

# Intraoperative conversion to on-pump coronary artery bypass grafting is independently associated with higher mortality in patients undergoing off-pump coronary artery bypass grafting: A propensity-matched analysis

Deepak Prakash Borde, Balaji Asegaonkar, Pramod Apsingekar, Sujeet Khade, Savni Futane, Babu Khodve, Ajita Annachhatre, Manish Puranik<sup>1</sup>, Sayaji Sargar<sup>1</sup>, Yogesh Belapurkar<sup>2</sup>, Anand Deodhar<sup>3</sup>, Antony George<sup>4</sup>, Shreedhar Joshi<sup>5</sup>

Ozone Anesthesia Group, <sup>1</sup>Seth Nandlal Dhoot Hospital, <sup>3</sup>United CIIGMA Hospital, Aurangabad, <sup>2</sup>MGM College and Hospital, Mumbai, Maharashtra, <sup>4</sup>Fortis Hospital, Bengaluru, Karnataka, <sup>5</sup>Nayati Hospital, Mathura, Uttar Pradesh, India

## ABSTRACT

**Context:** One of the main limitations of off-pump coronary artery bypass grafting (OPCAB) is the occasional need for intraoperative conversion (IOC) to on-pump coronary artery bypass grafting. IOC is associated with a significantly increased risk of mortality and postoperative morbidity. The impact of IOC on outcome cannot be assessed by a randomized control design. **Aims:** The objective of this study was to analyze the incidence, risk factors, and impact of IOC on the outcome in patients undergoing OPCAB. **Settings and Design:** Three tertiary care level hospitals; retrospective observational study. **Subjects and Methods:** This retrospective observational study included 1971 consecutive patients undergoing OPCAB from January 2012 to October 2015 at three tertiary care level hospitals by four surgeons. The incidence, patient characteristics, cause of IOC, and its impact on outcome were studied. **Statistical Analysis Used:** The cohort was divided into two groups according to IOC. Univariate logistic regression was performed to describe the predictors of IOC. Variables that were found to be significant in univariate analysis were introduced into multivariate model, and adjusted odds ratio (OR) was calculated. To further assess the independent effect of IOC on mortality, propensity score matching with a 5:1 ratio of non-IOC to IOC was performed. **Results:** The overall all-cause in-hospital mortality was 2.6%. IOC was needed in 128 (6.49%) patients. The mortality in the IOC group was significantly higher than non-IOC group (21 of 128 [16.4%] vs. 31 of 1843 [1.7%],  $P = 0.0001$ ). The most common cause for IOC was hemodynamic disturbances during grafting to the obtuse marginal artery (51/128; 40%). On multivariate logistic regression analysis, left main disease, pulmonary hypertension, and mitral regurgitation independently predicted IOC. We obtained a propensity-matched sample of 692 patients (No IOC 570; IOC 122), and IOC had OR of 16.26 (confidence interval 6.3–41;  $P < 0.0001$ ) for mortality in matched population. **Conclusions:** Emergency IOC increases odds for mortality by 16-fold. Hence, identification of patients at higher risk of IOC may improve the outcome.

**Key words:** Off-pump coronary artery bypass grafting; Intraoperative conversion; Mortality; Propensity matched analysis

**Address for correspondence:** Dr. Deepak Prakash Borde, Ozone Anesthesia Group, First Floor, United CIIGMA Hospital, Aurangabad, Maharashtra, India.  
E-mail: deepakborde2482@gmail.com

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

**For reprints contact:** reprints@medknow.com

**Cite this article as:** Borde DP, Asegaonkar B, Apsingekar P, Khade S, Futane S, Khodve B, *et al.* Intraoperative conversion to on-pump coronary artery bypass grafting is independently associated with higher mortality in patients undergoing off-pump coronary artery bypass grafting: A propensity-matched analysis. *Ann Card Anaesth* 2016;19:475-80.

Received: 25-02-16  
Accepted: 01-06-16

Access this article online

Website: www.annals.in

DOI:  
10.4103/0971-9784.185534

Quick Response Code:



## INTRODUCTION

Off-pump coronary artery bypass grafting (OPCAB) has become a standard alternative approach to traditional surgical revascularization with on-pump cardiopulmonary bypass (ONCAB). One of the main limitations of OPCAB is the occasional need for intraoperative conversion (IOC) to ONCAB. IOC is associated with a significantly increased risk of mortality and postoperative morbidity, which may potentially negate any benefit of OPCAB.<sup>[1-6]</sup>

The incidence of conversion is variable in literature.<sup>[7]</sup> An important point about IOC is that its impact on outcome cannot be assessed by randomized controlled trial design. Hence, it is often studied by retrospective observational studies; the independent effects of IOC on outcome in such a study can be assessed using propensity matching.

The objective of this study was to analyze the incidence, risk factors, and impact of IOC on the outcome in patients undergoing OPCAB.

## SUBJECTS AND METHODS

This retrospective observational study included 2073 consecutive patients undergoing isolated CABG from January 2012 to October 2015 at three tertiary care level hospitals. The Institutional Review Board approved the study with waiver of consent. Seventy-eight patients were excluded from analysis because they underwent surgery under elective cardiopulmonary bypass. Another 25 patients were excluded from analysis because of incomplete data. The final analysis included 1971 patients were scheduled for isolated OPCAB surgery.

All patients were operated under general anesthesia with standard midline sternotomy. The anesthesia protocol was standardized as per institutional protocol. All preoperative variables and intraoperative details were noted. The anesthesia and surgical records were analyzed for IOC to ONCAB. The incidence, patient characteristics, cause of IOC, and its impact on outcome were studied. The primary outcome was all-cause in-hospital mortality.

### Statistical analysis

Continuous data were summarized as mean and standard deviation and categorical data as percentage and were compared using the Student's *t*-test and

Chi-square test, respectively. The incidence of mortality in the whole cohort was calculated. Mortality was compared on the basis of IOC. Univariate logistic regression was performed to find the predictors of IOC. Variables that were found to be statistically significant in univariate analysis were introduced into multivariate model, and adjusted odds ratio (OR) was calculated. To further assess the independent effect of IOC on mortality, after balancing all other variables, propensity score matching with a 5:1 ratio of non-IOC to IOC groups was performed. The probability of IOC was estimated through logistic regression including all the variables that were unequally distributed in the groups with and without IOC ( $P < 0.3$ ). Once the probabilities were calculated, each converted patient was matched with five nonconverted patients who had the nearest estimated probabilities (matching with the nearest neighbors without replacement). The distribution of all the variables in the matched sample was again compared and the standardized difference was calculated to verify the effectiveness of the matching. SPSS 16.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Propensity score matching was conducted using MatchIt package (version: 2.4-21) for R software (R for Windows 3.1.2; The R Foundation for Statistical Computing, Vienna, Austria). The value of  $P \leq 0.05$  was considered statistically significant.

## RESULTS

The study population included 1971 patients who had undergone isolated OPCAB surgery. The patients' mean age was  $58.7 \pm 9.1$  years, and 19.2% of patients were female. The overall mortality was 2.6%. Emergency IOC was performed in 128 (6.49%) patients. The most common cause of this IOC was hemodynamic disturbances during grafting to the obtuse marginal (OM) artery (51/128; 40%), followed by grafting to the left anterior descending artery (LAD) (41/128; 32%) and grafting to the right coronary artery (17/128; 13%). The exact cause could not be found in 15% of converted cases.

Cohort was divided on the basis of IOC into two groups, and demographics and risk factors were described [Table 1]. The mortality in the IOC group was significantly higher than patients who underwent successful OPCAB surgery (21 of 128 [16.4%] vs. 31 of 1,843 [1.7%],  $P = 0.0001$ ). The converted patients were more likely to have preoperative triple vessel disease, left main disease, more number of grafts, higher

**Table 1: Baseline characteristics of patients**

Patient variables	Total (n=1971) (%)	No IOC (n=1843) (%)	IOC (n=128) (%)	P
Age (years) mean±SD	58.7±9.1	58.6±9.1	59.8±8.8	0.15
Female sex, n (%)	378 (19.2)	354 (19.2)	24 (18.8)	0.89
Height (cm)±SD	161.4±8.1	161.4±8.3	160.6±7.7	0.25
Weight (kg)±SD	62.8±10.5	62.9±10.9	62.6±11	0.75
HTN	1158 (58.8)	1074 (58.3)	84 (64.1)	0.1
Diabetes	722 (36.6)	681 (37.1)	41 (32)	0.26
COPD	317 (16.1)	293 (15.9)	24 (18.8)	0.39
PVD	56 (3.1)	53 (3)	3 (2.3)	0.65
CVA	22 (1.1)	20 (1.1)	2 (1.6)	0.62
Creatinine mg/dL	1.08±0.35	1.07±0.38	1.10±0.27	0.46
Creatinine clearance (mL/min)	68.3±21.9	68.5±20.5	65.1±21.2	0.09
>85	385 (19.5)	365 (19.8)	20 (15.6)	0.70
51-85	1205 (61.1)	1123 (60.9)	82 (64.1)	
<50	380 (19.3)	354 (19.2)	26 (20.3)	
EF				
Good	1068 (54.2)	1006 (54.6)	62 (48.4)	0.52
Moderate	852 (43.2)	790 (42.9)	62 (48.4)	
Poor	51 (2.6)	47 (2.6)	4 (3.1)	
History of recent MI	733 (37.2)	677 (36.7)	56 (43.8)	0.13
NYHA class				
II	1157 (58.75)	1092 (59.3)	65 (50.8)	0.11
III	808 (41)	746 (40.5)	62 (48.4)	
IV	6 (0.3)	5 (0.3)	1 (0.8)	
Number of diseased coronaries				
1	73 (3.7)	72 (4)	1 (1)	0.003
2	388 (19.7)	376 (20)	12 (9)	
3	1510 (76.7)	1395 (76)	115 (90)	
LMCA >50	283 (14.4)	255 (13.8)	28 (21.9)	0.01
Number of grafts				
1	52 (2.6)	52 (2.8)	0 (0)	0.005
2	255 (12.9)	251 (13.6)	4 (3.1)	
3	923 (46.8)	850 (46.1)	73 (57)	
>3	740 (37.8)	689 (37.4)	51 (39.3)	
MR				
No	1549 (78.6)	1466 (79.5)	83 (64.8)	0.000
Mild	367 (18.6)	332 (18)	35 (27.3)	
Moderate	53 (2.7)	43 (2.3)	10 (7.8)	
Severe	2 (0.1)	2 (0.1)	0 (0)	
PAP				
PASP <30	1610 (81.7)	1527 (82.9)	83 (64.8)	0.000
PASP 31-55	339 (17.2)	301 (16.3)	38 (29.7)	
PASP >55	22 (1.1)	15 (0.8)	7 (5.5)	
EuroSCORE II	1.7±1.2	1.7±1.2	2.0±1.5	0.03
Mortality	52 (2.6)	31 (1.7)	21 (16.4)	0.000

IOC: Intraoperative conversion, SD: Standard deviation, COPD: Chronic obstructive pulmonary disease, PVD: Peripheral vascular disease, CVA: Cerebrovascular accident, NYHA: New York Heart Association, LMCA: Left main coronary artery, PAP: Pulmonary artery pressure, PASP: Pulmonary artery systolic pressure, MI: Myocardial infarction, HTN: Hypertension, MR: Mitral regurgitation, EF: Ejection fraction

incidence of mitral regurgitation (MR), and pulmonary hypertension (HTN). The converted patients had higher EuroSCORE II ( $2.0 \pm 1.5$ ) than successful OPCAB patients ( $1.7 \pm 1.2$ ) ( $P = 0.03$ ) [Table 1].

The results of univariate analysis with IOC as end-point are shown in Table 2. A multiple regression was performed to predict on-pump conversion from different variables ( $P < 0.3$ ). On multivariate logistic

regression analysis, left main disease, pulmonary HTN, and MR independently predicted IOC [Table 3].

**Table 2: Univariate analysis for intraoperative conversion**

Variable	OR	95% CI	P
Age	1.015	0.995-1.035	0.148
Female	0.969	0.613-1.533	0.894
Weight	0.997	0.980-1.995	0.102
Creatinine	1.141	0.802-1.624	0.463
HTN	1.369	0.940-1.995	0.102
Diabetes	0.804	0.548-1.180	0.265
COPD	1.223	0.771-1.940	0.392
CVA	1.449	0.335-6.270	0.62
PVD	0.767	0.237-2.486	0.659
Hemoglobin	1.023	0.923-1.134	0.664
NYHA class			
II	Reference		
III	1.392	0.971-1.996	0.072
IV	3.351	0.386-29.101	0.273
TVD	5.931	0.817-43.073	0.078
LMCA >50%	1.745	1.124-2.708	0.013
EF	0.985	0.970-1.00	0.44
PAP			
Normal	Reference		
31-55	2.313	1.546-3.463	0.000
>55	8.552	3.395-21.544	0.000
MR			
No	Reference		
Mild	1.858	1.23-2.807	0.003
Moderate	4.099	1.99-8.445	0.000
EuroSCORE II	1.174	1.044-1.321	0.008

COPD: Chronic obstructive pulmonary disease, OR: Odds ratio, CI: Confidence interval, PVD: Peripheral vascular disease, CVA: Cerebrovascular accident, NYHA: New York Heart Association, LMCA: Left main coronary artery, PASP: Pulmonary artery systolic pressure, MR: Mitral regurgitation, HTN: Hypertension, PAP: Pulmonary artery pressure, EF: Ejection fraction, TVD: Triple vessel disease

**Table 3: Multivariate analysis for intraoperative conversion**

Variable	OR	95% CI	P
LMCA disease	1.693	1.080-2.654	0.022
pH			
No (reference)			
Moderate	1.972	1.270-3.064	0.003
Severe	6.293	2.230-17.761	0.001
MR			
No (reference)			
Mild	1.548	0.979-2.446	0.062
Moderate	2.745	1.231-6.123	0.014
EF	1.003	0.984-1.021	0.779
EuroSCORE II	0.996	0.857-1.158	0.996

LMCA: Left main coronary artery, OR: Odds ratio, CI: Confidence interval, EF: Ejection fraction, HTN: Hypertension, MR: Mitral regurgitation, pH: Pulmonary hypertension

To determine the independent impact of the emergency IOC on the mortality, we performed a 5:1 propensity score matching. We obtained a propensity-matched sample of 692 patients (No IOC 570; IOC 122) [Table 4]. IOC was significantly associated with mortality with OR 16.26 (confidence interval [CI] 6.3–41;  $P < 0.0001$ ) even in matched population.

## DISCUSSION

The main findings of this study are: In a retrospective analysis of 1971 patients undergoing OPCAB in three tertiary care level hospital involving four surgeons over span of 4 years, the rate of IOC was 6.49% (128/1971). On multivariate logistic regression analysis, left main disease, pulmonary HTN, and MR independently predicted IOC. IOC was significantly associated with mortality with OR 16.26 (CI 6.3–41;  $P < 0.0001$ ) in propensity-matched population.

The reported rate of conversion is quite variable in literature.<sup>[1-6]</sup> The presence of higher conversion rates within randomized trials reporting it compared with observational studies may be due to more accurate documentation.<sup>[7]</sup> In a recent meta-analysis ( $n = 18,870$ ) of 17 studies spanning over a decade, reported conversion rate was 4.9% (920/18,870).<sup>[7]</sup> In another meta-analysis of 20,744 OPCAB cases, overall conversion rate was 8.40% (1742/20,744).<sup>[8]</sup> Thus, our results of 6.49% (128/1971) are in accordance with the literature.

Emergency conversion is defined as the urgent institution of CPB to manage clinical instability (severe or persistent hypotension and arrhythmia), usually after the commencement of coronary anastomoses. Elective conversion is defined as a semi-planned measure to prevent clinical instability, usually before the commencement of any coronary anastomoses. Elective conversions which are reported in only a few studies, in general, had outcomes that are similar to unconverted OPCAB or risk-matched ONCAB patients.<sup>[1,9-11]</sup> In our study, we studied only emergency conversions. The phenomenon of emergency conversion is one that is likely to have deleterious effects on patient outcomes.

Across several recent studies on OPCAB, the predominant reason (64.1%) for all conversions was hemodynamic compromise. These were generally emergency conversions. The second most frequent cause (10.5%) of conversion was “anatomical considerations” which were elective conversions due to problematic coronary target access. Overall, almost three-quarters

**Table 4: Propensity-matched analysis**

Variable	Before matching (%)		After matching		Standard difference	
	No IOC (n=1843)	IOC (n=128)	No IOC (n=570)	IOC (n=122)	Before matching	After matching
Age	58.62±9.1	59.83±8.8	59.73±8.7	59.8±8.8	-13.52	-1.46
Female	19	19	17	20	1.17	-5.93
Height	161.4±8	160.6±8	161±8	160±10	10.66	9.31
Weight	62.9±10.2	62.6±11.0	62.6±10.0	62.1±10.5	2.72	5.55
HTN	58	66	65	65	-15.18	-0.4
Diabetes	37	32	32	32	10.36	0.0
COPD	16	19	15	18	-7.54	-7.93
PVD	3	2	3	2	4.29	3.22
Creatinine	1.07±0.4	1.1±0.3	1.1±0.3	1.1±0.2	-7.8	-2.9
EF	52±11.5	50±12	51±12	50±12	17.98	5.37
MI	37	44	41	43	-14.34	-04.05
TVD	76	90	91	89	-38.28	6.36
LMCA	14	22	59	57	-21.11	0.0
Mild MR	18	27	26	26	-22.42	0.0
Moderate MR	2	8	5	8	-25.17	-12.19
NYHA III	40	48	45	47	-16.07	-2.57
Moderate pH	16	30	28	31	-32.14	-7.42
Mortality	2	16	1	14	-53.12	-52.35

COPD: Chronic obstructive pulmonary disease, PVD: Peripheral vascular disease, NYHA: New York Heart Association, TVD: Triple vessel disease, HTN: Hypertension, pH: Pulmonary hypertension, MR: Mitral regurgitation, LMCA: Left main coronary artery, MI: Myocardial infarction, EF: Ejection fraction, IOC: Intraoperative conversion

of all conversions occurred during either LAD or OM anastomosis.<sup>[8]</sup> In our cohort, IOC was necessitated by hemodynamic instability during OM grafting in 40% and LAD grafting in 32% of conversions.

In a meta-analysis by Mukherjee *et al.*, emergency conversion raised the OR of mortality to 6.99 (95% CI 5.18–9.45).<sup>[7]</sup> There was a significant increase in the likelihood of stroke, myocardial injury, bleeding, renal failure, wound infection, intra-aortic balloon pump requirement, transfusion, and respiratory and gastrointestinal complications after conversion.<sup>[12]</sup> A recent study observing long-term impact of IOC concluded that converted patients had a poorer absolute survival (75% vs. 88%;  $P < 0.001$ ), lower survival free from AMI (69% vs. 89%;  $P < 0.001$ ), and lower survival free from MACCEs (47% vs. 72%;  $P < 0.001$ ) at 4-year follow-up.<sup>[11]</sup> Our findings of increased odds of mortality by 16-fold in IOC group even after (1:5) propensity matching confirms these findings in literature in the propensity-matched sample correspond to these results. In other words, IOC is associated with 16 times odds for mortality even after the neutralizing effect of all other variables.

Hence, identifying which patients have a higher likelihood of IOC maybe most important measures of reducing emergency conversion and thereby mortality.

Several studies used regression analysis to isolate specific predictors of conversion. Most notable among these are poor coronary targets, poor left ventricular ejection fraction, previous history of heart failure, surgeon's experience, nonuse of positioning device, redo surgery, MR, emergency surgery, and left main stenosis.<sup>[8,13,14]</sup> In the present study, triple vessel disease, left main disease, more number of grafts, higher incidence of MR and pulmonary HTN, and higher EuroSCORE II were associated with IOC. On multivariate logistic regression analysis, left main disease, pulmonary HTN, and MR independently predicted IOC.

Interestingly, it appears that higher risk patients may be more likely to benefit from an off-pump approach; yet, many of these patients may also have a higher risk of conversion, so careful patient selection is crucial. A very recent study revealed that higher EuroSCORE II predicts a higher probability of conversion to ONCAB.<sup>[15]</sup> Hence, we recommend that patients with higher EuroSCORE II and risk factors mentioned above should be very carefully evaluated preoperatively for the feasibility of OPCAB approach and intraoperatively, they should be monitored more meticulously. Elective conversion of such cases may help in improving the outcome.

Our study involved four surgeons with varying experience. Surgeon inexperience is one of the claimed

risk factors for conversion. However contrary to this, in a study, Hemli *et al.*<sup>[16]</sup> compared the results of the most recent fifty patients who required emergency conversion with the preceding fifty conversions and revealed that although the incidence of emergency conversion during OPCAB decreased with increasing surgical experience, the morbidity in these patients remained essentially unchanged. Hence, if IOC occurs even with most experienced teams, it is still associated with worse outcome.

### Limitations

Apart from the limitations inherent to any retrospective study, the effect of IOC on mortality is also affected by confounding factors. To minimize confounding, multivariate logistic regression was performed to control for most known predictors of IOC. We also performed propensity matching to assess the impact of IOC. However, we could not study detailed coronary anatomy, which is one of the most important causes of IOC.

### CONCLUSIONS

Our findings of increased odds of mortality by 16-fold in IOC group even after propensity matching confirm the deleterious effects of IOC. Hence, identifying which patients have a higher likelihood of IOC may be one of the most important measures of reducing emergency conversion and thereby mortality.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

### REFERENCES

1. Edgerton JR, Dewey TM, Magee MJ, Herbert MA, Prince SL, Jones KK, *et al.* Conversion in off-pump coronary artery bypass grafting: An analysis of predictors and outcomes. *Ann Thorac Surg* 2003;76:1138-42.
2. Landoni G, Pappalardo F, Crescenzi G, Aletti G, Marchetti C, Poli D, *et al.* The outcome of patients requiring emergency conversion from off-pump to on-pump coronary artery bypass grafting. *Eur J Anaesthesiol* 2007;24:317-22.
3. Légaré JF, Buth KJ, Hirsch GM. Conversion to on pump from OPCAB is associated with increased mortality: Results from a randomized controlled trial. *Eur J Cardiothorac Surg* 2005;27:296-301.
4. Patel NC, Patel NU, Loulmet DF, McCabe JC, Subramanian VA. Emergency conversion to cardiopulmonary bypass during attempted off-pump revascularization results in increased morbidity and mortality. *J Thorac Cardiovasc Surg* 2004;128:655-61.
5. Reeves BC, Ascione R, Caputo M, Angelini GD. Morbidity and mortality following acute conversion from off-pump to on-pump coronary surgery. *Eur J Cardiothorac Surg* 2006;29:941-7.
6. Novitzky D, Baltz JH, Hattler B, Collins JF, Kozora E, Shroyer AL, *et al.* Outcomes after conversion in the Veterans Affairs randomized on versus off bypass trial. *Ann Thorac Surg* 2011;92:2147-54.
7. 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;41:291-9.
8. Mukherjee D, Ahmed K, Baig K, Patel VM, Darzi A, Athanasiou T. Conversion and safety in off-pump coronary artery bypass: A system failure that needs re-emphasis. *Ann Thorac Surg* 2011;91:630-9.
9. Soltoski P, Salerno T, Levinsky L, Schmid S, Hasnain S, Diesfeld T, *et al.* Conversion to cardiopulmonary bypass in off-pump coronary artery bypass grafting: Its effect on outcome. *J Card Surg* 1998;13:328-34.
10. Novick RJ, Fox SA, Stitt LW, Kiaii BB, Abu-Khudair W, Lee A, *et al.* Effect of off-pump coronary artery bypass grafting on risk-adjusted and cumulative sum failure outcomes after coronary artery surgery. *J Card Surg* 2002;17:520-8.
11. Maroto Castellanos LC, Carnero M, Cobiella FJ, Alswies A, Ayaon A, Reguillo FJ, *et al.* Off-pump to on-pump emergency conversion: Incidence, risk factors, and impact on short- and long-term results. *J Card Surg* 2015;30:735-45.
12. Mukherjee D, Rao C, Ibrahim M, Ahmed K, Ashrafian H, Protopapas A, *et al.* Meta-analysis of organ damage after conversion from off-pump coronary artery bypass procedures. *Ann Thorac Surg* 2011;92:755-61.
13. Chowdhury R, White D, Kilgo P, Puskas JD, Thourani VH, Chen EP, *et al.* Risk factors for conversion to cardiopulmonary bypass during off-pump coronary artery bypass surgery. *Ann Thorac Surg* 2012;93:1936-41.
14. Hovakimyan A, Manukyan V, Ghazaryan S, Saghatelian M, Abrahamyan L, Hovaguimian H. Predictors of emergency conversion to on-pump during off-pump coronary surgery. *Asian Cardiovasc Thorac Ann* 2008;16:226-30.
15. Borde D, Asegaonkar B, Apsingekar P, Khade S, Futane S, Khodve B, *et al.* Risk stratification in off-pump coronary artery bypass (OPCAB) surgery – Role of EuroSCORE II. *J Cardiothorac Vasc Anesth* 2015;29:1167-71.
16. Hemli JM, Patel NC, Subramanian VA. Increasing surgical experience with off-pump coronary surgery does not mitigate the morbidity of emergency conversion to cardiopulmonary bypass. *Innovations (Phila)* 2012;7:259-65.