Effectiveness of Intraaortic Balloon Pumping in Patients Who Were Not Able to Be Weaned From Cardiopulmonary Bypass After Coronary Artery Bypass Surgery and Mortality Predictors in the Perioperative and Early Postoperative Period

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Objective: The intraaortic balloon pump (IABP) is usually the first choice of mechanical device used for perioperative cardiac failure. The aim of this retrospective study was to determine the effectiveness of intraoperative IABP use in patients who could not be weaned from cardiopulmonary bypass (CPB) and to determine the possible perioperative and early postoperative prognostic factors for mortality.
Methods: Between June 1992-December 2001 a total of 69 patients who underwent coronary artery bypass grafting and required IABP support in weaning from CPB due to cardiac pump failure were included into the study. The mean age was 61.9±7.5 years. The effectiveness of IABP and preoperative, operative and postoperative risk factors for mortality were evaluated retrospectively.
Results: Following the insertion of IABP, 59 (85.5%) patients could be weaned from CPB whereas 10 patients (14.5%) could not. In the early postoperative period, 13 (22%) patients died due to cardiac pump failure. The average in-hospital mortality rate for patients who were treated with an IABP was found as 33.3% (23 patients). Univariate analysis identified left ventricular enddiastolic pressure, ventricular performance score, urgent operation and perioperative myocardial infarction as the risk factors for early death. The minor and major IABP releated -complications occurred in only 8 patients.
Conclusion: Due to the contributory effects, effectiveness and low complication rate, IABP may be used in patients who cannot be weaned from CPB *(Anadolu Kardiyol Derg, 2003; 3: 124-128)*
Key Words: Intraaortic balloon pump, coronary artery bypass surgery, cardiopulmonary bypass, heart failure

Introduction

Mechanical circulatory assistance is frequently needed to support the failing heart. The intraaortic balloon pump (IABP) is usually the first choice of mechanical device used for perioperative cardiac failure (1). It is a pneumatic device that inflates and deflates a balloon placed in the descending thoracic aorta. The primary effect of IABP is based on reduction of ventricular afterload, augmentation of the arterial diastolic pressure and improvement of diastolic coronary perfusion (2,3). The perioperative cardiac failure and usage of IABP are increasing as the patient population referred for surgical treatment increases in age and severity of preoperative left ventricular dysfunction.

The aim of this retrospective study was to evaluate the effectiveness of IABP use intraoperatively in patients who could not be weaned from cardiopulmonary bypass (CPB) and to determine the possible prognostic factors for early death as well.

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Material and Methods

Patients: During the period from June 1992 to December 2001, 4873 patients underwent coronary artery bypass graft (CABG) operations in our hospital were included into the analysis. A total of 69 (1.4% of total) patients, among them 53 (76.8%) males and 16 (23.2%) females with a mean age of 61.9±7.5 years (range 45 to 74 years), required IABP support in weaning from CPB due to left ventricular (78.2%), right ventricular (11.5%) and biventricular (10.1%) cardiac pump failure.

Clinical parameters: The following clinical variables were included in the analysis: age, gender, hyperchlosterolemia (serum cholesterol>220 mg/dL), smoking (>10 cigarettes per day), hypertension (diastolic pressure>90 mm Hg), diabetes mellitus, preoperative New York Heart Association (NYHA) class, number of previous myocardial infarctions (MIs), urgent operations (operation within 24 hours of diagnosis including critical left main coronary artery or critical proximal left anterior descending artery (LAD) stenoses or unstable angina pectoris refractory to medical treatment) and serum creatinine level. Cardiac catheterization data included the number of diseased vessel (obstruction>50%), the left ventricular ejection fraction (EF%), the left ventricular end-diastolic pressure (LVEDP mm Hg) and ventricular performance score (VPS). Ventricular performance score is a scoring system of left ventricular function due to wall motions of seven segments at the left and right oblique ventriculography; normal:1, hypokinesia:2, akinesia:3, diskinesia:4, aneurysm:5. Perioperative MI was defined as development of new Q waves in association with increased enzyme creatine kinase-myocardial band (CK-MB). Quality assessment of each anastomosed native coronary artery had been defined during the operation according to the diameter and plaque formation of the vessel. The plaque formation was evaluated both by visual examination and palpation of the vessel and the diameter was assessed using 1, 1.5 and 2 mm metal-tipped coronary probes. The findings were noted as follows; Grade 1: normal distal run-off below the stenosis and vessel diameter > 1.5 mm, Grade 2: wall thickness and minimal plaque formation, vessel diameter ≤1.5 mm, Grade 3: multiple plaque formation and vessel diameter ≤1.5 mm, Grade 4: performing endarterectomy. Vessels which were regarded as non-graftable because of poor quality were accepted as incomplete revascularization.

Operative technique: Standard median sternotomy was used, full heparinization was done, aortic and two-stage venous cannulas were inserted. Cardiopulmonary bypass was performed with membrane oxygenator and non-pulsatile roller pump. Moderate hypothermia (rectal temperature 30-32 °C) was used and 2.4 lt/min/m2 flow rate was maintained during bypass. Alpha-stat arterial carbon dioxide tension management was used and arterial pressure maintained at 50 to 80 mm Hg. Cardiac arrest was performed by antegrade initial crystalloid cardioplegia (Plegisol, 4°C, 15cc/kg) and myocardial preservation was supported antegradely with 400 cc cold blood cardioplegia (that was a mixture (4:1) of the oxygenated blood of the patient and hyperkaliemic crystalloid concentration) in every 20 minutes and terminal warm blood cardioplegia (37°C) was performed just before removal of the cross clamp. Left internal mammary artery was used as a graft to LAD whereas saphenous vein grafts were used for the remaining vessels.

Intraaortic balloon pump use: The IABP was inserted in the presence of inadequate cardiac pump function during weaning from CPB and low systemic arterial pressure (< 90mmHg systolic blood pressure) after the first attempt of weaning despite administration of high doses of double inotropic agents (Adrenaline ≥ 2μg/min, Dopamine ≥10 μg/kg/min) in the presence of optimal preload and afterload. Sixty-seven IABPs were inserted percutaneously via right or left femoral artery whereas two were inserted through the ascending aorta because of the inaccessibility through the femoral arteries.

Major IABP-related complications were defined as aortic perforation, dissection and limb ischemia requiring a vascular operation. Minor complications included ipsilateral transient limb ischemia which recovered after removal of the IABP, and local infection or bleeding at the site of insertion.

Statistical analysis: All statistics were performed using SPSS statistical software (release 9.0, SPSS Inc., Chicago, IL). Means ± standard deviations are presented. The unpaired t-test and the x^2- test were used in statistical analysis and a p value equal to or smaller than 0.05 was considered as statistically significant. Univariate logistic regression analysis was used to determine independent risk factors for mortality.

Results

Clinical characteristics of the patients are presented in Table I. Twenty-nine (42%) patients were in

NYHA III+IV functional class and 52.1% of the patients had history of at least one or more MIs preoperatively. Sixteen (23.1%) patients were operated urgently. Following the insertion of IABP 59 (85.5%) patients could be weaned from CPB whereas ten patients (14.5%) could not. In the early postoperative period 13 (22%) patients died due to cardiac pump failure. The average hospital mortality rate including perioperative and postoperative one for patients who were used IABP was found to be 33.3% (23 patients).

Risk factors for mortality: When parameters of survived and not-survived patients were compared, there were statistically significant differences including hypertension (p=0.01), LVEDP (p=0.002), urgent procedure (p=0.03) and perioperative MI (p=0.03) (Table 2). However univariate analysis identified in all patients the following factors as associated with mortality; VPS (p=0.004), LVEDP (p=0.007), urgent operation (p=0.03) and perioperative MI (p=0.03).

Intaaortic balloon pump-related complications: Early minor and major complications related to the IABP occurred in five (7.2%) and three (4.3%) patients, respectively. The minor complications included local hematoma in two patients, local infection in two patients and transient limb ischemia, which recovered after removal of the IABP in one patient. The major complication included iliac artery perforation in two patients and femoral artery bleeding required surgical intervention in one patient.

Discussion

Intraaortic balloon pumping has been in widespread clinical practice for hemodynamic support since it was first reported in 1968 (4). It was commonly used for postcardiotomy pump failure (5). The major

Table1: Clinical characteristics of the patients

Characteristic	Value	No. of Patients (%)
Age (year)	61.9±7.5 (45-74)	
Gender		
Male		53 (76.8)
Female		16 (23.2)
Preop. risk factors		
Hypertension		27 (39.1)
Diabetes mellitus		22 (31.8)
Hypercholesterolemia		22 (31.8)
Smoking		42 (60.8)
Preop. NYHA class		
I+II		40 (57.9)
III+IV		29 (42.0)
No. of preop. MIs		
0		29 (42)
1		36 (52.1)
2		4 (5.7)
LVF parameters		
EF %	49.4±11.1 (22-77)	
VPS	10.6±2.9 (7-17)	
LVEDP mmHg	14.8±4.8 (7-32)	
No. of CAD		
One vesse		8 (11.5)
Two-vessel		19 (27.5)
Three-vessel		32 (46.3)
LMCA disease		10 (14.5)
Urgent Operations		16 (23.1)
Incomplet revascularization		7 (10.1)

CAD: Coronary artery disease; EF: Ejection fraction; LMCA: Left mean coronary artery; LVEDP: Left ventricular enddiastolic pressure; LVF: Left ventricular function; MI: Myocardial infarction; NYHA: New York Heart Association; VPS: Ventricular performance score beneficial effect of IABP is decreased myocardial oxygen demand by systolic unloading, however increased coronary perfusion through diastolic augmentation in the presence of severe coronary artery stenosis is controversial (6-8).

Although the more rigid hemodynamic criteria for IABP reduces its use, increase in the age of the patient population correspondingly increases its use. The preference of IABP use was the low cardiac output state that was refractory to maximum pharmacologic treatment and judicious volume load, in agreement with the other reports (9,10).

Despite ongoing improvements in surgical care and myocardial protection the early mortality rate for patients who are treated with an IABP remains high. The average early mortality rate in this study was 33% and this result was in correlation with the literature (1, 5, 9, 11, 12). Although we did not take into account in this study, survival rates were better in series with the prophylactic usage of IABP preoperatively (13, 14).

Identification of the group of patients who are at the highest risk of death at the time of IABP insertion will help to determine which patients may benefit from temporary support of the heart beyond that offered by the IABP (15) or from the other management strategies.

As we know, prolonged aortic cross-clamp (ACC) and CPB time are the two important reasons for mortality after heart operations. Although Arafa et al (16) have identified age, ACC and CPB time as risk factors for mortality, in our study we have found that urgent operation, LVEDP and VPS and perioperative MI as risk factors for mortality. This difference may be because of the inhomogeneity of surgical interventions between our study and the study of Arafa et al. In our study all patients were CABG patients whereas in Arafa's group the indication for operation included not only ischemic disease but also valvular disease.

As expressed in the literature, type of operation performed may effect the survival of patients who receive an IABP (9, 15, 17, 18) but our study was uni-

Table 2: Risk factors for early mortality[a] agreement

	Survived	Not-survived	P value
No. of patients	46 (66.6%)	23 (33.3%)	
Age (year)	62.5±7.6	60.9±7.4	NS
Gender (male%)	81.4	69.2	NS
Preop. risk factors (%)			
Hypertension	31	61.5	**0.01**
Diabetes	34.9	26.9	NS
Smoking	62.8	57.7	NS
Preop. NYHA class (%)			
I+II	55.8	61.5	NS
III+IV	44.2	38.5	NS
Preop.creatinine level (mg/dL)	1.05±0.2	1.01±0.2	NS
Previous MI (%)	53.5	65.4	NS
Urgent operation (%)	15.2	39.1	**0.03**
Ejection fraction (%)	48.7±10.7	50.7±11.7	NS
LVEDP (mm Hg)	13.5±3.0	17.1±6.3	**0.002**
VPS	10.9±2.9	10.2±2.8	NS
ACC time (min)	43.7±19.3	40.2±24.1	NS
CPB time (min)	100.2±44.2	124.7±84.2	NS
Number of bypass	2.6±1.0	2.8±1.2	NS
Vessel quality			
LAD	1.8±1.1	1.5±0.5	NS
Cx	1.6±0.8	1.8±0.6	NS
RCA	2.1±0.9	2.0±0.9	NS
Fluid balance (During CPB.ml)	+543±101	+519±113	NS
Peroperative MI (%)	8.7	30.4	**0.03**
Incomplet Revascularization	4 (8.6%)	3 (13%)	NS

[a]: Analysis of 21 possible risk factors for early death; ACC: Aortic cross-clamp; CPB: Cardiopulmonary bypass; Cx: Circumflex artery; LAD: Left anterior descending artery; LVEDP: Left ventricular enddiastolic pressure; MI: Myocardial infarction; NS: Not significant; NYHA: New York Heart Association; Preop: Preoperative; RCA: Right coronary artery; VPS: Ventricular performance score;

form, which includes only the CABG operations.

Perioperative MI is one of the most significant risk factors cited in the literature (9, 19). Similar results were obtained in our study where the mortality rate was 30.4% vs. 8.7% in the patients with and without perioperative MI respectively (p=0.034). However perioperative MI was not a risk factor for late death in patients who receive an IABP (16). In addition, incomplete revascularization is one of the reasons for perioperative MI and low cardiac output after open heart operations. Although the rate of incomplete revascularization was higher in patients who died (13% vs 8.6%) this finding was not found to be statistically significant in our study.

The morbidity rate related to IABP insertion is within a range of 8.7%-29% and in a wide range from minor local wound infection to death (12, 16, 20). Besides minor complications, we had two iliac artery perforations (2.8%) as the major vascular complications. However, in agreement with the previous studies, there was no statistically significant association between the IABP related complications and the short- or long-term mortality rate (1, 21).

In conclusion; all over survival rates 66.7% showed that the IABP supports the failing heart in weaning from CPB. Perioperative MI, urgent operation, VPS and LVEDP were found to be the risk factors for mortality. But, hospital survivors had a relatively good probability of late survival. Although the exclusion of preoperative and postoperative use of IABP is the drawback of this study, results obtained favor the usage of IABP as the best adjunct to inotropic support in the failing heart.

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