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Preoperative Intra-Aortic Balloon Pump Inserted in Acute Myocardial Infarction Patients without Cardiogenic Shock Undergoing Surgical Coronary Revascularization

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Abstract

Objectives: The benefit of preoperative Intra-Aortic Balloon Pump (IABP) implantation in high-risk cardiac surgery patients is still debated. The role of preoperative IABP insertion in Acute Myocardial Infarction (AMI) patients without Cardiogenic Shock (CS) undergoing Off-Pump Coronary Artery Bypass Grafting (OPCAB) remains unknown. This study aimed to determine the efficacy and safety of the preoperative IABP insertion in those patients undergoing OPCAB.

Methods: A total of 421 consecutive AMI patients without CS who underwent isolated OPCAB were enrolled in this retrospective observational propensity score-matched analysis study. Patients who received IABP before OPCAB (the IABP group, n=157) were compared to those who had not (control group, n=264). The 30-day postoperative survival, postoperative complications, and postoperative hospital length of stay were compared between the 2 groups.

Results: Ninety-nine pairs of patients were matched. The preoperative IABP did not show a 30-day postoperative survival benefit compared to the control group (hazard ratio, 0.9; 95% Confidence Interval [CI], 0.2-4.2; *P*=0.92). Patients with preoperative IABP were more likely to have short postoperative lengths of stay (8 days versus 10 days, *P*=0.02) and decreased total days in the hospital (median days: 18.2 *vs*. 21.8, *P*=0.02) compared to patients without balloon pumps.

Conclusion: Preoperative IABP insertion in AMI patients without CS undergoing OPCAB improved convalescence as shown by significantly shorter postoperative lengths of hospital stay.

Keywords: Intra-aortic balloon pump; Acute myocardial infarction; Off-pump coronary artery bypass grafting; mortality

Abbreviations

AKI: Acute Kidney Injury; AMI: Acute Myocardial Infarction; BMI: Body Mass Index; CABG: Coronary Artery Bypass Grafting; CI: Confidence Interval; CPB: Cardio Pulmonary Bypass; CS: Cardiogenic Shock; HR: Hazard Ratio; IABP: Intra-Aortic Balloon Pump; ICU: Intensive Care Unit; IQR: Inter Quartile Range; LCOS: Low Cardiac Output Syndrome; LOS: Length of Stay; LV: Left Ventricular; NYHA: New York Heart Association; OPCAB: Off-Pump Coronary Artery Bypass Grafting; PCI: Percutaneous Coronary Intervention; SD: Standard Deviation; STEMI: ST-segment Elevation Myocardial Infarction

Introduction

Acute Myocardial Infarction (AMI) patients undergoing surgery revascularization are often associated with a high mortality [1]. Off-Pump Coronary Artery Bypass Grafting (OPCAB) has been established as a method for the early reperfusion of patients with an acute ST-segment Elevation Myocardial Infarction (STEMI) at experienced centers [2,3]. The use of IABP support in AMI compared with CS has been downgraded in the international guideline [4,5]. In clinical practice, IABP may also be employed prophylactically prior to invasive cardiac procedures in patients in high risk for cardiovascular decompensation intra-operatively [6-11]. Several previous studies were performed to analyze the effect of preoperative IABP on STEMI patients without CS undergoing Percutaneous Coronary Intervention (PCI) or Coronary Artery Bypass Grafting (CABG) [8-11]. The most recent randomized controlled trial showed the preoperative use of an IABP did not reduce

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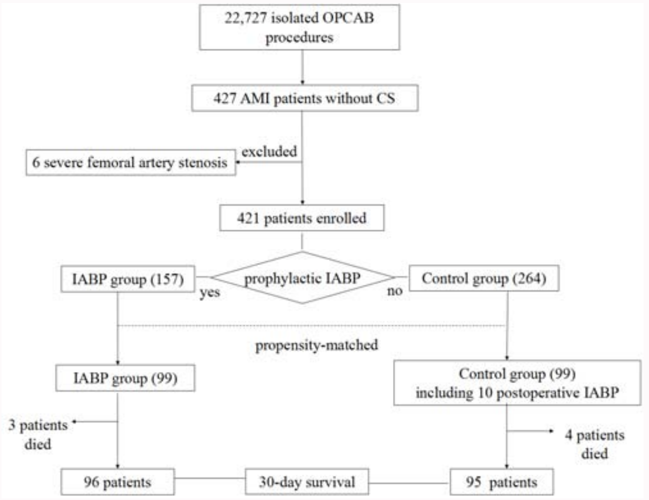

Figure 1: Study flow.
A total of 22,756 patients undergoing isolated OPCAB were screened and 421 acute STEMI patients without CS were enrolled. Preoperative IABP was inserted in 157 patients (IABP group); 264 patients did not receive preoperative IABP (control group); 198 patients (99 patients in each group) were propensity matched. The postoperative 30-day mortality and morbidity were compared.
AMI: Acute Myocardial Infarction; CS: Cardiogenic Shock; IABP: Intra-Aortic Balloon Pump; OPCAB: Off-Pump Coronary Artery Bypass Grafting; CABG: Coronary Artery Bypass Grafting

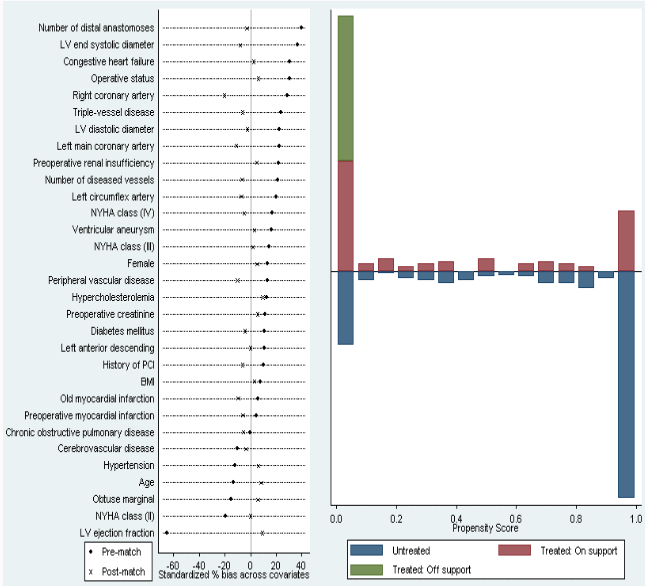

Figure 2: Balancing of covariates in the propensity score models.

the 30-day mortality and major complications in high-risk patients undergoing cardiac surgery [10]. A propensity score analysis study examined the use of preoperative IABP in AMI patients undergoing CABG and found no differences in overall in-hospital mortality and morbidity [11]. However, there is currently limited data regarding the effect of preoperative IABP insertion in patients presenting with acute STEMI without CS who undergo primary OPCAB.

Theoretically, IABP improves diastolic coronary blood flow and increases cardiac output. Furthermore, it may provide more stable hemodynamic status in OPCAB that has no cardiopulmonary bypass support during the procedure in high-risk patients [12]. Therefore, we hypothesis that the preoperative IABP in STEMI patients without CS undergoing OPCAB had a lower 30-day postoperative mortality rate and a shorter length of Intensive Care Unit (ICU) stay and postoperative length of hospital stay. We sought to conduct a propensity-matched cohort study to evaluate the effect of preoperative IABP as an adjunct therapy in patients undergoing isolated OPCAB after sustaining an acute STEMI without CS.

Material and Methods

Study patients

From January 2009 to December 2015, 22,727 consecutive patients underwent first-time isolated OPCAB at Beijing Anzhen Hospital. Of these, 427 patients (1.9%) underwent isolated OPCAB procedure within 4 weeks of an acute STEMI without CS. STEMI was defined by the American College of Cardiology/American Heart Association guidelines as ‘characteristic symptoms of myocardial ischemia in association with persistent ST segment elevation and subsequent release of biomarkers of myocardial necrosis’ [13]. CS was defined by systolic blood pressure <90 mmHg for at least 30 minutes, the need for infusion of catecholamines to maintain a systolic pressure >90 mmHg, or clinical signs of pulmonary congestion [14]. Patients who received preoperative IABP insertion for hemodynamic instability or CS were excluded. Patients with severe femoral artery stenosis were also excluded (Figure 1). Finally, 421 patients were included in the present study. Within this cohort, the patients were categorized according to preoperative IABP insertion into either the IABP group (n=157) or the control group (n=264). The study was approved by the Beijing Anzhen Hospital institutional ethics committee, which waived the requirement for informed consent because the study used de-identified data.

Data were retrospectively extracted from an institutional registry of OPCAB patients and the ICU clinical database. The data were collected as previously described [12].

Surgical technique

The OPCAB technique has been previously described [13]. At our center, OPCAB was performed routinely by 6 experienced cardiac surgeons (≥ 200 cases/year). A Cardio Pulmonary Bypass (CPB) circuit was always placed on stand-by during the procedures. Conversion to CPB was considered if there was any evidence of hemodynamic instability concerns, such as ventricular arrhythmia, hypotension (systolic pressure ≤ 80 mmHg), and cardiac arrest during OPCAB procedures.

IABP support

The detailed IABP implantation was previously described [12]. The patients in the control group were treated with IABP because of Low Cardiac Output Syndrome (LCOS) after the procedure. IABP was terminated once hemodynamic stability was restored (cardiac index >2.0 L/min/m^2 without or with only minimal inotropic agent support) after the operation.

Study points and clinical definitions

The primary endpoint were the rate of 30-day postoperative all-cause mortality (death occurring within 30 days after surgery) and postoperative Length of Hospital Stay (LOS). The secondary endpoints were major postoperative complications, such as LCOS, clinically significant bleeding, tracheotomy, Acute Kidney Injury (AKI), renal replacement therapy, and ICU stay. The incidence of stroke and IABP-related complications (severe limb ischemia, bleeding at the insertion

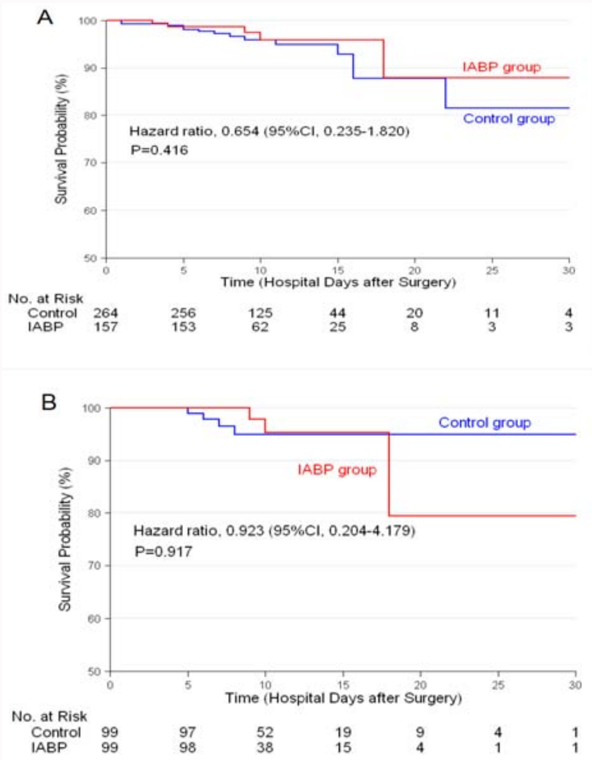

Figure 3: Kaplan-Meier cumulative 30-day mortality after surgery. Kaplan-Meier survival curves show 30-day mortality in surgical patients with preoperative IABP (red line) and without preoperative IABP (control, blue line) before (A) and after (B) propensity score matching. IABP: intra-aortic balloon pump.

site, IABP-related death, and balloon rupture) were evaluated as safety endpoints. LCOS was defined as the need for adrenaline, more than 5 μg/kg/min dopamine or dobutamine, or IABP support. Postoperative respiratory failure was defined as a requirement for prolonged ventilation (>48 hrs) or the occurrence of pneumonia. Postoperative stroke was defined as the occurrence of a new stroke as confirmed by computed tomography. Clinically significant bleeding was defined as any bleeding that required transfusion of more than 2 units of blood or that was associated with hemodynamic instability not explained by other conditions.

Statistical analysis

Continuous variables are shown as mean and standard deviations or median and interquartile ranges, and categorical variables are shown as frequencies and percentages. After testing for normality, baseline characteristics of the 2 groups were compared using Student's t-test or the Mann-Whitney U-test for continuous variables and chi-squared or Fisher's exact tests for categorical variables.

To minimize selection bias and obtain groups with similar baseline characteristics, coronary artery diseases, and OPCAB procedures, patients in the IABP group (n=99) were 1:1 matched with patients in the no IABP group (n=99) by propensity score matching [14]. Logistic regression was used to develop a propensity score quantifying the probability for each AMI without CS undergoing OPCAB procedure preoperative IABP insertion [15]. This included all the preoperative and OPCAB procedure variables accounting for severity of illness found to be different between groups in univariate analysis (*P*<0.10, Table 1). The independent covariates selected were age, sex, left ventricular ejection fraction, NYHA class, number of diseased vessels, left main coronary artery, right coronary artery, triple-vessel disease, ventricular aneurysm, congestive heart failure, preoperative renal insufficiency, emergent operation, and the number of distal anastomoses.

The in-hospital survival after OPCAB was calculated for each group using the Kaplan-Meier method and compared suing the log-rank test. The effect of IABP vs non-IABP was presented as a Hazard Ratio (HR) with associated 95% CI from the Cox regression model. All statistical analyses were performed with Stata software version 11 (Stata Corp, College Station, TX, USA). Two-sided testing was used with a *P* value significance level of less than 0.05.

Results

Patient baseline characteristics

A total of 421 patients were included in this study (Figure 1), with 157 in the IABP group and patients in the control group. The preoperative characteristics of the groups are listed in Table 1.

The patients in the IABP group showed significantly poorer left ventricular function (52.5 ± 12.0% *vs.* 44.7 ± 11.8%, *P*<0.01) and had larger left ventricular diastolic diameter (55.0 ± 8.0 *vs.* 53.2 ± 7.7 mm, *P*=0.02) and left ventricular end systolic diameter (41.3 ± 9.7 *vs.* 37.9 ± 8.8 mm, *P*<0.01). The patients in the IABP group had more diseased vessels (3.2 ± 0.6 *vs.* 3.0 ± 0.7, *P*=0.02) and were more likely to have right coronary artery disease (90.5% *vs.* 81.1%, *P*=0.01) and a higher rate of triple-vessel disease (91.1% *vs.* 82.6%, *P*=0.02) than the control group. Patients in the IABP group had a higher rate of history of congestive heart failure (28.0% *vs.* 14.8%, *P*<0.01) and preoperative renal insufficiency (6.4% *vs.* 1.9%, *P*=0.02), respectively. The IABP group was more likely to have emergent OPCAB procedures (16.6% *vs.* 6.4%, *P*<0.01) and a greater number of distal anastomoses (3.2 ± 0.7 *vs.* 2.9 ± 0.8, *P*<0.01) than the control group, respectively.

After the propensity score matching, 99 matched pairs were obtained (Figure 1). These matched pairs were well balanced for all known covariates (Table 1). No differences in demographics or preoperative risk factors were found between the 2 groups (*P*>0.05, Table 1). Figure 2 shows a Love plot for the absolute differences in the baseline covariates before and after matching; a jitter plot for propensity score distribution is also presented.

The intraoperative and early postoperative outcomes of both groups are listed in Table 2. Importantly, the mean number of anastomoses was comparable between the 2 groups after matching (3.0 ± 0.7 *vs.* 3.1 ± 0.8, *P*=0.84).

Postoperative 30-day mortality

The early postoperative outcomes are presented in Table 2. The overall 30-day postoperative mortality rate was 3.5%. The postoperative 30-day mortality was 3.0% in the IABP group compared to 4.0% in the control group (*P*=1.00). The Kaplan-Meier survival curves of the 2 groups before and after matching are shown in Figure 3. The preoperative IABP insertion was not an independent predictor of survival after adjusting for the propensity score using the Cox regression model (HR 0.17, 95% CI 0.2-4.2, *P*=0.92).

Postoperative major complications

The postoperative major complications are summarized in Table 2. The rate of conversion to CABG was lower in the IABP group than in the control group (1.0% *vs.* 3.0%). However, this difference was not statistically significant (*p*=0.31). There was no a significant

Table 1: Baseline characteristics before and after propensity score matching.

Baseline characteristics	Before matching		*P* value	After matching		*P* value
	IABP (n=157)	Control (n=264)		IABP (n=99)	Control (n=99)	
Age (years)			0.23			0.54
Mean ± SD	59.9 ± 9.7	60.94 ± 9.79		61.77 ± 8.96	60.97 ± 10.20	
Median (IQR)	59 (52-68)	62(54-69)		63(55-69)	59(54-70)	
Female	33 (21.0%)	43(16.3%)	0.22	21(21.2%)	19(19.2%)	0.85
BMI (kg/m^2)			0.20			0.85
Mean ± SD	25.2 ± 3.1	24.9 ± 2.8		25.3 ± 3.0	25.2 ± 3.2	
Median (IQR)	25.1 (23.4-26.6)	24.5(23.0-26.6)		25.2(23.7-26.7)	24.7(23.5-27.1)	
LV ejection fraction (%)			0.00			0.61
Mean ± SD	44.7 ± 11.8	52.5 ± 12.0		48.6 ± 11.7	47.4 ± 11.8	
Median (IQR)	41.5(35-55)	54(41-61)		50(40-58)	45(39-57)	
LV diastolic diameter			0.02			0.83
Mean ± SD	55 ± 8.0	53.2 ± 7.7		54.0 ± 8.4	54.2 ± 7.6	
Median (IQR)	54.5(50-61)	52(47-58)		53(48-59)	53(48-60)	
LV end systolic Diameter			0.00			0.73
Mean ± SD	41.3 ± 9.7	37.9 ± 8.8		39.2 ± 9.7	40.0 ± 8.8	
Median (IQR)	40.5(33-49)	36(32-44)		36(32-47)	38(33-46)	
NYHA class						
II	75 (47.8%)	157 (59.5%)	0.02	51(51.5%)	51(51.5%)	1.00
III	66 (42.0%)	90(34.1%)	0.13	37(37.4%)	38(38.4%)	1.00
IV	10 (6.4%)	7 (2.7%)	0.06	5 (5.1%)	6 (6.1%)	1.00
Number of diseased vessels			0.02			0.65
Mean ± SD	3.2 ± 0.6	3.0 ± 0.7		3.1 ± 0.6	3.1 ± 0.6	
Median (IQR)	3 (3-3)	3 (3-3)		3 (3-3)	3 (3-3)	
Vessels diseased, n(%)						
Left main coronary artery	31(19.8%)	31(11.7%)	0.03	16 (16.2%)	20 (20.2%)	0.59
Left anterior descending	153 (97.5%)	252 (95.5%)	0.30	97 (98.0%)	97 (98.0%)	1.00
Left circumflex artery	127 (80.9%)	193 (73.4%)	0.08	77 (77.8%)	80 (80.8%)	0.64
Right coronary artery	142 (90.5%)	214 (81.1%)	0.01	85 (85.9%)	92 (92.9%)	0.19
Triple-vessel disease	143 (91.1%)	218 (82.6%)	0.02	86 (86.9%)	88 (88.9%)	0.83
Comorbidities, n (%)						
Hypertension	84(53.5%)	156 (59.1%)	0.26	57 (57.6%)	54 (54.6%)	0.75
Hypercholesterolemia	21(13.4%)	25(9.5%)	0.21	12 (12.1%)	9 (9.1%)	0.66
Diabetes mellitus	57(36.3%)	83(31.4%)	0.31	30 (30.3%)	32 (32.3%)	0.87
History of PCI	21(13.4%)	25(9.5%)	0.21	11 (11.1%)	13 (13.1%)	0.83
Old myocardial infarction	40(25.5%)	58(22%)	0.41	20 (20.2%)	24 (24.2%)	0.62
Ventricular aneurysm	23(14.7%)	22(8.3%)	0.04	11 (11.1%)	10 (10.1%)	1.00
Chronic obstructive pulmonary disease	5 (3.2%)	8 (3.0%)	0.93	2 (2.0%)	3 (3.0%)	1.00
Peripheral vascular disease	34(21.7%)	44(16.7%)	0.20	16 (16.2%)	20 (20.2%)	0.60
Cerebrovascular disease	14(8.9%)	31(11.7%)	0.36	9 (9.1%)	10 (10.1%)	1.00
Congestive heart failure	44(28%)	39(14.8%)	0.00	22 (22.2%)	21 (21.2%)	1.00
Preoperative renal insufficiency	10 (6.4%)	5 (1.9%)	0.02	3 (3.0%)	2 (2.0%)	1.00
Preoperative creatinine (μmol/L)			0.07			0.64
Mean ± SD	89.9 ± 28.9	85.7 ± 33.9		88.7 ± 29.0	86.9 ± 31.0	
Median (IQR)	82.1 (70.1-101.0)	79.8(69.9-92.6)		81.2(70.0-99.0)	80.2(72.0-93.5)	
Preoperative myocardial Infarction (days)			0.63			0.69

Mean ± SD	16.8 ± 10.1	16.6 ± 9.2		15.7 ± 9.6	16.3 ± 9.9	
Median (IQR)	16 (9-24)	16 (10-22)		16 (8-22)	16 (10-23)	
Operative status				0.001		0.84
Elective	131 (83.4%)	247 (93.6%)		85 (85.9%)	87 (87.9%)	
Emergent	26 (16.6%)	17 (6.4%)		14 (14.1%)	12 (12.1%)	
Number of distal anastomoses			0.00			0.84
Mean ± SD	3.2 ± 0.7	2.9 ± 0.8		3.0 ± 0.7	3.1 ± 0.8	
Median (IQR)	3 (3-4)	3 (2-3)		3 (3-3)	3 (3-3)	

Continuous factors are summarized by median (25th percentile, 75th percentile) and categorical factors by frequency (percentage). BMI: Body Mass Index; IABP: Intra-Aortic Balloon Pump; IQR: Interquartile Range; LV: Left Ventricular; NYHA: New York Heart Association; PCI: Percutaneous Coronary Intervention; SD: Standard Deviation.

Table 2: Clinical outcomes and major complications of matched patients.

	IABP (n=99)	Control (n=99)	*P* value
			1.00
Postoperative 30-day mortality (%)	3 (3.0%)	4 (4.0%)	
			$^{+}$0.92
Conversion to CABG	1 (1.0%)	3 (3.0%)	0.31
LCOS	5 (5.1%)	9 (9.1%)	0.28
Mechanical ventilation duration (h)			0.30
Mean ± SD	37.6 ± 39.9	39.7 ± 50.6	
Median (IQR)	23 (17-44)	20.5 (14-45)	
Prolonged mechanical Ventilation (≥ 48 h)	20 (20.2%)	21 (21.2%)	1.00
Length of ICU stay (d)			0.63
Mean ± SD	61.5 ± 47.8	64.8 ± 67.3	
Median (IQR)	45 (28-74)	42 (20-90)	
Postoperative LOS (d)			0.02
Mean ± SD	9.5 ± 4.9	11.0 ± 5.7	
Median (IQR)	8 (6-11)	10 (6-15)	
Hospital LOS (d)			0.02
Mean ± SD	18.2 ± 9.6	21.8 ± 11.3	
Median (IQR)	16 (10-24)	21 (13-29)	
Transfusion volume Packed red blood cells (units)			0.86
Mean ± SD	4.1 ± 5.1	4.2 ± 4.6	
Median (IQR)	2 (0-6)	4 (0-6)	
Fresh frozen plasma (ml)			0.73
Mean ± SD	568.7 ± 513.4	557.6 ± 518.5	
Median (IQR)	400 (200-800)	400 (200-800)	
Postoperative complications			
Postoperative low cardiac output	5 (5.1%)	9 (9.1%)	0.28
Acute kidney injury	13 (13.1%)	17 (17.2%)	0.43
Reoperation for bleeding	5 (5.1%)	6 (6.1%)	1.00
Tracheotomy	4 (4.1%)	3 (3.1%)	1.00
Renal failure requiring dialysis	3 (3.0%)	5 (5.1%)	0.73
Postoperative stroke	0 (0.0%)	2 (2.0%)	0.50
Limb ischemia	2 (2.0%)	1 (1.0%)	1.00

IABP: Intra-Aortic Balloon Counter Pulsation; ICU: Intensive Care Unit; LOS: Length of Stay.
The P^{+} was calculated using the Cox model.

reduction in postoperative LCOS in the IABP group compared to the control group (5.1% *vs.* 9.1%, *P*=0.28). The incidence of reoperation for bleeding, tracheotomy, AKI, renal failure requiring dialysis, postoperative stroke, postoperative myocardial infarction, and limb ischemia was similar in both groups (*P*>0.05) (Table 2). There were no significant differences in the required transfusion of packed red blood cells (4 *vs.* 4 units, *P*=0.86) and fresh frozen plasma (400 *vs.* 400 ml, *P*=0.73), respectively.

No difference in the duration of mechanical ventilation was found in the 2 groups (IABP group: 37.6 ± 39.9 h *vs.* control group: 39.7 ± 50.6 h, *p*=0.30). There were no statistically significant differences in the required prolonged mechanical ventilation in the 2 groups (20.2% *vs.* 21.2%, *P*=1.00). No difference in the duration of ICU stay was found in either group (IABP group: interquartile range of 46 [28-73] h; control group: 26 [20-73] h, *P*=0.09). However, the mean postoperative LOS was shorter in the IABP group (interquartile range) of 8 (6-11) *vs.* 10 (6-15) days (*P*=0.02) than in the control group. The mean hospital length of stay was shorter in the IABP group (18.2 ± 9.6 *vs.* 21.8 ± 11.3 days, *P*=0.02) (Table 2).

IABP-related complications

Postoperative IABP was used in 10 patients in the control group, including 1 patient who required weaning from CPB and 9 who had LCOS. The mean duration of IABP support was shorter in the IABP group (59.4 ± 24.9 *vs.* 86.2 ± 53.4 h, *P*<0.01). There were no cases of IABP-related mortality. There was no severe bleeding at the IABP insertion site or balloon failure in any of the patients. Lower limb ischemia requiring surgical intervention was observed in 1 patient (1%) in the control group (Table 2).

Discussion

The major finding of this single-center, retrospective propensity matched analysis study was that in patients presenting with acute STEMI without CS, preoperative IABP insertion can promote postoperative recovery and short hospital stay. However, the preoperative IABP insertion does not improve the early postoperative clinical outcomes. To the best of our knowledge, this is the first study to systematically describe the safety and efficacy of IABP in AMI patients without CS undergoing OPCAB. Theoretically, preoperative IABP insertion can maintain blood hemodynamic stability during OPCAB and improve clinical outcomes in AMI patients. However, the data and statistical outcomes did not support this hypothesis in the present study.

IABP did not show a significant reduction of mortality in AMI patients without CS undergoing Percutaneous Coronary Intervention (PCI) in randomized controlled trials and observational studies [7,8]. Furthermore, several recent meta-analyses demonstrated the use of IABP was associated with a significant increase in stroke rates and higher incidence of major bleeding [18-21]. IABP support effect is still debated because of the differences between studies in the balance of risk factors between IABP and non-IABP groups. In STEMI patients without CS, those study outcomes do not support the preoperative use of IABP.

In studies on STEMI patients without CS treated with primary CABG, no beneficial effect of IABP was observed. In a group of 406 AMI patients who underwent CABG procedure, Yu and colleagues found that the in-hospital mortality rates were not lower in the patients with preoperative IABP insertion (2.5% *vs.* 1.0%). The use of preoperative IABP in patients undergoing CABG after AMI is associated with increased transfusion requirements, increased in-hospital morbidity, and increased hours in the ICU [11]. Similarly, recent large randomized trials using IABP in STEMI patients without CS have not shown reduced infarct size or improved clinical outcomes [10].

The preoperative IABP insertion did not decrease the 30-day postoperative mortality of AMI patients without CS who underwent OPCAB. In this study, the overall hospital mortality was 3.5%, which was similar to a previous study [22]. The interval of AMI to OPCAB was 15.7 ± 9.6 days and 16.3 ± 9.9 days and the rate of emergency surgery was 14.1% and 12.1% in the 2 groups, respectively. The overall 30-day postoperative mortality was low (3.5%). Therefore, no significant differences in 30-day postoperative morality were found between patients with and without preoperative IABP after propensity score matching (3.0% *vs.* 4.0%, *P*=0.92).

Preoperative IABP insertion did not increase in-hospital transfusion requirements in our study. In previous studies, preoperative use of IABP was associated with more bleeding complications resulting in a higher rate of blood transfusion and in-hospital morbidity [21,23]. Compared to patients without IABP, patients with preoperative IABP had increased red blood cell (*P*<0.01), fresh frozen plasma (*P*=0.03), and platelet (*P*<0.01) transfusions, respectively. Patients with IABP may have an increased risk for blood transfusions as they are not only at risk for vascular injury or bleeding at the access site, but they are also at increased hemorrhagic risk for prolonged exposure of blood components to the synthetic surface of the balloon [11]. Furthermore, our study showed that preoperative IABP could promote postoperative recovery. The mechanism may be that IABP can increase coronary blood flow, reduce myocardial ischemia injury, enhance myocardial tolerance to ischemia, and promote postoperative recovery [24]. Several meta-analysis studies found that high-risk CABG patients may be benefit from preoperative IABP support [7,25,26]. In contrast, Yu and colleagues reported that the use of preoperative IABP in patients undergoing isolated CABG after AMI is associated increased in-hospital morbidity and longer postoperative ICU stay. As compared to patients without preoperative IABP, patients with preoperative IABP had increased lengths of intensive care unit stay (67 *vs.* 47 hrs, *P*<0.01). When patients with hemodynamic instability were included, the indication was more likely for therapeutic rather than preoperative prophylactic IABP insertion.

Summarizing current clinical practice guidelines, preoperative IABP use in stable high-risk STEMI patients undergoing PCI or CABG procedures cannot be recommended [4,5,27]. Indications for preoperative IABP insertion should include hemodynamic instability, medically refractory low output state, and/or severe left ventricular dysfunction with left main disease or multi-vessel disease with involvement of critical lesions on the proximal left anterior descending artery.

Limitations

The present study had inherent limitations due to its design (single-center, propensity score match, and observational study) and sample size. First, the choice of preoperative IABP insertion was made by the cardiac surgeons. Despite using propensity match scoring to minimize selection bias, we cannot rule out the possibility of unmeasured cofounders. The residual bias could have a significant impact on our result. Second, the primary endpoint is 30-day postoperative mortality. A statistically significant difference in postoperative myocardial enzyme indexes or postoperative left ventricular function (cardiac index) may be shown. Additionally, owing to its relatively small sample size, it does not allow for subgroup analysis, and the high-risk patients were able to benefit from preoperative IABP insertion. Future studies should address these limitations. Randomized studies are necessary to elucidate the role of preoperative IABP treatment in those patients.

Conclusion

In this study, the patients with preoperative use of IABP had improved convalescence as shown by a significantly shorter postoperative length of hospital stay for AMI patients without CS undergoing OPCAB. However, the preoperative IABP insertion was not associated with a reduction of 30-day postoperative mortality. A further large-scale multi-center randomized controlled study is needed to confirm the benefits of preoperative IABP insertion in high-risk patients.

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Hui Wang had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All the help provided by Zhuang Tao is greatly appreciated.

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