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OFF-PUMP CORONARY BYPASS IN HIGH-RISK PATIENTS. SHORT-TERM RESULTS

Adkham Jalilov, MD, PhD[12], Vadim Merzlyakov, MD, PhD[1], Ivan Klyuchnikov, MD, PhD[1] Alisher Melikulov MD, PhD[1], M. Salomov, MD, Timur Ruzmatov, MD, PhD[3]Rustam Yarbekov MD, PhD[2], Maksud Murodov MD, PhD[2]

Adkham Jalilov, MD, PhD https://orcid.org/0000-0002-0364-6371
Timur Ruzmatov, MD, PhD https://orcid.org/0000-0001-7068-0214
Vadim Merzlyakov, MD, PhD https://orcid.org/0000-0001-5638-3723
Ivan Klyuchnikov, MD, PhD https://orcid.org/0000-0002-8652-9639
Alisher Melikulov MD, PhD https://orcid.org/0000-0002-5164-9702
M. Salomov, MD https://orcid.org/0000-0002-8602-3152
Rustam Yarbekov MD, PhD https://orcid.org/0000-0001-5918-8181
Maksud Murodov MD, PhD https://orcid.org/0000-0002-7599-9803

[1]A.N. Bakulev National Medical Research Center of Cardiovascular Surgery, Rublevskoe shosse, 135, Moscow 121552, Russian Federation.
[2]Karshi branch republican specialized scientific and practical medical center of cardiology, Karshi. Otchopar mach., St. Bunyodkor, 33. Uzbekistan
[3] Monash Health, Dandenong Hospital, 135 David St, Dandenong VIC 3175, Australia.
Correspondence: Adkham Jalilov, email: Jalilov_adham@mail.ru

ABSTRACT
Introduction: The life expectancy increase is steadily leading to the fact that more and more severe patients begin to undergo surgical treatment of coronary artery disease. Off-pump coronary artery bypass grafting may be the operation of choice in treating this category of patients.
Objective: To study the immediate results of surgical treatment of coronary artery disease using Off-pump myocardial revascularisation in patients with a high risk of mortality and complications.
Materials and Methods: The study summarised the results of surgical treatment of 1339 high-risk patients with coronary artery disease who were operated on in the period from 2003 to 2015, of which 672 - using the Off-pump revascularisation and 667 - using the conventional On-pump CABG with cardio-pulmonary bypass. The groups were comparable in age: the mean age in the Off-pump group was 69.6 ± 7.4 years, and in the On-pump group - 69.8 ± 7.7 years (p = 0.874).
Results: In both groups, most often, multivessel coronary artery bypass grafting was performed. In the Off-pump group, revascularisation of three or more coronary arteries was performed in 519 (77.3%) patients, and the On-pump group - in 521 (78.22%); there was no statistical difference (p = 0.699). The mean total duration of surgery was 5.3 ± 1.6 hours in the Off-pump group and 5.22 ± 1.3 hours in the On-pump group and had no significant difference (p = 0.3165). The intraoperative need for intra-aortic balloon pump counterpulsation in the On-pump group was significantly higher than in the Off-pump group (p = 0.0002). A significantly lower (p <0.05) number of cerebral and renal complications in the postoperative period was revealed in patients undergoing Off-pump myocardial revascularisation. In the general group of high-risk patients, both groups did not significantly differ in the frequency of deaths. Thus, in the Off-pump group, the frequency of deaths was 3.4% (23 patients) and in the On-pump group - 5.4% (36 patients) (p = 0.0785). In the On-pump CABG group, mortality in female patients was higher than in the Off-pump group (p = 0.031).
Conclusions: Based on the data obtained, it was concluded that Off-pump myocardial revascularisation is highly effective in the surgical treatment of high-risk patients.
Keywords: ischemic heart disease, CABG, surgical treatment, Off-pump, high risk, immediate results.

Introduction

The life expectancy increase is steadily leading to the fact that more and more severe categories of patients begin to undergo surgical treatment of coronary heart disease. Coronary artery bypass grafting on a beating heart may be the operation of choice in treating this category of patients.
The inconsistency of the available data and the lack of unity in assessing the feasibility of performing Off-pump coronary artery bypass grafting in patients with coronary artery disease from the high-risk group were the main reasons for our study. The study aimed to assess the immediate results of surgical treatment of coronary artery disease using Off-pump myocardial revascularisation in patients with a high risk of mortality and complications.

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Material and methods

From August 2003 to December 2015, 1339 high-risk patients with coronary artery disease group were operated. The patients were divided into two groups: The off-pump group (n=672) - coronary revascularisation on a beating heart and the On-pump group (n=667) CABG with cardiopulmonary bypass. The groups were comparable in age. The mean age of patients in the Off-pump group was 69.6 ± 7.4 years, and in the On-pump group - 69.8 ± 7.7 years (p = 0.874)

According to the EuroSCORE operational risk scale, the patients of both groups were comparable and did not have statistically significant differences. The mean EuroSCORE in the Off-pump group was 7.0 ± 1.8. In the On-pump group, the mean EuroSCORE was slightly higher -7.15 ± 1.6; however, it did not differ significantly (p = 0.225). Also, the patients were compared according to the EuroSCORE II scale: in the Off-pump group, the mean estimated mortality was 4.32 ± 1.9%, and in the On-pump group - 4.73 ± 1.2% (p = 0.398).

Statistical analysis was performed using the STATISTICA 10.0 software (StatSoft, USA). Descriptive statistics (mean values as well as standard deviations) were used to characterize groups. The results of the study were taken as statistically significant with a value of $p<0.05$.

Results and discussion

Among the risk factors for surgical mortality and complications, the age indicator of the patient was the most frequent. In the On-pump group, there were 368 (55%) patients of over 70 years old, and in the Off-pump group - the number was slightly higher - 405 (60%) patients; however, there was no statistically significant difference (p = 0.059). Also, both groups did not statistically differ in gender, in the incidence of unstable angina pectoris, and also in the incidence of lesions of the left main coronary artery. In both groups, 72% of patients had Class III-IV of angina (Canadian Cardiovascular Society grading of angina pectoris). In the Off-pump group, 108 (16%) patients underwent recent MI (less than three months) and 97 (14%) in the On-pump group. In the Off-pump group, 192 (29%) patients had an Ejection fraction of left ventricle (EF LV) of less than 50%, in the On-pump group - the EF LV of less than 50% was in 180 (27%) (Table 1).

Table 1
Patient characteristics

	Off-pump *(n= 672)*	On-pump *(n=667)*	*p*
Mean age	69.6± 7.4	69.8± 7.7	0.874
Age > 70 years	405 (60%)	368 (55%)	0.059
Females	196 (29%)	219 (33%)	0.146
BMI	28.6± 4.2	28.8± 4.6	0.916
HTN, n (%)	520 (77%)	538 (81%)	0.140
Unstable angina, n (%)	95 (14%)	102 (15%)	0.543
Recent (less that 3 month) MI, n (%)	108 (16%)	97 (14%)	0.437
Class III-IV CCS Angina, n (%)	483 (72%)	478 (72%)	0.931
Main left coronary artery lesion, n (%)	107 (16%)	102 (15%)	0.750
LVEF< 50%	192 (29%)	180 (27%)	0.517
LVEF 50-40 %	156 (23%)	164 (24%)	0.555
LVEF 40-30 %	30 (4.5%)	16 (2.4%)	0.037
LVEF< 30%	6 (0.9%)	-	0.189
History of PCA	44 (6.5%)	40 (6%)	0.677

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Note: BMI- Body mass index, HTM- hypertension, LVEF - left ventricular ejection fraction, PCA- percutaneous coronary angioplasty

The overwhelming majority of patients had multivessel coronary lesions. In the Off-pump group, stenosis of the left coronary artery was found in 107 (16%) patients and the On-pump group - in 102 (15%). The nature and severity of coronary lesions were calculated using the SYNTAX Score method. Both groups were dominated by moderate and severe coronary lesions, while severe coronary lesions in the On-pump group were more frequent and occurred in 311 (47%) patients, while in the Off-pump group - in 283 (42%) patients, but both groups did not have a statistically significant difference.

Thus, the patients of both groups were comparable in terms of the initial severity of the underlying disease, the severity of concomitant pathology, and the severity of coronary artery disease and they did not significantly differ in terms of the EuroSCORE and the EuroSCORE II.

As conduits, we mainly used the left internal mammary artery (LIMA): in the Off-pump group 92%, On-pump 87%; and autovenous grafts: 90% and 93%, respectively. The nature of coronary artery bypass grafting operations is shown in Table 2.

Table 2
Operations performed

The nature of CABG	Off-pump (n=672)	On-pump (n=667)	*p*
Sequential CABG with LIMA of the	72 (10.7%)	7 (1.1%)	0.0001
Sequential CABG with autovenous graft	108 (16%)	46 (6.9%)	0.0001
Composite CABG	8 (1.2%)	3 (0.5%)	0.133
Complete revascularisation	551 (82%)	540 (81%)	0.626
The average number of grafts per patient	3.21±1.04	3.12±1.08	0.063

Note: CABG- coronary artery bypass grafting, LIMA- left internal thoracic artery

Complete revascularisation was performed in 551 (82%) patients of the Off-pump group, which did not differ significantly compared to the second (On-pump) group - 540 (81%) ($p = 0.626$). The average number of grafts per patient in the Off-pump group was 3.21 ± 1.04, while in the On-pump group, it was slightly lower - 3.12 ± 0.8 and had a significant difference ($p = 0.063$).

In both groups, multiple bypass grafting was most often performed: for example, in the Of-pump group, three or more coronary arteries were bypassed in 519 (77.3%) patients, and in the On-pump group - in 521 (78.22%) patients; thus, there was no significant difference found ($p = 0.699$).

With a similar surgery volume, its mean total duration was 5.3 ± 1.6 hours in the Off-pump group and 5.22 ± 1.3 hours in the On-pump group and had no significant difference ($p = 0.3165$). In the case of combined operations (CABG+ carotid arteries revascularisation), the mean duration of intervention on the carotid arteries was 44 ± 5.4 minutes. In the On-pump group, the total duration of the CABG was 92.8 ± 42.9 min, and the aortic cross-clamp time was 49.1 ± 15.2 min.

In 153 (22.7%) patients of the Off-pump group, we used temporary intracoronary shunts of various sizes (from 1.5 to 3.5 mm) during the operation. Of the 672 patients, 18 (2.7%) patients required conversion to cardio-pulmonary bypass. The intraoperative need for intra-aortic balloon counterpulsation (IABCP) in the On-pump group was significantly higher than in the Off-pump group ($p = 0.0002$).

The volume of intraoperative blood loss was significantly less in the Off-pump group (349 ± 150 ml versus 574 ± 167 ml, $p = 0.0166$). It became necessary for two patients from the On-pump group to perform extracorporeal membrane oxygenation (ECMO). The mean ICU time was 21.4 ± 43 hours for the Off-pump group and 35.7 ± 95.3 hours for the On-pump group, which showed a statistically significant difference between the groups ($p = 0.0004$).

We did not find a significant difference in the incidence of perioperative MI; although, it was higher in the On-pump group - 21 (3.2%) cases versus 13 (1.9%) cases in the Off-pump group ($p = 0.1571$). In the Off-pump group, in 9 (1.4%) patients, myocardial infarction was localised in the zone of bypass grafting of diffusely altered coronary arteries, in three of them - in the area of endarterectomized arteries. In the Off-pump group, 21

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(3.2%) patients developed myocardial infarction, of which 12 (1.8%) developed in the zone of revascularisation of diffusely altered coronary arteries.

Acute heart failure (AHF) requiring IABCP occurred in 31 (4.7%) patients in the On-pump group and 11 (1.6%) patients in the Off-pump group and had a significant difference (p = 0.0016). The leading cause of AHF in 16 (51.6%) patients of the On-pump group was an initially low LV EF (EF <50%), due to extensive postinfarction cardiosclerosis with the addition of a new MI focus in the perioperative period, of which 8 (25.8%) AMI developed in connection with shunt thrombosis of a diffusely altered coronary artery.

In 5 cases, AHF was the cause of death. In 8 patients, its development was associated with the initial severity of the underlying pathology.These patients were operated on urgently due to the development of early postinfarction angina pectoris. It is possible that AHF in these patients was due to inadequate protection of the myocardium.

The incidence of cerebrovascular complications in the Off-pump group was 2.7%. They included the following types of complications: encephalopathy in 7 (1%), transient ischemic attack (TIA) in 6 (0.9%), and stroke in 5 (0.7 %) patients. In the On-pump group, the incidence of cerebrovascular complications was 7.6% including encephalopathy in 29 (4.4%), TIA in 8 (1.2%), and stroke in 14 (2.1%) patients.

Plasma cystatin C is an important marker of renal dysfunction. It was higher in patients who underwent On-pump CABG compared with patients who operated using Off-pump surgery at all stages of the early postoperative period (p <0.05). In the group of patients from the On-pump group, after using the CPB, there was a tendency for a gradual increase in the level of plasma cystatin C throughout the postoperative period.

Both groups of patients did not significantly differ in the frequency of deaths. Thus, in the Off-pump group, the frequency of deaths was 3.4% (23 patients), and in the On-pump group - 5.4% (36 patients) (p = 0.0785).

As for the hospital mortality in the Off-pump group, the reasons of death are described in detail. Stroke became the cause of death in 4 patients, multiple organ failure was in 4 patients. There was also one case with the initial severity of the condition caused by severe heart failure before surgery led to multiple organ failure (LV EF was 19%).This patient was urgently operated on for life-threatening reasons on the background of acute myocardial infarction.

In another case, the patient developed bilateral pneumonia in the early postoperative period, which led to the development of a septic state. In another patient, multiple organ failure was due to impaired renal function (acute renal failure). In addition, In another patient, multiple organ failure developed on the background of AMI in the early postoperative period. AMI was accompanied by severe acute respiratory failure, which required IABCP. In one patient, death occurred in the background of the development of a thyrotoxic crisis.

It is generally known that the female gender is one of the risk factors for perioperative complications, so the mortality rate in high-risk female patients was also compared. In the On-pump group, the mortality in female patients was higher than in the Off-pump group (p = 0.031) (Table 3).

Table 3
Mortality depending on the gender of the patient

	Off-pump (n=672)	On-pump (n=667)	*p*
General mortality, n(%)	23 (3.4%)	36 (5.4%)	0.0785
Deceased female patients, n(%)	8 (1.2%)	19 (2.8%)	0.0310
Deceased male patients, n(%)	15 (2.2%)	17 (2.6%)	0.7046

According to some authors, coronary artery bypass grafting with cardiopulmonary bypass in elderly patients with severe concomitant pathology, such as COPD, chronic kidney disease, the presence of extracardiac vascular pathology is associated with a high risk of early postoperative complications [1,2,3,4, 5]. This is the reason for the renewed interest in direct myocardial revascularisation without CPB. Currently, the most widely used Off-pump operations are through a median sternotomy. However, this technique has both supporters and many opponents, which requires further development of indications to use this method [1,6].

There is no consensus on the superiority of off-pump operations in high-risk patients compared with On-pump CABG. Some authors note that after myocardial revascularisation operations using the Off-pump technique, patients more often require repeated revascularisation than coronary artery bypass grafting performed by the traditional method [1,7,8]. Our study demonstrated the effectiveness and feasibility of performing Off-pump revascularisation in high-risk patients.

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In our study, the frequency of conversion for surgery with CPB during the Off-pump surgery was 2.7%. We agree with some authors [5,9] and believe that with the accumulation of experience of the surgeon, the frequency of conversion to cardiopulmonary bypass should gradually decrease. From 2003 to 2009, we performed 160 operations on high-risk patients, of which 9 cases required a CPB connection, and the conversion rate was 6%. In 2013–2015 out of 294 high-risk patients, 5 needed conversion, thus the conversion rate was 1.7% and had a significant decrease ($p = 0.0471$).

Conclusions

Although hospital mortality between the groups of patients who underwent CABG with cardiopulmonary bypass and Off-pump revascularisation did not statistically differ significantly in the general group, it was significantly lower in women who underwent CABG on the beating heart. A significantly lower ($p < 0.05$) number of cerebral and renal complications was revealed in the early postoperative period in patients who underwent Off-pump myocardial revascularisation.

Based on the data obtained, it can be concluded that Off-pump myocardial revascularisation is highly effective in the surgical treatment of high-risk patients.

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