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## REVASKULARIZACIJA MIOKARDA BEZ PRIMENE VANTELESNOG KRVOTOKA. ISKUSTVO SA OCTOPUS SISTEMOM ZA KORONARNU STABILIZACIJU

### OFF-PUMP MYOCARDIAL REVASCULARIZATION USING THE OCTOPUS TISSUE STABILIZER SYSTEM

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**Sažetak** - Hirurška revaskularizacija miokarda bez primene vantelesnog krvotoka (OPCAB) promenila je pristup savremenoj koronarnoj hirurgiji. Koronarni stabilizatori dodatno su unapredili revaskularizaciju miokarda na kucajućem srcu. Korišćenjem Medtronic Octopus 2/3 sistema, u periodu mart 2000 - april 2002. na Institutu za kardiovaskularne bolesti "Dedinje", 136 bolesnika operisano je OPCAB tehnikom. Našiveno je ukupno 180 arterijskih i 69 venskih anastomoza, prosečno 1,830,73 po bolesniku. Kod jednog (0,74%) bolesnika došlo je do smrtnog ishoda. Revizija je radena kod 3 (2,21%) bolesnika zbog obilnog krvarenja i jednog (0,74%) zbog disfunkcije grafta. Registrovana su 2 (1,47%) perioperativna infarkta miokarda, 3 (2,21%) pojave pneumotoraksa, 11 (8,09%) posleoperativnih aritmija, 1 (0,74%) tranzitorni neurološki defekt i jedna (0,74%) duboka infekcija. Produženu inotropnu potporu zahtevalo je 12 (8,82%) bolesnika. Rana rekoronarografija kod 8 (5,88%) bolesnika pokazala je dobru prohodnost graftova. Uvođenje koronarnih stabilizatora značajno je unapredilo koronarnu hirurgiju i omogućilo sigurniju i lakšu višestruku revaskularizaciju miokarda bez primene vantelesnog krvotoka.

**Cljučne reči:** Revaskularizacija miokarda + metode; Bajpas koronarne arterije; Vantelesni krvotok

**Summary** - Off-pump coronary artery bypass surgery (OPCAB) has changed the approach to contemporary coronary surgery. Development of new surgical devices and techniques has reduced morbidity and mortality during off-pump surgery. From March 2000 - April 2002, a total of 136 patients underwent open heart surgery using off-pump technique and fast-track anesthesia at Dedinje Cardiovascular Institute. Octopus Medtronic coronary stabilizer was used for stabilization of targeted vessel. Arterial grafts were used 169 times and saphenous vein 69 times. Average number of anastomoses was 1,830,73 per patient. One patient (0.74%) died. Three patients (2.21%) underwent surgery revision due to postoperative bleeding and one (0.74%) because of graft dysfunction. Perioperative myocardial infarction was registered 2 times (1.47%), pneumothorax 3 times (2.21%), postoperative arrhythmias 11 times (8.09%), transitory ischemic attack once (0.74%) and deep wound infection once (0.74%). Twelve patients (8.82%) required prolonged inotropic support. Angiographies early revealed patent grafts in 8 patients (5.88%). OPCAB is a safe and effective alternative approach to coronary artery revascularization. Use of coronary stabilizer has improved the safety and quality of OPCAB surgery.

**Key words:** Myocardial Revascularization + methods; Coronary Artery Bypass; Extracorporeal Circulation

#### Uvod

Prva direktna revaskularizacija miokarda urađena je 1964. god. Tada je Kollesov anastomozirao levu unutrašnju mamarnu arteriju (LIMA) sa prednjom descendnom koronarnom arterijom (LAD) bez primene vantelesnog krvotoka (ECC) kroz prednju levu torakotomiju [1]. Razvoj sistema za ECC i usavršavanje načina protekcije miokarda doveli su gotovo do potpunog napuštanja revaskularizacije miokarda na kucajućem srcu. Tek nakon dvadeset godina od prve ovakve revaskularizacije pojavili su se sporadično radovi koji daju prednost OPCAB operacijama nad standardnim, kod određenih populacija bolesnika [2-5]. Trebalo je da prođe još desetak godina da bi se sa novim saznanjima o štetnim efektima nefiziološke prirode vantelesnog krvotoka, pristupilo sve široj primeni OPCAB procedura u hirurškoj revaskularizaciji miokarda [6-14]. Razvoj interventne kardiologije bio je dodatni stimulans hirurzima da prihvate ovu manje invazivnu hiruršku tehniku. Sistemi za

#### Introduction

The first direct myocardial revascularization was performed in 1964, when Kollesov anastomosed left internal mammary artery (LIMA) with left anterior descending coronary artery (LAD) without use of extracorporeal circulation (ECC) through left anterior thoracotomy [1].

Development of ECC system and improvement of myocardial protection techniques provided almost complete exclusion of myocardial revascularization on the beating heart.

Twenty years after the first direct coronary revascularization, authors began sporadically publishing articles giving priority to OPCAB interventions [2-5]. However, with new knowledge regarding negative effects of non-physiological nature of extracorporeal circulation, 10 years later OPCAB procedures were broadly accepted in myocardial revascularization surgery [6-14].

**Skraćenice**

ACDx	- desna koronarna arterija
ACT	- aktivisano vreme koagulacije
Dg	- dijagonalna grana
EAT ACC	- karotidna endarterektomija
ECC	- vantelesni krvotok
ECG	- elektrokardiogram
GEA	- gastroepiploična arterija
LAD	- prednja descedentna koronarna arterija
LIMA	- leva unutrašnja mamarna arterija
LVEF	- ejskciona frakcija leve komore
MI	- infarkt miokarda
OM	- marginalna grana
OPCAB	- revaskularizacija miokarda bez primene vantelesnog krvotoka
RA	- radijalna arterija
RE-DO	- koronarna reoperacija
RI	- intermedijalna grana
RIMA	- desna unutrašnja mamarna arterija
VSM	- velika vena safena

**Abbreviations**

ACDx	- right coronary artery
ACT	- activated clotting time
Dg	- diagonal branch
EAT ACC	- carotid endarterectomy
ECC	- extracorporeal circulation
ECG	- electrocardiogram
GEA	- gastroepiploic artery
ICU	- intensive care unit
LAD	- left anterior descending coronary artery
LIMA	- left internal mammary artery
LVEF	- left ventricle ejection fraction
MI	- myocardial infarction
OM	- obtuse marginal artery
OPCAB	- off-pump coronary artery bypass
RA	- radial artery
RE-DO	- redo coronary surgery
RI	- intermediate ramus
RIMA	- right internal mammary artery
VSM	- major vena saphena

koronarnu stabilizaciju koji su se pojavili unazad par godina značajno su unapredili OPCAB hirurgiju omogućujući sigurnije i lakše izvođenje koronarnih anastomoza [15]. Njihovom primenom višestruka, kompletna hirurška revaskularizacija miokarda postala je jednostavnija i lakše izvodljiva. Danas, OPCAB procedure, u savremenim kardiohirurškim centrima zastupljene su sa 30% pa i do 90% od ukupnog broja hirurških revaskularizacija miokarda [16].

**Materijal i metode**

U periodu mart 2000 - april 2002. god. na Institutu za kardiovaskularne bolesti "Dedinje", 136 bolesnika operisano je OPCAB tehnikom. Izbor bolesnika izvršen je na osnovu individualne procene hirurga. U početku birani su bolesnici koji su imali jednosudovnu i dvosudovnu koronarnu bolest, dobrog opšteg stanja. Kasnije je procedura primenjena i kod bolesnika koji su imali difuznu, višesudovnu koronarnu bolest i/ili prateća oboljenja za koje se smatra da bi imali koristi od izbegavanja korišćenja ECC-a (Tabela 1). Za anesteziju je korišćena propofol i remifentanil infuzija kombinovana sa visokom torakalnom periduralnom analgezijom uz rano odvajanje bolesnika od respiratora. Kao operativni pristup korišćena je medijalna sternotomija, sem u 4 bolesnika gde je rađena donja ministernotomija. Od graftova korišćeni su: LIMA, desna unutrašnja torakalna arterija (RIMA), gastroepiploična arterija (GEA), radijalna arterija (RA) i velika vena safena (VSM). Nakon preparacije graftova dat je Heparin tako da se ACT održava na vrednosti oko 300 s. Po otvaranju perikarda za bolju ekspoziciju ciljnog krvnog suda korišćen je u početku Lima šav, a kasnije *Medtronic Starfish Heart Exposer*. Za stabilizaciju ciljnog područja korišćeni su *Medtronic Octopus 2+* i *Octopus 3* koronarni stabilizator, a za obezbeđivanje beskrvnog polja nakon otvaranja koronarne arterije proksimalno stavljen elastični šav i *Medtronic Blower*.

Development of interventional cardiology was an additional stimulus for surgeons to accept this less invasive surgical technique. Systems for coronary stabilization that appeared a few years ago, significantly improved OPCAB surgery providing safe coronary anastomoses. Thus, multiple, complete surgical myocardial revascularization became easier to perform. Nowadays, in modern cardiac surgery centers OPCAB procedures represent 30%, sometimes even 90% of the total number of surgical myocardial revascularization procedures [16].

**Methods**

From March 2000 to April 2002, 136 patients were operated using OPCAB technique at Dedinje Cardiovascular Institute. Selection of patients was based on surgeon's individual assessment. At first, only patients with single or double vessel disease were included. These patients were in good general condition. Later, as experience has grown, the procedure was performed in patients with diffused, multivessel coronary disease and/or associated diseases in whom extracorporeal circulation was not recommended (Table 1).

Propofol and remifentanil infusions combined with high thoracic peridural analgesia were used for anesthesia. Early extubation was considered in all patients.

In regard to surgical approach, we performed median sternotomy, except in 4 patients in whom ministernotomy was performed. LIMA, right internal mammary artery (RIMA), gastroepiploic artery (GEA), radial artery (RA) and major vena saphena (VSM) were used as grafts.

After preparation grafts, Heparin was administered - ACT was maintained at 300 s.

After opening of pericardium, in order to achieve better heart exposure we used Lima suture or *Medtronic Starfish Heart Exposer*. For stabilization of

Arterijski pritisak bolesnika tokom izvođenja anastomoza održavan je u normalnim vrednostima ili se radilo u kontrolisanoj hipotenziji. Pojave hemodinamičke nestabilnosti korigovane su infuzijom tečnosti, promenom položaja bolesnika ili rotacije srca i retko, kod 11 (8,09%) bolesnika, uz pomoć inotropne potpore. Rana rekronografija rađena je kod 8 (5,88%) bolesnika.

Našiveno je ukupno 249 anastomoza, prosečno 1,830,73 po bolesniku. LIMA je iskorišćena za 139 (55,82%), RIMA za 33 (13,25%), GEA za 4 (1,61%), RA za 4 (1,61%) i VSM za 69 (27,71%) anastomoza (Tabela 2). Od ukupnog broja operisanih bolesnika kod 32 (23,53%) urađena je kompletna arterijska revaskularizacija uz korišćenje dva ili više arterijskih graftova.

## Rezultati

Svi operisani bolesnici ekstubirani su unutar 12h od operacije izuzev 4 (2,94%) bolesnika koji su zahtevali produženu mehaničku ventilaciju. Od toga su 3 (2,20%) bolesnika ekstubirana na operacionom stolu. Inotropnu potporu dužu od 24h zahtevalo je 12 (8,82%) bolesnika.

U neposrednom posleoperativnom toku došlo je do jednog (0,74%) smrtnog ishoda. Radilo se o naprasnoj smrti sedmog posleoperativnog dana kod do tada neupadljive bolesnice. Obdukcijom je utvrđeno da se radilo o trombozi dominantne desne koronarne arterije, na mestu plaka koji je preoperativno procenjen na 30%. Arterija nije revaskularizovana tokom operacije. Našiveni graftovi bili su prohodni.

U jednom slučaju (0,74%) bolesnik je odmah po prevođenju u intenzivnu negu zbog hemodinamičke nestabilnosti i promena na ECG-u vraćen u salu gde je izvršena korekcija anastomoze na RIA uz korišćenje ECC-a. U daljem posleoperativnom toku bolesnik je bio stabilan i bez posledica.

Od drugih većih posleoperativnih komplikacija registrovana su 2 (1,47%) perioperativna infarkta miokarda, 3 (2,21%) retorakotomije zbog povećane drenaže, 3 (2,21%) pneumotoraksa, 1 (0,74%) tranzitorni neurološki defekt koji se povukao unutar 24h i jedna (0,74%) duboka infekcija sternalne rane koja je zahtevala produženo bolničko lečenje.

**Tabela 2.** Broj i distribucija graftova: N=249

**Table 2.** Grafts No & distribution: N=249

Koronarna arterija Coronary artery	LIMA	LIMA jump	RIMA	RA	RGEA	VSM
LAD	108		23			4
Dg	1	5				4
RI	3	2				3
OM	20		1			26
ACDx			9	4	4	32
Ukupno anastomoza Total	132	7	33	4	4	69

**Tabela 1.** Preoperativne karakteristike bolesnika

**Table 1.** Preoperative data

Promenljiva (variable)	N=136
Starost bolesnika (god) (age-years)	55.35(8,89)
Pol (žene/muškarci) (gender f/m)	23/113
Prethodni MI (previous MI)	54 (39,71%)
LVEF (%)	
>50	78 (57,35%)
30-50	43 (31,62%)
<30	15 (11,03%)
RE-DO	3 (2,21%)
EAT ACC + OPCAB	4 (2,94%)
Dijaliza (dialysis dependency)	3 (2,21%)
Hitna operacija (urgent operation)	2 (1,47%)

EAT ACC, karotidna endarterektomija; LVEF, ejskciona frakcija leve komore; MI, infarkt miokarda; OPCAB revaskularizacija miokarda bez primene vantelesnog krvotoka; RE-DO, koronarna reoperacija; EAT ACC, carotid endarterectomy; LVEF, left ventricle ejection fraction; MI, myocardial infarction; OPCAB, off-pump coronary artery bypass grafting; RE-DO, redo coronary surgery

the targeted vessel, we used Medtronic Octopus 2+ or Octopus 3 coronary stabilization system. The operating field was blood free using proximally placed elastic suture and Medtronic Blower. Arterial pressure of patients was maintained at normal values or controlled hypotension was present. Hemodynamic instabilities were corrected by liquid infusion, by changing patient's position or heart rotation and rarely, in 11 (8.09%) patients, by inotropic support. Early coronary angiographies were performed in 8 (5.88%) patients.

A total of 249 anastomoses were sewn, average 1.830.73 per patient. LIMA was used for 139 (55.82%), RIMA for 33 (13.25%), GEA for 4 (1.61%), RA for 4 (1.61%) and VSM for 69 (27.71%) anastomoses (Table 2). Complete arterial revascularization (using two or more arterial grafts) was performed in 32 (23.53%) pts.

## Results

All operated patients were extubated within 12h after surgery, except 4 (2.94%) patients who required prolonged mechanical ventilation. Three patients were extubated on the operating table. Twelve patients required inotropic support for more than 24 h.

Hospital mortality was registered in 1 case (0.74%). It was a case of sudden death on seventh postoperative day, in a female patient without manifestations. Autopsy revealed thrombosis of the dominant right coronary artery on site where plaque was present. Preoperatively, it was assessed 30%. The artery was not revascularized during surgery. Sewn grafts were viable.

Correction of anastomosis was required in 1 (0.74%) patient in whom hemodynamic instability and significant ECG changes appeared immediately after admission to the ICU. Correction was done using ECC. Later, during the postoperative period, the patient was stable without any sequels.

Prolazni poremećaji ritma registrovani su kod 11 (8,09%) bolesnika. Kod bolesnika kod kojih je rađena rekoronarografija verifikovana je dobra prohodnost graftova. Najveći broj bolesnika otpušten je između 5. i 8. dana od operacije. Kod 5 (3,68%) bolesnika hospitalizacija je iznosila između 9 i 17 dana, dok je jedan bolesnik (0,74%) zbog duboke infekcije rane hospitalizovan 46 dana.

### Diskusija i zaključak

Iako još uvek pojedini hirurzi smatraju za rizičniju i tehnički teže izvodljivu proceduru [17], OPCAB predstavlja jednako sigurnu metodu revascularizacije miokarda kao i standardna procedura uz korišćenje ECC-a. Primena koronarnih stabilizatora i drugih pomoćnih sredstava značajno je tome doprinela. Broj anastomoza, odnosno kompletnost revascularizacije, povećala se njihovom primenom ali i sa iskustvom hirurga. Morbiditet i mortalitet pri OPCAB revascularizaciji u potpunosti odgovara ili je čak niži nego kod standardnih procedura [18-20]. Rekoronarografije rađene u jednom broju studija pokazale su da posleoperativna i jednogodišnja prohodnost anastomoza kod OPCAB operacija odgovara standardnim uz korišćenje ECC-a [21,22].

U inicijalnoj fazi na našem Institutu operisani su bolesnici sa nižim stepenom rizika i manjim brojem graftova. Nakon faze obuke prisutan je trend povećanja broja anastomoza po operaciji i izvođenje zahvata kod bolesnika sa visokim stepenom rizika od standardne operacije i primene VTK. Što je iskustvo hirurga veće, komplikacija je manje. U poslednjih 50 operisanih slučajeva, iako se radi o kompleksnijim bolesnicima, sa višesudovnom koronarnom bolešću i pratećim oboljenjima nije registrovana nijedna ozbiljnija komplikacija. Procedura OPCAB pokazala se kao posebno pogodna kod bolesnika sa terminalnom bubrežnom insuficijencijom (na hemodijalizi), bolesnika kod kojih je zbog nestabilne forme angine pectoris i prisutne karotidne bolesti bilo neophodno uraditi simultanu operaciju revascularizacije miokarda i karotidne endarterektomije i bolesnika preko 70 godina starosti koji su rano odvajani od mehaničke ventilacije.

Ipak za konačnu ocenu ove procedure neophodno je sprovesti randomizovanu studiju na većem uzorku kojom će se porediti rezultati OPCAB bolesnika i bolesnika operisanih uz pomoć ECC-a. Ovakva studija u toku je na našem Institutu. Takođe je neophodno pratiti srednjoročne i udaljene rezultate do sada operisanih bolesnika OPCAB tehnikom i uporediti ih sa prihvaćenim standardom za konvencionalno operisane bolesnike.

Regarding other major postoperative complications, we registered 2 (1.47%) perioperative myocardial infarctions, 3 (2.21%) rethoracotomies due to increased drainage, 3 (2.21%) pneumothoraxes, 1 (0.74%) transient neurological defect that ended within 24 hours and one (0.74%) deep sternal wound infection that required prolonged hospitalization. Transient rhythm disturbances were registered in 11 (8.09%) patients. Normal graft viability was verified in patients in whom repeated coronary angiographies were performed.

The vast majority of patients were discharged between fifth and eighth postoperative day. In 5 (3.68%) patients duration of hospitalization was 9 - 17 days, while one patient (0.74%) was hospitalized for 46 days due to deep wound infection.

### Conclusion

Although some surgeons consider OPCAB very risky and difficult to perform [17], this procedure is a very safe method of myocardial revascularization, as well as standard procedure using ECC. Coronary stabilizing systems and other devices play key roles. Use of coronary stabilizing systems and, of course, surgeon's experience contribute to increased number of anastomoses per patient and completeness of revascularization. Morbidity and mortality rates in OPCAB revascularizations are similar or even lower than in standard procedures [18-20]. Repeated coronary angiographies performed in some studies showed that postoperative and one-year viability of anastomoses in OPCAB interventions is similar to that in standard procedures using ECC [21,22].

In our material, during the initial phase, we operated patients with lower risk and single or double vessel disease. After the phase of study, we started OPCAB surgery in patients with increased risk of ECC, patients with comorbidity and those with diffused, multivessel coronary disease. Number of complications was lower with experienced surgeons. In the last 50 patients with multivessel and associated diseases, we did not register any serious complication. OPCAB procedure is especially useful in patients with terminal kidney failure (hemodialysis) and in patients with unstable angina pectoris and carotid disease in whom it is necessary to perform simultaneous interventions - myocardial revascularization and carotid endarterectomy. Also, this procedure is very useful in patients over 70 years of age.

However, regarding final evaluation of OPCAB procedure, it is necessary to perform a randomized study with a large sample of patients comparing on-pump versus off-pump coronary surgery.

This kind of investigation is being done at our Institute. It is also necessary to follow-up long-term results of patients who had undergone OPCAB surgery and to compare them with accepted standards for conventional surgeries.

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