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Predictors of Intra-Aortic Balloon Pump Insertion in Coronary Surgery and Mid-Term Results

Kazim Ergüneş, M.D., Ismail Yurekli, M.D., Ersin Celik, M.D.,
Ufuk Yetkin, M.D., Levent Yilik, M.D., Ali Gurbuz, M.D.

Background: We aimed to investigate the preoperative, operative, and postoperative factors affecting intra-aortic balloon pump (IABP) insertion in patients undergoing isolated on-pump coronary artery bypass grafting (CABG). We also investigated factors affecting morbidity, mortality, and survival in patients with IABP support. ***Methods:*** Between January 2002 and December 2009, 1,657 patients underwent isolated CABG in İzmir Katip Celebi University Atatürk Training and Research Hospital. The number of patients requiring support with IABP was 134 (8.1%). ***Results:*** In a multivariate logistic regression analysis, prolonged cardiopulmonary bypass time and prolonged operation time were independent predictive factors of IABP insertion. The postoperative mortality rate was 35.8% and 1% in patients with and without IABP support, respectively (p=0.000). Postoperative renal insufficiency, prolonged ventilatory support, and postoperative atrial fibrillation were independent predictive factors of postoperative mortality in patients with IABP support. The mean follow-up time was 38.55±22.70 months and 48.78±25.20 months in patients with and without IABP support, respectively. The follow-up mortality rate was 3% (n=4) and 5.3% (n=78) in patients with and without IABP support, respectively. ***Conclusion:*** The patients with IABP support had a higher postoperative mortality rate and a longer length of intensive care unit and hospital stay. The mid-term survival was good for patients surviving the early postoperative period.

Key words: 1. Coronary surgery
2. Intra-aortic balloon pumping
3. Risk factors
4. Survival

INTRODUCTION

Nowadays, patients undergoing coronary artery bypass grafting (CABG) are older and have more common comorbitidies, more severe coronary artery disease, and severe left ventricular dysfunction due to an increase in the angioplasty and stenting applications. An intra-aortic balloon pump (IABP) is the most common tool of temporary mechanical circulatory support for coronary surgical patients who suffered from low cardiac output in the early postoperative phase [1,2].

IABP has been in widespread clinical practice for hemodynamic support since it was first reported in 1968 [3]. The main effects of IABP are reduction of ventricular afterload, improvement of diastolic coronary perfusion, and enhancement of subendocardial perfusion [4].

Department of Cardiovascular Surgery, İzmir Katip Celeby University Atatürk Training and Research Hospital
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Corresponding author: Kazim Ergüneş, Department of Cardiovascular Surgery, İzmir Katip Celeby University Atatürk Training and Research Hospital, 2040-2 Sokak, Selçuk-3, No. 2, Daire- 56, Mavişehir. 35540 Karşıyaka, Izmir, Turkey
(Tel) 90-232-244-4444 (Fax) 90-232-243-4848 (E-mail) kazimergunes@yahoo.com

Table 1. Characteristics of patients with and without intra-aortic balloon pump (IABP) support

Characteristic	Patients with IABP (n=134)	Patients without IABP (n=1,523)	p-value
Mean age (yr)	61.22±10.06	58.70±10.76	0.009
Advanced age (>70 yr)	21.6 (29)	14.9 (227)	0.046
Sex (female)	26.9 (36)	21.3 (325)	0.155
Smoking	65.7 (88)	56.9 (867)	0.030
Diabetes	70.9 (95)	32.6 (496)	0.000
Hyperlipidemia	67.2 (90)	43.1 (657)	0.000
Hypertension	53 (71)	45.5 (693)	0.104
Chronic obstructive pulmonary disease	10.4 (14)	3.9 (60)	0.002
Left main coronary artery disease	6.7 (9)	5.7 (87)	0.566
Renal failure or creatinine ≥2 mg/dL	4.5 (6)	1 (15)	0.005
Peripheral vascular disease	3.7 (5)	4.7 (71)	0.829
Preoperative atrial fibrillation	3.7 (5)	1.2 (18)	0.033
Previous stroke or transient ischemic attack	-	0.9 (13)	0.716
Previous percutaneous transluminal angioplasty	5.2 (7)	5.4 (82)	1.000
Aortic calcification	7.5 (10)	2.9 (44)	0.009
Ejection fraction (%)			0.000
<30	21.8 (29)	4.9 (74)	
30–50	72.9 (97)	39.1 (592)	
>50	5.3 (7)	56 (847)	
β-blocker	9.7 (13)	24.9 (379)	0.008

Values are presented as mean±standard deviation or % (number).

In this study, we aimed to display the preoperative, operative, and postoperative factors affecting the IABP insertion among patients undergoing isolated on-pump CABG. We also investigated factors affecting morbidity, mortality, and survival in patients with IABP support.

METHODS

Between January 2002 and December 2009, 1,657 patients underwent isolated CABG in İzmir Katip Celebi University Atatürk Training and Research Hospital. The number of patients with IABP support was 134 (8.1%).

Cardiopulmonary bypass was undertaken using standardized extracorporeal circulation utilizing a non-pulsatile flow and an alpha-stat management protocol. In our patients, isothermic blood cardioplegia was initially administered antegradely, retrogradely, and thereafter, continuously retrogradely.

A 7.5-Fr sheathless IABP catheter was inserted via percutaneous common femoral artery cannulation in 129 patients. The 7.5-Fr IABP catheter was inserted through the ascending aorta in the operating room in 5 patients having severe peripheral vascular disease or atherosclerotic disease of the abdominal aorta and iliac arteries.

Following data accumulation, statistical models were formed and analyzed using SPSS ver. 15.0 (SPSS Inc., Chicago, IL, USA). Non-categorical data were analyzed with a t-test and categorical data with a chi-square or Fisher's exact test where appropriate. The Mann-Whitney U-test was used for analyzing the duration of intensive care unit stay and hospitalization periods. Survival analysis was conducted using the Kaplan-Meier method. A log-rank test was used for analyzing the risk factors affecting survival. Variables with a p-value equal to or less than 0.05 were entered into the multivariate regression model.

Independent predictors of the length of the intensive care unit (ICU) and hospital stay were analyzed using a multivariate regression analysis, and independent predictors of postoperative mortality were analyzed using a multivariate logistic regression analysis. Further, independent predictors of survival were analyzed using a Cox regression analysis.

Table 2. Predictive factors of intra-aortic balloon pump insertion by multivariate logistic regression analysis in patients with intra-aortic balloon pumping support

Variable	Odds ratio	p-value
Prolonged cardiopulmonary bypass time	3.40	0.017
Prolonged operation time	21.41	0.000

Table 3. Predictive factors of postoperative mortality by multivariate logistic regression analysis in patients with intra-aortic balloon pumping support

Variable	Beta	Standard error	p-value
Postoperative renal insufficiency	3.12	1.23	0.011
Prolonged ventilatory support	2.31	0.72	0.001
Postoperative atrial fibrillation	2.67	0.95	0.005

RESULTS

Characteristics of patients with and without IABP support are given in Table 1. The IABP was inserted percutaneously through the common femoral artery in 129 patients (96.3%) and through an open access of the ascending aorta in the remaining 5 patients (3.7%).

The independent predictive factors of IABP insertion are listed in Table 2. The independent predictive factors of postoperative mortality in patients with IABP support are given in Table 3. We also showed that hypertension (p=0.049), preoperative renal insufficiency (p=0.022), peripheral vascular disease (p=0.005), ascending aorta calcification (p=0.004), cardiopulmonary bypass time (CPB) (p=0.000), operation time (＞4 hours) (p=0.000), and massive blood transfusion (p=0.027) were factors affecting postoperative mortality in a univariate analysis in patients with IABP support, but these factors were not independent predictive factors of postoperative mortality in a multivariate analysis. Postoperative mortality in patients with IABP support was caused by arrhythmia (n=4, 8.3%), arrhythmia and pneumonia (n=1, 2.1%), renal insufficiency (n=1, 2.1%), myocardial infarction (n=6, 12.5%), and multiorgan failure (n=36, 75%). The morbidity rate related to IABP insertion in our study was 6.7%. Pulse-less leg was detected in 9 patients with IABP support, and the problem was resolved after the removal of the IABP catheter in all these cases.

The length of ICU stay was 4.44±4.11 days and 2.52±3.05 days in patients with and without IABP support, respectively (p=0.000). The length of hospital stay was 8.88±5.37 days and 6.24±1.52 days in patients with and without IABP support, respectively (p=0.000).

The mean follow-up time was 38.55±22.70 months in patients with IABP support and 48.78±25.20 months in patients without IABP support, respectively. Advanced age (＞70 years) was the factor affecting mortality in the follow-up of the univariate analysis in patients with IABP support (p=0.032), but this factor was not an independent predictive factor of mortality in the follow-up of the multivariate regression analysis.

The follow-up mortality rate was 3% (n=4) and 5.3% (n=78) in patients with and without IABP support, respectively. Advanced age (＞70 years) was the factor affecting mortality in the follow-up of the univariate analysis in patients requiring support with IABP (p=0.032), but this factor was not an independent predictive factor of mortality in the follow-up of the multivariate regression analysis. Mortality revealed by the follow-up of patients with IABP support was due to multiorgan failure.

Postoperative renal insufficiency (p=0.042) and the length of ICU stay (＞2 days) (p=0.016) were factors that affected the survival in the log-rank test in patients with IABP support, but postoperative renal insufficiency (p=0.066) was not independent predictive factors of survival in the multivariate Cox regression analysis. The length of ICU stay (＞2 days) (p=0.031) was independent predictive factors of survival in patients with IABP support.

DISCUSSION

Recently, several studies have shown that patients undergoing cardiac surgery were older and had more multi-vessel disease, more impaired left ventricular function, and higher incidence of preoperative comorbid illnesses [2,5]. In patients with left ventricular dysfunction having a higher incidence of associated comorbidities undergoing CABG surgery, it is difficult to wean them from CPB due to impaired cardiac performance after CABG surgery, and the mortality rate is higher. IABP has been widely used during the perioperative period to support patients with preoperative left ventricular dysfunction and low cardiac output syndrome after CABG surgery [2,6-8]. The main physiological effects of the IABP are the reduction of the left ventricular afterload and an increase in the coronary perfusion pressure and collateral vessel blood flow secondary to an increase in the aortic diastolic pressure. The cardiac output increases because of improved myocardial contractility due to increased coronary blood flow and the reduced afterload and preload [4,9]. Identification of perioperative risk factors in patients undergoing CABG might assist the surgeon in planning the surgery and in the subsequent postoperative management.

In our study, IABP was used in 8.1% of our patients, which is similar to results reported in other studies [10,11]. Although some studies have shown that survival at follow-up was better for receiving preoperative IABP as compared to intra- or postoperative IABP [1,7,12,13], other studies have shown that the use of prophylactic IABP in high-risk patients did not lead to any survival advantage compared with the use of intraoperative or postoperative IABP [10,11]. In our study, preoperative IABP was used in patients with hemodynamic instability having a poor left ventricular function refractory to the maximum medical therapy.

Intra- and postoperative IABP were used in patients that could not be weaned from CPB despite the forced inotropic support; in patients with a low-cardiac output status just after the discontinuation of CPB, supported by high-doses of inotropes; and in patients showing symptoms of arrhythmia but not amenable to anti-arrhythmic continuous infusion with hemodynamic instability. In our study, the prophylactic IABP was not used in any of the patients. Prolonged cardiopulmonary bypass time and prolonged operation time were independent predictive factors of IABP insertion. In our study, the postoperative mortality rate in patients with IABP support was 35.8%, which was similar to that obtained in previous studies [8,12,14].

Several studies showed that advanced age [14], female gender [15], smoking [15], left main coronary artery disease [15], urgent or emergency operation [14], prolonged cross-clamping time [10], and prolonged CPB time [14] were factors affecting postoperative mortality in patients with IABP support undergoing cardiac surgery, but these factors could not be confirmed in our study. In our study, as in others [10,14,15], there was a significant relationship between postoperative renal insufficiency and postoperative mortality. Unlike former studies, we found that prolonged ventilatory support and postoperative AF were independent predictive factors of postoperative mortality in patients with IABP support.

The morbidity rate related to IABP insertion in our study was 6.7%, which is within the range reported elsewhere (range, 8.7% to 29%) [16,17]. In our study, a pulse-less leg was detected in 9 patients with IABP support, and the problem was resolved after the removal of the IABP catheter in all cases. The low incidence of IABP-related complications is most likely explained by the effect of newer technologies, increased experience of our surgical teams, and more focused attention to IABP-related complications.

In our study, the mean length of ICU and hospital stay was longer in patients with IABP support undergoing isolated on-pump CABG, and these findings were similar to those of previous studies [10,11].

One study reported that the 5-year survival was 79.2% in patients with IABP support undergoing CABG [18], and another study stated that the 4-year survival rate was 85.2% [5]. In our study, although the postoperative mortality of patients with IABP support remained high, the mid-term prognosis was good.

In conclusion, although the postoperative mortality rate of patients with IABP support remained high, the mid-term survival was relatively good for patients surviving the early postoperative period.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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