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Benefits of the Preemptive Intra-Aortic Balloon Pump: An Audit of Practice in a Regional Cardiothoracic Center

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ABSTRACT

Background: Recent evidence suggests that preemptive use of an intra-aortic balloon pump (IABP) is associated with better outcomes in high-risk patients undergoing cardiac surgery. This retrospective study compares preemptive (planned) use of the IABP to emergency (unplanned) use in a regional cardiothoracic center.

Methods: All patients who required an IABP from February 2003 to June 2006 were identified from theater records. The collected data included patient demographics, preoperative state, operative details, morbidity due to the IABP, and operative mortality. Patients were divided into 2 groups: planned use (preoperative plus elective intraoperative) and unplanned use (postoperative plus emergency intraoperative). Preoperative mortality risk was calculated with the logistic EuroSCORE.

Results: We identified 135 patients (75% male). There were no significant differences between the groups with respect to age, preoperative state, operation type, logistic EuroSCORE, or myocardial ischemia time. The 2 groups showed a significant difference in mortality: planned IABP insertion, 17%; unplanned insertion, 45% (P = .001). A multivariate analysis of the study population showed the logistic EuroSCORE (odds ratio, 0.974; 95% confidence interval, 0.950-0.998; P = .035) and timing of IABP use (odds ratio, 4.728; 95% confidence interval, 1.932-11.566; P = .001) to be independent predictors of mortality.

Conclusion: Preemptive use of the IABP in this patient cohort was associated with a 50% advantage in mortality compared with emergency IABP use. The logistic EuroSCORE may be used preoperatively to guide IABP use. Complications are rare and can be treated successfully. The risk-to-benefit ratio of preemptive IABP use is low in this cohort of patients.

INTRODUCTION

The intra-aortic balloon pump (IABP) is a mechanical support that reduces afterload and increases coronary perfusion. Early use of the IABP in cardiac surgery has been shown to be of benefit to patients with severely impaired left ventricular function, with unstable angina, with critical left main stem disease, in redo surgery, and in off-pump coronary artery bypass surgery [Dietl 1996; Christenson 1997a, 1997b; Christenson 1999; Gutfinger 1999; Kim 2001; Christenson 2002].

We noted in our cardiac surgical unit that a number of these patients were not receiving the IABP preemptively (planned placement) as the literature recommends [Dyub 2008] but were receiving it much later, either postoperatively or after a failed attempt at bringing the patient off cardiopulmonary bypass on the operative table (unplanned placement). Unplanned placement was invariably a "rescue" maneuver in perioperative pump failure that was unresponsive to maximal inotropic therapy. It also appeared that the decision to institute an IABP was approached with some caution because of the potential for complications. A retrospective audit was hence commissioned to investigate IABP use in our unit.

MATERIALS AND METHODS

Ethics approval was not needed because the study formed a part of good medical practice; however, this study was discussed with the chairman of the hospital ethics committee prior to its commencement. The study was a retrospective audit, and all patients who had required an IABP for cardiac surgery between February 2003 and June 2006 were identified from theater records. We identified 135 patients and reviewed and cross-checked their case notes with the Dendrite database, which is a computer-based patient-information system. Table 1 summarizes the distribution of operations, all of which were carried out with cardiopulmonary bypass.

The collected data included preoperative factors, operative factors, and outcomes. Preoperative factors included age,

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Table 1. Distribution of Cases*

Procedures	No. of Cases
CABG	105
CABG + AVR	7
CABG + MVR	2
AVR	1
MVR	2
AVR + MVR	1
Redo AVR	6
Redo AVR + CABG	1
Redo MVR	2
Redo CABG	3
Redo MVR + TVR	1
Postinfarct VSD	3
Postinfarct VSD + CABG	1

*CABG indicates coronary artery bypass grafting; AVR, aortic valve replacement; MVR, mitral valve replacement; TVR, tricuspid valve replacement; VSD, ventriculoseptal defect.

sex distribution, left main stem disease, and left ventricular function. The logistic EuroSCORE [Nashef 1999; Roques 2003] was also calculated for each patient. The recorded operative factors included cross-clamp time and type of operation. The outcomes recorded included time on the balloon pump, length of stay in the intensive-therapy unit, overall postoperative hospital stay, morbidity, and mortality.

The patients were divided into 4 groups for data analysis: group A, patients who had an IABP placed preoperatively; group B, patients who had an IABP placed intraoperatively before an attempt was made to bring the patient off cardiopulmonary bypass; group C, patients who had an IABP placed intraoperatively after failed attempts to come off bypass; and group D, patients who had an IABP placed postoperatively for hemodynamic instability not responding to inotropic support. In groups A and B, IABP use was part of a planned strategy, whereas IABP use in groups C and D were considered part of an unplanned strategy. Analyses evaluated differences between groups A through D and between the planned and unplanned groups.

Data were entered into Statistical Package for Social Sciences (SPSS) version 16 (SPSS, Chicago, IL, USA). Means and SDs were calculated for continuous variables, and frequencies were calculated for categorical variables. Summary statistics were generated to compare differences between the planned and unplanned groups. Because of the relatively small number of patients, we thought that statistical power would be lost by dividing the patients into groups; we therefore performed a multivariate analysis of the entire patient sample with mortality as an end point and logistic EuroSCORE, cross-clamp time, and planned versus unplanned procedure as predictors of mortality. The model fit was then assessed with the Hosmer–Lemeshow goodness-of-fit test. A *P* value <.05 was considered statistically significant.

Table 2. Preoperative Variables*

	Planned (n = 58)	Unplanned (n = 77)	*P*
Age, y	65 ± 9.9	66 ± 9.4	NS
Male sex, n	43 (74%)	52 (68%)	NS
Left main stem disease, n	23 (39%)	25 (32%)	NS
Inpatient, n	29 (50%)	21 (27%)	.01
Impaired left ventricle, n	18 (31%)	36 (48%)	NS
Logistic EuroSCORE	14.81 ± 19.02	9.66 ± 12.57	NS

*Age and EuroSCORE data are presented as the mean ± SD. NS indicates not statistically significant.

RESULTS

A total of 135 patients (95 male, 40 female) required an IABP during the period of the study. IABP placement was planned in 58 patients and unplanned in 77 patients.

The 2 groups were similar with respect to the preoperative factors recorded (Table 2), including mean age, sex distribution, proportion of patients with left main stem disease, impaired left ventricular function (ejection fraction <25%), and logistic EuroSCORE. The planned group had a higher proportion of inpatients (patients admitted more than 24 hours before their surgery, usually for unstable angina). This difference was because cardiologists would invariably place an IABP before transferring patients with unstable angina to cardiac surgery for revascularization.

The 2 groups (planned versus unplanned) were similar with respect to the intraoperative factors recorded (Table 3), including cross-clamp time, number of redo surgeries, and the type of operation. The 2 groups were also similar with regard to the duration of IABP support, length of stay in the intensive care unit, and the overall postoperative length of stay (Table 4). Morbidity rates were low, and there were no significant differences between the groups.

The most significant finding was the difference in mortality: 17% in the planned group and 45% in the unplanned group. This result indicated a 50% mortality advantage when the IABP was placed as part of a planned strategy (Table 4).

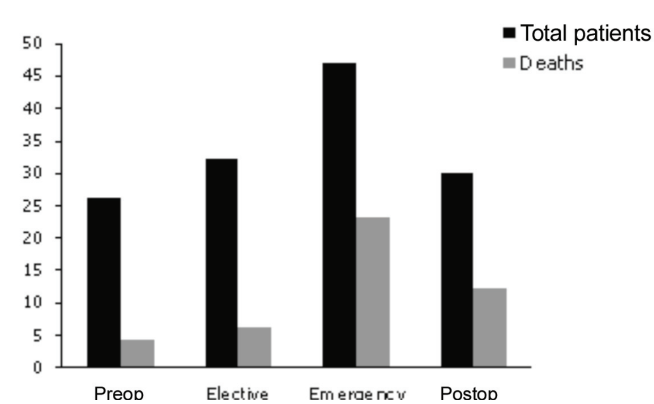

Figure 1. Subanalysis of mortality. Preop indicates preoperative; intraop, intraoperative; postop, postoperative.

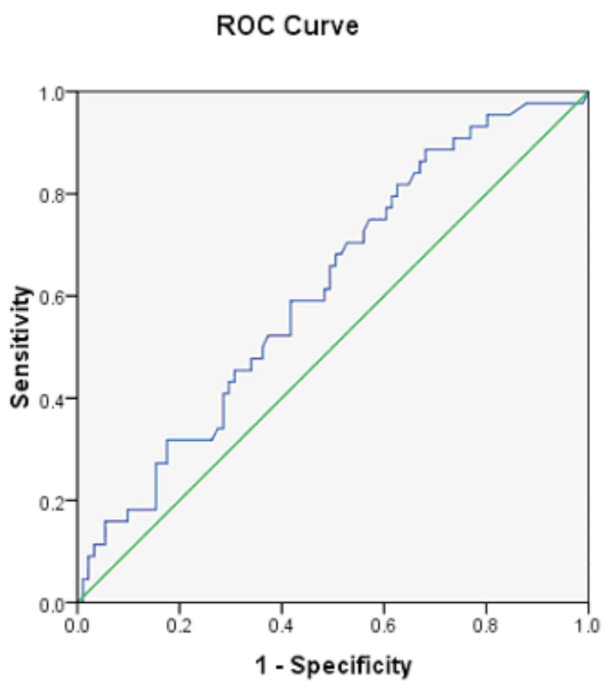

Figure 2. Logistic EuroSCORE as a predictor of mortality. Receiver operating characteristic (ROC) curve. Diagonal segments are produced by ties.

A subanalysis of the mortality data showed that the highest mortality rates were in groups C and D (49% and 40%, respectively; Figure 1). Mortality rates were much lower in groups A and B (15% and 19%, respectively).

The multivariate analysis (Table 5) revealed the significant independent predictors of mortality to be whether IABP use was planned or unplanned (odds ratio, 4.728; 95% confidence interval, 1.932-11.566; *P* = .001) and the logistic EuroSCORE (odds ratio, 0.974; 95% confidence interval, 0.950-0.998; *P* = .035). The Hosmer–Lemeshow test indicated a good fit for the model with a χ^2 value of 6.127 (*P* = .633).

The EuroSCORE is a preoperative scoring system that calculates a predicted mortality for a patient due to undergo cardiac surgery by adding the weights assigned to a number of risk factors [Nashef 1999; Roques 2003]. These risk factors include age, sex, left ventricular function, recent myocardial infarction, unstable angina, and previous surgery.

To investigate the use of the logistic EuroSCORE as a predictor of mortality, we plotted a receiver operating characteristic (ROC) curve (Figure 2). The area under the ROC curve was 0.614, and the asymptotic significance was 0.032. An asymptotic significance <0.05 indicates that the logistic EuroSCORE is a good predictor of mortality. The logistic EuroSCORE cutoffs of 2.06 and 3.09 showed sensitivities of 98% and 86%, respectively, and specificities of 88% and 68% in predicting mortality in this patient sample. Complication rates (morbidity) were slightly lower (5%) in the group with planned IABP placement, compared with 6% in the unplanned group.

A subanalysis of the median duration of IABP support also revealed some interesting findings. When the median duration of IABP support while the patient was in cardiology before transfer to cardiac surgery was discounted, it seemed that the median duration of IABP support was shortest in group A and longest in group D (Figure 3).

Table 3. Intraoperative Variables*

	Planned (n = 58)	Unplanned (n = 77)	*P*
Cross-clamp time, min†	62.5 (49.8-80.5)	62 (47.5-93.5)	NS
Redo surgery, n	4 (7%)	9 (12%)	NS
CABG, n	48 (83%)	57 (74%)	NS
CABG + valve, n	1 (2%)	8 (10%)	NS
Single valve, n	1 (2%)	2 (3%)	NS
Other, n	8 (14%)	10 (13%)	NS

*NS indicates not statistically significant; CABG, coronary artery bypass grafting.

†Data are presented as the median (interquartile range).

DISCUSSION

Our study suggests that planned placement of an IABP was associated with a 50% mortality advantage in this cohort of patients, compared with unplanned IABP use. This finding is comparable to larger studies that demonstrated that early use of the IABP in cardiac surgery benefited patients with severely impaired left ventricular function, with unstable angina, with critical left main stem disease, in off-pump coronary artery bypass surgery, and in redo surgery [Dietl 1996; Christenson 1997a, 1997b; Christenson 1999; Gutfinger 1999; Kim 2001; Christenson 2002].

Although most surgeons accept many of these indications, the decision to use an IABP and the timing of its use are often not clear [Baskett 2002]. The decision to place an IABP in a patient in our unit is up to the individual consultant, but retrospective analysis of high-risk cases at morbidity and mortality audit meetings suggests that the IABP should

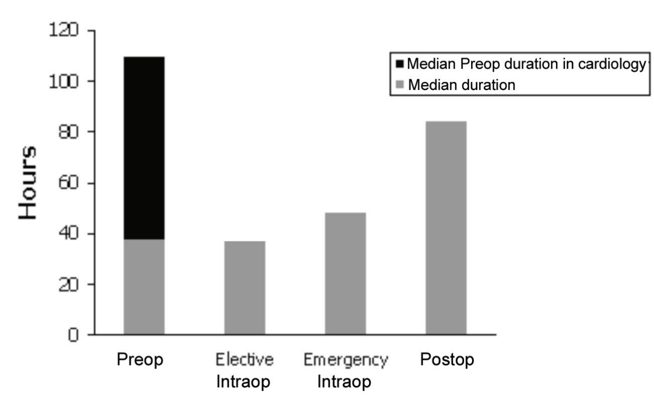

Figure 3. Median duration of intra-aortic balloon pump support in discharged patients. Preop indicates preoperative; intraop, intraoperative; postop, postoperative.

Table 4. Postoperative Variables*

	Planned (n = 58)	Unplanned (n = 77)	*P*
Time on IABP, h†	65 (27-120)	48 (23-82)	NS
ICU stay, d†	4 (2-14.5)	5 (2-13)	NS
Postoperative stay, d†	9 (6-23.25)	9 (2.5-19)	NS
Deaths, n	10 (17%)	35 (45%)	.001
Overall morbidity, n	3 (5%)	5 (6%)	NS
Leg ischemia (major), n	1 (2%)	3 (4%)	NS
Infection, n	2 (3%)	2 (3%)	NS

*IABP indicates intra-aortic balloon pump; NS, not statistically significant; ICU, intensive care unit.

†Data are presented as the median (interquartile range).

have been placed earlier in some cases. Most operations are performed without an IABP, and until recently IABP use was listed as a perioperative complication for audit purposes and was avoided when possible. Preoperative placement of an IABP was invariably for unstable preoperative angina and was usually placed by the cardiologist before the patient's transfer to cardiac surgery. Intraoperative and postoperative placement was for unforeseen perioperative myocardial dysfunction, most commonly difficulty coming off cardiopulmonary bypass. This explains the high mortality rate in this cohort of patients, because our overall mortality rates (the majority of whom did not require an IABP) are much lower.

In cases of perioperative myocardial dysfunction, the preemptive IABP is more likely to be used when unforeseen circumstances might necessitate it (during the early stages of compensated pump failure) allowing the reversal of the ischemic myocardial dysfunction before decompensation [Christenson 1997b]. On the other hand, unplanned perioperative placement usually occurs during decompensated pump failure, eg, after repeated attempts to come off cardiopulmonary bypass on maximal inotropic support. In such cases, ventricular-assist devices can be used as a rescue maneuver [Nwaejike 2008], but myocardial recovery is less likely with an IABP, hence the higher mortality. When an IABP is required in cases of failure to come off cardiopulmonary bypass, IABP placement within 10 minutes of initial bypass weaning has been associated with improved outcomes, compared with a delayed IABP insertion [Westaby 2007]. In this cohort, when an attempt to bring a patient off bypass was unsuccessful, the patient was put back on cardiopulmonary bypass, and the IABP was sent for and placed in the patient. For the patients in groups C and D, this period would have been greater than 10 minutes (although this time was not formally recorded), and such patients would have benefited from preemptive IABP placement (groups A and B). Protocols could be instituted in which the IABP is made available for use before an attempt is made to come off bypass and then placed in the patient if the attempt is unsuccessful. It is better to prevent a failed attempt to come off bypass (ie, to prevent ischemic myocardial injury) and we feel that preemptive IABP placement (groups A and B) is a safer and less stressful strategy.

We found the logistic EuroSCORE to be a predictor of mortality in this cohort of patients, and the EuroSCORE could be used preoperatively to guide preemptive use of the IABP, as has been described in the literature [Healy 2006]. The EuroSCORE has also been used to predict immediate and late outcomes after cardiac operations [Toumpoulis 2005; Biancari 2006]. Applying the results of our ROC curve analysis (to investigate the logistic EuroSCORE as a preoperative predictor of mortality in this cohort of patients) and considering that we found a 50% mortality advantage with planned IABP placement compared with unplanned placement (P = .001), one can infer that if all patients with a logistic EuroSCORE ≥2 had received the IABP as part of a planned strategy, our mortality would have been much lower.

Historically, there have been concerns about complications with the IABP, and for this reason the decision to use an IABP in our unit has been approached with some caution.

Larger studies have shown that complication rates with the IABP are low and have been decreasing in recent years, mostly because of smaller-sized catheters and sheathless insertion [Arafa 1999; Ferguson 2001; Baskett 2002; Christenson 2002; Meharwal 2002]. The risk of complications should not be a major issue in deciding to use an IABP in the absence of absolute contraindications, eg, aortic dissection. Current versions of the IABP (7.5F to 8.5F) can be inserted percutaneously at the patient's bedside and with the Seldinger technique.

There were 8 morbidities (6%) among the 135 patients in our study. Three patients required femoral artery embolectomy, 1 patient required femoral artery angioplasty, and 4 patients were treated successfully for groin wound infections. This result indicates a very low risk-to-benefit ratio for preemptive use of the IABP where indicated.

Our small study also showed that complication rates were lower when an IABP was placed as part of a planned

Table 5. Logistic Regression Analysis*

	B	SE	Wald	df	*P*	OR (95% CI)
Clamp time	−0.005	0.005	1.088	1	.297	0.995 (0.986-1.004)
Logistic EuroSCORE	−0.026	0.013	4.459	1	.035	0.974 (0.950-0.998)
Planned versus unplanned	1.553	0.456	11.582	1	.001	4.728 (1.932-11.566)

*B indicates logistic coefficient; SE, standard error; Wald, Wald statistic (ratio of B to SE); df, degrees of freedom; OR, unadjusted odds ratio; CI, confidence interval.

procedure (Table 4), compared with unplanned placement. In an emergency, patients are usually more hemodynamically compromised, the femoral artery is more difficult to locate and palpate, and in the tense setting of a long, stressful operation, situations leading to complications are usually more likely.

In conclusion, this study was retrospective in nature and therefore was subject to many biases, but it has examined what happens in real practice and thus may reflect what happens in other units. The small sample size was also reflected in the relatively wide confidence intervals for the odds ratios. Consequently, no firm conclusions can be drawn from this study, but it does suggest, as has been stated, "…the IABP is most useful before it is needed" (OC). This means preemptive use of the IABP. Despite evidence that showed that early use of the IABP is of benefit in high-risk patients, in some cases it remains difficult to identify patients who will benefit most from preemptive IABP use [Baskett 2002], as was shown in our study. The factor ultimately producing better hemodynamic recovery in acute pump failure with a preemptive IABP is reversal of the ischemic myocardial dysfunction before it develops into cell necrosis, ie, before decompensation occurs [Christenson 1997b]. The logistic EuroSCORE could be used as a predictor of mortality. Patients with a higher EuroSCORE are less likely to survive periods of ischemic myocardial dysfunction caused by unforeseen events occurring during an operation. A preemptive IABP in these patients produces a mortality advantage and should be encouraged, because preemptive IABP use avoids rather than treats perioperative myocardial ischemia [Christenson 1997a; Holman 2000]. The advantages of the preemptive IABP in this cohort of patients far outweigh the disadvantages, because complication rates are low.

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