

# Off pump Versus On pump Coronary Artery Bypass Grafting: Short-term Outcomes

Ilirijana Haxhibeqiri -  
Karabdic, Slavenka Straus,  
Nermir Granov, Amel  
Hadzimehmedagic, Behija  
Berberovic, Edin Kabil,  
Muhamed Djedovic, Damir  
Kurtagic

Clinic for Cardiovascular Surgery, Clinical  
Center of University of Sarajevo, Sarajevo,  
Bosnia and Herzegovina

Corresponding author: Ilirijana Haxhibeqiri-  
Karabdic, MD, PhD. Clinic for Cardiovascular  
Surgery, Clinical Center of University of  
Sarajevo, Sarajevo, Bosnia and Herzegovina.  
E-mail: ilirijanahk@yahoo.com. ORCID ID: [http://  
www.orcid.org/0000-0002-7836-2461](http://www.orcid.org/0000-0002-7836-2461).

doi: 10.5455/aim.2023.31.107-110

ACTA INFORM MED. 2023 JUN 31(2): 107-110

Received: MAY 05, 2023

Accepted: JUN 26, 2023

© 2023 Ilirijana Haxhibeqiri - Karabdic, Slavenka  
Strauss, Nermir Granov, Amel Hadzimehmedagic, Edin  
Kabil, Muhamed Djedović, Damir Kurtagic, Behija  
Berberovic

This is an Open Access article distributed under the  
terms of the Creative Commons Attribution Non-  
Commercial License ([http://creativecommons.org/  
licenses/by-nc/](http://creativecommons.org/licenses/by-nc/)) which permits unrestricted non-  
commercial use, distribution, and reproduction in any  
medium, provided the original work is properly cited.

## ABSTRACT

**Background:** Coronary artery disease (CAD) is a major public health issue and a leading cause of death globally. It is one of the most common indications for surgical intervention. There are a lot of different techniques, including CABG, which consists of two approaches: sternotomy and mini-thoracotomy. Different techniques have been developed to improve surgical outcomes, including the use of machine for extracorporeal circulation (on-pump) or without it (off-pump). **Objective:** The objective of this study was to assess whether off-pump CABG offers superior short-term outcomes compared to traditional on-pump CABG in patients undergoing isolated CABG. **Methods:** In period between 2022 – 2023, we performed CABG operation in 80 patients. CABG was performed either on- pump or off-pump. **Results:** The results have shown advantages and disadvantages of one or another type of CABG. We were comparing the duration of surgical procedure, time on mechanical ventilation, drainage volume, neurological incidents, time to discharge, indication for repeat revascularization and mortality between two groups. **Conclusion:** The choice of surgical technique should be based on individual patient factors, including comorbidities and surgical risks. It is important to say that OPCABG is more challenging than ONCABG, and it is very important that OPCABG is done by skilled, experienced and confident surgeon, which contributes to better outcome and survival. **Keywords:** coronary disease, Off pump coronary artery bypass, On pump coronary artery bypass, coronary artery bypass grafting.

## 1. BACKGROUND

On pump CABG (ONCABG) employs cardiopulmonary bypass to provide a calm, bloodless surgical field, but it is associated with a systemic inflammatory response and various postoperative complications. Off pump CABG (OPCABG) was introduced to minimize these risks and has shown potential in reducing operation time, intensive care unit (ICU) stay, transfusion rates, and early morbidity. However, the effectiveness of OPCABG remains a matter of controversy, with some studies reporting positive outcomes while others raising concerns about its effectiveness (1, 2)

## 2. OBJECTIVE

The objective of this study was to assess whether off-pump CABG offers superior short-term outcomes compared to traditional on-pump CABG in pa-

tients undergoing isolated CABG.

## 3. METHODS

The study was constructed as a retrospective, comparative cohort study. It enrolled 80 patients who underwent isolated CABG and were assigned to either the on-pump or off-pump group in equal numbers. All surgeries were performed by experienced surgeons at the Clinic for Cardiovascular Surgery-University Clinical Center of Sarajevo between January 2022 and January 2023

### Data collection

Patient data, including preoperative characteristics, perioperative data, postoperative outcomes, and complications, were collected and entered into a database. Follow-up data were recorded for mortality, myocardial infarction, newly onset heart rhythm abnormalities, renal dysfunction, and cerebrovascular incidents.

### Surgical Technique

All surgeries were performed under general endotracheal anesthesia. OPCAB procedures were conducted with the assistance of heart stabilizers to expose the coronary arteries. On-pump cases were carried out using the standard cardiopulmonary bypass (CPB) technique with ascending aortic cannulation and cannulation of the right atrium with a single two-staged cannula. The grafts employed were the left and right internal mammary arteries, as well as saphenous vein grafts.

### Statistical analysis

Descriptive statistics were calculated for the baseline demographic and clinical features, as well as treatment outcomes. Categorical variables were presented as numbers and percentages. All analyses were conducted using IBM Statistics SPSS, v23.0 (Chicago, Illinois, USA).

## 4. RESULTS:

The study included a total of 80 patients. They were divided into two groups based on whether they underwent off-pump or on-pump CABG. The female-to-male ratio (1:3) was equal in both groups.

### Preoperative data

The sample included a total of 84 patients, 42 in the ONCAB–on-pump coronary artery bypass grafting and 42 in the OPCAB–off-pump coronary artery bypass grafting group. Mean age of the respondents in the total sample was 65,83±7,7 years with the youngest patient at the age of 43 and the oldest at age of 82 years. The groups are consisted in the term of age with the mean age of 66,07±7,78 years in the ONCAB and 65,59±8,01 years in the OPCAB group.

According to gender, the groups are equal with the male to female ratio of 32 : 10.

The preoperative data regarding ECG characteristics showed no significant difference in the preoperative incidence of atrial fibrillation, bundle branch block, atrioventricular block, as well as ventricular or supraventricular tachycardia. Preoperative data analysis revealed no significant difference in preoperative ECG characteristics, including the incidence of atrial fibrillation, bundle branch block, atrioventricular block, ventricular or supraventricular tachycardia between the two groups. Regarding preoperative comorbidities, a significantly larger incidence of peripheral vascular disease was observed in patients who underwent OPCABG compared to those who underwent ONCABG ( $p=0.012$ ).

In addition, patients in the OPCABG group had a significantly higher incidence of hyperlipidemia compared to those in the ONCABG group ( $p=0.0001$ ). No significant differences were observed between the two groups regarding the presence of hypertension, diabetes, chronic obstructive pulmonary disease, renal dysfunction, or preoperative infection status.

A comparison of preoperative echocardiography showed that the patients in the OPCABG group had lower right ventricular strength (TAPSE mean value 16,40) compared to ONCABG group (TAPSE mean value 23,21). However, a higher incidence of LM stenosis was noted in patients who underwent OPCABG, as it was present among 28,6% of cases in the OPCAB and only 4,8% of cases in the ONCAB group ( $p=0.007$ ).

	ONCAB (n=42)	OPCAB (n=42)	p
Age	66,07±7,48	65,59±8,01	0,579
Gender	Male	32 (76,2)	-
	Female	10 (23,8)	10 (23,8)

Table 1. Demographic data

	ONCAB (n=40)	OPCAB (n=40)	p
One vessel	0 (0,0)	0 (0,0)	-
Two vessel	7 (21,4)	4 (9,5)	0,227
Three vessel	32 (76,2)	38 (90,5)	0,141
LM	2 (4,8)	12 (28,6)	0,007

Table 2. Coronography parameters before surgery

	ONCAB (n=40)	OPCAB (n=40)	p
Total duration of surgery (h)	4,06±0,91	3,56±0,67	0,005

Table 3. Comparison of parameters after the surgery

	ONCAB (n=42)	OPCAB (n=42)	p
Bypass 1	0 (0,0)	3 (7,1)	0,241
Bypass 2	13 (31,0)	23 (64,8)	0,023
Bypass 3	26 (61,9)	16 (38,1)	0,024
Bypass 4	3 (7,1)	0 (0,0)	0,120

Table 4. Number of coronary bypass in revascularisation

	ONCAB (n=40)	OPCAB (n=40)	p
1h	111,43±47,74	70,48±49,53	0,0001
2h	183,81±68,24	129,88±80,68	0,001

Table 5. Comparison of drainage volume (mL)

	ONCAB (n=40)	OPCAB (n=40)	P
AKI	2 (4,8)	0 (0,0)	0,247

Table 6. Comparison of renal status after the surgery.

### Perioperative data

In all surgical procedures, the grafts used were the mammary artery as well as the great saphenous vein. Regarding the number of vessels that received cardiosurgical revascularization, there was a statistically significant difference between the two groups. The patients who underwent ONCABG mostly had full revascularization which included three grafts (in 62% of cases) and four grafts (in 8% of cases). In the OPCABG groups the incidence of the triple or quadruple bypass was significantly lower than in the ONCABG group ( $p=0,024$ ) where patients mostly received two grafts (in 65% of the cases). While observing the total duration of the surgery significantly shorter total time was noted in the OPCABG group compared to the ONCABG group ( $p=0,005$ ).

In all surgical procedures, the mammary artery and the great saphenous vein were used as grafts for cardiac revascularization. The analysis showed a statistically significant difference between the two groups regarding the number of vessels that received revascularization. The majority of patients who underwent on-pump CABG received full revascularization, which included three coronary arteries (in 62% of cases) and four coronary arteries (in 8% of cases). In contrast, patients who underwent OPCABG had a significantly lower incidence of triple or quadruple bypass compared to the ONCABG group ( $p=0.024$ ). In the OPCABG group, most patients received double bypass (in 65% of cases). In many centers OPCABG is offered to patients who require one or two

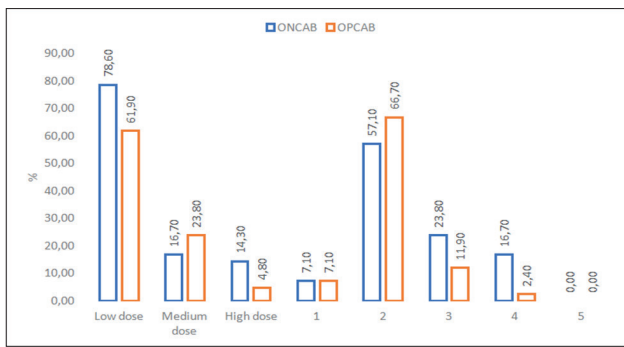


Figure 1. Number and doses of inotropes required after surgery

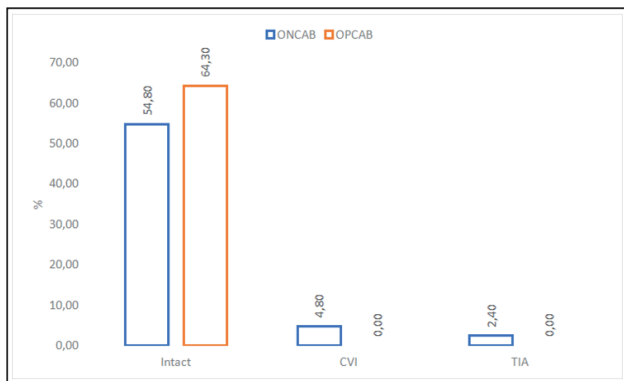


Figure 2. Comparison of neurological incidents. Both cardiac arrest (11,9 : 9,5%) and fibrillation (19,0 : 9,5%) were more present in ONCAB group

grafts, while more grafts often require use of the heart-lung machine. As in the other researches it is believed that some of the high risk patients are offered incomplete revascularization as a safer option for a better long-term survival.

#### Postoperative data

Patients who underwent OPCABG had a significantly lower amount of postoperative drainage, especially in the first and second hour after surgery, compared to the ONCABG group ( $p=0.0001$  and  $p=0.001$ ). This led to a smaller amount of blood and other derivative transfusions in the OPCABG group compared to the ONCABG group.

In the postoperative period, patients who underwent ONCABG required a larger number and higher doses of inotropes compared to the OPCABG group ( $p=0.029$ ).

The incidence of newly onset atrial fibrillation was equal in both groups. ONCABG was associated with a higher incidence of ventricular extrasystoles (VES), supraventricular extrasystoles (SVES), and ventricular tachycardia (VT) compared to OPCABG ( $p=0.006$ ).

Acute renal insufficiency was reported in 5% of patients in the ONCABG group, while there were no cases of the same in the OPCABG group.

Neurological incidents were reported in 8% of cases in the ONCABG group (5% cerebrovascular insult and 3% transitory ischaemic attack), while no cases of neurological incidents were noted in the OPCABG group.

Regarding total hospital stay, we have found that 21 out of 40 patient in ONCABG group were discharged on the 7th to 14th postoperative day. No patients in this group had shorter postoperative hospital stay than 7 days. In the OPCAB group 17 patients were discharged on the 5th postoperative day, 7 patients on the 4th postoperative day. The times of discharge were greatly shorter in OPCABG group compared to ON-

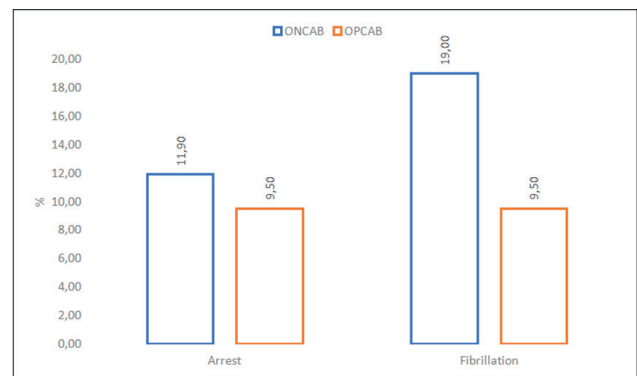


Figure 3. Occurrence of VF and cardiac arrest

CABG when comparing patients with similar preoperative state.

## 5. DISCUSSION

This study was undertaken to compare the short-term outcomes of on-pump and off-pump coronary artery bypass grafting (CABG) procedures in patients undergoing isolated CABG. 80 patients were enrolled, with 40 patients assigned to each group, and analyzed patient data, including preoperative characteristics, perioperative data, postoperative outcomes, and complications. In our group, bypass revascularization was needed more for male patients than for female patients, which was similar as in other studies. The study found that OPCABG resulted in a significantly shorter total duration of surgery compared to ONCABG, which was shown in previous studies by Zhang and Pompeu (1, 3). Our patients who were at off-pump were extubated from mechanical ventilation in shorter time than patients who were on-pump. The patients who were off-pump also required less blood products. In our study, significant differences were found in mortality, myocardial infarction, newly onset heart rhythm abnormalities and cerebrovascular incidents between the two groups, in which patients with off-pump had lower mortality, lower incidence of myocardial infarction and cerebrovascular incidents as well. These findings were different to some other research studies performed on a larger number of patients like the study "Off-pump versus on-pump coronary artery bypass surgery: meta-analysis and meta-regression of 13,524 patients from randomized trials", where they found that there was no difference in mortality, myocardial infarction, cerebrovascular incidents and heart rhythm abnormalities (3, 4, 5). An important benefit of OPCABG includes a reduction of neurological events or stroke, most likely due to minimal or no aortic manipulation. We have also found other studies that strongly suggest that OPCABG reduces neurological incidents (3, 6). In a large meta-analysis study performed by Gaudino and colleagues in 2018 showed in numerous researches different percentage of conversion from OPCBG to ONCABG between from less than 3% to up to more than 10% (12).

Another study performed by Kowalewski M. and colleagues showed the conversion rate from 0% to 22,5% (6). In regards to the previously mentioned in our study none of the patients required conversion from OPCABG to ONCABG surgery. During this research we have also noted that OPCABG patients have fewer anastomoses, which suggests that OPCABG patients receive incomplete myocardial revascu-

larization, due to it being a safer option for high-risk patients, which agrees with other research found (7, 8). Myocardial infarction (MI) as a safety predictor, and postoperative complication was observed and in our study and there was no incidence of MI in either group. In comparison, the study by Kowalewski M and colleagues showed that in 43 trials with a total of 15,733 subjects, no differences were found between OPCAB and CABG with respect to MI the event rate was 4.31% for OPCAB and 4.67% for CABG (6). When comparing all of the available data we are led to believe that OPCABG may be more beneficial for high-risk patients, reducing the risk of stroke and improving overall survival (6).

It is important to note that the study only evaluated short-term outcomes and did not analyze the long-term outcomes of the two procedures. In many centers, off-pump CABG is offered to patients who only require one or two grafts, whereas, all else equal, the same patient requiring four or five grafts will not be considered for off-pump CABG. It is important to say that OPCABG is more challenging than ONCABG, and it is very important that OPCABG is done by skilled, experienced and confident surgeon, which contributes to better outcome and survival. It is doubtless that despite the substantial learning curve associated with off-pump CABG in high-risk patients are better than of conventional on-pump CABG. However, these beneficial outcomes in high-risk patients can only be achieved if off-pump is offered to both high and low-risk patients. Ultimately, the choice of surgical technique should be based on individual patient factors, including comorbidities and surgical risks.

## 6. CONCLUSION

This study adds to the body of literature on the effectiveness of on- pump and off-pump CABG procedures. In fact, centers with established off-pump training programs have consistently shown that off-pump CABG can be safely and successfully taught to trainees without jeopardizing outcomes.

### Abbreviations

- CAD-coronary artery disease,
- CABG- coronary artery bypass grafting,
- ONCABG-om pump coronary artery bypass grafting
- OPCABG- off-pump coronary artery bypass grafting
- ICU- intensive care unit,
- MV- mechanical ventilation
- AF- atrial fibrillation,
- VT- ventricular tachycardia
- VES- ventricular extrasystole,
- SVES- supraventricular extrasystole
- MI- myocardial infarction.

- **Author's contributions:** All authors made a significant contribution to this study, whether in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; the drafting, revising, or critical reviewing of the article; giving final approval of the version to be published; agreeing on the journal to which the article has been submitted; and agreeing to be accountable for all aspects of the work.
- **Conflict of interest:** The author reports no conflicts of interest or financial interest in this work.
- **Financial support and sponsorship:** This work was no funded.

## REFERENCES

1. Zhang S, Huang S, Tiemuerniyazi X, Song Y, Feng W. *Frontiers in Cardiovascular Medicine*. [Online].; 2022 [cited 2023 04 13]. Available from: <https://www.frontiersin.org/articles/10.3389/fcvm.2022.869987/full>.
2. Guerra N. On pump vs. off-pump surgery: still no definitive answers. *Portugese Journal of Carac Thoracic Vascular Surgery*. 2022 April; 29(1).
3. Pompeu Barros de Oliveira SáI M, FerrazII PE, EscobarII, MartinsII WN, LustosaII PC, de Oliveira Nunes E, et al. Off-pump versus on-pump coronary artery bypass surgery: meta-analysis and meta-regression of 13,524 patients from randomized trials. *Brazilian Journal of Cardiovascular Surgery*. 2012; 27(4).
4. Lamy A, Devereaux P, Prabhakaran D, Taggart D, Hu S, Straka Z, et al. Five-Year Outcomes after Off-Pump or On-Pump Coronary-Artery Bypass Grafting. *The New England Journal of Medicine*. 2016 December; 375(24).
5. Rantanen M, Yousif R, Kallioinen R, Hynninen W, Peltoniem M, Söderholm M, et al. Retrospective observational analysis of a coronary artery bypass grafting surgery patient cohort: Off-pump versus on-pump. *Annals of Medicine and Surgery*. 2022 December; 84.
6. Kowalewski M, Pawliszak W, Malvindi P, Bokszanski M, Perlinski D, Raffa G, et al. Off-pump coronary artery bypass grafting improves short-term outcomes in high-risk patients compared with on-pump coronary artery bypass grafting: Meta-analysis. *Journal of Thoracic Cardiovascular Surgery*. 2015 August.
7. Fudulu D, Benedetto UGG, Chivasso P, Bruno VD, Rapetto F, Bryan A, et al. Current outcomes of off-pump versus on-pump coronary artery bypass grafting: evidence from randomized controlled trials. *Journal of Thoracic Disease*. 2015 November; 8(10).
8. Sousa Uva M, Cavaco S, Oliveira A, Matias F, Silva C, Mesquita A, et al. Early graft patency after off-pump and on-pump coronary bypass surgery: a prospective randomized study. *European Heart Journal*. 2010 October; 31(20).
9. Shahzad G R; Off-pump versus on-pump coronary artery bypass grafting: comparative effectiveness; *Comparative Effectiveness Research*, 2015; 5.
10. Quin JA, Wagner TH, Hattler B, et al. Ten-Year Outcomes of Off-Pump vs On-Pump Coronary Artery Bypass Grafting in the Department of Veterans Affairs: A Randomized Clinical Trial. *JAMA Surg*. 2022;157(4):303–310. doi:10.1001/jamasurg.2021.7578
11. Sheikhy, A., Fallahzadeh, A., Forouzannia, K. et al. Off-pump versus on-pump coronary artery bypass graft surgery outcomes in patients with severe left ventricle dysfunction: inverse probability weighted study. *BMC Cardiovasc Disord*. 2022; 22: 488. <https://doi.org/10.1186/s12872-022-02895-0>
12. Gaudino M, Benedetto U, Bakaeen F, Rahouma M, Tam DY, Abouarab A, Di Franco A, Leonard J, Elmously A, Puskas JD, Angelini GD, Girardi LN, Femes SE, Taggart DP. Off- Versus On-Pump Coronary Surgery and the Effect of Follow-Up Length and Surgeons' Experience: A Meta-Analysis. *J Am Heart Assoc*. 2018 Nov 6; 7(21): e010034. doi: 10.1161/JAHA.118.010034. PMID: 30373421; PMCID: PMC6404195.
13. R J Machado, F A Saraiva, J Mancio, P Sousa, R J Cerqueira, A S Barros, A P Lourenco, A F Leite-Moreira. A meta-analysis of randomized controlled studies comparing off-pump vs on-pump CABG in the elderly. [European Heart Journal](https://doi.org/10.1093/eurheartj/ehab724.1250) (IF 35.855) Pub Date: 2021-10-20 , doi: 10.1093/eurheartj/ehab724.1250.