The Heart Surgery Forum #2011-1011
14 (5), 2011 [Epub October 2011]
doi: 10.1532/HSF98.20111011

Online address: http://cardenjennings.metapress.com

Left Anterior Descending Artery Revascularization in Low-Risk Patients: Early Outcomes after Off-Pump versus On-Pump Surgery

Onur Gürer, MD, Ahmet Kırbaş, MD, Ömer Işık, MD

Department of Cardiovascular Surgery, Medicana Hospitals Çamlıca, Istanbul, Turkey

ABSTRACT

Background and Aim of the Study: This study aimed to compare the early outcomes of off-pump and on-pump myocardial revascularization in patients with stenosis in the left anterior descending artery (alone or with diagonal artery disease).

Methods: We retrospectively reviewed the medical records of 300 patients: 150 who underwent on-pump coronary artery bypass and 150 who underwent off-pump coronary artery bypass grafting. There were no significant differences between the 2 groups with respect to medical data and operative findings. On-pump and off-pump groups were compared in terms of mortality and morbidity within 30 days of the operation.

Results: Hospital mortality was 3.3% (5 patients) in the on-pump group and 2.6% (4 patients) in the off-pump group. Five patients (3.3%) in the on-pump group experienced myocardial infarction; 3 died of cardiogenic shock. Four patients (2.6%) in the off-pump group experienced myocardial infarction, and 2 of these patients died. Two patients (1.3%) in the on-pump group and 2 patients (1.3%) in the off-pump group experienced stroke; 1 patient in each group died. One patient (0.6%) in the on-pump group had mediastinitis and died of sepsis.

Conclusions: Among low-risk patients (defined according to EuroSCORE criteria) who underwent left anterior descending coronary artery bypass, the results obtained with the on-pump and off-pump methods showed no significant differences with respect to morbidity or mortality.

INTRODUCTION

Off-pump coronary surgery is increasingly popular. Many surgeons prefer to perform off-pump coronary surgery to avoid the unwanted effects of cardiopulmonary bypass (CPB), such as activation of inflammatory mediators, creation of a nonphysiological empty heart, preventing collateral flow to the ischemic regions, and worsening of the conservation of intraventricular septal movement [Goldstein 2003].

Studies have not shown consistent results. Whereas some studies have shown no significant differences [Cheng 2002; Boening 2003; Sabik 2004] or have shown results in favor of non–off-pump surgery [Takagi 2010] with respect to mortality and morbidity, others have provided significant results in favor of off-pump surgery [Patel 2002; Al-Ruzzeh 2003; Calafiore 2003; Puskas 2003; Mack 2004]. Although off-pump coronary artery bypass grafting (CABG) surgery can now be performed on many more coronary patients because of improvements in surgical technology, it is becoming the procedure of choice in patients having 1- or 2-vessel disease. Many surgeons, however, are not sure whether to choose on-pump or off-pump surgery for low-risk patients who have a suitable coronary anatomy and 1-vessel disease. The development of a clear consensus has been delayed by the lack of studies on the subject.

The objective of this study was to determine whether off-pump CABG is superior to on-pump surgery in low-risk patients with single-vessel disease of the left anterior descending artery.

MATERIALS AND METHODS

This retrospective study included 300 low-risk patients who underwent surgery in our center between 2003 and 2009. The cardiologist and the cardiac surgeon together made the decision for CABG. All patients had left anterior descending artery stenosis of 70% or greater, with or without diagonal artery disease. The EuroSCORE was used for risk stratification. In addition, our exclusion criteria were the presence of right coronary artery or circumflex artery lesions, coronary angioplasty indications, a change in the surgical procedure from off-pump surgery to on-pump surgery (only 1 patient), and serious obesity (body mass index >40 kg/m^2). This study was performed in accordance with the principles of the latest version of the Helsinki Declaration.

Of the 300 patients, 150 underwent off-pump surgery, and 150 underwent on-pump surgery. All the patients had a median sternotomy. The patients who underwent on-pump

Received January 22, 2011; received in revised form March 7, 2011; accepted April 13, 2011.

Correspondence: Ahmet Kırbaş, Çamlıca Medicana Hastanesi, Alemdağ Caddesi, No:85 Üsküdar, Istanbul, Turkey; 90-505-3480151; fax: 90-216-4431836 (e-mail: ahmetkirbas@gmail.com).

Table 1. Patients' Demographics and Medical Histories*

	On Pump (n = 150)	Off Pump (n = 150)	*P*
Sex, n			
Male	105 (70%)	109 (72.7%)	NS
Female	45 (30%)	41 (27.3%)	NS
Age, y	60 ± 8.3	62 ± 7.6	NS
Smoking, n	90 (60%)	95 (63.3%)	NS
Diabetes mellitus, n	32 (21.3%)	36 (24%)	NS
Dyslipidemia, n	47 (31.3%)	54 (36%)	NS
Family history of coronary artery disease, n	12 (8%)	14 (9.3%)	NS
Hypertension, n	87 (58%)	83 (55.3%)	NS
Peripheral vascular pathology, n	17 (11.3%)	14 (9.3%)	NS
Previous myocardial infraction, n	51 (34%)	56 (37.3%)	NS
Angina, n			
Stable	138 (92%)	131 (87.3%)	NS
Unstable	12 (8%)	19 (12.7%)	NS

*Data are given as n (%) or as the mean ± SD. NS indicates not statistically significant.

Table 2. Operative Characteristics*

	On Pump (n = 150)	Off Pump (n = 150)	*P*
No. of distal anastomoses	1.28 ± 0.45	1.2 ± 0.4	NS
Diagonal anastomosis, n	44 (22.7%)	30 (16.6%)	NS
Skin-to-skin time, min	159 ± 17	145 ± 15	NS
CPB time, min	39 ± 9	—	
Cross-clamp time, min	20 ± 7	—	
Conduits			
Left IMA			
Patients, n	147 (75.7%)	147 (81.6%)	NS
No. of IMA grafts/patient	0.98	0.98	NS
Great saphenous vein			
Patients, n	47 (24.2%)	33 (18.3%)	NS
No. of venous grafts/patient	0.31	0.22	NS

*Data are given as n (%) or as the mean ± SD. NS indicates not statistically significant; CPB, cardiopulmonary bypass; IMA, internal mammary artery.

surgery received an infusion of 4 mg/kg heparin and cannulation of the ascending aorta and right atrium. Intermittent antegrade cold blood cardioplegia (with 15 mEq/L K^+) or cold K^+ cardioplegia accompanied by systemic hypothermia (28°C-30°C) was performed. For the patients who underwent off-pump surgery, the heparin dose (1-1.5 mg/kg) was one-third of the standard dose for CPB. The target activated coagulation time was >300 seconds. The Octopus stabilizer system (Medtronic, Minneapolis, MN, USA) was used on all patients; proximal coronary occlusion with a metal bulldog clamp or snare was also performed on all patients.

The same anesthesiologist set the protocols in the intensive care unit. He made decisions for some outcomes in the intensive care unit in consultation with the surgical team. Conscious patients were extubated when they were hemodynamically stable, had no drainage, and had a vital capacity ≥10 to 15 mL/kg, a respiratory rate of less than 35/minute, a pH ≥7.30, a ratio of PaO_2 to the fraction of inspired oxygen (40%) ≥60 mm Hg, and a dopamine dosage of no greater than 5 µg/kg per minute. The necessary adjustments were made after measurements of blood gases, blood glucose, and electrolytes were taken at 30, 60, and 120 hours. All patients were assessed via electrocardiogram for myocardial infarction (MI) during the postoperative period (0, 8, 16, and 24 hours) and via the enzymatic curve of creatine kinase MB (CK-MB) at 0 and 16 hours. The result was considered significant if CK-MB levels were 5 times the normal value. Chest radiographs and hematologic and biochemical tests were rechecked on the first and fifth days. Blood transfusions were instituted for patients older than 70 years with a hemoglobin level <8 g/dL and for patients younger than 70 years with a hemoglobin level <7 g/dL.

Patients were assessed for morbidity and mortality during their hospital stay (mean ± SD, 7.8 ± 2.9 days for on-pump patients and 7.2 ± 2.1 days for off-pump patients) by the anesthesiologist, by the surgical team, and, if needed, by a specialist. Patients were also assessed during the first 30 days postoperatively by the surgical team and by a specialist, if needed, at 15-day intervals. The mean follow-up time was 37 ± 8 days for both groups. Morbidity assessment included evaluation for MI, acute renal dysfunction, intubation time, intra-aortic balloon pump use, new atrial fibrillation, reopening, total amount of bleeding and blood replacement, superficial wound infection, mediastinitis, stroke, gastrointestinal system complications, sepsis, inotrope requirements, and length of stay in the intensive care unit or hospital. In general, the criteria for discharging a patient from the hospital were as follows: sinus rhythm, body temperature <37.5°C, a hematocrit of approximately 30%, normal telecardiography findings, and optimal mobilization, including climbing stairs. At the first 30 days after the operation, patients were followed up with electrocardiography, transthoracic echocardiography, chest radiography, and hematologic and biochemical tests.

Data are presented as the mean ± SD or as a number (percentage). The χ^2 test, the Fisher exact test, and the nonparametric Mann-Whitney *U* test were used for statistical analyses. A *P* value <.05 was accepted as statistically significant.

RESULTS

Three hundred bypass patients with left anterior descending single-vessel disease (with or without diagonal artery disease) underwent CABG surgery over the 7-year period. Patients were divided into groups according to the method

Table 3. Postoperative Morbidity and Mortality*

	On Pump (n = 150)	Off Pump (n = 150)	*P*
Deaths, n	5 (3.3%)	4 (2.6%)	NS
Acute renal failure, n	1 (0.6%)	0 (0%)	NS
Intra-aortic balloon pump, n	5 (3.3%)	3 (2%)	NS
Stroke, n	2 (1.3%)	2 (1.3%)	NS
Myocardial infarction, n	5 (3.3%)	4 (2.6%)	NS
New atrial fibrillation, n	18 (12%)	13 (8.6%)	NS
Gastrointestinal system complications, n	1 (0.6%)	1 (0.6%)	NS
Reopening, n	7 (4.6%)	5 (3.3%)	NS
Wound infections, n	2 (1.3%)	2 (1.3%)	NS
Mediastinitis, n	1 (0.6%)	0 (0%)	NS
Sepsis, n	1 (0.6%)	0 (0%)	NS
Inotrope requirement, n	5 (3.3%)	3 (2%)	NS
Total blood loss, mL	721.2 ± 204	718.5 ± 225	NS
Transfusion requirement, units			
Packed cells	159	143	NS
Fresh frozen plasma	167	153	NS
Platelets	3	2	NS
Intubation time, h	10.7 ± 6.3	9.2 ± 5.1	NS
Length of stay in ICU, d	2.2 ± 1.4	2.1 ± 0.9	NS
Length of hospitalization, d	7.8 ± 2.9	7.2 ± 2.1	NS

*Data are given as n (%) or as the mean ± SD. NS indicates not statistically significant; ICU, intensive care unit.

of surgery: on pump (with CPB) or off pump (without CPB). In the on-pump group, 105 (70%) of the 150 patients were men, and 45 (30%) were women. In the off-pump group, 109 (73%) of the 150 patients were men, and 41 (27%) were women. The mean age was 60 ± 8.3 years in the on-pump group and 62 ± 7.6 years in the off-pump group.

When we compared patient demographics, medical histories (Table 1), and operative characteristics (Table 2), we found no statistically significant differences between the 2 groups. There were no significant differences between the groups with respect to morbidity, including MI, acute renal dysfunction, intubation time, intra-aortic balloon pump use, new atrial fibrillation, reopening, total amount of bleeding and blood replacement, superficial wound infection, mediastinitis, stroke, gastrointestinal system complications, sepsis, inotrope requirements, or length of stay in the intensive care unit or hospital (Table 3). There were no significant differences between the groups in mortality: Three patients in the on-pump group died of post-MI cardiogenic shock, 1 patient died of postmediastinitis septic shock, and 1 patient died after stroke and coma. In the off-pump group, 2 patients died of post-MI cardiogenic shock, and 2 patients died after stroke and coma (Table 3). There were no recurrences of angina and no events of death, MI, or stroke within 30 days postoperatively.

DISCUSSION

In this retrospective study, we evaluated mortality and morbidity following the on-pump and off-pump surgical techniques for CABG in low-risk patients with single-vessel disease. The study population consisted of patients with stenosis of the left anterior descending artery. The exclusion criteria were determined to obtain standardization for the 2 groups. We found that the on-pump and off-pump techniques during CABG did not significantly differ with respect to morbidity and mortality for low-risk patients with single-vessel disease.

The need for coronary revascularization has been increasing because of the increasing prevalence of coronary artery diseases worldwide. Currently, CABG is an often-preferred surgical technique; long-term studies are being conducted to improve the safety, reliability, and efficiency of this procedure. It is known, however, that contact of the blood with nonorganic surfaces, cross-clamping of the aorta, and reperfusion damage during CPB may cause a systemic inflammatory response that can lead to multiple-organ dysfunction [Goldstein 2003]. Therefore, avoiding CPB may decrease morbidity and mortality. There have been numerous developments since CABG was first performed without CPB in 1967 [Kolessov 1967]. Although Boening et al [2003] did not find significant differences between on-pump and off-pump CABG methods with respect to morbidity and mortality, Al-Ruzzeh et al [2003] found lower morbidity and mortality rates in off-pump patients than in on-pump patients. Mack et al [2004] showed that off-pump CABG was associated with less mortality and morbidity, including reductions in blood transfusions, stroke, renal failure, pulmonary complications, reoperation, atrial fibrillation, and gastrointestinal complications. Sabik et al [2004] reported that on-pump and off-pump CABG surgeries produced similar mid-term results; the lower graft count in off-pump patients did not decrease survival or increase ischemic events over a 4-year period.

Weerasinghe et al [2005] showed that the off-pump technique might reduce the risk for minor and major renal adverse outcomes after CABG; however, these findings are in contrast to the results of an analysis of a series of 690 cases conducted by Gamoso et al [2000]. In this study, the investigators excluded patients with severe left ventricular dysfunction (ejection fraction ≤35%), renal failure, and lesions of the circumflex artery and its branches, as well as patients with significant comorbidities that were inappropriate for randomization. They found no significant findings in favor of beating heart surgery with respect to renal function.

Bucerius et al [2004] have reported a lower prevalence of postoperative delirium with beating heart surgery. Taggart et al [1999] found no significant differences between on-pump and off-pump groups in early or late recovery patterns.

According to our study, there were no significant differences between the groups with respect to mortality and morbidity. The patients who died of post-MI cardiogenic shock were taken to the operating room emergently, and the grafts were detected as working. The other 4 patients with perioperative MI were monitored by angiography after hemodynamic stabilization, and the grafts were found to be working.

Although we could not detect the exact cause of the perioperative MI, thromboemboli and/or graft spasm might be responsible for perioperative MI.

As can be seen from the many articles mentioned above, comparative studies have not yet produced a clear consensus. There are 2 alternatives for an experienced surgeon in a case of single-vessel disease. Some surgeons prefer not to use off-pump CABG because of their concerns about thin, calcified, or intramyocardial vessels. They also defend a surgeon's comfort with anastomoses that on-pump surgery provides. Although there is still no consensus on this issue, others prefer off-pump surgery to avoid the worst effects of CPB.

The major limitation of this study is its retrospective design, which precluded postoperative prospective evaluation of patients who underwent their surgery with the on-pump or off-pump technique. Further prospective studies would prove the differences between off-pump and on-pump surgeries for low-risk patients with single-vessel coronary artery disease.

In conclusion, our findings showed no significant differences in mortality or morbidity between the on-pump and off-pump techniques during CABG surgery for low-risk patients with stenosis of the left anterior descending coronary artery. We attribute this result to the short duration of the pump in patients with single-vessel disease. We also believe that the low comorbidity level of these patients is an important factor. Thus, on-pump myocardial revascularization can be performed in low-risk patients with single-vessel coronary artery disease with the same degree of morbidity and mortality as the off-pump technique.

REFERENCES

Al-Ruzzeh S, Ambler G, Asimakopoulos G, et al. 2003. Off-pump coronary artery bypass (OPCAB) surgery reduces risk-stratified morbidity and mortality: a United Kingdom Multi-Center Comparative Analysis of Early Clinical Outcome. Circulation 108(suppl 1):II1-8.

Boening A, Friedrich C, Hedderich J, Schoettler J, Fraund S, Cremer JT. 2003. Early and medium-term results after on-pump and off-pump coronary artery surgery: a propensity score analysis. Ann Thorac Surg 76:2000-6.

Bucerius J, Gummert JF, Borger MA, et al. 2004. Predictors of delirium after cardiac surgery delirium: effect of beating-heart (off-pump) surgery. J Thorac Cardiovasc Surg 127:57-64.

Calafiore AM, Di Mauro M, Canosa C, Di Giammarco G, Iacò, Contini M. 2003. Myocardial revascularization with and without cardiopulmonary bypass: advantages, disadvantages and similarities. Eur J Cardiothorac Surg 24:953-60.

Cheng W, Denton TA, Fontana GP, et al. 2002. Off-pump coronary surgery: effect on early mortality and stroke. J Thorac Cardiovasc Surg 124:313-20.

Gamoso MG, Phillips-Bute B, Landolfo KP, Newman MF, Stafford-Smith M. 2000. Off-pump versus on-pump coronary artery bypass surgery and postoperative renal dysfunction. Anesth Analg 91:1080-4.

Goldstein DJ, Beauford RB, Luk B, et al. 2003. Multivessel off-pump revascularization in patients with severe left ventricular dysfunction. Eur J Cardiothorac Surg 24:72-80.

Kolessov VI. 1967. Mammary artery-coronary artery anastomosis as method of treatment for angina pectoris. J Thorac Cardiovasc Surg 54:535-44.

Mack MJ, Pfister A, Bachand D, et al. 2004. Comparison of coronary bypass surgery with and without cardiopulmonary bypass in patients with multivessel disease. J Thorac Cardiovasc Surg 127:167-73.

Patel NC, Grayson AD, Jackson M, et al, and on behalf of the North West Quality Improvement Programme in Cardiac Interventions. 2002. The effect off-pump coronary artery bypass surgery on in-hospital mortality and morbidity. Eur J Cardiothorac Surg 22:255-60.

Puskas JD, Williams WH, Duke PG, et al. 2003. Off-pump coronary artery bypass grafting provides complete revascularization with reduced myocardial injury, transfusion requirements, and length of stay: a prospective randomized comparison of two hundred unselected patients undergoing off-pump versus conventional coronary artery bypass grafting. J Thorac Cardiovasc Surg 125:797-808.

Sabik JF, Blackstone EH, Lytle BW, Houghtaling PL, Gillinov AM, Cosgrove DM. 2004. Equivalent midterm outcomes after off-pump and on-pump coronary surgery. J Thorac Cardiovasc Surg 127:142-8.

Taggart DP, Browne SM, Halligan PW, Wade DT. 1999. Is cardiopulmonary bypass still the cause of cognitive dysfunction after cardiac operations? J Thorac Cardiovasc Surg 118:414-20.

Takagi H, Matsui M, Umemoto T. 2010. Off-pump coronary artery bypass may increase late mortality: a meta-analysis of randomized trials. Ann Thorac Surg 89:1881-8.

Weerasinghe A, Athanasiou T, Al-Ruzzeh S, et al. 2005. Functional renal outcome in on-pump and off-pump coronary revascularization: a propensity-based analysis. Ann Thorac Surg 79:1577-83.