

## In-hospital Outcome of 212 Consecutive Patients with Off-pump Coronary Artery Bypass at Zagreb University Hospital Center

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**Aim.** To determine the in-hospital outcome of patients undergoing off-pump coronary artery bypass grafting.

**Methods.** The study included 212 consecutive patients (147 men and 65 women) undergoing off-pump coronary artery bypass grafting between March 2000 and March 2002. Mean  $\pm$  SD age of the patients was  $60 \pm 8$  years. We analyzed in-hospital mortality and perioperative and postoperative course of treatment of our patients.

**Results.** The mean  $\pm$  SD number of grafts was  $2.9 \pm 0.9$  per patient. More than 75% of patients were extubated within the first 6 h after surgery, and 6% received no blood transfusions. The mortality rate was 2.8% and there were no intraoperative deaths.

**Conclusion.** Off-pump coronary artery bypass procedure seems a safe alternative to standard on-pump revascularization procedures and can also be safely suggested to elderly population.

**Key words:** *cardiac surgical procedures; coronary artery bypass; coronary disease; myocardial revascularization; treatment outcome*

With the increasing awareness of the negative aspects of cardiopulmonary bypass, the interest has grown in off-pump coronary artery bypass surgery as an alternative method of surgical revascularization (1,2). There are numerous benefits from avoiding cardiopulmonary bypass, including circumvention of the deleterious effects of non-pulsatile flow (3) and reduction of oxidative stress (4) and renal dysfunction, which occurs in standard on-pump coronary artery bypass procedures (5,6). Off-pump coronary artery bypass surgery has been associated with a decrease in transfusion requirement (7), shorter postoperative length of stay (8), less frequent atrial fibrillation (9), and lower incidence of neurologic complications (10). This advantage is even more pronounced in high-risk patients, such as the elderly (11). Due to innovative technical developments, off-pump coronary artery bypass surgery can now be safely offered to patients with multivessel coronary artery disease (12). Avoidance of ascending aorta manipulation related to aortic cannulation and cross-clamping may be beneficial due to aortic atherosclerosis commonly seen in patients with overt coronary artery disease (13). This report describes our experience in the treatment of coronary artery disease by employing off-pump coronary artery bypass procedures in 212 consecutive unselected patients.

### Patients and Methods

#### *Patients*

Since March 2000 until March 2002, 217 consecutive patients referred for surgical coronary revascularization were scheduled for off-pump coronary artery bypass grafting. There were no exclusion criteria at the operation planning stage. All patients were accepted for surgical management of their coronary artery disease by a single surgeon and scheduled for off-pump coronary artery bypass surgery. Five patients (2.3%) in whom the operation started as an off-pump coronary artery bypass procedure had to be converted to surgical revascularization with the aid of cardiopulmonary bypass because of hemodynamic intolerance of heart manipulations. These patients were excluded from the study. The mean age of patients was  $60 \pm 8$  years (Table 1). There were 147 men and 65 women, and 37% of the analyzed patients had a history of myocardial infarction. In 22% of the patients, a baseline ejection fraction (EF) was  $< 35\%$ . These patients were considered high-risk, as well as other 39 patients in whom the procedure was scheduled with urgent priority. Seventy-two patients (34%) had diabetes mellitus, 7 (3.3%) had a history of cardiac surgical procedures, and 6 (2.8%) had a previous stroke (Table 1). Their mean EuroScore (14) was 4.3 (Table 1).

#### *Anesthetic Technique and Anticoagulation Protocol*

All patients received morphine in a dose of 0.1 mg/kg (Morphine Merck 10, Merck KGaA, Darmstadt, Germany) preoperatively. General anesthesia was induced with midazolam in a dose of 0.1 mg/kg (Dormicum, F. Hoffmann-La Roche, Basel, Switzerland), fentanyl in a dose of 10-15  $\mu$ g/kg (Fentanyl-Janssen, Janssen Pharmaceutica, Beerse, Belgium), and pancuronium in a dose of 0.15 mg/kg (Pavulon A, Organon Teknika, Bostel, Holland).

Anesthesia was maintained with inhalation agents (sevoflurane or isoflurane), as well as with repeated doses of fentanyl and

**Table 1.** Demographic data of the 212 patients who underwent off-pump coronary surgery

Parameter <sup>a</sup>	No. (%) of patients
Age (years, mean $\pm$ SD)	60 $\pm$ 8
Gender distribution (men/women)	147/65 (69/31)
Diabetes mellitus	72 (33.9)
Previous AMI	78 (36.8)
Previous CVA	6 (2.8)
Previous cardiac surgery	7 (3.3)
Urgent case	39 (18.4)
EuroScore	4.3
EF < 35%	47 (22.2)
EF 36-60%	74 (34.9)
EF > 60%	91 (42.9)

<sup>a</sup>Abbreviations: AMI – acute myocardial infarction; CVA – cerebral vascular accident; EF – ejection fraction.

pancuronium. Hypertension was treated with vasodilators (sodium nitroprusside and nitroglycerine). Arterial hypotension was managed with alpha agonists. We aimed at achieving a mean arterial pressure of 70-80 mm Hg. Partial heparinization (10,000 IU) was initiated during harvesting of the left internal mammary artery. Neutralization of heparin with protamine sulfate was not needed.

#### Surgical Technique

A Swan-Ganz catheter was introduced with the aim of monitoring each patient's hemodynamic performance. Routine intraoperative monitoring protocols were used for all patients (15). The off-pump coronary artery bypass surgery was performed via a full median sternotomy. The internal mammary artery and saphenous vein were then harvested. The left internal mammary artery was used for the left anterior descending artery graft in all patients. Of other conduits, saphenous vein grafts were used in all but 3 patients, in whom the radial artery was taken from the non-dominant arm and used as a conduit. Our institution's standard practice is to administer a non-dihydropyridine calcium channel blocker, verapamil (Isoptin, Pliva d.d., Zagreb, Croatia), in all patients receiving arterial conduits. The coronary arteries and their principal branches were inspected and the optimal location for placing a distal anastomosis identified. We found no anatomic contraindications for performing off-pump coronary artery bypass procedures. A deep pericardial traction suture was placed to facilitate heart mobilization. The Medtronic<sup>®</sup> Octopus 2 and 3 devices (Medtronic, Minneapolis, MN, USA) were deployed for mechanical epicardial anastomotic site stabilization. The Starfish Medtronic<sup>®</sup> Heart Positioner (Medtronic) was used for dislocating the apex of the heart to gain access to the left circumflex artery and the obtuse marginal branches. Clearview intracoronary shunts (Medtronic) of variable sizes were used in most cases to maintain distal coronary perfusion of a nonoccluded vessel.

The first anastomosis was performed between the left internal mammary artery and the left anterior descending artery in all patients, with little or no hemodynamic instability during this stage. Our next step in revascularization was to graft the right coronary artery territory. Grafting of the circumflex artery region was the last and most critical segment of off-pump coronary artery bypass surgery, because significant hemodynamic instability may occur during the exposure of the circumflex artery. Accordingly, a reduction in left ventricular compliance and restrictive diastolic filling with concomitant impairment of systolic function were recorded by transesophageal echocardiography (16). Fortunately, these changes in myocardial performance were of limited duration and resolved after the completion of the left circumflex coronary artery anastomosis.

The standard postoperative regimen included administration of Aspirin 100 mg and ticlopidine 250 mg, starting 6 h after surgery.

## Results

The average number of distal anastomoses was  $2.9 \pm 0.89$  (Table 2). Over 76% of the patients were

extubated within 6 h of arrival to the intensive care unit. Four patients (2%) had to be reintubated due to respiratory insufficiency. Most patients (84%) required no inotropic support. Left ventricular function and coronary perfusion were increased in 8 (4%) patients by intra-aortic balloon pump counter pulsation, which was placed preoperatively in two cases (Table 3). Sixty percent of patients did not receive any blood products in the perioperative period. There were no intraoperative deaths. Over 40% of patients were transferred to the step-down unit after spending only a day in the intensive care unit: 87 patients stayed in intensive care unit for a day, 76 for 2 days, 30 for 3 days, and 19 for more than 3 days. Nineteen patients required prolonged treatment and 6 (2.8%) died in the intensive care unit (Table 4).

**Table 2.** Revascularization strategy of the 212 patients who underwent off-pump coronary surgery

No. of distal anastomoses	No. (%) of patients
1	16 (7.5)
2	46 (21.7)
3	95 (44.8)
4	53 (25.0)
5	2 (0.9)
Mean $\pm$ SD	2.9 $\pm$ 0.9

**Table 3.** Early postoperative course of the 212 patients who underwent off-pump coronary surgery

Procedure	No. (%) of patients
Extubation within 6 h	162 (76.4)
Extubation after 6 h	50 (23.6)
Inotropic drugs administered	33 (15.6)
No inotropic drugs administered	179 (84.4)
Preoperative IABP <sup>a</sup>	2 (0.9)
Perioperative IABP	6 (2.8)

<sup>a</sup>IABP – intra-aortic balloon pump.

**Table 4.** Causes of death in 6 patients who underwent off-pump coronary surgery<sup>a</sup>

Cause of death	No. of patients	Preoperative risk factors			
		sex	age (years)	EF (%)	urgency of operation
AMI	2	man	57	40	elective
		man	64	50	urgent
CVA	1	man	63	40	elective
MOF	1	woman	60	60	urgent
Sudden death	2	woman	59	45	urgent
		man	60	40	elective
Total	6				

<sup>a</sup>Abbreviations: AMI – acute myocardial infarction; CVA – cerebral vascular accident; MOF – multiple organ failure; EF – ejection fraction.

## Discussion

Recent technical developments and accumulated surgical experience have made off-pump coronary artery surgery a safe and reliable alternative to conventional coronary artery bypass grafting procedures. Off-pump coronary artery bypass operations have been associated with a decrease in the incidence of stroke as one of the most devastating complications of cardiac surgery (17). The requirement for blood products has been also significantly reduced, as well as the length of stay in the intensive care unit, incidence of mediastinitis, and postoperative atrial fibrillation (18). Off-pump myocardial revascularizati-

on has been shown to improve the outcome in high-risk patients, including the elderly (19-21). Our experience corroborates these findings, as many of our patients fall into this category. A fifth of our patients have had a significant left ventricular dysfunction preoperatively, which manifested with a reduction in the ejection fraction to < 35%. Since the inhospital mortality in our study was 2.8%, we can conclude that off-pump coronary artery bypass procedures can safely be performed even in the high-risk group of patients. Over 70% of patients in the investigated group had three-vessel coronary artery disease. We believe that patients with multivessel disease can safely be evaluated for off-pump coronary artery bypass procedures. Innovative techniques of epicardial stabilization have made grafting of the left circumflex artery territory possible. Our revascularization technique involved three or more distal anastomoses in over two-thirds of cases. Hemodynamic disturbances are most commonly seen during heart positioning to gain access to the circumflex artery. This instability arises from restrictive diastolic filling of the left ventricle, as well as a reversible systolic dysfunction. In five patients who were initially scheduled for off-pump coronary artery bypass, the procedure could not be completed due to hemodynamic intolerance of the required heart manipulations. These patients were converted to conventional coronary artery bypass grafting and excluded from the study. The avoidance of cardiopulmonary bypass is associated with a reduced systemic inflammatory response, which is a well-established cause of morbidity following cardiac surgical procedures (22).

The postoperative length of the stay was reduced with the introduction of off-pump coronary artery bypass. In our series, over 40% of patients stayed in the intensive care unit for only a day, as opposed to only 9% of patients who stayed for over three days. We believe that the reason was a more expeditious recovery of the respiratory function, as indicated by the fact that 76% of our patients were extubated within 6 h of arrival to the intensive care unit. Reduced administration of blood products was a consequence of less blood loss in the operating room. Blood transfusions were not required in as many as 60% of our cases. Inotropic support, which is routinely used in all our on-pump cases for at least a limited amount of time, was unnecessary in 84% of patients undergoing off-pump coronary artery bypass. We believe that this indirectly testifies to the fact the off-pump coronary artery bypass procedures are less damaging to the myocardium and allow an earlier recovery. All of these factors provide a solid basis for early patient discharge.

In conclusion, we believe that off-pump coronary artery bypass is an excellent alternative method of myocardial revascularization even in the setting of multivessel disease. The advantages of avoiding cardiopulmonary bypass are best seen in the reduced requirement for blood products and positive inotropic agents as well as shorter stay in intensive care unit. The decreased incidence of stroke, which is one of the most catastrophic complications of cardiac surgery, is another strong incentive to favor off-pump

coronary artery bypass procedures over conventional coronary artery bypass grafting.

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