Original Article

Conversion During Off-pump Coronary Artery Bypass Graft Surgery: A Case–control Study

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Abstract

Objectives: Off pump coronary artery bypass (OPCAB) surgery is carried out as an alternative to conventional coronary artery bypass grafting using cardiopulmonary bypass (CPB). At times 'conversion' to CPB may be required to bail out a situation resulting from acute decompensation of the heart. It is reported that such conversion carries significant mortality risk. Since we conduct coronary revascularization by OPCAB technique as the preferred technique, we conducted this study with an aim to identify the markers of adverse outcome during conversion in Indian patients. **Design:** Case control retrospective study. **Setting:** Tertiary referral center. **Participants:** We conducted three thousand two hundred OPAB surgeries in the period between 2013 to16. Ninety patients (3.1%) required conversion to complete the revascularization (Con version group). Twice the number of patients who underwent OPCAB surgery without conver sion were chosen as controls (Control group). **Intervention:** OPCAB surgery **Results:** Mortality in the conversion group was 5.56% in contrast to 0.06% in the controls (P = 0.01). The conversion group had higher left ventricular end diastolic pressure, incidence of endarterectomy, and intra-aortic balloon counter pulsation requirement. Female gender was also predictive of conversion. The total chest drain, duration of ventilation, ICU stay and hospital stay were also higher in the conversion group. Conversion was associated with 9.47 times the odds for mortality. **Conclusion:** Conversion during OPCAB is associated with significantly increased mortality. Female gender, increased left ventricular end diastolic pressure and preoperative requirement of Intra-aortic balloon are markers of increased risk of mortality when converted.

Keywords: *Conversion, intra-aortic balloon pump, mortality, off-pump coronary artery bypass surgery*

Introduction

The practice of off-pump coronary artery bypass surgery (OPCAB) is an alternate method to carry out coronary artery bypass graft (CABG) surgery under cardiopulmonary bypass (CPB) and has gained acceptance. OPCAB avoids systemic inflammatory response syndrome,[1] coagulopathy,[2] postoperative neurocognitive dysfunction[3] kidney injury, transfusion, and pulmonary dysfunction[4,5] resulting from the contact of blood with extracorporeal circuit of CPB. Several undesirable outcomes such as lower rate of 5-year survival and event-free survival,[6-8] less-effective revascularization,[9] and lower graft patency at the end of 1 year have been attributed to OPCAB.[10] Conventional surgery utilizing CPB and OPCAB have been analyzed; the outcomes have been reported to be similar.[11,12]

Despite the popularity and purported advantages of OPCAB, conversion to CPB may still be required in a few patients because of either hemodynamic disturbance or ischemia or physical difficulty in grafting or arrhythmias. Many authors have reported morbid outcomes following conversion.[12-14]

The word "conversion" will be used to imply conversion of surgical technique from OPCAB to CPB to facilitate completion of CABG surgery. We hypothesized that the outcome of patients who underwent conversion was poor in contrast to patients who underwent successful OPCAB.

Materials and Methods

This study was carried out between January 2013 and December 2016. Institutional review board approval was obtained, and the need for patient consent was waived in view of retrospective nature of the study. Patients scheduled to undergo elective OPCAB, requiring conversion were

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studied. Approximately, two consecutive OPCAB cases (without conversion) after each conversion were taken as "controls" for comparison. Patients who underwent elective surgery under CPB were excluded. Patients receiving two or more inotropes preoperatively, hemodynamically unstable (low mean arterial pressure, elevated pulmonary artery wedge pressure, signs of hypoperfusion such as low mixed venous oxygen saturation and elevated serum lactate level) with/without intra-aortic Balloon pump (IABP) or ventilation, requiring additional procedure such as valve replacement or repair in addition to CABG and coronary artery coronary endarterectomy were electively subjected to CABG under CPB. Indications for conversion were one or more of the following: inability to carry on with OPCAB due to acute hemodynamic disturbance not responding to conventional inotropic medications, or severe arrhythmias, or excessive uncontrollable bleeding from the anastomotic site or inability to carry on with CABG by the surgeon due to technical difficulty.

Monitoring

Before induction of general anesthesia, femoral arterial catheter and Swan Ganz catheter were inserted. Pulse oximetry, end-tidal carbon dioxide, intermittent arterial blood gases and electrolytes, blood loss, urine output, rectal and esophageal temperature were measured additionally. Transesophageal echocardiography probe was inserted after intubation of trachea.

Anesthesia and surgical technique

All patients were administered a standardized technique of general endotracheal anesthesia and were mechanically ventilated. Left internal mammary artery was harvested following midsternotomy; based on requirement, either saphenous vein or left radial artery or right internal mammary artery was additionally harvested. Activated clotting time of about 240 s was achieved by administering 200 mg/kg intravenous bolus of heparin. Proximal anastomoses of the vein grafts were carried out using aortic side clamp before conducting distal anastomoses. The left internal mammary artery was most often anastomosed to left anterior descending artery first, and subsequently, the other grafts were performed. After completion of grafting, residual heparin was neutralized using protamine. The patients were transferred to intensive care unit for further care.

Inotropes

The inotrope of first choice was intravenous infusion of noradrenaline (0.025–0.1 mic/kg/min). If the response was inadequate, intravenous adrenaline (0.025–0.1 mic/kg/min) infusion was added. Other agents such as milrinone, vasopressin, and dopamine were used based on the hemodynamic parameters such as cardiac index, central venous pressure, pulmonary artery wedge pressure, mean arterial pressure, systemic vascular resistance, and mixed venous oxygen saturation.

IABP counter pulsation: As per the hospital protocol, patients with elevated pulmonary capillary wedge pressure, poor left ventricular function, ongoing angina, and pulmonary edema would receive preoperative intra-aortic balloon pumping. ST segment changes, regional wall motion abnormalities, evidence of congestive heart failure, and inability to support hemodynamic parameters were considered indications for intraoperative IABP.

The incidences of conversion and inhospital mortality (defined as any cause mortality in the same hospital admission) were described. Odds ratio for mortality in conversion was estimated from this cohort using a logistic regression model. Factors associated with/predicting conversion were analyzed. Analysis was performed using the statistical package "R for Statistics" 3.3.1 (Vienna, Austria). The values were shown as mean ± standard deviation.

Results

During the period of January 2013 to December 2016, a total of 3239 cases of CABG were conducted at our facility, of which 2857 underwent using OPCAB technique. Ninety patients (3.1%) required conversion to CPB. One hundred and sixty-two patients were chosen as controls. During this period, 382 patients (excluding the CPB due to conversion) underwent CABG surgery electively under CPB. The reasons for conducting them under CPB are mentioned in Table 1.

Table 2 compares the characteristics of patients who underwent conversion and their controls. The mortality in the conversion group was 5.56% in contrast to 0.6% among the controls (P = 0.01). The conversion group had higher percentage of females, and lesser percentage of diabetics. They also had higher baseline blood urea, left ventricular end diastolic pressure (LVEDP), higher incidence of coronary endarterectomy, and increased intraoperative IABP requirement. They did not differ in aspects such as age, height, weight, body surface area, presence of left main coronary artery disease, and baseline ejection fraction. The total chest drain, duration of ventilation, Intensive Care Unit stay, and hospital stay were also higher in the conversion group. Patients who required conversion had

Table 1: The reasons for institution of elective cardiopulmonary bypass

Total 382	*n* (%)
Likely additional procedure (such as possible valve repair)	60 (15.7)
Patients on prior 2 or more inotropic support	128 (33.5)
Likely coronary artery endarterectomy	67 (17.5)
Patients on intra-aortic balloon counter pulsation support	43 (11.3)
Patients on ventilatory support for hemodynamic reasons	84 (22.0)

9.5 times higher probability of mortality compared to those undergoing uncomplicated OPCAB [Table 3].

Factors associated with higher risk of conversion (from a univariate regression model) were female gender, LVEDP, and use of intraoperative IABP [Table 4]. In a multivariate analysis of variables using backward stepwise method, baseline creatinine level, LVEDP, and intraoperative use of IABP were found to be independent predictors for conversion [Table 5]. Conversion was associated with an OR of 3.2 for subsequent use of intraoperative use of IABP [Table 6].

Outcome differences between the two groups were interesting to note [Table 7].

Discussion

This prospective case–control study found significant increase in mortality when OPCAB surgery patients required intraoperative unplanned conversion. The incidence of conversion is similar to the earlier reported works in the literature; however, we observed that female sex, elevated LVEDP, and intraoperative requirement of IABP were predictors for conversion.[12-15] A recent large study by Keeling *et al*. concluded that intraoperative conversion from OPCAB to CPB remains a morbid event with a risk of mortality much higher than expected. They opined that surgeons should consider elective on-pump coronary artery bypass graft surgery in those with a high risk for conversion during OPCAB.[12] Borde *et al*. in a recent study of nearly 2000 consecutive patients scheduled for OPCAB reported a conversion rate of 6.49%.[13] Chowdhury *et al*. reported a conversion rate of 2.5% in a study of 8077 consecutive patients undergoing OPCAB at a single American academic center.[16] In a review of 14 RCTs, Urso *et al*. reported that the conversions ranged from 0% to 13.3%.[17] It may be pertinent to note that the

Table 2: Difference in demographics between the groups

	No conversion (*n*=162)		Conversion (*n*=90)		*P*
	Mean±SD	*n* (%)	Mean±SD	*n* (%)	
Age (years)	61±8.6		61.4±8.4		0.8
Female		18 (11.1)		19 (21.6)	0.03
Height (cm)	162.5±7.5		162.3±8.4		0.8
Weight (kg)	68.4±11		66.7±11.3		0.3
Body surface area (m^2)	1.7±0.2		1.7±0.2		0.24
Systemic hypertension		81.00 (50.31)		45.00 (52.94)	0.7
Diabetes mellitus		91.00 (56.52)		36.00 (40.91)	0.02
Chronic obstructive pulmonary disease		6.00 (3.73)		3.00 (3.70)	0.99
Hemoglobin	13.20±1.75		13.42±1.74		0.34
Blood urea (mg/dL)	26.52±11.57		32.64±12.84		0.00
Serum creatinine	0.97±0.23		1.04±0.29		0.68
Abnormal liver function test		3.00 (1.86)		0.00 (0.00)	0.24
Left main coronary artery disease		25.00 (15.43)		16.00 (18.18)	0.57
Ejection fraction	51.37±10.37		49.24±10.33		0.15
Left ventricular end diastolic pressure	17.84±5.72		24.65±8.59		<0.01
Presence of regional wall motion abnormalities		96.00 (76.19)		39.00 (70.91)	0.5
Coronary artery endarterectomy		0.00 (0.00)		4.00 (4.44)	0.01
Non requirement of IABP		153.00 (94.44)		57.00 (63.33)	0.00
Preoperative IABP		8.00 (4.94)		25.00 (27.78)	
Intraoperative IABP		0.00 (0.00)		5.00 (5.56)	
Postoperative IABP		1.00 (0.62)		3.00 (3.33)	

IABP: Intra-aortic balloon pump, SD: Standard deviation

Table 3: Difference in outcome between groups

	Control (*n*=162)		Conversion (*n*=90)		*P*
	n (%)	Mean±SD	*n* (%)	Mean±SD	
Inhospital mortality	1 (0.6)		5 (5.6)		0.3
Need for postoperative IABP	1 (0.6)		3 (3.3)		<0.01
Postoperative bleeding		538.78±236.08		987.65±828.35	<0.01
Ventilation		7.10±8.24		21.17±31.17	0.03
Length of stay - intensive care unit (h)		35.15±18.98		54.36±71.31	0.04
Length of stay - hospital (days)		8.85±3.06		10.53±6.91	<0.01

SD: Standard deviation, IABP: Intra-aortic balloon pump

Table 4: Odds ratio for conversion-univariate regression

	Significant	OR	95.0% CI for OR	
			Lower	Upper
Age	0.79	1.00	0.95	1.04
Female gender	0.03	2.20	1.09	4.46
Weight	0.25	0.99	0.96	1.01
Body surface area	0.24	2.80	0.51	14.90
Hypertension	0.69	1.10	0.66	1.90
Diabetes mellitus	0.19	0.53	0.31	0.90
Chronic obstructive pulmonary disease	0.99	0.99	0.24	4.08
hemoglobin	0.34	1.08	0.93	1.25
Serum creatinine	0.07	2.60	0.93	7.06
Abnormal liver function test	-			
Left main coronary artery obstruction	0.57	1.20	0.61	2.40
Ejection fraction	0.15	0.98	0.95	1.10
Left ventricular end diastolic pressure	0.00	1.14	1.07	1.30
Regional wall motion abnormality	0.45	0.76	0.37	1.50
Requirement of coronary endarterectomy	-			
Preoperative intra-aortic balloon pump	0.00	8.40	3.60	19.70

OR: Odds ratio, CI: Confidence interval

Table 5: Odds ratio for conversion-multivariate regression

	Significant	Exp (B)	95.0% CI for Exp (B)	
			Lower	Upper
Chronic obstructive pulmonary disease	1.000	-	-	-
Serum creatinine	0.014	106.228	2.525	4469
Left ventricular end diastolic pressure	0.003	1.183	1.059	1.321
Regional wall motion abnormalities	0.998	-	-	-
Intra-aortic balloon pump	0.019	10.540	1.482	74.990

CI: Confidence interval

outcome of this minority may shadow that of the majority who proceeded with the off-pump technique. It has also been showed that the rate of conversion may be related to the long-term survival of patients. The primary finding of our study is that patients undergoing conversion are at a higher risk of mortality. Similar findings have been reported in the literature.[1,15] This may be because, *per se*, patients requiring conversion are high-risk patients or become higher risk after exposure to circumstances necessitating conversion. Although patients belonging to the first category could be optimized, early institution of corrective strategies on the onset of factors precipitating conversion

Table 6: Odds ratio for mortality in the conversion group

Significant	OR	95.0% CI for OR	
		Lower	Upper
0.04	9.47	1.09	82.40

OR: Odds ratio, CI: Confidence interval

Table 7: Odds ratio of use of intra-aortic balloon pump for in cases undergoing conversion

	Significant	OR	95.0% CI for OR	
			Lower	Upper
Conversion for intra/postoperative IABP	0.00	3.20	1.40	7.20

IABP: Intra-aortic balloon pump, OR: Odds ratio, CI: Confidence interval

is important. The impact of a streamlined decision-making process is of paramount importance in these situations. An early and smooth institution of CPB might have a prognostic significance. The presence of standard operating procedures and management flow charts aid in the process of decision-making. Knowledge, training, and experience of the team members with respect to these may thus affect the outcome. Mortality in our conversion cohort was 5.5%, being significantly higher than the control group. However, the mortality in the OPCAB cohort is lower than that reported in the literature.[1,17,18]

An analysis of factors associated with conversion is important in manifold ways.

It could help us identify patients at a higher risk of conversion. It is known that the outcomes of elective institution of CPB are superior to conversion.[19] Modifiable factors could be optimized to improve the outcome. Unlike this study, a larger control group may help us derive a scoring system specific to risk of conversion, thus risk stratifying patients at risk. Such a risk score could be possibly used in modifying treatment options or formulating therapeutic algorithms. In this study, all patients who underwent OPCAB could not be included for analysis.

Chowdhury *et al*. demonstrated the influence of experience of the surgeon as a most significant multivariate risk factor for conversion.[16] In our cohort, all surgeries were performed by the same surgeon, and thus, the possible effect of variation of results between different surgeons was nullified. We found female gender, higher LVEDP, and intraoperative requirement of IABP to be significant predictors of conversion. These factors as risks for mortality have not been hitherto identified**.** About 50% of the females constituted the conversion group. Female gender is therefore associated with a higher risk of mortality after cardiac surgeries. A similar trend was observed in our cohort too. Females have lesser operative mortality after off-pump compared to on-pump techniques.[19] Thus, avoidance of CPB was found to improve the outcome in

them. The association between female gender and mortality in our cohort might be due to 2-fold impact of higher operative risk of cardiac surgery and higher risk of CPB. This is usually attributed to the associated risk factors such as advanced age and higher comorbidities; our cohort displayed no significant differences in any of the assessed factors.[20]

The role of LVEDP in prognostication of CABG patients has been studied. Salem *et al*. reported that the LVEDP (>19 mmHg) is an independent predictor for mortality after cardiac surgery even after adjusting for the LVEF.[21] We describe the role of LVEDP in predicting the need for conversion, thus underlining the impact of diastolic dysfunction on the same. After noting its impact on mortality and morbidity in our study, we opine that it may be desirable to record this data during coronary angiogram. In absence of this data, pulmonary capillary wedge pressure might serve as its surrogate.

The role of requirement of intraoperative IABP has been studied in OPCAB as a bailout device, especially in patients with severe left ventricular dysfunction. It reduces the 30-day mortality and improves the outcomes.[22] Although many meta-analyses have reported beneficial effect of IABP in CABG patients, most of those patients underwent conventional CABG under CPB.[23-26] In our study, intraoperative IABP requirement was identified as an independent risk for conversion. This association may not imply causality but the importance of anticipating the conversion in such high-risk patient. It is logical to expect this because any patient requiring IABP would be seriously ill. On the other hand, intraoperative requirement of IABP is more in converted patients. The indications for requirement of IABP after bypass in our cohort were as mentioned above. The association between intraoperative IABP, intraoperative conversion, post-CPB IABP is interesting and they point at left ventricular dysfunction in general. The indications and contraindications of intraoperative IABP, conversion, and post-CPB IABP have to be well defined to better delineate the relationship between these.

Limitations

The method of selection and the number of controls is the major limitation of the study. They were chosen that way because we had to manually extract the data from case records. Collecting data from all the cases would have been optimal and provided more statistical power but would have posed practical issues with its execution. Most high-risk patients may not have got included in the converted cohort either because of the small size of coronary arteries or difficult surgery, which were our indication for elective CPB. Considering these reasons, the observations of this study may still be an underestimate.

Conclusion

Conversion during OPCAB is associated with significantly increased mortality; the major risk factors contributing to it are female gender, increased LVEDP, and intraoperative requirement of IABP.

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Conflicts of interest

There are no conflicts of interest.

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