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MYOCARDIAL REVASCULARIZATION WITHOUT EXTRACORPOREAL CIRCULATION IN PATIENTS AT HIGH OPERATIVE RISK

REVASKULARIZACIJA MIOKARDA BEZ EKSTRAKORPORALNE CIRKULACIJE KOD PACIJENATA S VISOKIM OPERATIVNIM RIZIKOM

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Summary – It is considered that over 25% of surgical patients with coronary artery disease are treated without extracorporeal circulation, i.e. off-pump coronary artery bypass. The aim of the study was to evaluate results of surgical myocardium revascularization in patients at high operative risk. During the period 2005-2008, 148 patients were operated without the use of extracorporeal circulation. According to the logistic European System for Cardiac Operative Risk Evaluation (EuroSCORE) stratification, 28 patients (19%) were designated as the high risk patients. The average age of these high risk patients was 72 years (55-86). The group consisted of 23 men (82.1%) and 5 women (17.8%). The postoperative mortality in the whole group of patients was 0.68% (1/148), whereas it was 0% in the high risk group. The average number of coronary anastomoses was 2.4. Eight patients (28.6%) had some sort of postoperative complications. Our results demonstrate safety and efficacy of surgical revascularization without cardiopulmonary bypass in patients at high operative risk.

Key words: Myocardial Revascularization; Coronary Artery Disease; Coronary Artery Bypass, Off-Pump; Postoperative Complications; Risk Assessment; Male; Female
NON MESH: EuroSCORE

Introduction

The surgical method of myocardial revascularization, coronary artery bypass grafting (CABG) using extracorporeal circulation (ECC) became a routine procedure even before the 1970s. Using this approach, the surgeon can create coronary anastomoses on a bloodless, quiet operative field, but ECC can have numerous side-effects: poor tissue perfusion, disturbance of the acid-base balance, haemodilution, systemic inflammatory response together with multiple organ dysfunction, alteration of intrinsic properties of the coagulation system etc. [1]. In addition, aortic cross clamping and cardioplegic arrest can cause global myocardial ischemia, cerebrovascular and other complications [2,3]. Data from the literature suggest that almost 40% of the patients have some form of neurocognitive dysfunction five years after such a surgery, although the influence of the age and degree of atherosclerosis still remains unknown [4,5]. Finally, any surgical treatment is accompanied with a long convalescence period of 2-3 months.

The mortality in coronary surgery, nowadays, is very low (around 2%), and it mostly depends on the age (the older the patient the greater the risk), concomitant diseases, urgency of operation and other factors. During the last decade of the previous century, a rising number of percutaneous cardiac interventions with stent implantation forced the surgeons to revascularize older patients and those with complex coronary lesions and various co-morbidity [6]. Several risk stratification models aimed at calculating the surgical risk based on numerous factors before the operation have been developed. These mod-

els can identify the patient at high risk of cardiac surgery. The most popular and widely accepted system is EuroSCORE (European System for Cardiac Operative Risk Evaluation) [7,8]. EuroSCORE was initially accepted in the European countries and later on other continents [9,10]. In 2003, EuroSCORE was improved in the form of logistic regression analysis, especially for risk prediction in high risk patients [11].

The need for a less traumatic but safe operation as well as the motivation of the cardiac surgeons to improve surgical technique in order to increase the efficiency of operation, reduce the invasiveness and number of complications and to shorten the postoperative period, and to decrease medical costs led to the introduction of new surgical technique of myocardial revascularization without ECC, off-pump coronary artery bypass (OPCAB) [12-14]. A lot of cardiac surgeons recognized OPCAB surgery as a new, improved method of treating patients with coronary artery diseases. The main argument in favour of this method is avoidance of the ECC effect on renal and other functions (especially brain function – avoidance of the cerebrovascular insult, delirium and many subtle neurocognitive disorders) [15-19]. Opinions that the method is insufficient because of a suboptimal exposition of the coronary arteries, the presence of hemodynamic instability and arrhythmias during the intervention, as well as poor quality of anastomoses, have been denied by Sergeant, who introduced his own surgical technique with excellent results [14]. We have been using this concept (for off-pump myocardial revascularization) since 2005.

Abbreviations

EuroSCORE	– European System for Cardiac Operative Risk Evaluation
CABG	– Coronary artery bypass graft
ECC	– Extracorporeal circulation
OPCAB	– Off-pump coronary artery bypass
ACT	– Activated clotting time
LIMA	– Left internal mammary artery
RIMA	– Right internal mammary artery
LAD	– Left anterior descending artery
AF	– Atrial fibrillation

Material and methods

During the period August 2005 – September 2008, 148 patients were operated without the use of ECC. Two centres were enrolled in this study (Institute of Cardiovascular Diseases, Clinical Centre of Serbia, from August 2005 till May 2006 and Institute of Cardiovascular Diseases of Vojvodina in Sremska Kamenica from June 2006 to September 2008).

For risk stratification, we used widely accepted EuroSCORE logistic model. According to the EuroSCORE risk stratification system, the category of patients at very high risk are those in who the anticipated mortality rate exceeds 10% (in the additive model it is higher than 8%).

Surgical technique

The surgical technique was uniform for all patients. Cardiac structures were approached by performing the standard median sternotomy. After harvesting one or both internal thoracic arteries, the pericardium was opened with an inverted T-shaped incision. The left pleural space was also opened. Normothermia was maintained by warm intravenous solutions, heating blanket, heated air ventilating the patient and the appropriate temperature in the operating room. The heart was stabilized in the convenient position by the special vacuum stabilizer - Octopus 3 (Medtronic, Minneapolis, USA) (**Figure 1**). Deep pericardial retraction stitches were used to achieve even better positioning of the heart. Anticoagulant treatment required the administration of heparin (300 IU/kg). If necessary, heparin was administered again in order to maintain the value of activated clotting time (ACT) over 480 seconds, and its effect, at the end of the surgical procedure, was neutralized by protamine. The left internal mammary artery (LIMA) had to be anastomosed with the anterior descending branch of left coronary artery (LAD), while the proximal anastomosis with the right internal thoracic artery (RIMA) or saphenous vein (GSV) was set as the termino-lateral anastomosis on the LIMA, and the distal one to one of the coronary arteries (diagonal branch, marginal branch, right coronary artery)

Results

Of the total number of patients who underwent OPCAB surgery, 28 patients (19%) had the operative

Table 1. Preoperative characteristics of high risk patients**Tabela 1.** Preoperativne karakteristike pacijenata s visokim rizikom

Cause <i>Uzrok</i>	No of pts. <i>Broj pacijenata</i>	Percentage <i>Procenat</i>
Recent myocardial infarction <i>Skorašnji infarkt miokarda</i>	15	53,57%
Extracardiac arteriopathy <i>Ekstrakardijalna arteriopatija</i>	11	39,28%
Unstable angina/ <i>Nestabilna angina</i>	10	35,71%
Emergency surgery/ <i>Hitna operacija</i>	8	28,57%
Pulmonary hypertension/ <i>Plućna hipertenzija</i>	5	17,86%
Neurological dysfunction <i>Neurološka disfunkcija</i>	4	14,28%
Chronic pulmonary disease <i>Hronična plućna bolest</i>	4	14,28%
Previous cardiac surgery <i>Ranija kardijalna operacija</i>	4	14,28%
Chronic renal insufficiency <i>Hronična slabost bubrega</i>	1	3,57%

risk higher than 10% (from 10.69% to 71.46% for logistic, and from 8% to 17% for the additive EuroSCORE model). The average age of patients was 72 years (55-86). The group consisted of 23 male (82.1%) and 5 female patients (17.8%). The preoperative patient characteristics are shown in **Table 1**.

In all the patients, LIMA was anastomosed to LAD. RIMA as a free graft was used in 3 patients (10.7%) - its proximal end was sutured in the form of Y-joints in the LIMA and the distal end to the one or two coronary arteries sequentially. VSM was used in the same way instead of RIMA in 25 patients (89.3%). The number of distal anastomoses ranged from 2-4 with the average of 2.4.

All patients received low-molecular-weight-heparin administered subcutaneously in appropriate doses 1 to 2 hours after leaving the operating room and anti-platelet therapy at the beginning of the first postoperative day.

The postoperative mortality was 0.68% (1/148) in all patients operated without ECC, whereas it was 0% in the high-risk group of 28 patients. There was no need for conversion to ECC. A postoperative complication was observed in 8 patients (28.6%) (**Table 2**). Postoperative arrhythmias were found in 5 patients (17.8%). The reported atrial fibrillation (AF) was con-

Table 2. Frequency of postoperative complications**Tabela 2.** Učestalost postoperativnih komplikacija

Postoperative complications <i>Postoperativne komplikacije</i>	No of pts. <i>Broj pacijenata</i>	Percentage <i>Procenat</i>
Postoperative atrial fibrillation <i>Postoperativna atrijalna fibrilacija</i>	5	17,86%
Intensive care unit stay more than 1 day/ <i>Boravak u jedinici intenzivne nege duže od 1 dana</i>	2	7,14%
Pleural drainage due to effusion <i>Drenaža pleure usled izliva</i>	2	7,14%
Re-intubation/ <i>Reintubacija</i>	1	3,57%
Revision due to haemorrhage <i>Revizija zbog krvarenja</i>	1	3,57%

verted using medications in 2 patients, in 1 patient it was solved by synchronous defibrillation and 2 patients had residual AF. All patients received postoperative amiodarone and beta-blockers.

There was need for drainage of pleural effusion on the 6th postoperative day in two patients (7.1%), so that their hospitalization extended to 12 postoperative days. One of these patients had a pronounced chronic obstructive pulmonary disease and it was the patient in who we used both internal thoracic arteries in the previously described manner. The other one had chronic renal failure.

Revision of the haemostasis was required in one patient (3.5%) six hours after leaving the operating room. We noticed bleeding from the branches of mammary arteries in the chest wall and diffuse bleeding from the soft tissue during the re-intervention. There were no cerebral, renal or other significant complications. A prolonged wound healing was reported in a patient (3.5%) who had diabetes and chronic obstructive pulmonary disease and in whom we used both internal thoracic arteries as grafts.

All patients were extubated during the zero or the first postoperative day. In four patients (14.1%), inotropic therapy was administered during the surgery, and was continued later in the intensive care unit due to unsatisfactory hemodynamic parameters. The average length of postoperative hospital stay was 7.4 days (4 to 12 days).

Discussion

To make a clear distinction between OPCAB and CABG procedures in the ECC is not as simple as it may first appear because both models involve a series of very different surgical techniques. Considering the revascularization technique with the use of ECC, we note that they can be implemented with or without placing an aortic clamp (on-pump beating heart procedure) at different body and heart temperatures, using different methods of myocardial protection, using different types of grafts and different techniques to create proximal and distal anastomosis [20-24]. Even Calafiore et al showed that avoiding manipulation of the aorta was almost as important as the avoidance of ECC in terms of cerebral complications [16]. Sergeant et al showed that off-pump surgery with avoidance of manipulation of the aorta, the use of composite arterial or arterial-venous grafts eliminated cerebrovascular complications [14].

The concept of OPCAB was given by Sergeant and associates at the end of the last century. "CABG NOUVEAU TECHNIQUE" has removed most of the flaws of the former off-pump surgery and provided the patient stability during the operation, availability of all coronary arteries, the ability to create good anastomosis, the applicability in all patients (with minimal restrictions), the absence of cerebral complications and very low mortality [14]. The creation of distal anastomoses has been improved by using myocardial stabilizer to avoid significant displacement of tissue on the surface in the radius of

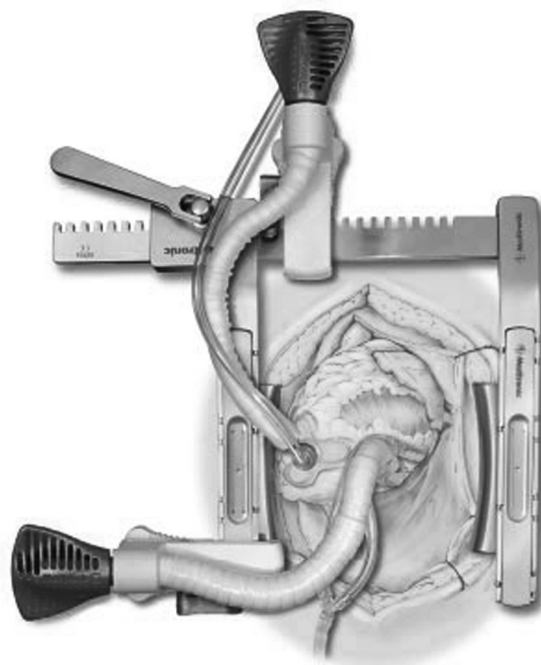


Fig. 1. Octopus 3 system installation

Slika 1. Prikaz pozicioniranja sistema Octopus 3

around 2 cm (Figure 1). The number of anastomoses was increased using various techniques of positioning and displacement of the heart to allow exposure to all coronary arteries.

We have been using this concept for myocardial revascularization on "the beating heart" since 2005. Our experience with "CABG NOUVEAU" technique confirmed the points of Sergeant in terms of absence of significant risk both in high-risk and all other patients treated in this way by our surgical team. In our series, there were no significant cerebral, renal and other complications which supports the claim that the method is safe and secure. Our results show that "CABG NOUVEAU" technique is a safe and effective method for patients at high operative risk. Although indicative, because of the aforementioned facts, it is hard to prove that this is a superior method but it is clear that it is at least as good as the other, previously proven techniques. After years of experience of using this method, we think that it should be used by all cardiac surgeons and cardio anaesthesiologists.

Nowadays, over 25% of the patients are subjected to the surgical revascularization without ECC [25,26] all over the world. Randomized studies have shown no statistically significant reduction in morbidity and mortality; however, a large number of non-randomized studies have found a significant clinical improvement after the off-pump surgery due to the avoidance of ECC, especially in patients with neurological and renal diseases [1,18,23,24,27-31]. Although surgical revascularization of the heart muscle without the use of ECC is performed in all

major cardio surgical centres, most surgeons still do not use this technique or use it only in cases of a single bypass to the LAD, so that conventional revascularization using ECC remains the most widely used method of CABG [3,15,32]. The results following conventional CABG using ECC are still satisfactory and the percentage of re-intervention two years after the initial surgery is around 6%, while the cumulative risk of death or myocardial infarction is around 12% [6].

Early randomized studies that included patients at low risk showed a shorter postoperative recovery period, reduced use of blood and blood products, reduced postoperative incidence of coagulopathy and incidence of atrial fibrillation in patients undergoing off-pump surgery [15,17,21,23]. Although the use of blood and its derivatives was reduced together with the reduction of CK-MB isoenzyme, there was no significant difference in the rate of postoperative complications [12,24,27]. Furthermore, there were no significant differences in clinical outcomes 1 to 3 years after the intervention, occurrence of stroke, myocardial infarction and death. On the other hand, the number of patients with recurrent angina and need for re-intervention in this period was higher in the off-pump group, which can be attributed to incomplete revascularization and bad graft patency. Revascularization of all the arteries requiring it is an important determinant of asymptomatic long term

period [34]. Recent studies showed the advantage of the off-pump surgery in reducing mortality and morbidity in female patients, in the reoperation, in patients at increased risk of stroke and with renal insufficiency; whereas a decrease in respiratory and gastrointestinal complications with lower risk for the development of postoperative atrial fibrillation was observed [2]. At the same time, it has been shown that the four-year survival rate following CABG did not differ significantly between the "on pump" and "off pump" groups. The same observation stands for the occurrence of myocardial infarction and reoperation rate, regardless of the observed lower number of grafts in the off-pump group [1]. Recent studies have demonstrated that the mortality and morbidity in patients at very low risk (less than 1%) do not differ with respect to the applied technique of myocardial revascularization [23]. However, in order to establish a statistically significant difference (difference in mortality of 0.1%) a large study population is required (encompassing more than 400,000 patients).

Conclusion

Our results indicate that myocardial revascularization without extracorporeal circulation is a safe and effective method for patients at extremely high surgical risk, who are not eligible for conventional coronary surgery mostly due to co-morbidity.

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Sažetak

Uvod

Danas se u svetu kod više od 25% pacijenata izvodi hirurška revaskularizacija bez korišćenja ekstrakorporalne cirkulacije.

Cilj rada je bio da se prikažu rezultati hirurške revaskularizacije miokarda bez korišćenja ekstrakorporalne cirkulacije kod pacijenata s izrazito visokim operativnim rizikom kod kojih je vrednost logističkog EuroSCORE-a veća od 10.

Materijal i metode

U institutima za kardiovaskularne bolesti Vojvodine u Sremskoj Kamenici i u Beogradu, od septembra 2005. godine do septembra 2008. godine, kod 28 pacijenata, prosečne starosti 72,1 godina, koji su pripadali grupi bolesnika s izrazito povišenim ope-

rativnim rizikom (vrednost logističkog EuroSCORE-a veća od 10%), načinjena je hirurška revaskularizacija miokarda bez ekstrakorporalne cirkulacije.

Rezultati

Postoperativni mortalitet u grupi visokorizičnih pacijenata bio je 0%. Prosečan broj načinjenih anastomoza bio je 2,4. Kod 8 pacijenata (28,6%) registrovane su postoperativne komplikacije.

Zaključak

Naši rezultati ukazuju na to da je hirurška revaskularizacija bez upotrebe ekstrakorporalne cirkulacije siguran i efikasan način lečenja u grupi pacijenata s visokim operativnim rizikom koji nisu kandidati za klasičnu koronarnu hirurgiju.

Ključne reči: Miokardijalna revaskularizacija; Bolest koronarnih arterija; Bajpas bez ekstrakorporalne cirkulacije; Postoperativne komplikacije; Procena rizika; Muško; Žensko; Ne Meš: EuroSCORE

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