

Minimally Invasive Coronary Revascularization in Women: A Safe Approach for a High-Risk Group

(#2000-0409 ... January 13, 2000)

Kathleen R. Petro, MD, Mercedes K.C. Dullum, MD, Jorge M. Garcia, MD,
Albert J. Pfister, MD, Anjum G. Qazi, MD, Steven W. Boyce, MD, Ammar S. Bafi, MD,
Sotiris C. Stamou, MD, Paul J. Corso, MD

Division of Cardiac Surgery, Department of Surgery, Washington Hospital Center, Medstar Research Institute, Washington, DC

ABSTRACT

Purpose: Female gender has been shown to be an independent risk factor for mortality in coronary artery bypass graft (CABG) surgery. This report analyzes our early outcomes in 304 women who underwent off-pump coronary artery bypass (OPCAB) surgery at the Washington Hospital Center (Washington, DC) over the last 3 years to determine whether this is a safe approach for coronary bypass in women.

Methods: A retrospective review of 5,528 cases of CABG bypass (on-pump) and 840 cases of OPCAB surgery, from June 1996 to July 1999, was performed. Women accounted for 1,527 (27.6%) of the on-pump bypass cases and 304 (36.2%) of the OPCABs. All cases without cardiopulmonary bypass were included, with the majority of the most recent cases being multivessel revascularization. The data for analysis were obtained from our cardiac surgery database and included cases from all surgeons operating at the Washington Hospital Center, although the majority of off-pump cases were performed by only a few of these surgeons.

Results: The two groups were similar with respect to urgent cases, redos, and other comorbidities including pre-operative congestive heart failure, peripheral vascular disease, transient ischemic attack (TIA), cerebral vascular accident, and previous myocardial infarction. The mean age for the two groups was similar, 67 years for the off-pump group and 66 years for the on-pump group. The absolute

number of all off-pump cases increased each year (from 175 to a total of 373), representing a corresponding increase in percentage of all coronary artery bypass procedures (from 9% to 16%). Of the total number of patients undergoing CABG, the percentage of women who underwent OPCAB doubled from 3% to 6% over the time period analyzed. The percentage of single-vessel cases in the off-pump group fell from 88% to 41% as multivessel bypasses became more routine. However, the percentage of patients aged ≥ 75 years was greater for the off-pump group (30%) than for the on-pump group (24%). Otherwise, the two groups differed only in diabetic disease (36% off-pump compared with 46% on-pump; $p = 0.001$) and previous transcatheter therapy (38% off-pump compared with 29% on-pump; $p = 0.003$). Patients who had OPCABs received fewer postoperative transfusions (40%) than the on-pump group (59%; $p < 0.001$). The off-pump group also had fewer neurological complications in the form of TIAs or strokes (0.3%) compared with the on-pump group (3.5%; $p = 0.001$). The mortality rate was 2.3% off-pump versus 4.1% on-pump but did not reach statistical significance in this study ($p = 0.12$).

Conclusion: Myocardial revascularization in women can be performed safely without cardiopulmonary bypass. In our series, the mortality for women receiving off-pump revascularization was lower than the on-pump cohorts despite an older age and higher incidence of diabetes. Although the absolute mortality rates did not reach statistical significance, we were encouraged that the mortality rate for women operated on without CPB dropped to the mortality rate typically seen in men. We also observed a favorable tendency in the off-pump group for a shorter length of stay and a lower incidence of transient ischemic attacks, strokes, post-op bleeding, and blood transfusions. A larger series of patients with multivariate analysis and/or a prospective trial will need to be analyzed in order to confirm our findings.

Presented at the third annual NewEra Cardiac Care conference, San Diego, California, January 13-16, 2000.

Address correspondence and reprint requests to: Mercedes K.C. Dullum, MD, Division of Cardiac Surgery, Washington Hospital Center, 106 Irving Street, NW, Washington, DC 20010. Fax: (202) 291-1436. Email: mkcd@erols.com

INTRODUCTION

Women who undergo conventional coronary artery bypass graft (CABG) surgery using cardiopulmonary bypass (CPB) are shown to have a higher perioperative mortality compared with men. This difference has been attributed to many factors including anatomical characteristics, comorbid conditions, functional class, and conduit usage [Fisher 1982, Richardson 1986, Khan 1990, O'Connor 1993, Mickleborough 1995]. Female gender itself has been shown to be an independent predictor of mortality [Edwards 1998].

Off-pump coronary artery bypass (OPCAB) surgery has been shown to be a feasible, safe alternative to on-pump CABG surgery. Complete revascularization can now be accomplished in a majority of patients with excellent short-term results [Bergsland 1998, Cartier 1999]. OPCAB surgery has also been shown to be a viable alternative in some high-risk groups such as octogenarians and those with impaired left ventricular (LV) function [Yaron 1997, Stamou, in press]. Others have demonstrated not only the safety of OPCAB but also the beneficial effect of avoiding CPB during CABG in patients with impaired LV function [Pfister 1992]. In the present study, we analyze our early outcomes in another high-risk group consisting of 304 women.

MATERIALS AND METHODS

The computerized database of the Division of Cardiac Surgery of the Washington Hospital Center was used to identify all patients who underwent CABG surgery between June 1996 and July 1999. During that time, there were 5,528 cases of CABG (on-pump) and 840 OPCAB. Women accounted for 1,527 (27.6%) of the on-pump cases and 304 (36.2%) of the off-pump cases. Data analyzed included cases from all surgeons ($n = 11$) at the Washington Hospital Center, although the majority of off-pump cases (80%) were performed by only a few of these surgeons ($n = 4$).

Indications for OPCAB changed over the course of the study. Early on, indications included patients who were considered at high risk for CPB due to medical comorbidities such as renal failure, diffuse cerebrovascular and peripheral vascular disease, aortic atherosclerosis, chronic obstructive pulmonary disease, and religious convictions that precluded blood transfusions. As the study progressed and surgeons gained more experience, however, the only indication for OPCAB became the need for CABG. On-pump CABG was performed in cases of severe hemodynamic instability and whenever accuracy or patency of the distal anastomosis was in doubt due to suboptimal or small vessels on the back of the beating heart.

Operations were performed through either median sternotomy, left anterior thoracotomy (MIDCAB approach), or left posterolateral thoracotomy. Routine hemodynamic, electrocardiographic, and arterial blood gas monitoring

were performed throughout the procedure. A heparin bolus of 10,000 IU was administered to all patients. Activated clotting time was kept in a range of 300–350 seconds. Lidocaine and magnesium were given to all patients prior to manipulation of the heart.

The majority of cases were performed through a median sternotomy which facilitated multivessel revascularization. The internal mammary artery was harvested using a Rultract™ retractor (Rultract Inc., Cleveland, OH). Pericardial traction sutures were placed anterior to the left pulmonary veins, transverse sinus, and inferior vena cava in order to lift the heart and provide ideal exposure. The target coronary arteries were occluded proximally with a silastic suture bolstered with a felt plegget. No ischemic preconditioning was used for myocardial protection. One of the commercially available mechanical stabilizers was used to stabilize the target vessels (CardioThoracic Systems Inc., Cupertino, CA; Medtronic Octopus II, Minneapolis, MN). A blower device was used to keep the field clear of blood (Aries CO₂ Blower; CardioThoracic Systems Inc.). Distal anastomoses were constructed using continuous 7-0 monofilament sutures. Proximal anastomoses were sewn to the aorta under partial occlusion clamp with 5-0 sutures.

The MIDCAB approach through a left anterior thoracotomy was used for isolated disease of the proximal or mid-left anterior descending artery or first diagonal. This approach utilized a 6–9 cm incision through which the fourth intercostal space was entered without removal of the rib. The left internal mammary artery was harvested under direct visualization from the level of the fifth intercostal space to the left subclavian vein. The pericardium was incised in a longitudinal fashion close to the pedicle of the internal mammary artery and suspended by traction sutures. Distal anastomoses were performed as described above.

Major indications for posterolateral thoracotomy included stenosis and regrafting of the circumflex system. Single lung ventilation, lateral decubitus positioning of the patient, and a fifth intercostal incision were used as appropriate. With the lung retracted, the pericardium was opened posterior to the phrenic nerve. The radial artery or saphenous vein were used as conduits to graft the second and third marginal arteries as well as the posterolateral branch of the circumflex artery. The proximal anastomosis was placed on the descending thoracic aorta with this approach.

Baseline demographics, procedural data, and perioperative outcomes were recorded according to pre-specified data entry forms. Data were analyzed according to the Society of Thoracic Surgery National Cardiac Database guidelines and definitions. Primary comparisons were performed between off pump and on pump cases. Data are expressed as percentages or as mean \pm SD. Categorical variables were compared using Fischer exact chi-square test. Continuous variables were compared using a two-tailed, unpaired Student's t-test. P values ≤ 0.05 were considered statistically significant. All statistical analyses were performed using the program SPSS 8.0 for Windows 95 (SPSS Inc., Chicago, IL).

Table 1. Preoperative Demographics

Variable	Off-pump	On-pump	P value
Urgent cases, %	53	57	0.2
Redos, %	7.6	7.0	0.7
CHF, %	11	12	0.6
PVD, %	22	20	0.4
CVA/TIA, %	13	13	1
Previous MI, %	40	45	0.1
Mean age, y	67	66	0.5
≥75 years, %	30	24	0.03
≥80 years, %	12	8	0.03
Diabetes, %	36	46	0.001
Previous TCT	38	29	0.003

CHF = congestive heart failure; PVD = peripheral vascular disease; CVA = cerebral vascular accident; TIA = transient ischemic attack; MI = myocardial infarction; TCT = transcatheter therapy

RESULTS

All cases without CPB were included in the analysis. The preoperative clinical characteristics of the off-pump CABG and the on-pump CABG groups are summarized in Table 1 (◎). Although this study was not risk stratified, the two groups were similar with respect to urgent cases, redos, and other comorbidities including congestive heart failure, peripheral vascular disease, transient ischemic attack (TIA), cerebral vascular accident, and previous myocardial infarction. The mean age for the two groups was similar, 67 years for the off-pump group and 66 years for the on-pump group. However, the percentage of patients aged ≥75 years was greater for the off-pump group (30%) than for the on-pump group (24%); the percentage of patients aged ≥80 years was also greater for the off-pump group (12%) than for the on-pump group (8%). Otherwise, the two groups differed only in diabetic disease (36% off-pump compared with 46% on-

Table 2. Postoperative Outcomes

Variable	Off-pump	On-pump	P value
Mean no. grafts/patient	1.7	3.5	<0.001
All SVG, %	14	28	<0.001
Arterial conduits, %	86	72	<0.001
Transfused, %	40	59	<0.001
TIA/CVA, %	0.3	3.5	0.001
Reop for bleeding, %	1.3	2.2	0.4
Afibrillation/flutter, %	26	31	0.09
Renal failure, %	0.3	0.5	1.0
Mortality, %	2.3	4.1	0.12

SVG = saphenous vein graft; TIA = transient ischemic attack; CVA = cerebral vascular accident

pump; $p = 0.001$) and previous transcatheter therapy (38% off-pump compared with 29% on-pump; $p = 0.003$).

The postoperative outcomes for both groups are summarized in Table 2 (◎). Complete revascularization was achieved in all patients. The mean number of grafts was significantly higher in the on-pump group (3.5 grafts per patient) when compared with the off-pump group (1.7 grafts per patient; $p < 0.001$). Of note, a large percentage of patients who underwent off-pump surgery received arterial conduits (86% compared with 72% on-pump; $p < 0.001$). Furthermore, only 14% of the off-pump cases involved using all saphenous vein grafts (SVGs), whereas 28% of on-pump cases used only SVGs.

Patients who had OPCABs received fewer postoperative transfusions (40%) than the on-pump group (59%; $p < 0.001$). The off-pump group also had fewer neurological complications in the form of TIAs or strokes (0.3%) compared with the on-pump group (3.5%; $p = 0.001$).

Off-pump patients had a shorter length of stay compared with on-pump patients. More than half of off-pump patients (59%) were discharged by the fifth postoperative day compared with only 39% of on-pump patients ($p <$

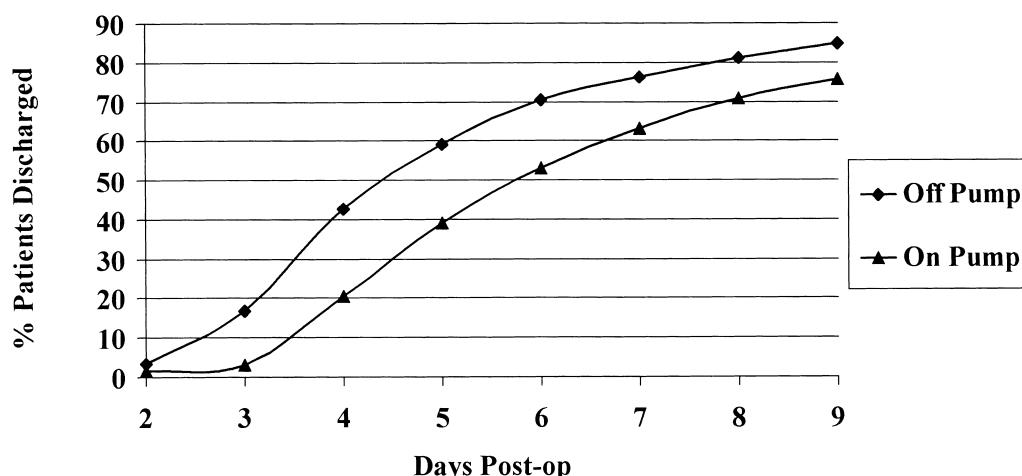


Figure 1. Length of stay for off-pump compared with on-pump CABG.

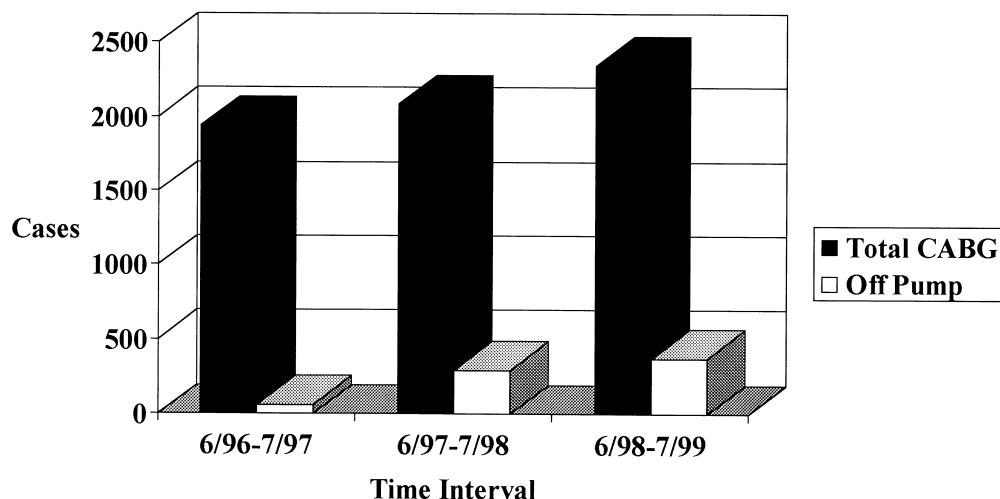


Figure 2. Total number of cases performed with and without cardiopulmonary bypass.

0.001); 75% of all off-pump patients were discharged by day seven compared with 75% of on-pump patients who were discharged by Day 9 (Figure 1, ②).

The two groups did not differ significantly in other outcomes such as reoperation for bleeding, renal failure, and interestingly, the rate of postoperative atrial fibrillation/flutter, despite the absence of atrial manipulation and cardiopulmonary bypass.

Mortality after OPCAB for patients included in our study was low ($n = 7$; 2.6% overall). In women undergoing off-pump revascularization, the mortality rate was 2.3% as compared with 4.1% when using cardiopulmonary bypass. Despite the low total mortality rate in women undergoing OPCAB, a statistically significant difference could not be documented ($p=.012$). Causes of death for the off-pump group included heart failure ($n = 3$), multi-organ failure ($n = 3$), and respiratory failure ($n = 1$).

DISCUSSION

There has been renewed and increasing interest in coronary revascularization performed on the beating heart. As techniques have become more refined, the number of cases performed off-pump has increased substantially and the indications continue to change. Shown to be both safe and effective, the role of off-pump CABG (OPCAB) is now being studied in high-risk groups.

During the past three years, the number of OPCAB operations performed at our institution has significantly increased. The absolute number and percentage of all off-pump cases increased each year, from 175 to 373 (from 9% to 16% of all coronary artery bypass procedures, respectively) (Figure 2, ②). A parallel increase in the percentage of women who underwent off-pump procedures has also been documented. During this time period, the percentage

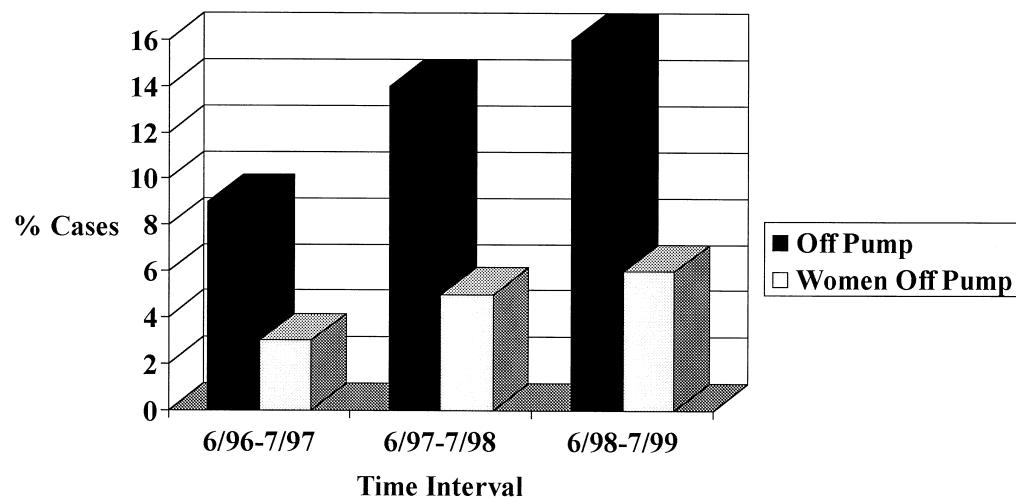


Figure 3. Percentage of all cases performed off-pump and percentage of cases performed off-pump in women.

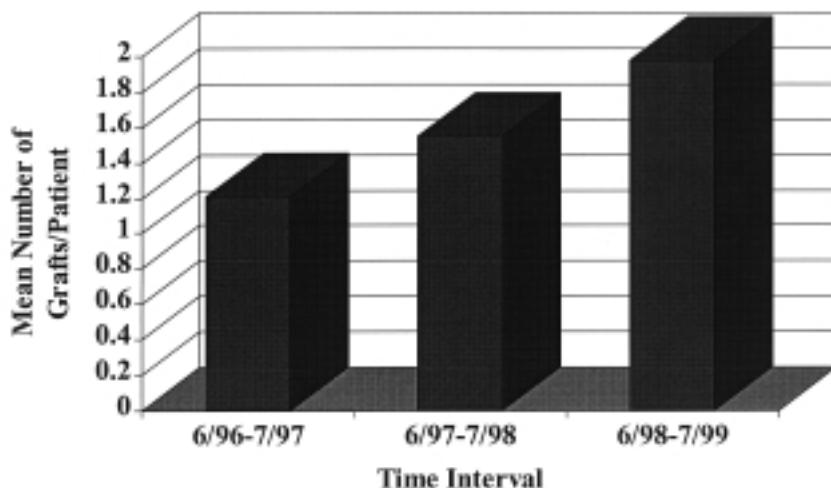


Figure 4. Mean number of grafts per patient.

of women who underwent off-bypass CABG as a component of the total number of patients undergoing CABG doubled from 3% to 6% (Figure 3, \oplus).

Technical improvements and better stabilization have also facilitated an increase in multivessel revascularization procedures on the beating heart. During the course of this study, multivessel bypasses became more routine and the mean number of grafts performed increased linearly (Figure 4, \oplus).

Other important trends in this analysis included decreased morbidity, in terms of neurologic complications and need for blood transfusions, as well as a tendency for shorter lengths of stay, all of which can potentially lower the risk/benefit ratio in addition to the economic cost of cardiac operations.

Our findings are preliminary but are important on a number of fronts. First, the CABG mortality rate for men has always been lower than for women. This was confirmed by logistic regression analysis on 344,913 entrants in the STS National Cardiac Surgery Database [Edwards 1998]. The elevated risk was confirmed for each of the risk factors examined (age, comorbidity, operative technique, etc.). The causes of this risk elevation were not identified. In our study, we examined whether the use of off-pump techniques would render a survival benefit for women not previously seen in the national database or other reports. Our retrospective review indicated that OPCAB was associated with fewer neurologic complications (0.3% versus 3.5%) and fewer postoperative transfusions (40% versus 59%) when compared with conventional CPB in our study cohort (both $p < 0.0001$). Although there was also an observed reduction in mortality (2.3% versus 4.1%), this trend did not reach statistical significance. We believe there is still importance to the observation that our OPCAB mortality in women is now on par with the mortality rates seen in men with conventional CPB. Although we have not proven our hypothesis yet, it is possible that OPCAB neutralizes part of the risk seen in women undergoing CABG by conventional tech-

niques. Only further study will be able to confirm or deny these initial findings.

The limitations of our study include drawbacks inherent in any retrospective study. A longer period of clinical follow-up and angiographic studies would have enabled documentation of the early and late graft patency in women undergoing off-pump CABG. Moreover, our conclusions are also weakened by the use of risk-unadjusted groups. Clearly, a randomized, prospective study with risk-stratified populations is needed to confirm our data and determine the safety, efficacy, and role of OPCAB in women.

REFERENCES

1. Bergsland J, Schmid S, Yanulevich J, Hasnain S, Lajos TZ, Salerno TA. Coronary artery bypass grafting (CABG) without cardiopulmonary bypass (CPB): A strategy for improving results in surgical revascularization. *Heart Surgery Forum* #1998-1593 1(2):107-10, 1998.
2. Cartier R. Systematic off-pump coronary artery revascularization: Experience of 275 cases. *Ann Thorac Surg* 68:1494-7, 1999.
3. Edwards FH, Carey JS, Grover FL, Bero JW, Hartz RS. Impact of gender on coronary bypass operative mortality. *Ann Thorac Surg* 66:125-31, 1998.
4. Fisher LD, Kennedy JW, Davis KB, et al. Association of sex, physical size and operative mortality after coronary artery bypass in the Coronary Artery Surgery Study (CASS). *J Thorac Cardiovasc Surg* 84:334-41, 1982.
5. Khan SS, Nessim S, Gray R, et al. Increased mortality of women in coronary artery bypass surgery: evidence for referral bias. *Ann Intern Med* 112:561-7, 1990.
6. Mickleborough LL, Takagi Y, Maruyama H, Sun Z, Mohamed S. Is sex a factor in determining operative risk for aortocoronary bypass graft surgery? *Circulation* 92(Suppl 2):80-4, 1995.
7. O'Connor GT, Morton JR, Diehl MJ, et al. Differences between men and women in hospital mortality associated with coronary artery bypass graft surgery. *Circulation* 88(Part 1):2104-

10, 1993.

- 8. Pfister AJ, Zaki MS, Garcia JM, et al. Coronary artery bypass without cardiopulmonary bypass. *Ann Thorac Surg* 54:1085-92, 1992.
- 9. Richardson JV, Cyrus RC. Reduced efficacy of coronary artery bypass grafting in women. *Ann Thorac Surg* 42:S16-21, 1986.
- 10. Stamou SC, Dangas G, Dullum MKC, Pfister AJ, Boyce SW, Bafi AS, et al. Beating heart surgery in octogenarians: Perioperative outcome and comparison with younger age groups. *Ann Thorac Surg* (in press).