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Conversions in Off-Pump Coronary Surgery

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ABSTRACT

Methods: There have been 784 coronary artery bypass grafting (CABG) procedures performed at a new center for treating cardiovascular disease in Tuzla, Bosnia and Herzegovina, and the surgical team has been fully trained in off-pump coronary artery bypass (OPCAB) surgery. All surgical patients were considered for on-pump CABG (ONCAB) and OPCAB surgical procedures. Minimally invasive direct coronary artery bypass grafting and robotic procedures were done as OPCAB. For multivessel median sternotomy cases, the selection criteria were arbitrary (approximately 50% were performed as ONCAB for perfusionist training). Patients who were scheduled for and began their operations as OPCAB but who were then placed on cardiopulmonary bypass during the surgical procedure were counted as conversions. The outcomes of converted patients were studied and are the subject of this report.

Results: Of the 784 CABG procedures, 391 (49.6%) were scheduled and performed as ONCAB operations; 357 (45.5%) were performed as OPCAB; and 36 (9.2% of the originally scheduled OPCAB patients or 4.6% of the total number of CABG surgeries) were originally scheduled as OPCAB operations but were converted to ONCAB. Reasons for conversions were hemodynamic instability (21 patients), difficult revision of grafts (8), ventricular fibrillation (5), and poor native vessel (2). Outcomes of patients undergoing conversions were analyzed with respect to the conversion cause. When the cause of the conversion was mild-to-moderate hemodynamic instability or difficult graft revision (n = 27), no adverse ischemic effects were seen; however, when the cause of conversion was severe hemodynamic instability, ventricular fibrillation, or cardiac arrest (n = 9), 6 patients (66.6%) had severe ischemic complications involving the central nervous system or the myocardium.

Discussion: Myocardial ischemia must be monitored and treated aggressively in OPCAB surgery. In patients with mild hemodynamic instability, conversion did not adversely affect outcome. In patients with severe hemodynamic compromise and cardiac arrest, serious complications of cerebral and myocardial ischemia were observed. The appropriate timing of conversion is essential.

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INTRODUCTION

Since the initiation of the cardiac program in Tuzla, off-pump coronary artery bypass (OPCAB) grafting has been the preferred approach to treat coronary artery disease in our institution. Half of the operations that have been performed, however, have been on-pump coronary artery bypass (ONCAB) for the purpose of perfusionist training. The purpose of this study was to examine the group of OPCAB patients who underwent conversion to cardiopulmonary bypass (CPB) during the procedure.

MATERIALS AND METHODS

In the first 4 years after the opening of the new center, 784 coronary artery bypass grafting (CABG) procedures were performed. The preferred approach for coronary surgery has been OPCAB, and surgical team members have been trained in this procedure from the beginning of their cardiac training. All patients were considered as potential candidates for both the ONCAB and OPCAB surgical procedures. Minimally invasive direct coronary artery bypass grafting (MIDCAB) and robotic procedures were done as OPCAB. For multivessel median sternotomy cases, the selection criteria were arbitrary. There was a need to do approximately 50% of the cases on CPB to develop perfusionist proficiency.

ONCAB was carried out through a median sternotomy. CPB was instituted after the ascending aortic and right atrium were cannulated. Myocardial protection was achieved by intermittent anterograde and/or retrograde cold blood cardioplegia. After completion of all distal anastomoses on the arrested heart, the aortic cross-clamp was removed, and the proximal anastomoses were performed with partial occlusion of the aorta.

OPCAB was mainly done through a median sternotomy, and 25 operations were performed as MIDCAB procedures. To achieve an adequate exposure of the heart, we placed a deep pericardial Lima stitch [Lima 1995] in the oblique sinus of the posterior pericardium. Manipulating this stitch enabled the safe and effective positioning of the heart [Karamanoukian 1999].

The target vessel was exposed and snared above and/or below the anastomotic site with a 4-0 pledgetted polypropylene (Prolene) suture and a soft rubber tourniquet to avoid injury to the coronary artery. An intracoronary shunt was frequently used to prevent bleeding during the anastomosis and distal ischemia [Rivetti 1997]. Visualization of the anastomotic site was improved by the use of a surgical blower. The CPB machine was kept in the immediate vicinity with the

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Table 1. Patient Demographic Data*

	ONCAB (n = 391)	OPCAB (n = 357)	Conversions (n = 36)
Sex, n			
Male	330 (84.39%)	287 (80.39%)	27 (75.00%)
Female	61 (15.60%)	70 (19.60%)	9 (25.00%)
Age, y	56.15	57.09	57.38
Ejection fraction	51.86%	52.42%	51.38%
Grafts, n	3.09	1.98	2.75

*Data are averages where appropriate. ONCAB indicates on-pump coronary artery bypass; OPCAB, off-pump coronary artery bypass.

Table 2. Postoperative Morbidity and Mortality*

	ONCAB, n	OPCAB, n	Conversions, n
Stroke	8 (2.04%)	4 (1.12%)	3 (8.33%)
IABP	3 (0.76%)	0 (0.00%)	3 (8.33%)
Total ischemic complications	11 (2.81%)	4 (1.12%)	6 (16.66%)
Mortality	11 (2.81%)	2 (0.56%)	0 (0.00%)

*ONCAB indicates on-pump coronary artery bypass; OPCAB, off-pump coronary artery bypass; IABP, intra-aortic balloon pump.

circuit mounted but without the machine being primed. Tubes were not placed on the operating table.

The left anterior descending coronary artery was revascularized first to secure a proper perfusion of the septum and the anterior wall prior to the major manipulation of the heart. Heparin was given in doses of 3 mg/kg in ONCAB to keep the activated coagulation time above 400 seconds and in doses of 2 mg/kg in OPCAB to keep the activated coagulation time above 300 seconds.

Intraoperative flow verification with transit time flow measurement (CardioMed Flowmeter; Medi-Stim AS, Oslo, Norway) was used in all grafts as a quality assurance measure [Di Giammarco 1999]. When no reversible cause of poor transit time flow measurement results was identified, the graft was revised [D'Ancona 2000].

Patients who were scheduled for and whose procedures started as OPCAB but who were then placed on CPB during the surgical procedure were counted as having undergone conversions. OPCAB patients who needed graft revisions usually had their graft(s) revised without CPB [D'Ancona 1999]. When the revision of the graft was too difficult, the patient underwent conversion to CPB. Other reasons for conversions were hemodynamic instability, ventricular fibrillation, and poor native vessel. After the decision was made to convert, the pump was rapidly primed, the patient was fully heparinized, and rapid cannulation was performed after purse-string sutures were placed on the aorta and right atrium. In cases of ventricular fibrillation or cardiac arrest, the patient was immediately defibrillated, and cardiac massage was initiated if necessary. The operation was then completed with or without cross-clamping of the aorta and cardioplegic arrest, depending on the situation.

RESULTS

Of the 784 CABG procedures, 391 were ONCAB (49.6%), 357 were OPCAB (45.5%), and 36 operations were converted from OPCAB to ONCAB. Of the originally scheduled OPCAB procedures, 9.16% were converted to CPB. Reasons for conversions were hemodynamic instability (21 patients, 58.3%), revision of grafts (8 patients, 22.2%), ventricular fibrillation (5 patients, 13.8%), and poor native vessel (2 patients, 5.6%).

Demographic data of patients for all 3 groups are shown in Table 1. All groups were comparable in terms of sex, age, and ejection fraction. The groups comprised predominantly male patients, the average ages were similar, and ejection fraction values were almost identical. The mean number of grafts per patient was higher in the ONCAB group (3.09) than in the OPCAB group (1.98). This difference was probably due to tendencies to select patients requiring more grafts for the ONCAB procedure and not to graft very small vessels with the OPCAB technique.

Major ischemic postoperative complications are shown in Table 2. The most common ischemic complications were stroke and global myocardial ischemia requiring an intra-aortic balloon pump. There were no deaths in the patients who underwent conversions, whereas 11 deaths in the ONCAB group (2.81%) and 2 deaths in the OPCAB group (0.56%) were registered (Table 2).

As can be seen from Table 2, conversions had a markedly increased rate of ischemic complications. Twenty-six patients with mild-to-moderate hemodynamic instability or a malfunctioning graft underwent conversions in a controlled fashion. These patients had no ischemic complications. Nine patients underwent conversions after cardiac arrest or severe hemodynamic collapse that could not be relieved by pharmacologic measures. Of these 9 patients, 3 experienced postoperative stroke, and 3 required an intra-aortic balloon pump for a total ischemic complication rate of 66.6%.

DISCUSSION

OPCAB has been the preferred approach for treating coronary artery disease in our center. This preference is due to the reduced complication rate seen with this procedure [Bergsland 1998]. Additionally, the economic conditions in our country make it necessary to reduce costs as much as possible. However, we performed 50% of CABG operations as ONCAB during this period to provide perfusionist training.

One of the significant risks of OPCAB surgery is the possibility of ischemia and the need to convert to CPB [Soltoski 1998]. The creation of the anastomosis requires the full attention of the surgeon while the anesthesiologist carefully monitors and treats ischemia. The main tools for detecting ischemia are electrocardiography and monitoring hemodynamic status. Visual inspection of the contractility of the heart is also important.

We believe that the 9 patients in our series who experienced cardiac arrest or severe hemodynamic instability during OPCAB represent a failure to detect ischemia at a sufficiently early stage. As we have demonstrated, such events have severe consequences. The patients who underwent conversion under controlled circumstances did not have any severe complications.

Besides a more careful monitoring of basic hemodynamics, we believe that a more frequent use of pulmonary artery pressure monitoring and, in high risk cases, transesophageal echocardiography may be helpful. In borderline cases with unstable hemodynamics, an early conversion to CPB or at least the priming of the CPB machine is indicated. This step will shorten the time necessary to initiate CPB.

Our early experience reemphasises the importance of careful monitoring of ischemia during OPCAB surgery. Careful attention to detail is important, and if conversion becomes necessary, it must be performed prior to cardiac arrest.

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