



## Myocardial Revascularization in Patients with Reduced Ejection Fraction

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### ABSTRACT

**Background :** Many studies have shown that a left ventricular ejection fraction (LVEF)  $\leq 35\%$  is associated with a reduced long term survival in patients on medical therapy and increased early mortality in those undergoing coronary artery bypass grafting (CABG). This study aims to investigate the short term outcome of patients with LVEF  $< 40\%$  undergoing on or off pump CABG. **Material and Methods:** 604 patients undergoing surgical myocardial revascularization (342 on pump and 262 off pump) between January 2014 – December 2015, in the Department of Cardiovascular Surgery of "Niculae Stancioiu" Heart Institute, were retrospectively analysed. Of these, 76 (34 on pump and 42 off pump) had an LVEF  $< 40\%$  at admission and were considered suitable for the study. Indication, type of surgery and short term outcome were retrospectively analysed. Patients with combined procedures (CABG + valve surgery/LV aneurysmectomy) were excluded.

**Results:** Myocardial revascularization was performed for stable angina in 18 patients and unstable angina in 58 cases. Subjects undergoing on pump CABG required more often inotropic support (15 vs 6,  $p = 0,0001$ ) and longer periods of mechanical ventilation (15.2h vs 9.3h,  $p = 0,038$ ). Perioperative hemorrhage was more important (936 vs 725 ml,  $p = 0,01$ ) and metabolic acidosis more frequent (11 vs 5,  $p = 0,001$ ) in these cases. Moreover, they had longer hospital stay (9,2 vs 7,6,  $p = 0,001$ ). Short term mortality in patients with LVEF  $< 40\%$  was 5.8% in those undergoing on pump CABG and 2.3% in those with off pump surgery. **Conclusion:** The results have shown that off pump CABG is safe and effective even in patients with impaired ejection fraction, with fewer adverse events and reduced mortality compared to the on pump strategy.

### KEYWORDS

#### Introduction

Left ventricular ejection fraction (LVEF) is the strongest independent predictor of survival in patients with coronary artery disease undergoing non-surgical therapy. Moreover, it is a significant predictor of both in-hospital and long term mortality.

Many studies have shown that a left ventricular ejection fraction (LVEF)  $\leq 35\%$  is associated with a reduced long term survival in patients on medical therapy and increased early mortality in those undergoing coronary artery bypass grafting (CABG).

This study aims to investigate the short term outcome of patients with LVEF  $< 40\%$  undergoing on or off pump CABG.

#### Materials and methods

604 patients undergoing surgical myocardial revascularization (342 on pump and 262 off pump) between January 2014 – December 2015, in the Department of Cardiovascular Surgery of "Niculae Stancioiu" Heart Institute, were retrospectively analysed. Of these, 76 (34 on pump and 42 off pump) had an LVEF  $< 40\%$  at admission and were considered suitable for the evaluation. Patients with combined procedures (CABG + valve surgery/LV aneurysmectomy) were excluded. The informed consent was waived due to the retrospective nature of the study.

Patients were divided based on the type of surgical revascularization: on pump or off pump. Indication, type of surgery and a number of parameters such as preoperative LVEF, postoperative bleeding, postoperative inotropic support, Troponin levels, length of mechanical ventilation, days of hospitalization, local complications and short term mortality were retrospectively analysed.

In subjects with a history of myocardial infarction, an imaging stress test (either scintigraphy or dobutamine echocardi-

ography) was performed in order to test myocardial viability. Depending on the results, patients were considered suitable or not for CABG. Those with important areas of reversible ischemia related to significant coronary artery stenoses are candidates for myocardial surgical revascularization even if systolic left ventricular function is severely impaired (LVEF  $< 30\%$ ; Table 2).

Unstable patients received aspirin, nitrates, beta blockers, calcium antagonists, antiarrhythmic drugs and low molecular weight heparin until the day of the surgery. In stable cases anticoagulation was avoided, and aspirin stopped 4-5 days before intervention whenever possible. Intra-aortic counterpulsation balloon was not used before surgery.

#### Surgical Protocol

A catheter placed into the radial artery was used to monitor the arterial blood pressure. A Swan Ganz catheter was needed only in selected cases.

#### On pump surgery

In all patients a classic cardio-pulmonary bypass, with a venous catheter, moderate hypothermia (28-30C) and hemodilution (hematocrit 20-30%) was used. The heart is cooled down with saline at 4 C infused into the pericardium. After clamping the aorta, 1000 ml of cardioplegic solution 1:1, at 4 C, is injected into the aortic root.

When the heart is stopped and empty, coronary arteries are dissected in areas with a diameter  $> 1$  mm and wall suitable for anastomosis, while delivering upstream cardioplegic solution at a rate of 50 ml/min. Anastomoses on the right coronary artery followed by circumflex and left anterior descending (LAD) are performed. Subsequently, the aorta is unclamped and the proximal anastomoses on the ascending aorta realised, while the heart is beating.

**Off pump surgery**

For a better exposure of the coronary arteries, traction wires placed on the pericardium are used: on the left superior pulmonary vein (LSPV), at 2/3 between LSPV and the diaphragm, posterior to the phrenic nerve, and a third wire on the posterior pericardium between the inferior vena cava and LSPV. Pulling the first and second wire, the heart is exposed for the LAD and the first diagonale; pulling the first and third, with the table in Trendelenburg, the marginal arteries and the posterior or descending artery are exposed. Pulling the pericardial wires and tilting the operating table allows easy access to the affected coronary arteries with minimal hemodynamic changes. An OCTOPUS 1, 2, or 3 (Medtronic) cardiac stabilizer was used in all cases. Right pleura was opened whenever the marginal branches were approached in order to facilitate the fall of the heart into the right pleural space, avoiding its compression between the pericardium and the stabilizer. Distal anastomoses are always performed first, beginning with the left internal mammary artery on the LAD.

**Statistical analysis**

Analysis was performed using SPSS Statistics 22 (IBM, Chicago, USA). All continuous variables were expressed as means, if normally distributed, or otherwise by medians. Normality was assessed with the ShapiroWilk test. Data were compared by unpaired t-test when normally distributed or by Wilcoxon rank sum test otherwise. Statistical significance was set at a twotailed probability level of <0.05.

**Results**

Myocardial revascularization was performed for stable angina in 18 patients and unstable angina in 58 cases.

Preoperative characteristics of the patients with LVEF <40% undergoing myocardial revascularization are summarized in Table 1.

A similar number of patients with LVEF > 30% underwent either on pump or off pump CABG. However, off pump strategy was more often preferred for subjects with LVEF ≤ 30% (Table 2).

The analysed postoperative parameters are shown in Table 3, while the major adverse events in Table 4. Subjects undergoing on pump CABG required more often inotropic support (15 vs 6, p = 0.0001) and longer periods of mechanical ventilation (15.2h vs 9.3h, p = 0.038). Perioperative hemorrhage was more important (936 vs 725 ml, p = 0.01) and metabolic acidosis more frequent (11 vs 5, p = 0.001) in these cases. Moreover, they had longer hospital stay (9.2 vs 7.6, p = 0.001).

Short term mortality of patients with LVEF ≤ 40% undergoing CABG was 5.8% in case of on pump surgery and 2.3% in case off pump strategy.

**Discussion**

Recent development of the off pump revascularization technique and accumulation of surgical experience,

have transformed this method in a safe alternative to the conventional revascularization approach with extracorporeal circulation. Off pump strategy was associated from the beginning with lower incidence of stroke, blood transfusion, major septic complications (mediastinitis), reduced hospitalization in ICU and shorter hospital stay, reducing the overall costs per patient. Moreover, the method improves postoperative and long term outcome in high risk patients, including those with old age ( 1,2,3,4,5,6 ).

In a study published in 2015, enrolling 604 patients operated in our service during a time period of 2 years, we have shown the benefits of off pump revascularization versus on pump approach, without selecting patients according to particular pre-operative parameters. (9).

As in the present study, the results were statistically significant

supporting the group operated off pump in almost all analysed parameters, including the postoperative minor and major adverse events, or in-hospital mortality (3.2% in those operated on pump, 1.52% in those operated off pump).

N.T. Kouchoukos in a study conducted in 15 centers in the US (5000 patients), had shown a mortality of 4.7% in patients with EF <30% and 2.8% in patients with EF> 30%, all patients undergoing on pump surgery. (10).

Short term mortality after off pump revascularization is between 1.5-3.5% in most published studies (3,4,5,9,10,11), without making a selection of patients according to the ejection fraction.

The presented data have shown that either off pump or on pump revascularization strategies could lead to great results even in patients with impaired LV function, in-hospital mortality in case of elective interventions not exceeding 5-10% .

In our study mortality was 5.8% in those operated on pump and 2.3% in those operated off pump.

The incidence of perioperative myocardial infarction appears to be higher in the group of patients with LVEF <40% operated on pump, compared to patients with normal myocardium or minimal dysfunction (8.8% versus 2.9%), while the two groups have similar incidence when revascularization is performed off pump (2.3% versus 2.2%).

**Conclusions**

The results have shown that off pump CABG it's safe and effective even in patients with impaired ejection fraction, with fewer adverse events and reduced mortality compared to the on pump strategy. Time will confirm the superiority of one method or another, and establish the limits of each of them.

**Table 1. Preoperative characteristics of the patients with LVEF < 40% undergoing myocardial revascularization**

Characteristics	On pump	Off pump
Operated patients, n	34	42
Sex		
- M, n	28	32
- F, n	6	10
Age, years	56,1 ani	55,7 ani
History of myocardial infarction, n	28 (82%)	30 (71%)
Stable angina pectoris, n	8	10
Unstable angina pectoris, n	26	32
Nr. of distal anastomoses, n	2,4	2,25

**Table 2. Preoperative left ventricular ejection fraction in operated patients**

Ejection Fraction	On pump	Off pump
≤ 30%	4	10
31 – 35 %	10	12
36 – 40 %	20	20

**Table 3. Postoperative results in patients with myocardial revascularization and left ventricular ejection fraction <40%**

Postoperative parameters	On pump	Off pump	P value
Bleeding during day 1-2, ml	936	725	0.01
Inotropic support (nr. of patients), n	15 (44.1%)	6 (14.28%)	0.0001
Metabolic acidosis (nr. of patients), n	11 (32.35%)	5 (11.9%)	0.001
Mechanical ventilation, hours	15.4	9.3	0.038
Hospitalization, days	9.2	7.6	0.001

**Table 4. Postoperative major adverse events in patients with myocardial revascularization and left ventricular ejection fraction<40%**

Advers event	On pump	Off pump	P value
Mediastinitis, n	1 (2.9%)	1 (2.3%)	NS
Sternal dehiscence,n	2 (5.8%)	0	0,001
Reinterventions for hemorrhage, n	6 (17.6%)	1 (2.3%)	0,001
Myocardial infarctionday 1-2, n	3 (8.8%)	1 (2.3%)	0,001

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