Prophylactic use of a preoperative intra-aortic balloon pump in patients with severe left ventricular dysfunction undergoing coronary artery bypass grafting

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Received 20 October 2014
Accepted 06 January 2015

The Egyptian Journal of Cardiothoracic Anesthesia 2014, 8:97–100

Objective
The aim of this work was to study the effectiveness of preoperative intra-aortic balloon pump (IABP) in patients with severe left ventricular dysfunction undergoing coronary artery bypass grafting (CABG).
Materials and methods
We studied 80 consecutive patients of both sexes undergoing elective on-pump CABG having an ejection fraction less than 30%. Thirty patients received preoperative IABP support prophylactically, whereas 50 patients did not. The decision to put an IABP was made by the individual surgeon operating the patient. Preoperative, intraoperative, and postoperative variables were recorded and 30 days' follow-up was obtained. Results were subjected to statistical analysis.
Results
Fifty one patients (63.7%) were male while 29 (36.25%) were female with a mean age of 55.62 ± 9.65 years. Patients who received preoperative IABP had high in-hospital mortality (P = 0.002) and decreased rate of postoperative acute kidney injury (P = 0.048), ICU stay (P = 0.031) and less requirement for postoperative inotropic support (P = 0.047) compared to those who did not receive IABP preoperatively.
Conclusion
The prophylactic use of IABP in patients with a low ejection fraction undergoing CABG does not decrease the mortality, but it has a favorable effect on postoperative major complications.

Keywords:
coronary artery bypass grafting, intra-aortic balloon pump, severe left ventricular dysfunction

Egypt J Cardiothorac Anesth 8:97–100

1687-9090

Introduction

Widespread use of percutaneous coronary intervention for coronary artery disease has resulted in a large number of patients treated without surgery. Consequently, patients who are candidates for surgery have a comparatively high-risk profile including poor left ventricular function. The American Heart Association/American College of Cardiology declares coronary artery bypass grafting (CABG) a class I recommendation in patients with symptomatic coronary artery disease with left ventricular dysfunction [1]. The operative mortality is high compared with patients with a normal or a moderately dysfunctional myocardium [2]. For this reason, various support measures are taken to support the left ventricle perioperatively including pharmacological support and mechanical support. Better understanding of the pathophysiology, more time-tested methods of myocardial protection, pharmacological support in the perioperative period, mechanical circulatory support, and even bridge to therapy ventricular assist devices have helped improve the mortality and the morbidity in patients undergoing CABG with severe left ventricular dysfunction [3].

Intra-aortic balloon pump (IABP) counterpulsation is the most widely used mechanical circulatory support device [4]. The IABP increases coronary blood flow and peripheral perfusion by inflating in the aorta during diastole and augments the intrinsic elastic recoil force of the aorta (the Windkessel effect), respectively [5]. It deflates just at the beginning of systole and thus decreases the peripheral resistance, improving the cardiac output and decreasing the workload of the heart [4].

While generally agreed that the use of IABP improves the cardiac function, some studies have shown that the use of preoperative prophylactic IABP in patients with severe left ventricular dysfunction undergoing CABG does not lead to improved outcomes in terms of the mortality and major complications [6].

'Exactly which patient will benefit from the prophylactic use of IABP' is not clear. Prophylactic

use in hemodynamically unstable patients has been studied well, but there are only limited reports about the prophylactic use of IABP in stable patients with poor left ventricular function. Our study challenged the important question of the rationale of the prophylactic use of the IABP counterpulsation in the perioperative management of patients with a low ejection fraction and thus a poor left ventricular performance.

Materials and methods

This prospective nonrandomized observational study was conducted from June 2012 to June 2014. The hospital ethical committee gave permission for the study. Individual consent from patients was waivered. All the consecutive patients undergoing CABG having an ejection fraction less than 30% were included in the study. Patients were divided into two groups. Group I included patients who received preoperative IABP and group II included those who did not. Patients operated in emergency, patients with additional procedures such as valve surgery, and those with ischemic mitral regurgitation were excluded from the study. The ejection fraction was measured though conventional two-dimensional echocardiogram. The use of an IABP was decided by the individual surgeon. Hemodynamically unstable patients were not included in the study because the use of IABP in such patients is therapeutic rather than prophylactic. The IABP was introduced through the right femoral artery using the modified Seldinger technique in all patients. Preoperative, intraoperative, and postoperative variables were recorded and patients were followed up for 30 days postoperatively.

Data analysis

SPSS (SPSS Version 16.0. Chicago, SPSS Inc.) was used for data analysis. Quantitative variable were presented as mean ± SD and qualitative variables were presented as frequency and percentages. For the comparison of the quantitative data, the independent-sample *t*-test was applied, whereas for qualitative data, the χ^2-test was used. *P*-value of 0.05 or less was considered as significant.

Results

Eighty consecutive patients with left ventricular ejection fraction less than 30% undergoing CABG with cardiopulmonary bypass (CPB) were included in the study. Patients were divided into two groups: group I included patients in whom preoperative prophylactic IABP was used (n = 30), whereas group II included patients who did not receive preoperative IABP (n = 50). Out of 80 patients, 51 (63.7%) were male, whereas 29 (36.25%) were female. The mean age of the patients was 55.62 ± 9.65 years. Clinical and demographic characteristics of the patients in both the groups are shown in Table 1.

More patients in the IABP group were in NYHA III or IV dyspnea compared with those who did not receive IABP preoperatively. This variable reached statistical significance although the variations in other variables such as diabetes, smoking, hypertension, and a history of ischemic heart disease did not reach any statistical significance. The trend towards bypass time was found to be higher in group II than in group I although statistically insignificant. The preoperative IABP was associated with a higher in-hospital mortality (10.6 vs. 7%; P = 0.002). The incidence of postoperative acute kidney injury (AKI) was significantly more common in group II compared with group I (15.6 vs. 5.7%; P = 0.048). Patients who did not receive preoperative IABP required more postoperative inotropic support (>3 days) than those who received preoperative IABP

Table 1 Clinical and demographic characteristics of the study population

Variables	IABP (n = 30) (group I) [n (%)]	Non-IABP (n = 50) (group II) [n (%)]	*P*-value
Sex			
Male	11 (36.7)	40 (80)	0.001
Female	19 (63.3)	10 (20)	
Age (years)	56.7 ± 8.8	54.54 ± 10.5	0.343
Hypertension	16 (53.3)	18 (36)	0.129
Diabetes	12 (40)	24 (48)	0.486
Smoking	11 (36.7)	12 (24)	0.226
NYHA class III or IV	15 (50)	17 (35)	0.023
Prior family history of IHD	12 (40)	16 (32)	0.468
Hyperlipidemia	4 (13.3)	7 (14)	0.933
Bypass time (min)	79.00 ± 19.99	83.13 ± 31.91	0.654
Cross-clamp time (min)	40.12 ± 5.67	47.03 ± 15.45	0.626
Number of grafts			
1–2	2 (5.3)	10 (20.5)	0.643
3–4	26 (89.47)	38 (76.47)	
≥5	2 (5.3)	2 (2.9)	
Postoperative AKI	2 (5.7)	8 (15.6)	0.048
Need for postoperative inotropic support for more than 3 days	4 (13.3)	10 (20.0)	0.047
Stroke	2 (5)	3 (4.5)	0.332
ICU stay (days)	4.80 ± 2.2	8.67 ± 2.8	0.031
Mortality (in-hospital)	3 (10.6)	4 (7)	0.002

AKI, acute kidney injury; IABP, intra-aortic balloon pump; NYHA, New York Heart Association; IHD, ischemic heart disease.

(20 vs. 13%; $P = 0.047$). The postoperative ICU stay for patients in group II was longer than for those in group I (8.67 ± 2.8 vs. 4.80 ± 2.2, $P = 0.031$) (Table 1).

Discussion

The main finding of this study is that preoperative IABP, when used prophylactically, does reduce the morbidity in terms of the postoperative AKI, the ICU stay, and the use of inotropic support postoperatively in patients with severe left ventricular dysfunction undergoing CABG. Although used widely, reports that include single-centre studies and multicentre randomized studies show that the prophylactic use of IABP in this context may not be useful in terms of the postoperative outcome.

Patients in the IABP group in our study had a higher mortality compared with those who did not receive it. Davoodi *et al.* [7] showed that the insertion of IABP in patients with severe left ventricular dysfunction before surgery is a strong predictor of increased mortality and morbidity. Similarly, our results are in conformity with Aksnes *et al.* [8] who also showed that patients receiving IABP had a high mortality rate compared with patients without IABP. However, the beneficial effects of IABP in high-risk patients are nonetheless a question addressed by many investigators. Gutfinger *et al.* [9] showed that the liberal use of preoperative IABP in elderly patients undergoing CABG leads to results comparable to that in low-risk patients. A meta-analysis by Dyub *et al.* [10] in which 1034 high-risk patients received IABP preoperatively and 1329 patients did not receive IABP showed that it is associated with a decreased overall mortality. This discrepancy may be because of the fact that patients receiving IABP are already at risk of increased mortality because of other factors. It is also evident that more patients in our study who received IABP had NYHA III or IV dyspnea, which depicts the high-risk profile of these patients. Thus, they had a high mortality compared with those who were comparatively asymptomatic. Another factor may be the unclear definition of high-risk patients who can actually benefit from the use of IABP [10]. Propensity score-matched studies are needed in this regard.

Our study did not show any significant effect of the sex on the outcome in the overall study population. This is in consensus with the conclusion drawn by Argenziano *et al.* [11]. However, in our study, the occurrence of complications was more in women than in men. Beiras-Fernandez *et al.* [12] showed that women have a worse outcome after receiving IABP compared with men even with a good left ventricular ejection fraction. The contributing factors in women may be advanced age, advanced disease, comorbidities, and a smaller body surface area [13].

AKI occurs in about 13% of the patients after coronary artery bypass surgery [14]. A preoperative low ejection fraction is an independent predictor for postoperative AKI [15]. The beneficial effect of preoperative IABP on the postoperative renal function in patients with a low ejection fraction has not been studied well. Our study shows that the insertion of a prophylactic IABP in such patients reduces the postoperative AKI. This marked difference can be attributed to the fact that IABP improves the cardiac output and thus renal perfusion. Micelli *et al.* [16] have shown that the occurrence of postoperative AKI is not affected by the presence or the absence of IABP. Still, there are reports that favor the insertion of IABP preoperatively for improved renal function postoperatively [17,18]. Inspite of the beneficial effect of IABP in this patient population, the higher rate of postoperative AKI in our study may be due to the fact that these patients are at a higher risk for postoperative AKI because of other factors such as a low ejection fraction, advanced age, etc. The timing of insertion has been debated in the literature, but most studies point towards the fact that the time factor is not important [19].

Our study shows that the unloading of the heart preoperatively reduces the need for postoperative inotropic support. This can be attributed to the fact that the increased coronary blood flow and afterload reduction has a beneficial effect that is carried to the postoperative period. A meta-analysis of the randomized control trials about the use of IABP in high risk patients by Michel Pompeu *et al.* [20] showed that IABP does reduce postoperative low cardiac output syndrome, and thus, reduces the need for inotropic support. IABP leads to an indirect improvement in the left ventricular diastolic function, and this may also be a reason for the decreased inotropic support postoperatively [21]. John *et al.* reported an increase in the ejection fraction after CABG in patients with a low ejection fraction supported preoperatively with IABP [22]. They stated an increase in ejection fraction from 24.6% before bypass grafting to 33.2% after grafting. This degree of change is not only statistically significant, but also large enough to be of physiologic and clinical relevance. This definitely decreases the use of postoperative pharmacologic support and morbidity.

With improved hemodynamics and reduced morbidities such as AKI, it can be postulated that IABP reduces the length of stay in the ICU after surgery. Many reports have confirmed this, although some point out the complication rate with IABP, which

increases the length of stay in the ICU [20]. Our study confirmed that IABP significantly reduces the length of stay in the ICU. The report by Micelli *et al.* [16], which is a propensity score-matched study, shows that it does reduce the length of stay in the ICU. The reduced length of stay can have a significant impact on morbidity, early return to work, and cost implications.

To the best of our knowledge, this is the first study in Pakistan addressing the important question of the prophylactic use of IABP in patients with severe left ventricular dysfunction undergoing CABG. However, a small sample size, the retrospective design, and limited follow-up are some of the main shortcomings of our study. Second, the process of patient selection for IABP was purely the surgeon's choice, and this bias may have affected the results. For these reasons, the results of our study should be viewed with caution. Randomized control trials addressing this important question are needed. There is evidence of the beneficial use of IABP in hemodynamically unstable patients. However, outcomes in stable patients need to be studied more extensively. Our study confirms that the use of IABP in patients with a low ejection fraction does not lead to a reduction in the mortality. It is beneficial in reducing postoperative AKI and the need for pharmacological inotropic support in the ICU. It also reduces the length of stay in the ICU, thus reducing morbidity and health costs.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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