

Outcome of Coronary Artery Bypass Graft with On-pump Beating-heart Technique

Kambiz Alizadeh¹, Masoomeh Tabari^{2,*}, Zohreh Rouhandeh², and Azra IZanloo³

¹ Department of Cardiovascular Surgery, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

² Department of Anesthesiology, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

³ Razavi Cancer Research Center, Razavi Hospital, Imam Reza International University, Mashhad, Iran

* **Corresponding author:** Masoomeh Tabari, Department of Anesthesiology, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran. Email: tabarim@mums.ac.ir

Received 2018 March 03; Accepted 2018 September 18.

Abstract

Background: This paper intends to evaluate the effects of on-pump beating-heart coronary artery bypass graft (CABG) in patients with coronary artery disease. Studies have shown that this surgical procedure can have acceptable results.

Objectives: This study intends to share experiences and results of on-pump beating-heart CABG.

Methods: We reported preliminary results related to mortality and morbidity in patients who underwent CABG in the period from 2015 to 2017 in Ghaem hospital, Mashhad, Iran.

Results: 80 patients, in the period from 2015 to 2017, underwent general anesthesia and on-pump beating-heart CABG surgery was done for them. The average number of grafts was 3.18 ± 0.474 and two patients died, unfortunately: one during surgery and one in ICU. There were no postoperative myocardial infarctions during the study. None of the patients reported kidney dysfunction. The average length of hospitalization was 4 ± 1.11 days and the mean follow-up of the patients was 6 months. The average ejection fraction (EF) of patients was 43.28 ± 9.58 .

Conclusion: In the last decade there has been a big challenge between using off-pump CABG and on-pump CABG, on-pump beating method could present acceptable and effective results.

Keywords: Beating heart technique, Cardiovascular disease, High-risk, Off-pump, On-pump

1. Background

There are controversies over benefits and shortcomings of off-pump coronary artery bypass grafting (CABG) surgery, and on the other hand cardiopulmonary bypass can have several harmful effects. Preliminary tests have shown that off-pump CABG can be used in patients with low risk and results similar to conventional on-pump technique have been reported (1). In experienced institutions known for using off-pump CABG method, the rate of major adverse events and complete revascularization and graft patency rate were identical to on-pump CABG (2-4). A randomized on/off bypass trial between conventional on-pump and off-pump CABG has shown that among patients in low risk group, mortality rate and major complications 30 days after surgery are the same in both on-pump and off-pump CABG techniques, but the latter has higher rate of incomplete revascularization and inferior outcome in the following years (5). Another study has reported that short-term mortality and morbidity in two groups are similar (6). In any case, it has been shown that in high risk populations, Off-pump Coronary Artery Bypass (OPCAB) has potentials to be converted into unplanned On-pump CABG during surgery, and this can increase the mortality rate (7). In 2012, 61.14% of CABG procedures in Japan were performed off-pump technique with a change rate of 2.1% from OPCAB to on-pump CABG (8).

According to Keeling et al., 5.2% of OPCAB patients with low ejection fraction (EF) are subjected to unplanned conversion to on-pump, and it can cause in-hospital mortality by 9.3% (9). Thus, as stipulated by 2014 ESC / EACTS guidelines, in myocardial revascularization state, OPCAB, the subgroup of high risk patients in centers with high-volume of off-pump (Class IIa) has to be taken into account (10). A hybrid procedure of beating heart CABG with concomitant use of CPB called on pump beating-heart CABG was proposed as a suitable alternative for high-risk patients. Previous studies have demonstrated clinical benefits of this method in high-risk patients (11,12).

It is clear that using minimally invasive techniques is crucial to improve the results of CABG, especially in high risk population. As we know, off-pump beating-heart CABG is a minimally invasive procedure that prevents cardiac arrest with lower morbidity and mortality rates, especially in high-risk patients. (9,13,14).

Given the controversies and challenges surrounding the use of various surgical methods, this study intends to share experiences and results of on-pump beating-heart CABG.

2. Objectives

This study intends to share experiences and results of on-pump beating-heart CABG.

3. Methods

In this report, we discuss the experience of 80 patients with artery coronary disease with or without left ventricular dysfunction in a community hospital in the period from 2015 to 2017. In this descriptive study, the medical records of patients undergoing on-pump beating-heart CABG were analyzed retrospectively. The 6-month mortality rate, length of stay in hospital and ICU, comorbidity and underlying and hemodynamic parameters were extracted and coded before being subjected to descriptive analysis and paired t-test was used to assess changes in experimental factors before and after the surgery. It should be noted that during the study, patients were treated by a specialist and their disease was confirmed by coronary angiography and Transesophageal Echocardiography (TEE).

Surgical technique and anesthesia:

All patients underwent general anesthesia. Patients were monitored by 5 lead ECG with ST segment analysis, pulse-oximetry, capnography, temperature, arterial blood pressure by cannulating radial or femoral artery, 3-lumen central line via internal jugular vein or subclavian vein. Anesthetic induction was done using midazolam, opioids (fentanyl or sufentanil), Propofol or Etomidate. The patients received Atracurium or Cisatracurium as muscle relaxant.

Before starting on-pump beating heart technique, 3mg/kg heparin was injected like conventional method. After cannulating of aorta and right atrium cardiopulmonary bypass (CPB) commenced without use of cardioplegia and without aortic cross clamp. Operation technique is like off-pump method, but there is better access to posterior coronary artery and better visualization of small vessels and no need for deep cooling.

4. Results

The mean age of participants was 59.14 ± 11.02 years and 72.5% of patients were male. The mean length of stay in ICU was 3.6 days and on average, they were hospitalized for 4 ± 1.11 days. Demographic data are depicted in [Table 1](#).

In more than 42.5% of patients, blood transfusion was performed in the operating room and 18.7% of patients required blood transfusion after surgery.

Table 1. Demographic features

Feature	No.
Male	72.5% (58)
COPD	2.5% (2)
Hypertension	52.5% (42)
DM	45% (36)
HLP	41.3% (33)
RF	1.3% (1)
Addiction	15% (12)

One patient had intraoperative arrhythmias and 2 patients had postoperative arrhythmias. One patient (1.3%) developed postoperative GI Bleeding but none of the patients reported breathing problems after surgery. 78 patients (97.5%) survived after surgery and 2 patients died of cardiac arrest at ICU and during operation. The average number of grafts was 3.18 ± 0.474 . One of the patients had kidney dysfunction. The average length of follow-up was 6 months and the mean EF of patients was 43.38 ± 9.58 .

5. Discussion

As we know, one of the key factors that increases morbidity and mortality during and after off-pump surgery is crush conversion specially in left ventricle dysfunction with low EF. Despite of the protection techniques, both in anesthesia and surgery, postoperative complications associated with intraoperative ischemia have not been completely eliminated. On the other hand, off pump CABG can cause hemodynamic instability in patients who need posterior graft (like obtuse marginal (OM), posterior descending artery (PDA)). This can lead to myocardial ischemia and, or arrhythmia and cardiovascular collapse. To solve this problem, alternative techniques such as on-pump beating-heart with CPB have been proposed; in this method aortic cross clamp and cardioplegia were not used (15). The results of this study reveal that on-pump beating-heart CABG surgery offers a safe alternative with satisfactory short-term clinical outcomes. Similar results have been reported in several other studies (12,16,17).

The results of this study demonstrated acceptable morbidity and mortality during and after the surgery along with acceptable post-operative complication which is consistent with the literature, according to which reported complications were significantly lower in on-pump beating-heart CABG (15,17-20).

Mizutani compared conventional CABG and on-pump beating -heart CABG, finding that on-pump beating-heart CABG could significantly diminish in-hospital mortality rate (12). Edgerton also reported that despite the predicted mortality risk in patients undergoing on-pump beating-heart CABG, the expected rate of mortality was not significantly different between on-pump beating-heart CABG and conventional CABG groups (11).

One of the limitations of this study was its small sample size and retrospective approach, which impeded the generalization of clinical results. It is recommended that further studies use larger sample sizes and comparison with other technique to determine the clinical effectiveness of this procedure.

6. Conclusion

The results showed that on-pump beating-heart

CABG had acceptable morbidity and mortality and it could be considered as an effective treatment alternative for patients.

Acknowledgments

None.

Conflicts of interest

None.

References

- Diegeler A, Börgermann J, Kappert U, Breuer M, Böning A, Ursulescu A, et al. Off-pump versus on-pump coronary-artery bypass grafting in elderly patients. *N Engl J Med*. 2013; **368**(13):1189-98. doi: [10.1056/NEJMoa1211666](https://doi.org/10.1056/NEJMoa1211666). [PubMed: [23477657](https://pubmed.ncbi.nlm.nih.gov/23477657/)].
- Nathoe HM, van Dijk D, Jansen EW, Suyker WJ, Diephuis JC, van Boven WJ, et al. A comparison of on-pump and off pump coronary Bypass surgery in low-risk patients. *N Engl J Med*. 2003; **348**(5):394-402. doi: [10.1056/NEJMoa021775](https://doi.org/10.1056/NEJMoa021775). [PubMed: [12556542](https://pubmed.ncbi.nlm.nih.gov/12556542/)].
- Widimsky P, Straka Z, Stros P, Jirasek K, Dvorak J, Votava J, et al. One-year coronary bypass graft patency: a randomized comparison between off-pump and on-pump surgery: angiographic results of the PRAGUE-4 trial. *Circulation*. 2004; **110**(22):3418-23. doi: [10.1161/01.CIR.0000148139.79580.36](https://doi.org/10.1161/01.CIR.0000148139.79580.36). [PubMed: [15557371](https://pubmed.ncbi.nlm.nih.gov/15557371/)].
- Puskas JD, Williams WH, Mahoney EM, Huber PR, Block PC, Duke PG, et al. Off-pump vs. conventional coronary artery bypass grafting: early and 1-year graft patency, cost, and quality-of life outcomes: a randomized trial. *JAMA*. 2004; **291**(15):1841-9. doi: [10.1001/jama.291.15.1841](https://doi.org/10.1001/jama.291.15.1841).
- Shroyer AL, Grover FL, Hattler B, Collins JF, McDonald GO, Kozora E, et al. On-pump versus off-pump coronary-artery bypass surgery. *N Engl J Med*. 2009; **361**(19):1827-37. doi: [10.1056/NEJMoa0902905](https://doi.org/10.1056/NEJMoa0902905). [PubMed: [19890125](https://pubmed.ncbi.nlm.nih.gov/19890125/)].
- Lamy A, Devereaux PJ, Prabhakaran D, Taggart DP, Hu S, Paolasso E, et al. Off-pump or on-pump coronary artery bypass grafting at 30 days. *N Engl J Med*. 2012; **366**(16):1489-97. doi: [10.1056/NEJMoa1200388](https://doi.org/10.1056/NEJMoa1200388). [PubMed: [22449296](https://pubmed.ncbi.nlm.nih.gov/22449296/)].
- Mukherjee D, Ashrafian H, Kourliouros A, Ahmed K, Darzi A, Athanasiou T. Intra-operative conversion is a cause of masked mortality in off-pump coronary artery bypass: a meta-analysis. *Eur J Cardiothorac Surg*. 2012; **41**(2):291-9. doi: [10.1016/j.ejcts.2011.05.023](https://doi.org/10.1016/j.ejcts.2011.05.023). [PubMed: [21684171](https://pubmed.ncbi.nlm.nih.gov/21684171/)].
- Masuda M, Kuwano H, Okumura M, Amano J, Arai H, Endo S, et al. Thoracic and cardiovascular surgery in Japan during 2012. *Gen Thorac Cardiovasc Surg*. 2014; **62**(12):734-64. doi: [10.1007/s11748-016-0622-7](https://doi.org/10.1007/s11748-016-0622-7).
- Keeling WB, Williams ML, Slaughter MS, Zhao Y, Puskas JD. Off-pump and on-pump coronary revascularization in patients with low ejection fraction: a report from the Society of thoracic surgeons national database. *Ann Thorac Surg*. 2013; **96**(1):83-9. doi: [10.1016/j.athoracsur.2013.03.098](https://doi.org/10.1016/j.athoracsur.2013.03.098). [PubMed: [23743061](https://pubmed.ncbi.nlm.nih.gov/23743061/)].
- Kolh P, Windecker S, Alfonso F, Collet JP, Cremer J, Falk V, et al. 2014 ESC/EACTS guidelines on myocardial revascularization: the Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). Developed with the special contribution of the European Association of Percutaneous Cardiovascular Interventions (EAPCI). *Eur J Cardiothorac Surg*. 2014; **46**(4):517-92. doi: [10.1093/ejcts/ezu366](https://doi.org/10.1093/ejcts/ezu366). [PubMed: [25173601](https://pubmed.ncbi.nlm.nih.gov/25173601/)].
- Edgerton JR, Herbert MA, Jones KK, Prince SL, Acuff T, Carter D, et al. On-pump beating heart surgery offers an alternative for unstable patients undergoing coronary artery bypass grafting. *Heart Surg Forum*. 2004; **7**(1):8-15. [PubMed: [4980839](https://pubmed.ncbi.nlm.nih.gov/4980839/)].
- Mizutani S, Matsuura A, Miyahara K, Eda T, Kawamura A, Yoshioka T, et al. On-pump beating-heart coronary artery bypass: a propensity matched analysis. *Ann Thorac Surg*. 2007; **83**(4):1368-73. doi: [10.1016/j.athoracsur.2006.11.011](https://doi.org/10.1016/j.athoracsur.2006.11.011). [PubMed: [17383341](https://pubmed.ncbi.nlm.nih.gov/17383341/)].
- Polomsky M, He X, O'Brien SM, Puskas JD. Outcomes of off-pump versus on-pump coronary artery bypass grafting: impact of preoperative risk. *J Thorac Cardiovasc Surg*. 2013; **145**(5):1193-8. doi: [10.1016/j.jtcvs.2013.02.002](https://doi.org/10.1016/j.jtcvs.2013.02.002). [PubMed: [23597624](https://pubmed.ncbi.nlm.nih.gov/23597624/)].
- Chawla LS, Zhao Y, Lough FC, Schroeder E, Seneff MG, Brennan JM. Off-pump versus on-pump coronary artery bypass grafting outcomes stratified by preoperative renal function. *J Am Soc Nephrol*. 2012; **23**(8):1389-97. doi: [10.1681/ASN.2012020122](https://doi.org/10.1681/ASN.2012020122). [PubMed: [22595302](https://pubmed.ncbi.nlm.nih.gov/22595302/)].
- Erkut B, Dag O, Kaygin MA, Senocak M, Limandal HK, Arslan U, et al. On-pump beating-heart versus conventional coronary artery bypass grafting for revascularization in patients with severe left ventricular dysfunction: early outcomes. *Can J Surg*. 2013; **56**(6):398-404. doi: [10.1503/cjs.018412](https://doi.org/10.1503/cjs.018412). [PubMed: [24284147](https://pubmed.ncbi.nlm.nih.gov/24284147/)].
- Rastan AJ, Bittner HB, Gummert JF, Walther T, Schewick CV, Girdauskas E, et al. On-pump beating heart versus off-pump coronary artery bypass surgery evidence of pump-induced myocardial injury. *Eur J Cardiothorac Surg*. 2005; **27**(6):1057-64. doi: [10.1016/j.ejcts.2005.03.007](https://doi.org/10.1016/j.ejcts.2005.03.007). [PubMed: [15896617](https://pubmed.ncbi.nlm.nih.gov/15896617/)].
- Izumi Y, Magishi K, Ishikawa N, Kimura F. On-pump beating-heart coronary artery bypass grafting for acute myocardial infarction. *Ann Thorac Surg*. 2006; **81**(2):573-6. doi: [10.1016/j.athoracsur.2005.08.036](https://doi.org/10.1016/j.athoracsur.2005.08.036). [PubMed: [16427854](https://pubmed.ncbi.nlm.nih.gov/16427854/)].
- Munos E, Calderon J, Pillois X, Lafitte S, Ouattara A, Labrousse L, et al. Beating-heart coronary artery bypass surgery with the help of mini extracorporeal circulation for very high-risk patients. *Perfusion*. 2011; **26**(2):123-31. doi: [10.1177/0267659110395650](https://doi.org/10.1177/0267659110395650). [PubMed: [21242193](https://pubmed.ncbi.nlm.nih.gov/21242193/)].
- Narayan P, Rogers CA, Bayliss KM, Rahaman NC, Panayiotou N, Angelini GD, et al. On-pump coronary surgery with and without cardiologic arrest: comparison of inflammation, myocardial, cerebral and renal injury and early and late health outcome in a single-center randomized controlled trial. *Eur J Card Thorac Surg*. 2011; **39**(5):675-83. doi: [10.1016/j.ejcts.2010.08.032](https://doi.org/10.1016/j.ejcts.2010.08.032).
- Lin CC, Wu MY, Tsai FC, Chu JJ, Chang YS, Haung YK, et al. Prediction of major complications after isolated coronary artery bypass grafting: the CGMH experience. *Chang Gung Med J*. 2010; **33**(4):370-9. [PubMed: [20804666](https://pubmed.ncbi.nlm.nih.gov/20804666/)].