

## Off-Pump Coronary Artery Bypass Surgery—Initial Experience in Gdansk: A Brief Review

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### ABSTRACT

**Background:** Before the introduction of cardiopulmonary bypass (CPB), coronary artery bypass grafting (CABG) procedures were performed on a beating heart. In 1967, Kolessov first reported “off-pump” revascularization of the left anterior descending artery (LAD). This technique was later abandoned when the use of cardioplegia and the heart-lung machine allowed a motionless and bloodless operative field. This study reports our initial clinical experience in off-pump coronary bypass surgery performed at the Department of Cardiac Surgery of the Medical University of Gdansk, Poland.

**Methods:** This study enrolled all consecutive patients who were operated on at our institution without CPB between January 1998 and December 2001. Patients were selected for the off-pump procedure individually by the surgeon. Demographics, operative procedures, postoperative mortality, morbidity, and early outcomes were analyzed. The observation period included 30 postoperative days.

**Results:** An average of 1.8 grafts per patient were completed. Conversion to CPB was required in 4.1% of patients. Complete revascularization was attained in 91% of the procedures. Surgical mortality was 1.3% and perioperative myocardial infarction was reported in 2.4%.

**Conclusions:** In selected patients, off-pump CABG may be used as a suitable and safe alternative to conventional on-pump coronary surgery and permits complete revascularization with comparable short-term results.

### INTRODUCTION

Conventional coronary artery bypass grafting (CABG) surgery with the use of cardiopulmonary bypass (CPB) and cardioplegia has been considered the standard revascularization procedure for the past 30 years. However, despite

advances in CPB techniques, the procedure is still associated with a number of adverse effects. CPB-related complications like systemic inflammatory response, atheromatous macroembolization, microembolization, stroke, and neurocognitive impairment are well documented [Roach 1996, Ascione 2000, Murkin 2000].

First reported by Kolessov, coronary artery bypass grafting without CPB was revived by Benetti, Buffolo, and Subramanian, who reported good results from their experiences with the technique [Kolessov 1967, Benetti 1991, Calafiore 1996, Subramanian 1997]. With the development of new technologies, there has been a resurgence of interest in off-pump coronary artery bypass surgery (OPCAB). The most commonly reported advantages of OPCAB are lower postoperative mortality and morbidity rates and shorter hospital stay [Hart 2000].

Complete revascularization of the heart by accessing all coronary territories requires adequate exposure and stabilization of target coronary arteries. Mechanical stabilizers have greatly contributed to achieving this goal and have demonstrated the feasibility of beating heart surgery with acceptable results [Hart 1999].

In this report, the authors present a review of 662 consecutive off-pump procedures performed at the Department of Cardiac Surgery in Gdansk, Poland.

### PATIENTS AND METHODS

Between January 1998 and December 2001, 708 coronary artery revascularization procedures were performed without the use of CPB. This represent 17.6% of all patients operated on at our department for coronary artery disease during the same period. Increasing proportions of OPCAB procedures are shown in Figure 1 (●).

The study group consisted of 662 patients (93.5%), all of whom underwent standard median sternotomy. The remaining 46 patients (6.5%) operated on off-pump were approached through a small anterior thoracotomy and were not included in this report. All data was retrieved from our local database and then retrospectively analyzed.

The mean age of studied patients was  $60.6 \pm 10.3$  years, with a range from 41 to 80. The group was predominantly male 475 (71.7%). In 305 patients (46%), the operative indication was unstable angina or failed angioplasty. Average left ventricular ejection fraction (LVEF) was  $49\% \pm 12\%$ . Left ventricular dysfunction, defined as LVEF  $<35\%$ , was present

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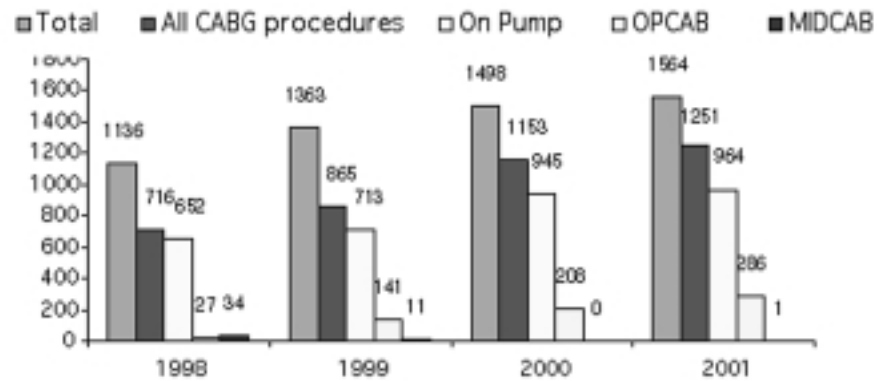


Figure 1: Overall cardiac surgery procedures at the Department of Cardiac Surgery in Gdansk

in 14% of cases. Positive myocardial infarction history was found in 324 patients (48.9%). Other demographics and pre-operative characteristics are summarized in Table 1 (⊙).

The average operative risk in the studied population according to the *EuroSCORE* was  $3.9 \pm 1.97$ .

Surgical access was through median sternotomy. After bypass conduits were harvested, anticoagulation was achieved with heparin administered at a dose of 1-2mg/kg. After all anastomoses were constructed, heparin was fully reversed with protamine sulfate. Exposure of target arteries was achieved by using deep pericardial retraction sutures in combination with wide opening of the right pleura for the visualization of the circumflex territory. In order to enhance the presentation of target vessels on the lateral and inferior wall of the heart, patients were placed in Trendelenburg position. Stabilization of the heart was achieved either with the Medtronic Octopus stabilization system or a mechanical suction-based stabilizer of our own construction, as shown in Figure 2 (⊙).

Tolerance to local ischemia was always assessed by means of repeated occlusion and reperfusion tests of the target coronary artery. Arterial occlusion was achieved by proximal and distal clamping. Figure 3 (⊙) presents the “Gdansk III” stabilizer during the construction of the anastomosis.

Table 1. Pre-operative characteristics.

Risk factors	%
Age >70 years	18.1%
Unstable angina	46%
Previous MI history	48.9%
LVEF <35%	14%
Hypertension	53%
Diabetes	22.8%
COPD	7.1%
PVD	11.8%
Neurological event	4.1%
ESRD	6%
Left main stenosis	23.7%

MI = myocardial infarction; COPD = chronic obstructive pulmonary disease; PVD = peripheral vascular disease; ESRD = end-stage renal disease; LVEF = left ventricular ejection fraction

## RESULTS

A total number of 1,192 anastomoses were constructed, with a mean number of  $1.8 \pm 0.4$  distal anastomoses per patient (range from 1 to 4). The left internal mammary artery (LIMA) was used as the bypass conduit in 413 patients (62.3%). Complete revascularization was achieved in 91% of procedures. The reasons for incomplete revascularization are listed in Table 2 (⊙). Conversion to CPB was needed in 4.12% of patients because of hemodynamic instability requiring inotropic support.

The coronary surgery procedure was combined with transmyocardial laser revascularization (TMLR) in five patients and with partial lung resection in eight patients.

Perioperative myocardial infarction was observed in 14 patients (2.41%). Low output syndrome with need of inotropic or intraaortic balloon pump (IABP) support occurred in 32 patients (4.83%), and there were nine re-explorations (1.35%) due to graft dysfunction and subsequent hemodynamic instability.

New atrial fibrillation and other atrial dysrhythmias requiring treatment were observed in 86 (12.9%) patients.

Reoperation for bleeding was needed for seven patients (1.05%). Transfusion of blood products was necessary in 39%



Figure 2: Vacuum based mechanical stabilizer: “Gdansk III”

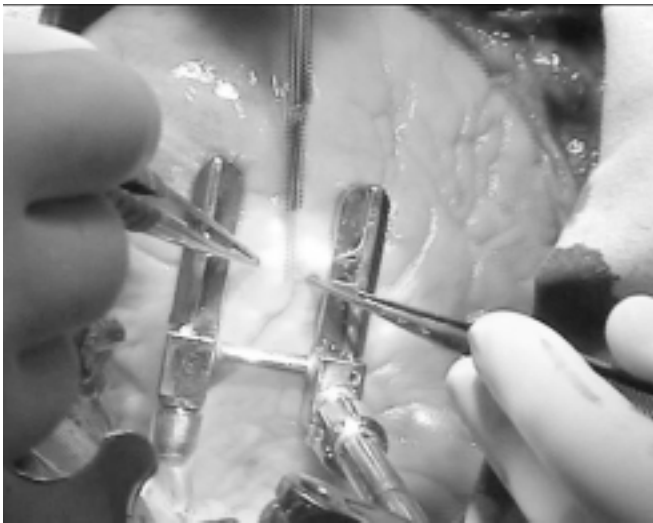


Figure 3: The "Gdansk III" stabilizer during the construction of the anastomosis.

of patients and reached an average of three units per patient. There were six major neurological events (0.9%) in this group. We also observed transient psychiatric disorders in nine patients (1.35%), a relatively high rate. New renal failure was observed during the postoperative course in 25 patients (3.7%), and prolonged mechanical ventilation for more than 12 hours was required for 39 patients (5.8%).

In-hospital and 30-day mortality occurred in nine patients (1.35%). Average length of stay in the intensive care unit was  $1.7 \pm 1.5$  days, and patients were discharged from the hospital generally on the sixth postoperative day (average  $6.2 \pm 2.2$  days).

## DISCUSSION

Coronary revascularization without CPB continues to evolve as a surgical procedure. Following the initial enthusiasm with minimally invasive bypass procedures, the LIMA-to-LAD bypass through an anterior small thoracotomy tended to be abandoned.

The advent of vacuum-based stabilizers permitted easier off-pump procedures in patients with multivessel disease. In our experience, the sternotomy approach appears to have advantages over the anterior thoracotomy approach even for single LIMA-to-LAD grafting.

The procedure is technically more demanding and requires more attention to details than conventional CABG. The rising number of OPCAB operations reflects the development of surgical strategies in conjunction with strategies and techniques that permit lower mortality and morbidity. In addition, the development of interventional cardiology has resulted in progressively more high-risk patients in need of surgical revascularization.

In our opinion, the success of the procedure is related to good exposure and stabilization. We have learned that the completeness of revascularization depends not only on coro-

Table 2. Reasons for incomplete revascularization.

Reason for incomplete revascularization	%
Diffuse and distal coronary lesions / Vessel diameter <1 mm	3.3%
Calcified arteries / scar	4.6%
Hemodynamic instability	1.75%

nary anatomy and cardiac displacement intolerance but also on the individual surgeon's virtues of maturity, vigilance, and patience. During our experience we have observed that the mean number of grafts per patient and the proportion of patients undergoing off-pump versus conventional revascularization are gradually increasing.

## CONCLUSION

The OPCAB technique can permit a precise and reproducible construction of coronary bypass anastomoses on the beating heart. We believe that this method can be used in the majority of our patients as a safe, reliable, and effective procedure for the treatment of coronary artery disease. Although patient selection for the off-pump procedure was at the discretion of the surgeon, the results presented here suggest that off-pump procedures resulted in the avoidance of complications related to extracorporeal circulation and contributed to faster recovery. Patients for whom surgery poses a higher risk may benefit more from OPCAB procedures.

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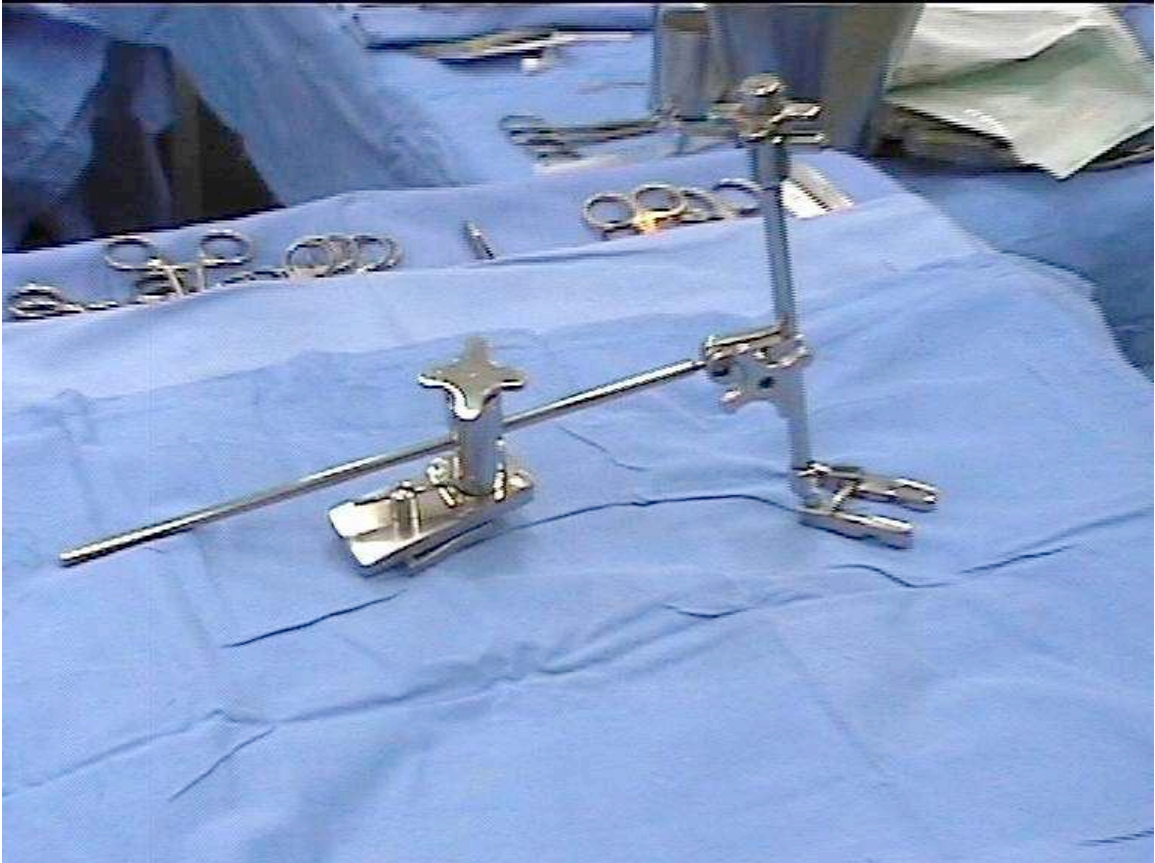


Figure 2: Vacuum based mechanical stabilizer: "Gdansk III"

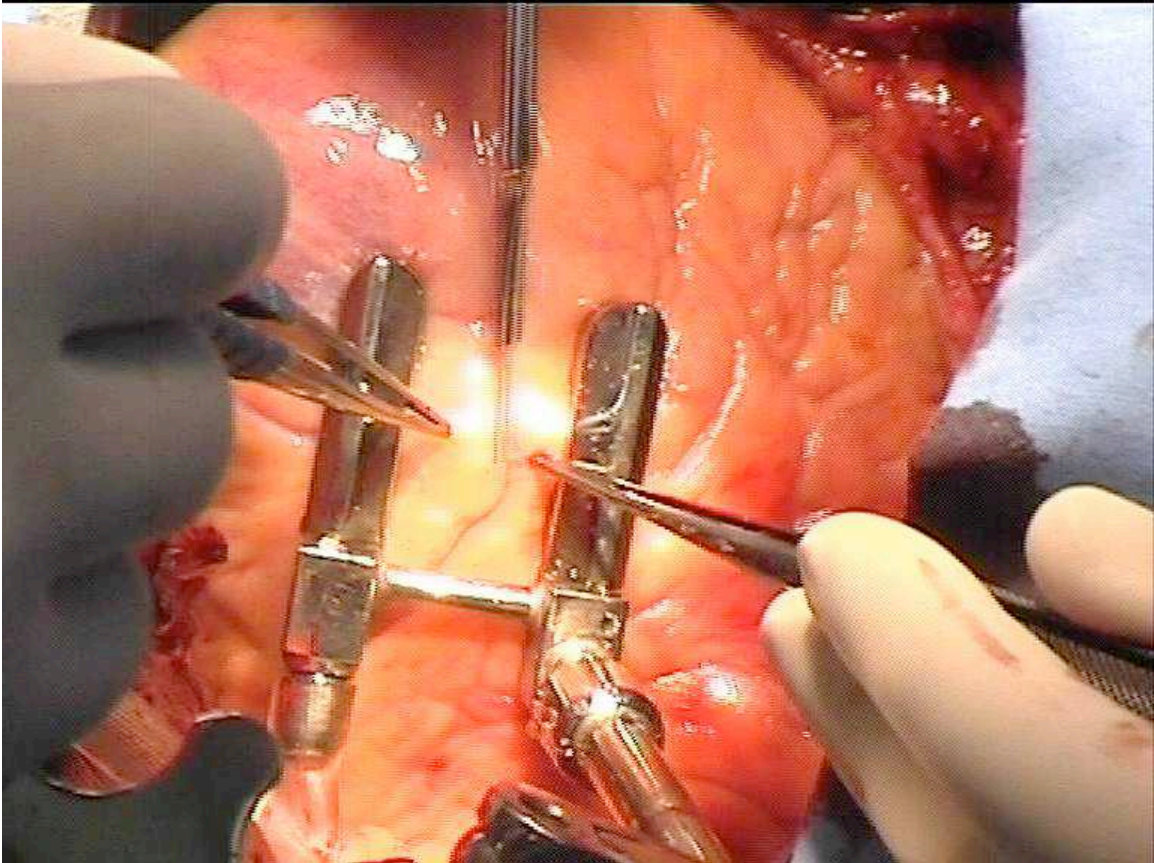


Figure 3: The "Gdansk III" stabilizer during the construction of the anastomosis.