Original Article

Impact of preoperative intra-aortic balloon pump on outcomes in coronary artery bypass grafting for unprotected left-main coronary artery disease

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Background: Preoperative intra-aortic balloon pump (IABP) before coronary artery bypass grafting (CABG) could improve operative outcomes by augmenting the diastolic coronary blood flow. Data on preoperative IABP use in patients with left-main coronary artery (LMCA) disease are limited. This study aimed to characterize patients who received preoperative IABP before CABG for LMCA and evaluate its effect on postoperative outcomes.

Methods: This multicenter retrospective cohort study that included consecutive 914 patients who underwent CABG for unprotected LMCA disease from January 2015 to December 2019 in 14 tertiary referral centers. Patients were grouped according to the preoperative IABP insertion into patients with IABP (n=101) and without IABP (n=813). Propensity score matching adjusting for preoperative variables, with 1:1 match and a caliber of 0.03 identified 80 matched pairs. The primary outcomes used in propensity score matching were cardiac mortality and major adverse cardiac and cerebrovascular events (MACCE).

Results: IABP was commonly inserted in patients with previous myocardial infarction (MI), chronic kidney disease, peripheral arterial disease, and congestive heart failure. IABP patients had higher EuroSCORE [ES >8%: 95 (11.86%) *vs.* 40 (39.60%), P<0.001] and SYNTAX {29 [interquartile range (IQR) 25–35] *vs.* 33 (IQR 26–36); P=0.02} scores. Preoperative cardiogenic shock and arrhythmia were more prevalent in patients with IABP, while acute coronary syndrome was more prevalent in patients without IABP. After matching, there was no difference in vasoactive inotropic score between groups [3.5 (IQR 1–7.5) *vs.* 6 (IQR 1–13.5), P=0.06], and lactate levels were nonsignificantly higher in patients with IABP [2.4 (IQR 1.4–4.5) *vs.* 3.1 (IQR 1.05–7.75), P=0.05]. There were no differences between groups in acute kidney injury [20 (25%) *vs.* 26 (32.5%), P=0.34], cerebrovascular accidents [3 (3.75%) *vs.* 4 (5%), P>0.99], heart failure [5 (6.25%) *vs.* 7 (8.75%), P=0.75], MI [7 (8.75%) *vs.* 8 (10%), P>0.99], major adverse cardiac and cerebrovascular events [10 (12.5%) *vs.* 17 (21.25%), P=0.21], and cardiac mortality [6 (7.50%) *vs.* 14 (17.50%), P=0.09]. Patients who received IABP had longer ventilation times [8.5 (IQR 6–23) *vs.* 15.5 (IQR 5–50.5) h, P=0.03] and intensive care unit (ICU) stays [3 (IQR 2–5) *vs.* 4 (IQR 2–7.5) days, P=0.01].

Conclusions: Preoperative IABP in patients with LMCA might not be associated with reduced cardiac mortality or hospital complications. IABP could increase the duration of mechanical ventilation and ICU stay, and its use should be individualized for each patient.

Keywords: Intra-aortic balloon pump (IABP); coronary artery bypass grafting (CABG); left-main coronary artery disease (LMCA disease)

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Introduction

Background

Exposing patients to unnecessary medical procedures might increase morbidity and mortality (1). Clinical and nonclinical factors influence clinical decision-making; moreover, several medical procedures depend on the experience of the treating teams (2). Intra-aortic balloon pump (IABP) is commonly used in high-risk patients undergoing coronary artery bypass grafting (CABG); however, its effectiveness in this indication is unproven (3). IABP use is not standardized, and a study by Del Carmen and associates reported that the use of IABP before CABG was increased on weekends compared to weekdays (4). Additionally, the published results of IABP use in patients undergoing CABG are controversial. A meta-analysis of clinical trials reported reduced 30-day mortality with IABP in high-risk patients undergoing elective CABG (5). However, the clinical trials contained heterogeneous groups of patients. The definition of high-risk groups varied widely and included low ejection fraction (<30%), significant left-main coronary artery (LMCA) disease (>70%), high EuroSCORE (>8%), and ST-elevation acute myocardial infarction (6). Furthermore, recent trials did not show a reduction in mortality with prophylactic use of IABP in high-risk CABG patients (7,8).

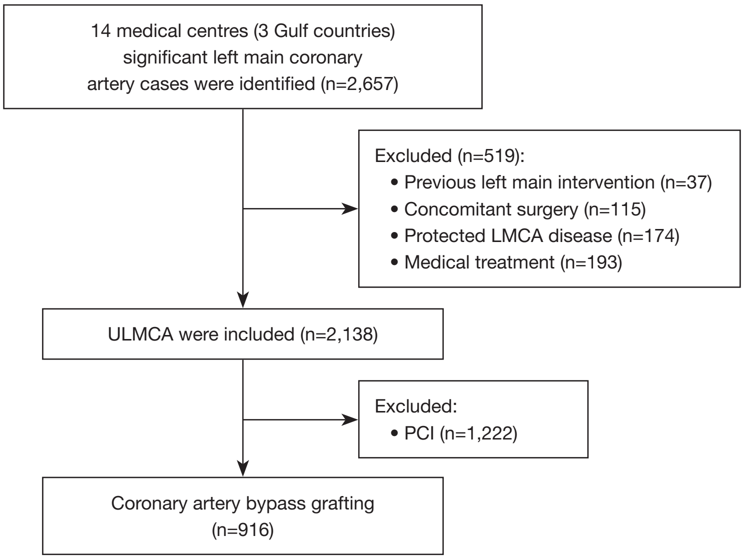

Figure 1 Study flow diagram. LMCA, left-main coronary artery disease; ULMCA, unprotected LMCA; PCI, percutaneous coronary intervention.

Rationale and knowledge gap

The variations in the outcomes of preoperative IABP use in patients undergoing CABG could be attributed to several factors, including the heterogeneity of the included patients and the mechanism of action of IABP. IABP works by increasing the oxygen supply to the myocardium and decreasing the afterload (9). Therefore, the effects of IABP on postoperative outcomes are not the same for all patients; consequently, IABP use should be selective.

There is a paucity of data regarding the beneficial effects of IABP before CABG in patients with LMCA disease. Gatti *et al.* reported that LMCA should not be considered a sole indication for prophylactic IABP use (10). Fasseas *et al.* reported no difference in adjusted mortality after using IABP in LMCA patients (11). Studies reporting the use of IABP in LMCA disease are limited by the small patient number and the study design (6,10,11).

Objective

To date, no randomized trial has been dedicated to evaluating the effect of IABP in patients with LMCA. Thus, this multicenter study aimed to characterize patients who received preoperative IABP before CABG for LMCA and evaluate its effect on postoperative outcomes. We present this article in accordance with the STROBE reporting checklist (available at https://cdt.amegroups.com/article/view/10.21037/cdt-23-418/rc).

Methods

Design

This retrospective study was conducted in 14 tertiary referral centers on patients who underwent CABG for unprotected LMCA disease between January 2015 and December 2019. The study was conducted on The Gulf Left main registry data (12,13). Patients with protected LMCA disease, concomitant valve or aortic surgery, previous left-main revascularization, and preoperative mechanical support other than IABP were excluded (*Figure 1*). The study included 914 patients who were grouped into two groups according to the preoperative use of IABP. Group 1 included patients without preoperative IABP (n=813), and Group 2 included patients with preoperative IABP (n=101). This study was approved by the Institutional Review Board (IRB) of King Faisal Specialist Hospital and Research Center in Riyadh (12 November 2020 – RAC #2201226: Gulf-LM Registry) and was carried out in accordance with the local guideline and ethical guidelines of the Declaration of Helsinki (as revised in 2013). All participating centers were informed and agreed on the study. Informed consent was waived by the IRB for this study due to its retrospective and observational nature and the absence of any patient identifying information.

Data

Data required for this study included age at the time of surgery, gender, body mass index (BMI), and associated comorbidities [diabetes mellitus, hypertension, previous myocardial infarction (MI), chronic kidney disease (CKD), peripheral arterial disease (PAD), history of cerebrovascular accidents (CVA), and atrial fibrillation]. Patients were assigned a risk category (low, intermediate, or high) based on their EuroSCORE II score: low (<4%), intermediate (4–8%), and high (>8%) (14). The complexity of coronary artery disease was evaluated using the SYNTAX score, and the SYNTAX score was divided into three categories: low [0–22], intermediate [23–32], and high [>32] (15).

The main hospital-presenting symptoms were reported and included cardiogenic shock, acute coronary syndrome (ACS), arrhythmia, and cardiac arrest. Operative data included off-pump CABG, minimally invasive CABG, numbers of grafts, cardiopulmonary bypass, and ischemic times.

Outcomes and definitions

Operative outcomes included bleeding requiring re-exploration, CVA, extracorporeal membrane oxygenation use (ECMO), acute kidney injury (AKI), surgical site infection, congestive heart failure (CHF), MI, major adverse cardiac and cerebrovascular events (MACCE), and cardiac deaths. The duration of mechanical ventilation and intensive care unit (ICU) stay were reported.

AKI was defined as an increase in serum creatinine ≥1.5 times compared to the baseline measure or the need for postoperative dialysis or renal support (16). Cardiac death was defined as any reported mortality related to a cardiac cause, such as MI, CHF, or arrhythmia. CVA included stroke, transient ischemic attacks, or reversible neurological deficits diagnosed with computed tomography scanning. Postoperative MI was diagnosed according to the Fourth Universal Definition of Myocardial Infarction definitions (17). MACCE was defined as the composite endpoint of MI, CVA, or cardiac death. The following equation was used to calculate the vasoactive inotropic score (VIS): dopamine dose (μg/kg/min), dobutamine dose (μg/kg/min) 100 × epinephrine dose (μg/kg/min) 10 × milrinone dose (μg/kg/min) 10,000 × vasopressin dose (unit/kg/min) 100 × norepinephrine dose (μg/kg/min) (18).

Statistical analysis

Data presentation

All analyses were performed using Stata 17 (Stata Corp, College Station, TX, USA). Normally distributed continuous data were described as the mean and standard deviation and compared with the unpaired *t*-test before matching and paired *t*-test after matching. Nonnormal data were presented as the median (25^{th}–75^{th} percentiles) and compared with the Wilcoxon test before matching and Wilcoxon matched-pairs signed rank test after matching. Normality was assessed using the Shapiro-Wilk test. Categorical variables were expressed as counts and percentages and compared with the chi-squared or Fisher exact tests before matching or the McNemar test after matching. A two-sided P value of less than 0.05 was considered statistically significant.

Propensity score matching

The propensity score was calculated based on the probability of receiving IABP, adjusting for the preoperative variables. Variables included in the propensity score model were selected based on their potential influence on inserting IABP. These variables included age, MI, history of PCI, CHF, EuroSCORE II, ejection fraction, SYNTAX score, and presentation with shock, arrhythmia, or ACS. The propensity score was used to match the patients using a 1:1 nearest neighbor match with no replacement, a caliber of 0.03 and a random selection in case of ties. The primary outcomes used in propensity score matching were cardiac mortality and MACCE. An absolute standardized mean difference of 0.2 was considered to indicate satisfactory matching (19,20). Propensity score distribution is shown in *Figure 2*.

Results

Preoperative data

Patients who received preoperative IABP had a significantly higher prevalence of previous MI, CKD, PAD, and CHF than those who did not receive preoperative IABP. IABP patients had higher EuroSCORE and SYNTAX scores. Preoperative cardiogenic shock and arrhythmia were more prevalent in patients with IABP, while ACS was more prevalent in patients with IABP. Propensity score

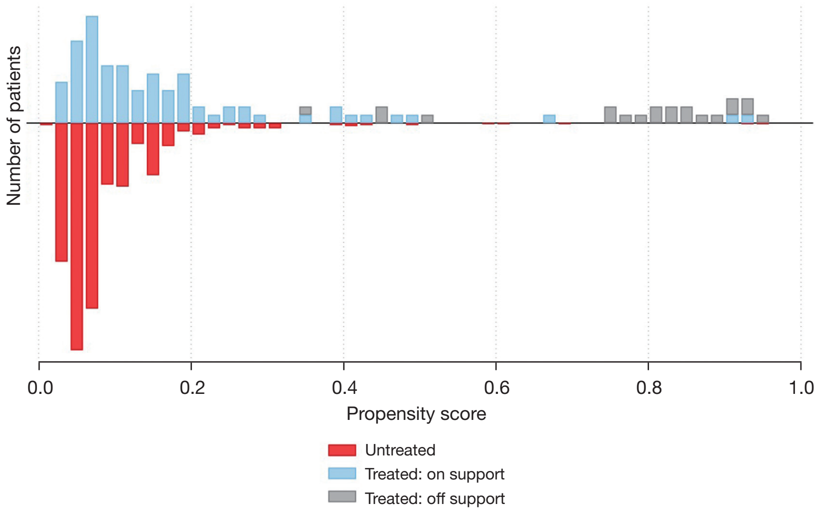

Figure 2 Propensity score distribution between patients who received an intra-aortic balloon pump (treated) and those who did not receive it (untreated). On-support refers to patients whose propensity scores fall within the common support region and were matched; however, off-support refers to those with propensity score outside the common support region.

matching identified 80 matched pairs. After propensity score matching, there was no difference in preoperative demographics, comorbidities, risk stratification, and presenting symptoms in patients with and without IABP (*Table 1*; *Figure 3*).

Operative data

Before matching, there were no differences regarding off-pump CABG, minimally invasive CABG, or the number of grafts between groups. However, left internal mammary artery use was significantly lower in patients with preoperative IABP, and they had longer cardiopulmonary bypass and ischemic times. There were no differences between groups after matching (*Table 2*).

In the unmatched cohort, the IABP was removed intraoperatively in six patients, and 36 patients with no preoperative IABP required IABP insertion intraoperatively. In the matched cohort, the IABP was removed intraoperatively in six patients, and four patients with no IABP had IABP insertion intraoperatively.

Postoperative outcomes

In the unmatched cohort, VIS score (P=0.003), lactate (P=0.001), bleeding (P<0.001), acute kidney injury (P<0.001), ventilation time (P<0.001), ICU stay (P<0.001), perioperative MI (P=0.02), MACCE (P<0.001), and mortality (P<0.001) were significantly higher in patients who received IABP.

After matching, there was no difference in VIS between groups (P=0.06), and lactate levels were nonsignificantly higher in patients with IABP (P=0.05). There were no differences between groups in ECMO use (P>0.99), bleeding (P=0.33), AKI (P=0.34), CVA (P>0.99), surgical site infections (P=0.14), CHF (P=0.75), MI (P>0.99), MACCE (P=0.21), or cardiac mortality (P=0.096). Patients who received IABP had longer ventilation times (P=0.03) and ICU stays (P=0.01) (*Table 3*). Subgroup analysis showed no difference in cardiac mortality or MACCE with and without IABP in patients with ejection fraction <40%, EuroSCORE >8%, and SYNTAX score >32. Cardiac mortality (6.45% *vs.* 17.65%, P=0.06) and MACCE (11.29% *vs.* 23.53%, P=0.10) were higher in patients with IABP and ACS than in those without IABP but did not reach significant levels. Mortality (P=0.04) and MACCE (P=0.009) were significantly higher in patients with IABP and NSTEMI. IABP was associated with significantly increased mortality in patients with EF ≥40% (P=0.01) (*Table 4*).

Discussion

Key findings

Although IABP is one of the most commonly used

Table 1 Matched and unmatched comparison of the preoperative data between patients with and without IABP insertion before coronary artery bypass grafting for unprotected left main coronary artery disease

Baseline characteristics	Unmatched cohort			Matched cohort		
	No IABP (n=813)	IABP (n=101)	P	No IABP (n=80)	IABP (n=80)	SMD
Male	697 (85.73)	86 (85.15)	0.69	64 (80.00)	69 (86.25)	0.17
Age (years)	61.31±9.75	62.02±10.63	0.49	62.89±10.67	62.25±11.09	0.05
Age >70 years	147 (18.08)	21 (20.79)	0.50	21 (26.25)	18 (22.50)	0.09
BMI (kg/m^2)	27.68 [24.86–31.12]	28.01 [25.71–31.21]	0.45	27.93 [25.23–30.80]	28.49 [25.46–31.37]	–0.06
Smoking	332 (40.84)	37 (36.63)	0.41	29 (36.25)	27 (33.75)	0.05
Diabetes mellitus	586 (72.08)	76 (75.25)	0.50	62 (77.50)	62 (77.50)	<0.001
Dyslipidemia	565 (69.50)	75 (74.26)	0.32	60 (70.00)	61 (76.25)	–0.03
Hypertension	557 (68.51)	78 (77.23)	0.07	65 (81.25)	63 (78.75)	0.06
History of MI	158 (19.43)	36 (36.64)	<0.001*	24 (30.00)	28 (35.00)	–0.11
Previous PCI	143 (17.59)	26 (25.74)	0.047*	19 (23.75)	22 (27.50)	–0.09
CKD	95 (11.69)	25 (24.75)	<0.001*	22 (27.50)	19 (23.75)	0.09
PAD	48 (5.90)	13 (12.87)	0.008*	7 (8.75)	10 (12.50)	–0.12
History of CVA	37 (4.55)	6 (5.94)	0.46	3 (3.75)	4 (5.00)	–0.06
Atrial fibrillation	24 (2.95)	5 (4.95)	0.39	5 (6.25)	3 (3.75)	0.11
History of CHF	42 (5.17)	22 (21.78)	<0.001*	17 (21.25)	14 (17.50)	0.09
EuroSCORE II			<0.001*			–0.05
<4%	453 (56.55)	29 (28.71)		28 (35.00)	27 (33.75)	
4–8%	253 (31.59)	32 (31.68)		28 (35.00)	26 (32.50)	
>8%	95 (11.86)	40 (39.60)		24 (30.00)	27 (33.75)	
Ejection fraction (%)	50 [40–55]	50 [40–55]	0.95	48.5 [40–55]	50 [40–55]	–0.05
Ejection fraction			0.69			–0.12
<40%	165 (20.30)	22 (21.78)		19 (23.75)	17 (21.25)	
40–49%	209 (25.71)	22 (21.78)		21 (26.25)	17 (21.25)	
≥50%	439 (54.00)	57 (56.44)		40 (50.00)	46 (57.50)	
SYNTAX score	29 [25–35]	33 [26–36]	0.02*	33 [25–36]	32.5 [25–36]	–0.05
SYNTAX category			0.02*			–0.12
0–22	113 (14.04)	12 (11.88)		6 (7.50)	10 (12.50)	
23–32	389 (48.32)	37 (36.63)		30 (37.50)	30 (37.50)	
>32	303 (37.64)	52 (51.49)		44 (55.00)	40 (50.00)	
Arrest	8 (0.98)	3 (2.97)	0.11	2 (2.50)	3 (3.75)	–0.07
Shock	4 (0.49)	20 (19.80)	<0.001*	2 (2.50)	3 (3.75)	0.07
Arrhythmia	28 (3.44)	10 (9.80)	0.002*	7 (8.75)	5 (6.25)	0.09
ACS	542 (66.67)	87 (86.14)	<0.001*	62 (77.50)	68 (85.0)	0.19

Data are presented as the mean ± standard deviation, median [25th–75th percentiles] or counts and percentages. *, indicates a significant P value. IABP, intra-aortic balloon pump; SMD, standardized mean difference; BMI, body mass index; MI, myocardial infarction; PCI, percutaneous coronary intervention; CKD, chronic kidney disease; PAD, peripheral arterial disease; CVA, cerebrovascular accident; CHF, congestive heart failure; ACS, acute coronary syndrome.

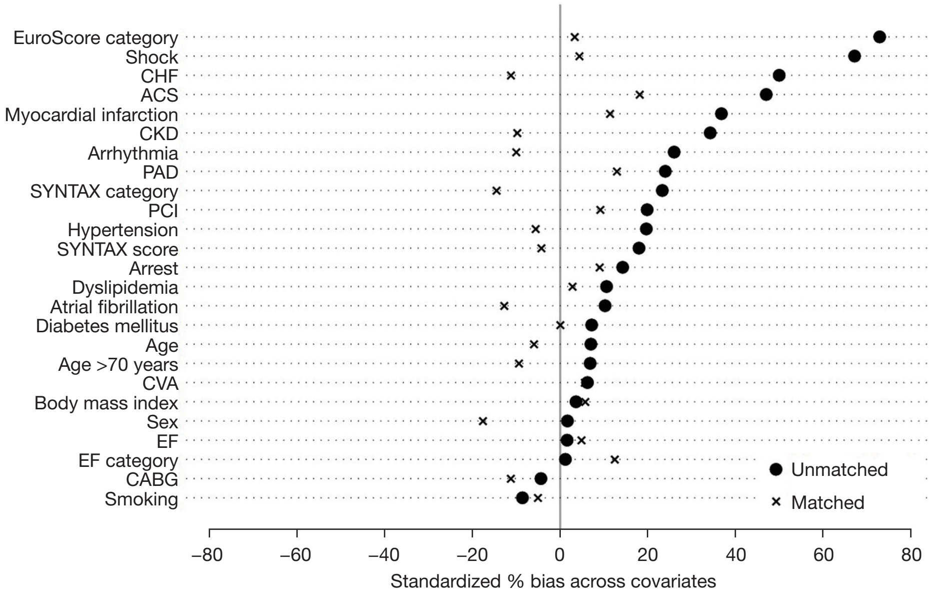

Figure 3 Standardized percent of bias before and after matching. CHF, congestive heart failure; ACS, acute coronary syndrome; CKD, chronic kidney disease; PAD, peripheral arterial disease; PCI, percutaneous coronary intervention; CVA, cerebrovascular accident; EF, ejection fraction; CABG, coronary artery bypass grafting.

Table 2 Matched and unmatched comparison of the operative data between patients with and without IABP insertion before coronary artery bypass grafting for unprotected left main coronary artery disease

Operative characteristics	Unmatched cohort			Matched cohort		
	No IABP (n=813)	IABP (n=101)	P	No IABP (n=80)	IABP (n=80)	P
Off-pump CABG	106 (13.04)	16 (15.84)	0.43	12 (15)	14 (17.5)	0.83
Minimal invasive CABG	34 (4.18)	1 (0.99)	0.16	3 (3.75)	0	0.25
Number of grafts	3 [2–4]	3 [2–4]	0.47	3 [2–4]	3 [2–4]	0.53
LIMA	784 (96.43)	90 (89.11)	0.001*	72 (90.0)	70 (87.5)	0.79
RIMA	139 (17.10)	12 (11.88)	0.18	14 (17.5)	11 (13.75)	0.67
Radial	69 (8.49)	4 (3.96)	0.17	4 (5.0)	3 (3.75)	>0.99
Saphenous vein	691 (84.99)	93 (92.08)	0.055	72 (90.0)	72 (90.0)	>0.99
Bypass time (min)	99 [77–130]	115 [90–160]	<0.001*	100 [78–146]	110 [90–136]	0.08
Ischemic time (min)	60 [46–78]	68 [56–90]	<0.001*	62 [45–80]	68 [56–90]	0.07

Data are presented as median [25^{th}–75^{th} percentiles], or counts and percentages. *, indicates a significant P value. IABP, intra-aortic balloon pump; CABG, coronary artery bypass grafting; LIMA, left internal mammary artery; RIMA, right internal mammary artery.

mechanical circulatory supports in patients undergoing CABG, the efficacy of preoperative IABP is still debatable, and its use is not standardized (4). The efficacy of IABP in improving patient outcomes varies widely in the literature. This study evaluated preoperative IABP insertion in LMCA disease patients undergoing CABG. There were no differences in postoperative inotropic support, AKI, CHF, MI, MACCE, or cardiac mortality between patients with and without IABP. Furthermore, IABP was associated with increased ventilation and ICU stay time.

Table 3 Matched and unmatched comparison of the postoperative data between patients with and without IABP insertion before coronary artery bypass grafting for unprotected left main coronary artery disease

Postoperative characteristics	Unmatched cohort			Matched cohort		
	No IABP (n=813)	IABP (n=101)	P	No IABP (n=80)	IABP (n=80)	P
VIS	3 [1–8]	5.6 [1–12.4]	0.003*	3.5 [1–7.5]	6 [1–13.5]	0.06
Lactate (mmol/L)	2.4 [1.3–4.5]	3.8 [1.3–8]	0.001*	2.4 [1.4–4.5]	3.1 [1.05–7.75]	0.05
ECMO	7 (0.86)	3 (2.97)	0.08	3 (3.75)	2 (2.50)	>0.99
Bleeding	34 (4.18)	14 (13.86)	<0.001*	7 (8.75)	12 (15)	0.33
AKI	91 (11.19)	35 (34.65)	<0.001*	20 (25)	26 (32.5)	0.34
CVA	17 (2.09)	5 (4.95)	0.08	3 (3.75)	4 (5)	>0.99
Surgical site infection	75 (9.23)	5 (4.95)	0.19	9 (11.25)	3 (3.75)	0.14
Ventilation time (h)	8 [4–12]	15 [5–48]	<0.001*	8.5 [6–23]	15.5 [5–50.5]	0.03
ICU stay (days)	3 [2–5]	4 [2–7]	<0.001*	3 [2–5]	4 [2–7.5]	0.01
CHF	14 (1.72)	25 (24.75)	<0.001*	5 (6.25)	7 (8.75)	0.75
Perioperative MI	44 (5.41)	11 (10.89)	0.02*	7 (8.75)	8 (10)	>0.99
MACCE	44 (5.41)	27 (26.73)	<0.001*	10 (12.5)	17 (21.25)	0.21
Cardiac mortality	19 (2.34)	23 (22.77)	<0.001*	6 (7.50)	14 (17.50)	0.09

Data are presented as median [25^{th}–75^{th} percentiles] or counts and percentages. *, indicates a significant P value. IABP, intra-aortic balloon pump; VIS, vasoactive inotropic support; ECMO, extracorporeal membrane oxygenation; AKI, acute kidney injury; CVA, cerebrovascular accident; ICU, intensive care unit; CHF, congestive heart failure; MI, myocardial infarction; MACCE, major adverse cardiac and cerebrovascular events.

Strengths and limitations

Several limitations should be considered when interpreting the results of this multicenter study. First, the study is retrospective and prone to selection and referral biases. IABP insertion may occur at the discretion of the treating teams and their experience, in addition to the availability of other mechanical assist devices. Second, the study is multicenter, which could be considered an advantage; however, multicenter nonrandomized studies may be biased by the wide variability in practice, especially with no guidelines for the preoperative use of IABP in LMCA disease patients. Third, although this could be one of the largest studies evaluating IABP in LMCA patients before CABG, the number of patients with IABP is limited, affecting the significance of the results. Fourth, the study included a heterogeneous group of patients with different IABP indications. This could present a real-world experience; however, the number of patients in subgroups might be too small to detect the beneficial effects of IABP in those patients. Last, the study included all patients with preoperative IABP, and this does not differentiate between therapeutic and prophylactic indications, which could have affected the outcomes.

Comparison with similar researches

The European and American College of Cardiology/American Heart Association guidelines for myocardial revascularization do not recommend the routine use of IABP in patients with cardiogenic shock and before high-risk revascularization (21,22). Nevertheless, IABP is commonly used electively before cardiac surgery. Pilarczyk and associates performed a meta-analysis of nine randomized trials evaluating IABP insertion before surgery. They reported a lower incidence of low cardiac output syndrome and shorter duration of stay with IABP use; however, there was no effect on mortality (6). The authors of this meta-analysis reported heterogeneity in the included patients and the definition of high-risk patients. High-risk patients were defined in some studies as having a reduced EF <30%, critical left-main stenosis, or reoperation. Poirier and associates conducted a meta-analysis of randomized and observational studies and included 11 trials and 22 observational studies with a total of 46,067 patients (23).

Table 4 Comparison of mortality and MACCE in patients with and without IABP according to ejection fraction, EuroSCORE, SYNTAX score, and acute coronary syndrome

Postoperative clinical outcome	No IABP (n=80)	IABP (n=80)	P
Cardiac mortality			
EF <40%	3/19 (15.79)	1/17 (5.88)	0.60
EF ≥40%	3/61 (4.92)	13/63 (20.63)	0.01*
EuroSCORE II			
≤8%	2/56 (3.57)	6/53 (11.32)	0.15
>8%	4/24 (16.67)	8/26 (30.77)	0.33
SYNTAX score			
≤32	3/36 (8.33)	6/40 (15.0)	0.48
>32	3/44 (6.82)	8/40 (20.0)	0.10
Acute coronary syndrome	4/62 (6.45)	12/68 (17.65)	0.06
STEMI	1/16 (6.25)	6/29 (20.69)	0.39
NSTEMI	5/46 (10.87)	11/39 (28.21)	0.04*
MACCE			
EF <40%	6/19 (31.58)	7/17 (41.18)	0.73
EF ≥40%	4/61 (6.56)	10/63 (15.87)	0.15
EuroSCORE II			
≤8%	6/56 (10.71)	11/53 (20.75)	0.19
>8%	4/24 (16.67)	6 (22.22)	0.73
SYNTAX score			
≤32	4/36 (11.11)	6/40 (15.0)	0.74
>32	6/44 (13.64)	11/40 (27.50)	0.17
Acute coronary syndrome	7/62 (11.29)	16/68 (23.53)	0.10
STEMI	4/16 (25.0)	5/29 (17.24)	0.70
NSTEMI	3/46 (6.52)	11/39 (28.21)	0.009*

Data are presented as numbers and percentages. *, indicates a significant P value. MACCE, major adverse cardiac and cerebrovascular events; IABP, intra-aortic balloon pump; EF, ejection fraction; STEMI, ST-elevation myocardial infarction; NSTEMI, non-ST-elevation myocardial infarction.

The authors reported improved survival with IABP in clinical trials, while the evidence from observational studies remained inconclusive. Kralev and coworkers evaluated the role of prophylactic IABP in patients with reduced ventricular function, defined as left ventricular ejection fraction ≤30% (24). The study excluded patients with hemodynamic instability, recent MI, off-pump CABG, and reoperations. The authors reported a lower incidence of low cardiac output syndromes and inotropic support with IABP, with no difference in mortality and other complications in the adjusted analysis. Other meta-analyses showed improved outcomes with IABP before CABG; however, in addition to the previous limitation of patient heterogeneity, some studies included patients with IABP inserted before weaning from cardiopulmonary bypass and with small patient numbers (5,25).

Some other factors might affect the outcomes of IABP other than the indications. Li and colleagues reported that prolonged IABP use improved the outcomes after acute MI (26). IABP settings and weaning techniques also affect hemodynamics. Gelsomino and colleagues found that the 1:1 mode enhanced coronary hemodynamics and cardiac contractility, while the 1:2 and 1:3 modes had no benefits (27).

Explanations of findings

The mechanism of action of IABP may guide the choice of the optimal patients for IABP support. IABP causes systolic unloading and diastolic augmentation of the aortic pressure, thus improving coronary perfusion, increasing oxygen supply, and decreasing demand (28). Patients with LMCA may benefit from increasing coronary blood flow, while in the case of total occlusion, IABP may not be effective in improving coronary blood flow. Therefore, IABP could benefit stable patients with borderline ventricular function, and its benefits in ACS are questionable. In patients with cardiogenic shock, IABP might indirectly increase distal perfusion by improving cardiac contractility; however, the significance of this action is doubtful, especially since end organ perfusion is one of the main determinants of survival in patients with cardiogenic shock (29). Apart from IABP-related factors that may affect the outcomes, several operative, surgeon, and patient-related factors could affect the outcomes and were not included in the analysis (30,31).

Earlier studies (32,33) showed beneficial effects for using IABP in selected high-risk patients. However, the fundamental differences between these studies and this research are limited number of the included patients and the time era with the major advancement in diagnostic and therapeutic tools. Furthermore, the current study focused on patients with unprotected LMCA.

Therefore, it is still difficult to standardize IABP use before CABG, and studies exclusive to LMCA disease are limited. Research on IABP is limited, and its role in other conditions is inconclusive (34,35). Zheng and colleagues evaluated the effect of prophylactic IABP in patients with LMCA disease undergoing off-pump CABG (36). They reported no difference in perioperative MI and mortality between the prophylactic IABP and control groups; furthermore, they reported prolonged mechanical ventilation in IABP patients. Gatti *et al.* evaluated 74 LMCA disease patients who received prophylactic IABP and found no significant effect of IABP on mortality, MI, or other postoperative complications (10).

Implications and actions needed

This study showed that IABP in patients with LMCA might not improve surgical outcomes, maintaining doubt about the usefulness of IABP before CABG. The variability in patients' characteristics who received IABP indicates the need for clinical guidelines to standardize the clinical use of IABP in LMCA disease patients. These guidelines should be guided by a clinical trial randomizing LMCA disease patients into prophylactic *vs.* conservative use of preoperative IABP. The current evidence is limited to a few clinical trials and is not exclusive to LMCA disease patients. Most clinical trials that constitute the current evidence were performed over 20 years ago (6), and recent advancements in the surgical and medical management of heart failure and ischemic heart disease have been achieved (37). Unjustified use of IABP may expose patients to balloon-related and unrelated complications, and the revascularization process might be delayed in some cases.

Conclusions

Routine use of IABP preoperatively in patients with LMCA might not be associated with reduced cardiac mortality or hospital complications. IABP could increase the duration of mechanical ventilation and ICU stay, and its use should be individualized for each patient. Further randomized trials are highly recommended.

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Footnote

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