Intraaortic Balloon Pump in Open Heart Surgery: Comparisons of the Results Obtained in the Preoperative, Intraoperative and Postoperative Implantations Periods

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ABSTRACT

Introduction: No exact consensus exists on the timing of the placement of an intraaortic balloon pump (IABP), yet still, it is the most common mechanical support device used in patients requiring open heart surgery. The purpose of this study was to investigate the results of the implantation of IABP in three different periods as preoperative, intraoperative, and postoperative and to compare the results obtained in these periods.

Patients and Methods: This study included 193 patients undergoing open-heart surgery with IABP support between January 2014 and December 2016. The patients were divided into three groups as preoperative period, intraoperative period and postoperative period, based on the beginning of IABP support. The patients were compared in terms of preoperative characteristics, surgical data and postoperative results.

Results: Of the 193 patients, 32 (16.5%) received preoperative, 64 (33.1%) intraoperative, and 97 (50.2%) postoperative IABP support. The length of ICU stay (20.15 ± 23 days) was longer for the postoperative group compared with the preoperative (7.63 ± 9.8 days) and intraoperative (12.98 ± 25 days) groups (p1: 0.005; p2: 0.007 respectively, $p< 0.05$). The new dialysis incidence rate in the pre-, intra-, and postoperative periods was 9.4%, 23.4%, and 33.0%, respectively. The veno-arterial extracorporeal membrane oxygenation implantation rate in the preoperative, intraoperative, and postoperative groups was 3.1%, 23.4%, and 22.7%, respectively. The incidence of hospital mortality was 25.0% in the preoperative group, which was significantly lower compared to the intraoperative (54.7%) and the postoperative groups (70.1%) (p1: 0.011; p2: 0.000 respectively, $p< 0.05$).

Conclusion: Any delay in insertion of IABP may cause progressive hemodinamic deteoriation. Determining the indication of implantation may even be difficult in some clinical scenarios. IABP support should be started without delay in the intraoperative period when a second inotropic support is needed and the patient has difficulty in weaning from CPB.

Key Words: Cardiac surgery; intra-aortic balloon pump; low cardiac output syndrome

Açık Kalp Cerrahisinde İntraaortik Balon Pompası Kullanımı: Preoperatif, İntraoperatif ve Postoperatif Dönemlere Ait İmplantasyon Sonuçlarının Karşılaştırılması

ÖZET

Giriş: Açık kalp ameliyatı gerekli hastalarda kullanılan ve halen en yaygın mekanik destek cihazı olan intraaortik balon pompasının (IABP) yerleştirilme zamanlaması konusunda yerleşmiş kesin bir konsensüs yoktur. Bu çalışmanın amacı; açık kalp cerrahisi geçiren hastalarda IABP'nin preoperatif, intraoperatif ve postoperatif; üç ayrı periodda yerleştirilmesine ait sonuçlarının incelenmesi ve üç döneme ait sonuçların birbirleri ile karşılaştırılmasıdır.

Hastalar ve Yöntem: Bu çalışmaya Ocak 2014 ile Aralık 2016 tarihleri arasında IABP desteği ile açık kalp cerrahisi yapılan 193 hasta dahil edildi. Hastalar İABP desteğinin başlandığı döneme göre; preoperatif dönem, intraoperatif dönem ve postoperatif dönem olarak 3 ayrı gruba ayrıldı. Hastalar; preoperatif özellikler, operatif veriler ve postoperatif sonuçlar açısından diğer gruplarla karşılaştırmalı olarak değerlendirildi.

Bulgular: 193 hastanın: 32'si (%16.5) preoperatif, 64'ü (%33.1) intraoperatif ve 97'si (%50.2) postoperatif İABP desteğine alınmış hastalardır. Yoğun bakımda kalış süresi postoperatif grupta (20.15 ± 23 gün), preoperatif (7.63 ± 9.8 gün) ve intraoperatif (12.98 ± 25 gün) gruplara göre daha uzundu (sırasıyla p1: 0.005; p2:

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0.007, p< 0.05). Preoperatif, intraoperatif ve postoperatif gruplarda yeni diyaliz insidans oranı sırasıyla %9.4, %23.4 ve %33 iken venoarterial ekstrakorporeal membran oksijenasyonu implantasyon oranı yine sırasıyla %3.1, %23.4 ve %22.7 idi. Preoperatif grubunda hastane mortalitesi görülme oranı (%25.0) intraoperatif (%54.7) ve postoperatif2 (%70.1) gruplarından anlamlı düzeyde düşük bulunmuştur (sırasıyla p1: 0.011; p2: 0.000, p< 0.05).

Sonuç: IABP takılmasındaki gecikme hemodinamik bozulmanın ilerlemesine neden olabilir. Gerekliliğe ilişkin endikasyonu belirlemek dahi bazı hastalarda zor olabilir. IABP desteği ikinci bir inotropik desteğe ihtiyaç duyulduğunda ve hastanın CPB'den ayrılmakta güçlük çektiği intraoperatif dönemde gecikmeden başlatılmalıdır.

Anahtar Kelimeler: Kalp cerrahisi; intraaortik balon pompası; düşük kardiyak debi sendromu

INTRODUCTION

Most patients referred to undergo open-heart surgery are elderly or have some comorbidities[1]. The stress related to cardiac surgery in this patient group can lead to a number of negative consequences in the preoperative period. These include low cardiac output syndrome, which is one of the most important results due to the high likelihood of mortality. When the desired hemodynamic response is not achieved in this situation, the need for mechanical support arises despite sufficient volume replacement and medical inotropic support. The first mechanical support device used in the development of low cardiac output syndrome is the intra-aortic balloon pump (IABP) [2], which has been used safely as a cardiovascular mechanical support device since its first use in 1968[3].

No exact consensus exists regarding in which hemodynamic clinical conditions an IABP should be used in heart surgery in preoperative, intraoperative, and postoperative periods. The literature mostly presents single-center studies with small case groups. The main reason why an algorithm cannot be created in this regard is that IABP is inserted in many cases only when hemodynamic problems occur. On the contrary, the use of short-term heart support devices and extracorporeal membrane oxygenator in adult open-heart surgery has increased in recent years. In a meta-analysis study on the use of extracorporeal membrane oxygenation (ECMO) for the indication of postcardiotomy cardiogenic shock in adult open-heart surgery conducted in 1926, the discharge rate was found to be 30.8%[4].

This study aimed to examine pre-, intra-, and postoperative results of IABP use as a first attempt in patients undergoing open-heart surgery during this period with an increasing use of different devices.

PATIENTS and METHODS

This study was performed on 5496 patients who underwent coronary artery bypass grafting (CABG), valve and ascending aortic replacement surgeries between January 2014 and December 2016 in our centre. Of these patients, 193 (3.51%), who received IABP support, were chosen. Patients with heart failure undergoing heart transplantation, congenital heart surgery, peripheral artery diseases and pulmonary endarterectomy were excluded.

The patients were divided into three groups; pre-, intra-, and postoperative, according to the period when IABP support was started. Patients who developed new myocardial infarction (MI) and hemodynamic problems, patients with lung edema or surgical indication due to mechanical complications received preoperative IABP. Preoperative IABP was not implanted in hemodynamically stable elective patients. The patients received IABP during the intraoperative period if they had received high doses of the inotropic agent and a second inotrope had been required, they had had difficulties in weaning from perfusion, or signs of right ventricular failure and segmental ventricular muscle wall disturbances had been observed macroscopically. Postoperative IABP was inserted mainly in low cardiac output syndrome.

These groups were compared in terms of preoperative characteristics (Table 1), intraoperative surgical data (Table 2) and postoperative results (Table 3).

The study protocole was approved by the ethical department of clinical research of Kartal Koşuyolu High Training and Research Hospital (No: 2018.6/18-124). The study was carried out in accordance with the Helsinki Declaration.

Statistical Analysis

IBM SPSS Statistics 22 (SPSS IBM, Turkey) program was used for evaluating the findings of this study. When evaluating the data, the suitability of the parameters to normal distribution was assessed using the Shapiro-Wilk test. Descriptive statistical methods (mean and standard deviation) were used for evaluating the data. One-way analysis of variance and Tukey's HDS (honestly significant difference) test were used for comparing quantitative data between the groups with normal distribution. Kruskal-Wallis test and Mann-Whitney U test were used for comparing parameters with non-normal distribution and investigating the reason for the difference between the groups. Chi-square test was used to compare the qualitative data. Significance was evaluated at P< 0.05.

RESULTS

Of the 193 patients, 32 (16.58%) received preoperative IABP support, 64 (33.16%) intraoperative IABP support, and 97 (50.26%) postoperative IABP support. Mean age of the patients was 61.89 ± 11.67 years. Of the patients with an age

Table 1. Preoperative patients' characteristics of the groups

		Insertion period of IABP			
		Preoperative (n= 32)	**Intraoperative (n= 64)**	**Postoperative (n= 97)**	**p**
Age Mean ± SD		59.41 ± 11.50	62.42 ± 0.55	62.36 ± 12.95	[1]**0.421**
BMI Mean ± SD		27.35 ± 3.99	27.39 ± 4.67	27.53 ± 4.93	[1]**0.974**
Gender n (%)	Woman	7 (%21.9)	15 (%23.4)	37 (%38.1)	[2]**0.071**
DM n (%)	Yes	17 (%53.1)	33 (%51.6)	40 (%41.2)	[2]**0.316**
Renal failure n (%)		2 (%6.3)	3 (%4.7)	13 (%13.4)	[2]**0.143**
Urgency or emergency of operation	Yes	8 (%25)	7(%10.9)	7(%7.2)	[2]**0.023***
LVEF n (%	≤ %30	9 (%28.1)	15 (%23.4)	17 (%17.5)	
	%30-50	14 (%43.8)	19 (%29.7)	24 (%24.7)	[2]**0.066**
	≥ %50	9 (%28.1)	30 (%46.9)	56 (%57.7)	
Redo operation n (%)	Yes	1 (%3.1)	3 (%4.7)	7 (%7.2)	[2]**0.628**

[1] One way Anova Test [2] Chi Square Test *p< 0.05
IABP: Intraaortic balloon pump, BMI: Body mass index, DM: Diabetes mellitus, LVEF: Left ventricle ejection fraction.
*preoperative vs. postoperative: p: 0.011.

Table 2. Evaluation of the groups in terms of intraoperative characteristics

	Insertion period of IABP			
	Preoperative (n= 32)	**Intraoperative (n= 64)**	**Postoperative (n= 97)**	**p**
CABG n (%)	24 (%75)	36 (%56.3)	41 (%42.3)	[1]**0.004***
Valve n (%)	4 (%12.5)	7 (%10.9)	20 (%20.6)	[1]**0.219**
CABG+Valve n (%)	4 (%12.5)	13 (%20.3)	12 (%12.4)	[1]**0.351**
As. Aort Rep.+CABG n (%)	0 (%0)	8 (%12.5)	24 (%24.7)	[1]**0.003****
ACCT (min) (Mean ± SD)	71.34 ± 36.10 (66)	115.85 ± 71.88 (92.5)	99.56 ± 62.55 (83)	[2]**0.006*****
CPB time (min) (Mean ± SD)	120.70 ± 42.36 (119)	221.05 ± 124.82 (191.5)	173.14 ± 87.16 (148)	[2]**0.001******

[1]Chi Square Test [2]Kruskal Wallis Test *, **,***,**** p< 0.05
IABP: Intraaortic balloon pump, CABG: Coronary artery bypass grafting, As. Aort Rep: Ascending aortic replacement; ACCT: Aortic cross-clamp time, CPB: Cardiopulmonary bypass.
*: preoperatif vs postoperative p: 0003.
**: preoperative vs intraoperative and postoperative; p: 0.049; p: 0.004 respectively.
***: preoperative vs intraoperative and postoperative; p: 0.002; p: 0.016 respectively.
****: preoperative vs intraoperative and postoperative; p: 0.001; p: 0.002 respectively.

range of 21-87 years, 134 (69.4%) were males and 59 (30.6%) were females.

A statistically significant difference was found between the groups in terms of emergency and urgency of the surgery among the preoperative patient characteristics (p: 0.023; p< 0.05). Percentage of emergency and urgency of the cases (25%) was higher in the preoperative IABP group compared with the postoperative (7.2%) group (p: 0.011; p< 0.05). Further, no statistically significant difference in other patient characteristics (age, height, weight, body mass index (BMI), sex, diabetes mellitus presence, kidney failure, ejection fraction, and redo operation) was observed (p> 0.05). Demographics of the patients are given in Table 1. Comparison of additional surgical interventions, ACC (aortic cross clamping) and total CPB (cardiopulmonary bypass) times are given in Table 2.

The length of intensive care unit (ICU) stay was significantly longer in the postoperative IABP group compared with the preoperative and intraoperative groups (p1: 0.005; p2: 0.007 respectively, P< 0.05). The new dialysis rate was significantly lower in the preoperative IABP group (9.4%) compared with the postoperative group (33%) (p: 0.018; p< 0.05) (Table 3).

The veno-arterial ECMO insertion rate was significantly lower in the preoperative group (3.1%) compared with the

Table 3. Evaluation of groups in terms of postoperative complications and mortality

	Insertion period of IABP			
	Preoperative (n= 32)	**Intraoperative (n= 64)**	**Postoperative (n= 97)**	**p**
ICU-stay (days) (Mean ± SD)	7.63 ± 9.80	12.98 ± 25.53	20.15 ± 23.20	**[1]0.003***
Tracheostomy n (%)	2 (%6.3)	6 (%9.4)	16 (%16.5)	**[2]0.208**
Hemodialysis n (%)	3 (%9.4)	15 (%23.4)	32 (%33)	**[2]0.026****
Postop. reexpl. n (%)	3 (%9.4)	17 (%26.6)	30 (%30.9)	**[2]0.054**
ECMO n (%)	1 (%3.1)	15 (%23.4)	22 (%22.7)	**[2]0.036*****
In hospital mortality, n (%)	8 (%25)	35 (%54.7)	68 (%70.1)	**[2]0.001******

[1]Chi Square Test [2]Kruskal Wallis Test *, **,***,**** p< 0.05
IABP: Intraaortic balloon pump, ICU-Stay, the length of intensive care unit stay; ECMO: Extracorporeal membrane oxygenation.
*: postoperative vs. preoperative and intraoperative; p:0.005; p: 0.007 respectively.
**: preoperative vs. postoperative; p: 0.018.
***: preoperative vs. intraoperative and postoperative; p: 0.026; p: 0.025 respectively.
****: preoperative vs. intraoperative and postoperative; p: 0.011; p: 0.000 respectively.
****: intraoperative vs. postoperative; p: 0.046.

intraoperative group (23.4%) and the postoperative group (22.7%) (p1: 0.026, p2: 0.025 respectively, p< 0.05).

The incidence of hospital mortality in the preoperative IABP group was 25%, which was significantly lower compared with the intraoperative1 group (54.7%) and the postoperative2 group (70.1%) (p1: 0.011; p2: 0.000 respectively, p< 0.05). Hospital mortality rate was significantly lower in the intraoperative IABP group compared with the postoperative group (p: 0.046; p< 0.05).

DISCUSSION

The most striking finding of this study was a statistically significant increase in postoperative mortality and adverse events parallel to the periodic progression of the starting time of IABP support.

Hospital mortality rate of preoperative, intraoperative, and postoperative IABP implantation was 25%, 54.7%, and 70.1%, respectively (p = 0.001). Similar to the present study, mortality has a similar trend in studies dealing with three different periods in open-heart surgery. Early mortality rate of preoperative IABP implantation has been reported as 18%-19%[5,6]; however, this rate is reported as 44% in patients with hemodynamic problems[7]. Mortality rate has been reported as 32%-33% in intraoperative balloon implantation[5-7] and as 40.5%-58.33% in postoperative implantations[5-8].

The need for preoperative prophylactic insertion of an IABP is controversial. Of the patients, 32 (16.58%) received preoperative IABP. We do not use preoperative prophylactic balloon insertion for elective patients unless they have hemodynamic problems. In a study using CABG and covering 10 centers, 1856 patients receiving preoperative IABP were compared with the 28.054 who did not[3]. This study showed no benefit of preoperative IABP. A meta-analysis covering 33 studies has reported that the clinical benefit of IABP insertion is limited[9]. In the same study, it has been emphasized that high-risk criteria should be determined well. We insert preoperative IABP in patients who develop new MI and hemodynamic problems, patients with lung edema, or patients with surgical indication due to mechanical complications. We do not recommend preoperative IABP insertion in hemodynamically stable elective patients, even if the risk of comorbid condition is high.

Intraoperative IABP support was provided to 64 (33.16%) of the patients in the present study. The basic indication for intraoperative IABP is low cardiac output. No established guidelines exist for IABP implantation. It is generally suggested to implant IABP without any delay[6,7,10]. ST-segment elevation, deterioration of regional contractility, left ventricle ejection fraction (LVEF) reduction in Transesophageal echocardiography (TEE), right ventricular failure findings, positive shock index and high-dose catecholamine, cardiac index (CI) <1.8, and inability to separate from cardiopulmonary bypass (CPB) are the main indications for implantation[11]. IABP can be inserted during the intraoperative period if a patient is given medium to high doses of an inotropic agent, a second inotrope is required, a patient has difficulties in exiting perfusion, or signs of right ventricular failure and segmental wall disorder are observed macroscopically.

Postoperative IABP support was provided to 97 (50.26%) of the patients in this study. Postoperative mortality rate was 70.1%. Mortality rates in the case of postoperative implantation have been reported as more than 40%[8,10] and 50% in published studies[5,7]. These high mortality rates are associated with the fact that the etiology of low cardiac output is often unclear, and it cannot be corrected[8].

Other major complications also show an increase in the mortality rate while transitioning from the preoperative to the postoperative period. ICU stay of the postoperative group was significantly longer compared with the preoperative and intraoperative groups. Similarly, the new dialysis incidence rate was significantly higher in the postoperative group compared with the preoperative group. The veno-arterial ECMO insertion rate was significantly lower in the preoperative group compared with the intraoperative and postoperative groups.

CONCLUSION

Hence, the benefits of IABP support in patients undergoing cardiovascular surgery are indisputable. Initiation timing of the support may affect clinical outcomes, mortality, and morbidity. Thus, the support should be implanted as soon as possible. We believe that IABP support should be started without delay especially in the intraoperative period, when a second inotropic support is needed and the patient has difficulty in weaning from perfusion.

Ethics Committee Approval: The approval for this study was obtained from Kartal Kosuyolu High Training and Research Hospital Non-Invasive Clinical Research Ethics Committee (Decision no: 2018.6/18-124 Date: 25.09.2018).

Informed Consent: Given the retrospective nature of the investigation and no additional therapeutic interventions were conducted, patients' informed consent was not required.

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