical methods, with or without CPB by a single surgeon.

MATERIALS AND METHODS

The cardiac surgical registry of our hospital was asked for a retrospective review of patients who underwent CABG-only procedures between January 1, 1996 and July 1, 2000. Presentation as elective status, full median sternotomy approach, and single-institute/single-surgeon operations were inclusion criteria for the study cohort of 480 patients. Emergency cases, reoperations, patients with cardiogenic shock and combined operations were excluded in both groups. The population was then divided into two groups for comparison.

Group 1: 210 CABG patients were revascularized using off-pump techniques. Anatomic suitability and patient risk factors were the two major factors for choosing off-pump CABG techniques. The decision to proceed with OPCAB was made in the O.R. after an evaluation of coronary artery anatomy and

Table 1. Patient demographics

	Group 1	Group 2	p
N	210	270	ns
AGE	72 ± 13	73 ± 7	ns
Gender (M/F)	3.4	3	ns
LVEF< 35 %	12%	18%	ns

M: Male
F: Female
LVEF: Left ventricle ejection fraction

the patients tolerance to cardiac displacement. Octopus 2 and 3 (Medtronic Inc., Minneapolis, MN) were used for tissue stabilization in all patients. Details of our off-pump revascularization strategy has been described previously [Akpinar 2000].

Group 2: Among 2,100 patients undergoing CABG using CPB during the same period, 270 patients were assigned in a retrospective manner. In this group standard CPB techniques were employed. Myocardial protection was achieved by tepid antegrade retrograde blood cardioplegia, with distal and proximal anastamosis completed during a single cross clamp period.

In both groups, patients older than 65 years of age with peripheric vascular or carotid artery disease received echocardiography before manipulating the aorta, as suggested by Davila-Roman et al. [Davila-Roman 1996]. All patients were operated on by the same surgeon. Demographic variables were comparable between the two groups (see Table 1, ◎).

Table 2. Allegheny Clinic Risk Scoring Scale

Variable	Clinical Risk Score	Odds Ratio
Cardiogenic shock	7	29.9
Emergency	5	7.1
Urgent	4	3.5
Catheter-induced coronary closure	4	3.7
EF < 30%	4	2.9
Age > 75	3	2.9
Cardiomegaly	2	3.3
Peripheral vascular disease	2	1.7
Creatinine >1.9	2	2.6
Age 70-74	2	1.5
IDDM	2	2.5
NonIDDM	1	1.5
Low body mass index	1	1.4
Female	1	1.5
Reoperation	1	1.4
Age 65-69	1	1.4
Anemia	1	1.8
Cerebrovascular disease	1	1.6
COPD	1	1.4
Albumin < 4 mg/dL	1	1.2
Creatinine 1.5-1.9	1	1.8
BUN>29 mgdL	1	1.7
Congestive heart failure	1	2.3
Atrial arrhythmias	1	1.4

Table 3. Allegheny Clinic Risk Scoring Scale

Mortality	Points	% Predicted
Low	0-4	0.2
Average	5-8	2
Moderate	9-11	6
High	12-18	30
Extremely high	19+	95

Allegheny Clinic Risk Scoring and Evaluation Scale was used for scoring patients in each group according to their existing risk factors [Magovern 1996]. This is a stepwise logistic regression model, which is used to assign weights to 24 variables using morbidity and mortality as one dependent variable (see Tables 2 and 3, ◎). In this study we only examined mortality as an end point. For practical reasons, patients were scored as low, moderate (moderate+average), or high risk in both groups. There were no patients who scored extremely high in any of the two groups.

Risk stratification is based on an assessment of three important categories of risk factors. These are patient demographics, comorbidities, and cardiac disease. Acuity/priority of the operation is also a factor but since urgent cases were not included in the study, this was not important. Risk factors such as peripheric vascular disease, renal disease, age, carotid artery disease, and atherosclerosis of the ascending aorta were higher in the off-pump group (see Table 4, ◎). This fact led to a higher number of high risk patients in Group 1 (37 %) as compared to Group 2 (14%). In addition, the mean risk score for Group1 high risk patients was higher than Group 2 high risk patients. A control angiography was performed for the first 72 patients in our OPCAB experience, which revealed an overall 95% graft patency rate. We do not perform routine coronary angiography for OPCAB patients anymore but instead use TTFM (Guidant, Santa Clara, CA) for perioperative graft evaluation for all CABG patients. Graft revision rates were 1.2% in Group 1 ver-

Table 4. Patient Risk Factors

	Group 1	Group 2	P
PVD	14 %	5 %	< 0.05
Creatinine >1.5	17 %	4 %	< 0.05
AGE > 75	27 %	11 %	< 0.05
CVA	4 %	1 %	ns
CAD	20 %	11 %	< 0.05
COLD	21 %	17 %	ns
Malignancy	2 %		–
Aortic Atherosclerosis	32 %	6 %	< 0.05

PVD: Peripheric vascular disease
CVA: Cerebrovascular accident
CAD: Carotid disease
COLD: Chronic obstructive lung disease

Table 5. Graft Distribution

	Group 1	Group 2	p
MNG	2.6 ± 0.6	3.2 ± 0.5	< 0.05
One vessel	38 %	19 %	< 0.05
Two vessel	32 %	27 %	ns
Three vessel	28 %	48 %	ns
Four vessel	2 %	6 %	ns

MNG: Mean number of grafts per patient

sus 1.0% in Group 2 (p = ns). Flow rates (mean, ml/min) and pulsatile indexes were examined separately for the same type of anastomosis in both groups, thus yielding similar flows.

Statistical analysis: Data are presented as mean plus or minus standard deviation unless indicated otherwise. Comparisons between the two groups for statistical significance were performed using the student's t test for continous variables and chi square test for categoric variables. Alfa < 0.05 was considered significant.

RESULTS

In Group 1, 2.6 ± 0.6 grafts per patient were performed versus 3.2 + 0.5 in Group 2 (p < 0.05). Distribution of the number and region of grafts are shown in Tables 5, 6, and 7 (◎). Complete revascularization was achieved in 97% of Group 2 patients and 84 % of Group 1 patients (p = 0.19). However, 6% of the patients in Group 1 underwent a PTCA procedure (hybrid therapy) before discharge and complete revascularization reached 90 %. Table 7 (◎) summarizes the type of conduits used in both groups. There were significantly more Y grafts using ITA's than the RA in Group 1. Four patients in Group 1 (1%) had to be converted to CPB because of hemodynamic instability during the procedure.

Overall mortality was 1.4% in Group 1 and 1.5% in Group 2 (p = 0.17) (see Table 8, ◎). Postoperative complications in both groups are shown in Table 9 (◎).

Neurological complications were identified as Type 1 or Type 2. Type 1 was defined as stroke, coma, or other major neurological deficit. Type 2 was defined as delirium, agitation but no major neurological deficit. No patient in Group 1 and one patient in Group 2 (0.4%) developed Type 1 neurological complications. There were more Type 2 complications in Group 2 (p < 0.05).

Table 6. Details of Revascularization

	Group 1	Group 2	p
LAD	99 %	97 %	ns
Cx	34 %	72 %	< 0.05
RCA	61 %	74 %	ns
CR	84 %	97 %	ns

LAD: Left anterior descending
Cx: Circumflex
RCA: Right coronary artery
CR: Complete revascularization

Table 7. Conduits used for revascularization

Group 1	Group 2	p
LITA 99 %	97 %	
LITA + RITA	37 %	27 %
GSV 70 %	89 %	
RA 15 %	9 %	
Y-Graft 11 %	1 %	< 0.05

LITA: Left internal thoracic artery
RITA: Right internal thoracic artery
GSV: Great saphenous vein
RA: Radial artery

Pulmonary complications were defined as Type 1 or Type 2. Type 1 complications were prolonged ventilation over 48 hours; this was similar in both groups. Type 2 complications were defined as necessity for re-intubation due to pulmonary problems within 48 hours after extubation. Only one patient in Group 1 but five in Group 2 needed reintubation.

Overall renal complications leading to dialysis postoperatively were less in Group 1 but not statistically significant. However, while 10% of patients in Group 1 with preoperative high creatinine levels (1.6-1.9) needed dialysis postoperatively, 21 % in Group 2 required dialysis (p < 0.05).

There were no difference in perioperative MI rates betweeen the two groups. (Group 1: 0.9%; Group 2: 1.3 % (p = 0.15)).

There was no difference in postoperative atrial fibrillation rates between the two groups (Group 1: 27 %; Group 2: 20 % (p = 0.17)).

Patients in Group 1 needed less transfusion and inotropes in the early postoperative period (p < 0.05) (see Table 9, ◎).

Group 1

For low risk patients, actual mortality was 0. Expected mortality was 0.2% (p = 0.16). In the moderate risk group, the actual versus expected mortality was 1.2% versus 2-6% (p = 0.09). For high risk patients, the actual/expected mortality rate was 3.9% versus 30% (p < 0.05).

Group 2

For low risk patients, actual versus expected mortality was 0.4 % versus 0.2 %. In the moderate risk group, this was 1.7 % versus 2.6 % (p = 0.12). In high risk patients,

Table 8. Mortality

	Group 1	Group 2
TOTAL (N)	1.4 % (3)	1.5 % (4)
BOWEL ischemia	2	0
Cardiac	0	1
Neurologic	0	0
Renal	0	1
Multiorgan Failure	1	1
Pulmonary	0	1

Table 9. Postoperative Complications

	Group 1	Group 2	P
Bleeding (%)	0.8	1.1	ns
Infection (%)	0.7	0.9	ns
Pulmonary complication (%)			
1	0.5	1.1	ns
2	0.5	2	ns
Renal complication (%)	1.2	1.9	ns
Neurologic complication (%)			
T1	0	0.4	ns
T2	6	14	P < 0.05
ICY stay (hr)	20 ± 4	22 ± 6	ns
Transfusion (units)	1.2 ± 0.8	4.3 ± 1.7	P < 0.05
Inotropies mcg/kg/min	2.8 ± 0.4	8.4 ± 2.7	P < 0.05
Atrial fibrillation (%)	27	20	ns

actual mortality was 7.9%, while the expected mortality was 30% ($p < 0.05$).

Mortality was less in Group 1 high risk patients (3.9%) than in Group 2 high risk patients (7.9%), without statistical significance.

DISCUSSION

With the continued rise in patient age and multiple system impairment, an evaluation of various surgical treatment modalities for high risk patients is warranted. However, new surgical strategies in the treatment of coronary artery disease have also generated controversy and debate [Buffalo 1996]. CPB has long been recognized as one of the major causes of the systemic inflammatory response that may contribute to postoperative complications and multiple organ dysfunction [Gu 1998, Czerny 2000]. The major theoretical advantage of eliminating CPB is the reduction of inflammatory response, which is mostly seen as the trigger mechanism for postoperative complications [Edmunds 1995, Gu 1998].

In a recent report, Hart et al. [Hart 2000] have stated that CPB, manipulation of the aorta, and median sternotomy are three major invasive steps during open heart surgery. By avoiding CPB and minimizing aorta manipulation, it should be possible to reduce some of the complications after CABG surgery. Off-pump CABG has regained popularity since wide usage of stabilization devices. Techniques have been developed that allow access to all cardiac surfaces with little disturbance to hemodynamics [Spooner 1998, Bergsland 2000, Hart 2000, Murkin 2000].

The Octopus device enables surgeons to perform precise anastomoses even on lateral or posterior wall coronary arteries [Akpinar 2000, Hart 2000]. Latest reports from different groups have shown similar early graft patency rates of CABG performed on CPB [Mack 1999, Akpinar 2000]. Groups performing off-pump CABG have shown repeatedly many advantages of the technique [Calafiore 1998, Ascione 1999, Arom 2000, Murkin 2000, Ricci 2000]. However, other findings have not [Taggart 1999]. There may be several explanations for this. Some studies have compared outcomes between two techniques in the general cardiac surgical population, which consisted mostly of low and moderate risk patient groups. Randomized studies comparing both techniques in high risk patients have been limited so far. CPB techniques have also undergone refinement and it may be difficult to show advantages of off-pump techniques over CPB in patients with low operative risk [Akpinar 2000, Hart 2000, Kshettry 2000]. We have been using the Allegheny Risk Scoring system routinely to evaluate preoperative risk factors and have found it easy to use and useful in evaluating prognosis and outcome [Magover 1996]. Figure 1 (◎) shows the validation of this scoring system on 700 CABG patients operated using CPB between 1997-1999 in our institution, which shows the actual and predicted rates within the 95% confidence limits. Scoring systems tend to overestimate morbidity and mortality. This was no exception for the Allegheny scoring system as well, however, an estimation of outcome in borderline cases can still be given. Validation of the Euroscore scoring system by Sergeant et al. (Sergeant PT, 14th EACTS meeting, Frankfurt Germany 2000) have revealed similar results, especially in high risk patients. Overscoring was also more prominent for the off-pump group in their study.

Our study demonstrated that for low risk patients both in Group 1 and Group 2, mortality was comparable regardless of the surgical technique used within the predicted limits. For high risk patients in both groups, the actual mortality was significantly less than predicted (Figure 1, ◎). Finally, mortality in the high risk Group 1 patients was less than the high risk Group 2 patients, but this was not statistically significant. However, one should remember that the percentage of high risk patients was 37 % in the off-pump group and 14 % in the CPB group, with the mean risk score being higher in the off-pump high risk group. Overall mortality between two groups however was similar (1.4 % versus 1.5 %). Two patients in Group 1 died of mesenteric ischemia during the third and fourth days after surgery. Both patients were over 75 years of age, and one had atrial fibrillation. Disturbed by Mariani's findings [Mariani 1999] of a hypercoaguable state in the early postoperative period, we now routinely treat all planned off-pump CABG patients with Plavix starting two days before the operation. We start Plavix and Aspirine from the NG tube when the patient comes to the ICU. Plavix is continued for 30 days and aspirine indefinitely.

Evaluating outcome parameters was more difficult. Instead of using the Allegheny Clinic scoring system for morbidity analysis, we evaluated each outcome parameter separately for reasons of simplicity. In terms of postoperative infection, perioperative myocardial infarction, and atrial fibrillation, no significant difference could be observed between the two groups. Among patients who had high levels of blood creatinine before the operation, 10 % of patients in Group 1 needed dialysis versus 21 % of the cases in Group 2 ($p < 0.05$). Need for blood tranfusion, inotropes and some pulmonary complications (Type 2) were less in Group 1 ($p < 0.05$).

Neurological complications were low in both groups. None of the patients in Group 1 and only one patient in Group 2 had a major neurological event, whereas Type 2 events were more common in Group 2 ($p < 0.05$) This was important because Group 1 patients were older, had carotid

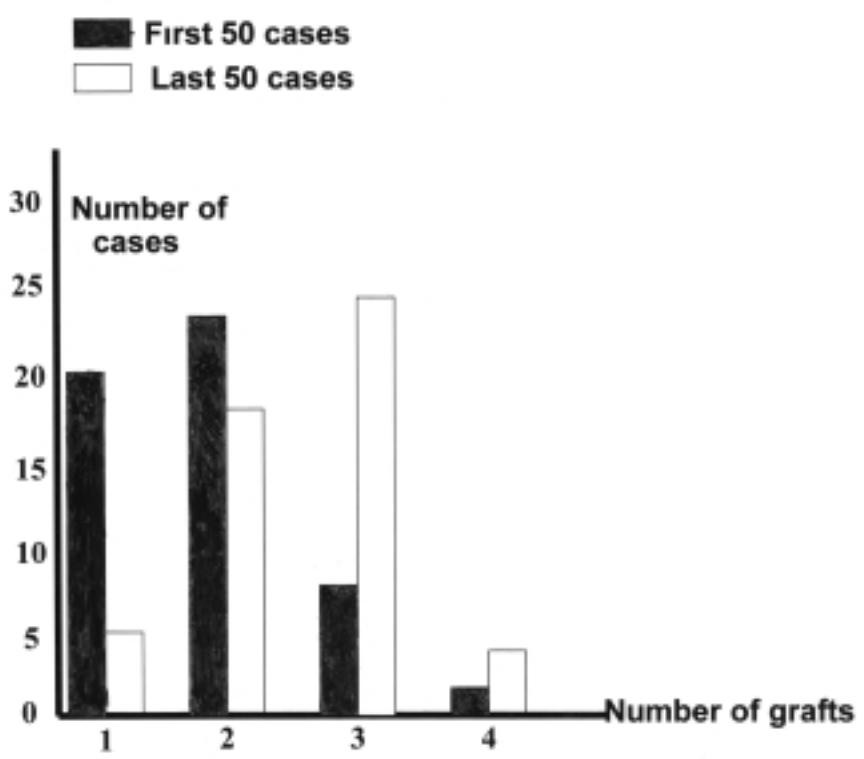

Figure 1.

artery disease, and, most importantly, had atherosclerosis of the ascending aorta (see Table 4, ◎). It is difficult to say whether this favorable outcome was only due to the avoidance of CPB or other factors. Routine use of epiaortic echocardiography in high risk patients avoided aortic manipulation in the atherosclerotic aorta in both groups [Davila-Roman 1996]. Arterial cannulation sites were changed when necessary, with bilateral ITA's, Y or T grafts or hybrid revascularization being preferred. In Group 2 also, the "single-clamp" technique was routinely used to avoid partial clamping. Whether the lower neurological complication rate reflects the avoidance of CPB or is the avoidance of aortic manipulation remains to be seen. Many factors contribute to neurological dysfunction after CABG, especially age greater than 70 years, duration of CPB, atherosclerosis of the aorta, and cerebrovascular circulation [Puskas 1999, Murkin 2000, Ricci 2000]. A study conducted by Taggert et al. [Taggert 1999] showed similar patterns of early decline and late recovery of cognitive function in patients undergoing CABG with and without CPB, suggesting that CPB may not be the major cause of postoperative cognitive impairment, although others disagree [Hart 2000, Murkin 2000, Ricci 2000].

Recently Ricci et al. [Ricci 2000] reported a lower incidence of stroke rate in the off-pump CABG group in comparison to the CPB group. Mack et al. [Mack 1999] also demonstrated significant differences in favor of OPCAB in terms of renal and pulmonary outcomes as well as mortality, especially in high risk patients. Although these studies have limitations, they are important in showing that by adapting or individualizing different surgical techniques, predicted complication rates can be reduced and the outcome improved.

The limitations of our study are that it is retrospective and nonrandomized. Patient selection for OPCAB was at the discretion of the surgeon and therefore selection bias could not be excluded. Higher risk patients were often selected for OPCAB because of the surgeon's belief that it is a safer procedure in those patients than the risk factors from CPB. On the other hand, the study has the advantage of being a single-institute and single-surgeon study comparing patients in similar risk groups.

A recent review of 1,582 off-pump coronary bypass patients showed low rates of morbidity and mortality. This compared favorably with the CPB supported CABG procedures in spite of high risk patients were often selected for OPCAB [Hart 2000]. A study conducted by Arom et al. demonstrated that patients at high risk benefited more from off-pump techniques and that multi vessel off-pump CABG can safely be performed in this group [Arom 2000, Kshettry 2000]. We have encountered a non homogenous patient group that needs "patient tailored surgery" (Cooley D, 1999 AATS meeting). A drastic reduction in the expected complication rate can be achieved in the highest risk group of patients by adapting or changing the surgical technique [Hart 2000]. Our findings also support these findings and can be summarized as follows.

1. This study has demonstrated that in low or moderate risk patients, CABG can be performed safely with or without CPB. It is difficult to show the advantage of one method over another in this group.
2. In high risk patients with comorbidities, mortality was reduced by using off-pump techniques, but this was not statistically significant.When interpreting these results,

one should consider there were more high risk patients with higher risk scores in Group 1 than in Group 2.
3. The incidence of neurological complications can be reduced by avoiding the atherosclerotic aorta, using epiaortic scanning in high risk groups, and changing strategy accordingly. Off-pump CABG can safely be performed in this high risk group to reduce neurological complications combined with minimal aortic manipulation.
4. The need for blood transfusions and inotropes can be reduced with off-pump techniques. Also, patients with preoperative renal and pulmonary problems seem to be less affected by off-pump techniques. However, the incidence of atrial fibrillation and perioperative MI were similar .
5. Risk scoring systems can be criticized for overestimating mortality, especially in high risk groups. On the other hand, they can provide patients and their families insight into the real risk of complications and mortality, as well as increase the awareness of the surgeon to the high risk patient for whom standard techniques can be modified.

In summary, within the limitations of this nonrandomized retrospective study, it is our belief that off-pump CABG operations are a safe procedure that may avoid some potential risks of CPB in certain high risk patients. Higher volume and prospective randomized trials are needed to further define the benefits of OPCAB.

REFERENCES

1. Akpinar B, Guden M, Sagbas E, Sanisoglu I, Aytekin V, Bayindir O. Off-pump coronary bypass grafting with use of the Octopus 2 stabilization system. Heart Surg Forum #2000-1909 3(4):282-6, 2000.
2. Arom KV, Flavin TF, Emery RW, Kshettry VR, Janey PA, Petersen R.J. Safety and efficacy of off-pump coronary artery bypass grafting. Ann Thorac Surg 69:704-10, 2000.
3. Ascione R, Lloyd CT, Underwood MJ, Lotto AA, Pitsis AA, Angelini GD. Economic outcome of off-pump CABG. Ann Thorac Surg 68:2237-42, 1999.
4. Bergsland J, Ancona GD, Karamanoukian H, Ricci M, Salerno T. Technical tips and pitfalls in OPCAB surgery. The Buffalo Experience. Heart Surg Forum #2000-7789 3(3):189-93, 2000.
5. Buffalo E, Silva de Andrade JC, Rodriquez B. Coronary artery bypass grafting without cardiopulmonary bypass. Ann Thorac Surg 61:63-6, 1996.
6. Calafiore AM, Giammarco GD, Teodori G, et al. Recent advances in multivessel coronary grafting without cardiopulmonary bypass. Heart Surg Forum #1998-33589 1(1):20-5, 1998.
7. Czerny M, Baumer H, Kilo J, Lassnigg A, Hamvi A, Vukovich T, Wolner E, Grimm M. Inflammatory response and myocardial injury following coronary artery bypass grafting with or without cardiopulmonary bypass. Eur J Cardiothorac Surg 17:737-42, 2000.
8. Davila–Roman VG, Phillips KJ, Daily BB, Kouchokos NT, Barzilai B. Intraoperative transesophageal echocardiography and epiaortic ultrasound for assessment of atherosclerosis of the thoracic aorta. J Am Coll Cardiol 28(4):942-7, 1996.
9. Edmunds LH. Why cardiopulmonary bypass makes patients sick: strategies to control the blood synthetic surface interface. Karp RB, Laks H Wechsler AS, eds. Advances in cardiac surgery, vol 6. (St. Louis: Mosby) 131-67, 1995.
10. Gu YJ, Mariani MA, Van Oeveren W, Grandjean JG, Boonstra PW. Reduction of the inflammatory response in patients undergoing minimally invasive coronary artery bypass grafting. Ann Thorac Surg 65:420-4, 1998.
11. Hart JC, Sponer T, Pym J, Flavin FT, Edgarton JR, Mack MJ, Jansen WLE. A review of 1582 consecutive octopus off-pump coronary bypass patients. Ann Thorac Surg 70(3):1017-21, 2000.
12. Kshettry VR, Flavin T, Emery R, Nicoloff D, Arom K, Petersen RJ. Does multivessel off-pump coronary artery bypass reduce postoperative morbidity? Ann Thorac Surg 69:1725-30, 2000.
13. Mack MJ, Magorvern JA, Acuff TA, et al. Results of graft patency by immediate angiography in minimally invasive coronary artery surgery. Ann Thorac Surg 68:383-90, 1999.
14. Magovern JA, Sakert T, Magovern G et al. A model that predicts morbidity and mortality after coronary artery bypass surgery. J Am Coll Cardiol 28: 1147-53, 1996.
15. Mariani MA.,Gu YJ, Boonstra PW, Grandjean JG, Oeveren W, Ebels T. Procoagulant activity after off-pump coronary operation: is the current anticoagulation adequate? Ann Thorac Surg 67:1370-75, 1999.
16. Murkin MJ, Neurological outcomes after OPCAB. How much better is it? Heart Surg Forum #2000-30945 3(3):207-10, 2000.
17. Puskas JD, Wright CE, Ronson RS, Brown M, Gott JB, Guyton RA. Clinical outcomes and angiographic patency in 125 consecutive off-pump coronary bypass patients. Heart Surg Forum #1999-95310 2(3):216-21, 1999.
18. Ricci M, Karamanoukıan H, Abraham R, et al. Stroke in octagenarians undergoing coronary artery surgery with and without cardiopulmonarybypass. Ann Thorac Surg 69:1471-75, 2000.
19. Spooner TH, Dyrud PE, Monson BK, Dixon GE, Robinson LD. Coronary artery bypass on the beating heart with the Octopus: a North American experience. Ann Thorac Surg 66:1032-5, 1998.
20. Taggart DP, Browse SM, Halligan PW, Wade DT. Is cardiopulmonary bypass still the cause of cognitive dysfunction after cardiac operations? J Thorac Cardiovasc Surg 118: 414-21, 1999.

REVIEW AND COMMENTARY

1. Editorial Board Member TS513 writes:

The OPCAB group received fewer circumflex grafts and fewer grafts per patient. In addition, the OPCAB group included a significant number of patients that received "hybrid" therapy with PTCA.

a) It would help to know why there was a significant difference in grafting the lateral wall in the OPCAB group. Was this just the effect of the early learning curve of OPCAB for this surgeon?
b) What techniques were used for lateral wall exposure?
c) Was there much reliance on pharmacologic support—specifically were alpha agonists used in conjunction with Trendelenberg positioning?
d) Could this combination explain the two mesenteric infarctions in the OPCAB group rather than blaming the so-called hyper-coagulable state?

Authors' Response by Belhhan Akpinar, MD:

a) The mean number of anastomoses were less in the off-pump CABG group. As the editorial board member has

indicated, the main reason for this was the effect of the early learning curve. This can be seen in Figure 1 (◉).

b) To improve exposure, we use 3-4 pericardial stay sutures as suggested by Dr. Lima. For the lateral wall exposure, volume is given and the table is brought to a steep Trendelenburg position. If necessary, the right pleural space is opened and the right hemi-sternum is elevated to accomodate the apex of the heart while the table is tilted to the right. Octopus III is used as a tissue stabilizer.

c) Our policy to use alfa agonists is only when the above mentioned measures are not enough to obtain hemodynamic stability. This is usually the case in dilated hearts or patients with depressed left ventricle function during lateral wall revascularization. These agents are used temporarily.

d) Both events of mesenteric infarction occurred when these cases were not receiving any vasoactive drugs. We have to mention that both cases were over 70 years of age and one was in chronic atrial fibrillation. Therefore, we do not know the real cause for mesenteric ischemia.

2. Editorial Board Member LO23 writes:

This is a retrospective analysis where the inclusion / exclusion criterea are the same for both groups, however, the "control" group of 270 patients is then non-randomly assigned out of 2,100 patients. This "selected" control group then had lower risk factors - however the aforementioned methoodolgy must invalidate any conclusions on this basis.

The lower number of vessels bypassed in the off-pump group is also "pre-selected" as this is a retrospecitve non-randomized study and no interpretations can therefore be made from this comparison.

Authors' Response by Belhhan Akpinar, MD:

The author agrees with the board member that there are flaws in the study design. The intention in the beginning was to include two groups that were computer matched. However, it was not possible to match the two groups completely, because this was a single surgeon and this surgeon had the intention to operate on patients with comorbidities using off-pump techniques. This went to a point even where patients regarded as not suitable for operations by other centers because of these comorbidities were operated on using off-pump techniques. For this reason there were less patients with comorbidities in the CPB group. On the other hand, there more patients with impaired LV function in the CPB group (12 %-18%). As our experience with off-pump CABG grew, we tended to operate on patients with impaired LV function who needed lateral wall revascularization more using CPB, which is our policy presently.

The number of anastomoses (total and lateral wall) were less in the off-pump group. The main reason for this was the learning curve, as can be seen from Figure 1 (◉).

However, if one looks to studies by Michael Mack, MD and James Edgarton, MD, they also report fewer number of anastomoses in the Cx area.

3. Editorial Board Member GX21 writes:

There are two patient selection issues. First, how were patients selected for off-pump surgery in the first place? The paper says "anatomic suitability and patient risk factors" but gives no details.

Second, how were the two study groups selected? The paper says that the population was divided into two groups for comparison. What this population was is not clear. Group 1 = 210 off-pump CABG: were these all of the off-pump patients during the period (1996-2000), or a selection of them and, if selected, how? Group 2 = 270 "non-randomly assigned in a retrospective manner" from among 2,100 CPB patients. How? It would be possible to select 270 from 2,100 to obtain virtually any result.

Authors' Response by Belhhan Akpinar, MD:

Patient Selection Criteria:

In the beginning of our experience with off-pump CABG, we chose patients with one or two vessel disease, trying to avoid patients needing lateral wall revascularization. Some patients even received a hybrid therapy for this purpose. However, during the last two years, we did more and more lateral wall revascularization as can be seen from Figure 1 (◉). Our policy to avoid patients with calcific vessels or vessels with severe calcification or intramyocardial arteries has not changed. It is our policy to operate on patients with comorbidities like renal insufficiency, pulmonary problems, cerebrovascular events, malignancies, or atherosclerotic aorta's using off-pump techniques.

One group of patients that we are cautious with are those with a low LVEF or dilated LV's who need lateral wall revascularization. We operate on these patients using CPB .

Selection of the two groups

During 1996-2000 there were 315 off-pump CABG cases performed in the institute, 214 by the author.Four were excluded because they were reoperations. So, nearly all off-pump cases operated by the author were included.

A better way to match the two groups would be a computer matching program or by a propensity score as proposed by Blackstone et al. However, we were not able to this at that time.There were major differences in the operated patient population, the author had a bias towards operating patients with above mentioned comorbidities without using CPB Our selection criteria for the CPB group was:

Among the 2,100 patients operated by the author and his team using CPB during the mentioned period, CABG only, first time procedures operated by the author himself (as the off-pump group) were included and all the training cases were excluded.

Another criteria was comparing intraoperative graft flow, in both groups (TTFM). During the study this was possible in all off-pump CABG cases (72 underwent an additional angiography) and 270 CPB cases.

As a result, 270 first time on-pump CABG patients operated by the author whose TTFM could be performed were included as the control group.