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EFFECT OF INTRA-AORTIC BALLOON PUMPING AFTER CARDIAC SURGERY : COMPARATIVE STUDY OF USE IN CORONARY BYPASS AND VALVE REPLACEMENT

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INDEXING WORDS

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SYNOPSIS

To compare the effects of intra-aortic balloon pumping (IABP) between use for coronary artery bypass grafting (CABG) and for valve replacement, the results were reviewed in 513 patients who underwent CABG (n=215) or valve replacement (n=298). The rate of weaning from IABP and in-hospital survival after IABP support were excellent in CABG patients, where all 21 CABG patients (100%) and 17 out of 25 valve replacement patients (68%) could be weaned from IABP, and 19 out of 21 CABG patients (90%) and 14 out of 25 valve replacement patients (56%) survived for a long period. From comparative studies of pre- and postoperative data, the duration of IABP support in patients who could be weaned from IABP or who achieved in-hospital survival tended to be more prolonged in patients with valve replacement than in those with CABG. Among patients having IABP postoperatively, 4 CABG patients and 8 valve replacement patients had definite indications for IABP support. In the other 34 patients, preoperatively depressed cardiac function was observed in 12 patients where most of them were patients with valve replacement. Postoperative improvements in cardiac index were not as marked in patients undergoing valve

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replacement with IABP. The outcome for patients who had definite causes of post-operative cardiac failure, which were more numerous in the valve replacement group, was poor even if they could be weaned from much longer IABP support.

In conclusion, the IABP was more effective in patients with CABG compared with those with valve replacement, because the number of patients who had a depressed cardiac function during the pre- and postoperative periods was lower in the CABG group and the incidence of serious perioperative complications was less frequent in these patients.

INTRODUCTION

Intra-aortic balloon pumping (IABP) has been widely accepted as an effective means of circulatory assistance for the improvement of cardiac function in patients with serious cardiac failure during or after cardiac surgical procedures, not only for coronary artery disease but also for valvular heart disease[3,8,11,1416,17,20,23]. However, judging from the difference in benefits from the reversal of myocardial ischemia as an immediate result of surgery, there might be some differences in the effect of IABP between cases of coronary artery bypass grafting (CABG) and valve replacement surgery. Better therapeutic utility of IABP after CABG than after valve replacement was suggested in a few articles[5,21], but no precise comparison of the postoperative IABP effect between these two surgical procedures has been made thus far. To clarify this problem, we compared the results of patients with postoperative IABP use in CABG to those in valve replacement surgery.

MATERIALS AND METHODS

Hospital records of 513 patients who underwent CABG (n=215, ranging in age from 34 to 78 years old with an average age of 59 years) or valve replacement (n=298, from 25 to 73 years old with an average age of 51 years) in our hospital from January 1980 to October 1992 were reviewed. In CABG patients, patients undergoing concomitant surgical procedures such as left ventricular aneurysmectomy or mitral repair for complications from acute myocardial infarction were excluded. In valve replacement patients, those with redo valve replacement or concomitant CABG were excluded. This study also excluded patients who required more advanced mechanical support such as a veno-arterial bypass or left ventricular assist device in association with IABP postoperatively. Among 513 patients examined, IABP was used in 21 of 215 patients (9.8%) undergoing CABG (bypass-IABP pa-

tients), and in 25 of 298 patients (8.4%) undergoing valve replacement (valve-IABP patients). IABP was initiated preoperatively in 6 CABG patients because of crescendo angina and in one valve replacement patient because of intractable cardiac failure, perioperatively in 15 CABG patients and 22 valve replacement patients for removal of the cardiopulmonary bypass, and immediately postoperative in 2 valve replacement patients because of the recurrent cardiac failure.

The criteria for IABP application were as follows: profound low output state associated with low systolic blood pressure (≤80 mmHg), high left atrial pressure (≥ 20 mmHg), and low cardiac output (≤2.0 L/min/m^2), in spite of the administration of a large amount of catecholamines with appropriate volume loading.

The examined parameters were as follows: preoperative cardiac status according to the Canadian Cardiovascular Society (CCVS, for coronary artery disease) or the old New York Heart Association (NYHA, for valvular heart disease) functional classification, preoperative hemodynamic function derived from cardiac catheterization (cardiac index, pulmonary wedge pressure, left ventricular ejection fraction and left ventricular end-diastolic pressure), perfusion time of cardiopulmonary bypass and the time of aortic cross clamp during the operation, duration and the result of IABP support, cause of postoperative cardiac failure, and patients' outcome.

The values were expressed as a mean ± standard deviation. The unpaired Student's t-test was used for the evaluation of the significance of the difference in the values of two different surgical procedures. P values less than 0.05 were considered to be significant. Statistical treatment of nonparametric data was performed using Fisher's exact probability test.

RESULTS

The result of IABP support in each surgical group is shown in **Table I.** Among patients who used IABP postoperatively, all 21 bypass-IABP patients (100%) and 17 out of 25 valve-IABP patients (68%) could be weaned from IABP, the rate of weaning in bypass-IABP patients being significantly higher ($p<0.05$) than that in valve-IABP patients. Also, the rate of in-hospital survival was significantly better in bypass-IABP patients ($p<0.05$), where 19 out of 21 bypass-IABP patients (90%) achieved in-hospital survival whereas only 14 out of 25 valve-IABP patients (56%) survived for a long period.

Table II summarizes the pre- and perioperative data among patients who did not have and those who had postoperative IABP support in CABG and in valve

Table I. Results of postoperative IABP support for each surgical procedure. IABP: intra-aortic balloon pumping, CABG: coronary artery bypass grafting.

surgical procedure	no. of patient	postop. IABP use		
		patients	weaned	survived
CABG	215	21	21	19
≤ 2 grafts	*149*	*15*	*15*	*14*
≥ 3 grafts	*66*	*6*	*6*	*5*
valve replacement	298	25	17	14
single	*240*	*21*	*15*	*12*
double	*58*	*4*	*2*	*2*

replacement. Among these values, the cardiac index in valve-IABP patients tended to decrease, but that was statistically insignificant compared with the values of other group patients. Also, no statistical differences were found in the values of the other parameters examined, such as age, CCVS/NYHA functional class, pulmonary arterial wedge pressure, left ventricular ejection fraction, left ventricular end-diastolic pressure, or duration of aortic cross clamping, not only between patients who did not have and those who had postoperative IABP support in each surgical procedure but also between bypass-IABP patients and valve-IABP patients. Although it is not statistically significant, the duration of cardiopulmonary bypass was prolonged in patients with IABP support in both surgical procedures, because much longer circulatory assistance was given to some of them for the removal of the cardiopulmonary bypass after the completion of cardiac operation.

Table II. Pre- and perioperative values in patients with CABG and those with valve replacement. CCVS/NYHA:Canadian Cardiovascular Society /New York Heart Association functional classification, CI: cardiac index, PAWP: pulmonary arterial wedge pressure, LVEDP: left ventricular end-diastolic pressure, CPB: duration of cardiopulmonary bypass, ACC: duration of aortic cross clamping.

parameter	CABG		valve replacement	
	without IABP (n=194)	with IABP (n=21)	without IABP (n=273)	with IABP (n=25)
age (years old)	59±9	59±9	59±10	60±10
CCVS/NHYA	2.5±0.7	3.0±0.9	3.0±0.7	3.1±0.8
CI (l/min/m^2)	3.09±0.66	2.94±0.44	2.72±0.63	2.47±0.43
PAWP (mmHg)	8.3±4.1	9.4±4.5	17.1±6.5	15.7±4.0
LVEDP (mmHg)	14.2±7.3	15.4±6.3	14.7±6.0	13.0±5.7
LVEF (%)	58.6±13.1	55.1±9.6	57.8±10.8	54.2±8.5
CPB (min)	149±47	199±97	150±45	187±58
ACC (min)	90±34	87±25	102±31	106±28

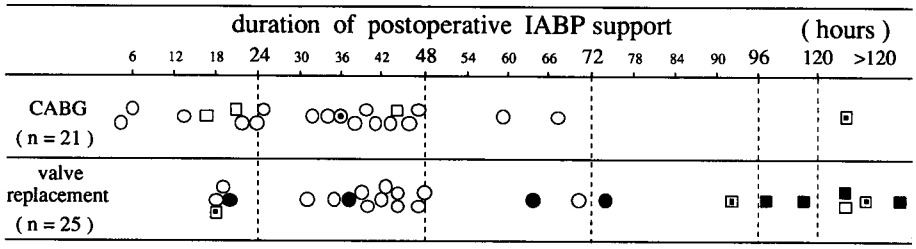

Fig. 1 Duration and outcome of postoperative IABP support in patients with CABG or those with valve replacement. ○ : weaned from IABP, survived, ◉ : weaned from IABP, died; ● : not weaned from IABP, died, □ ▣ ■ : patients in whom the IABP was used because of perioperative definite complications.

Figure 1 shows the duration of IABP support in each bypass-IABP patient or valve-IABP patient. In bypass-IABP patients, in-hospital survival was achieved in 19 patients, as shown in **Table I**, and in those for whom the duration of IABP support was shortened to within 72 hours. The duration of IABP support tended to be prolonged not only in patients who could not be weaned from IABP but also in patients who were weaned from IABP but eventually died. This trend was more significant in valve-IABP patients, except for a few patients who deteriorated to a seriously low output state and died within one day after the initiation of IABP.

Table III shows the results of postoperative IABP support based on the various causes of postoperative cardiac failure. Among patients who had undergone IABP postoperatively, 4 out of 21 bypass-IABP patients and 8 out of 25 valve-IABP patients had definite causes of IABP support: perioperative myocardial infarction in all of the 4 bypass-IABP patients and in 4 valve-IABP patients, left ventricular rupture in 2, stuck valve in 1, and intractable bleeding in one valve-IABP patient. The other 34 IABP patients deteriorated due to postoperative cardiac failure despite uneventful operations. In this group of patients, for 2 bypass-IABP patients and 10

Table III. Results of postoperative IABP support in each surgical procedure based on the causes of IABP support. ( ) = number of patients who survived for a long period after IABP support.

	with IABP				without IABP
			no definite cause		
	no. of patient	perioperative complications	CI <2.0 and/or LVEF < 45	others	CI <2.0 and/or LVEF < 45
CABG	21	4 (3)	2 (1)	15 (15)	15
valve replacement	25	8 (1)	10 (7)	7 (6)	34

valve-IABP patients, it was thought that their postoperative cardiac failure was induced by the significantly reduced preoperative cardiac function, revealed by a depressed cardiac index (<2.0 L/min/m^2) and/or left ventricular ejection fraction (<45%). The outcome for patients with valve replacement who had definite causes of postoperative cardiac failure was poor: only one of 8 valve-IABP patients in this category survived for a long period. In contrast, in patients who did not have definite causes of postoperative cardiac failure, which included patients in whom preoperatively depressed cardiac function might have influenced their postoperative course, the results of IABP support were somewhat better.

Table IV summarizes the above-mentioned values of the durations of postoperative IABP support in the two surgical procedures. The duration of IABP support in patients who died during or after IABP support was much longer than in patients who survived after IABP not only in CABG but also in valve replacement. Moreover, the differences were not significant, but the values of all, weaned, or surviving valve-IABP patients were prolonged to about 20 hours compared with those of bypass-IABP patients.

Table IV. The values of the duration of postoperative IABP support in patients with CABG and those in valve replacement. * one patient in whom 107 days of postoperative IABP support was given was excluded.

	duration of postoperative IABP (hours)			
	all patients	weaned	survived	died
CABG	39.3±32.9	39.3±32.9	32.8±16.9	100.5±91.2
valve * replacement	66.1±53.2	60.0±55.5	48.4±34.0	90.9±66.2

Figure 2 shows the changes of the cardiac index during the early postoperative periods in bypass-IABP patients and in valve-IABP patients. The cardiac index simultaneously decreased to about 2.0 L/min/m^2 at 6 or 24 hours after operation in both groups of patients. At

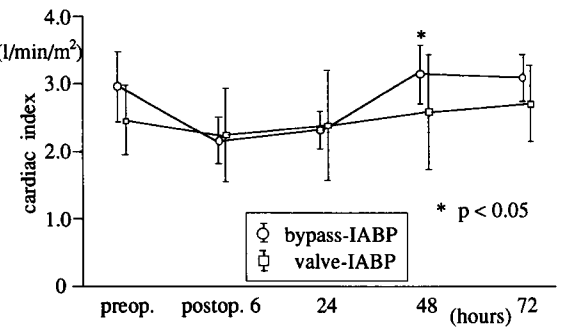

Fig. 2 Changes in cardiac index in patients with postoperative IABP support.

48 hours after surgery, the cardiac index in bypass-IABP patients improveded to approximately 3.0 L/min/m^2. In contrast, the cardiac index in valve-IABP patients was not greatly restored at that time, and the values were significantly lower than those in bypass-IABP patients.

DISCUSSION

Several recent technical advances, including myocardial protection, have improved the results of surgery not only for ischemic heart disease but also for valvular heart disease. Even with such developments, 2.4% to 15% of cardiac patients undergoing surgery still require IABP support in the peri- or immediate postoperative period[2,9,10,13,15,19,21]. Regarding the survival rate after this support, it was reported that 27% to 58% of IABP patients who underwent cardiac surgery achieve long-term survival[2,3,10,14,19,22]. These reports also indicate that various factors such as preoperative left ventricular dysfunction[3,12,20], grade IV of NYHA cardiac function[1,14,15], and the age of patients[6,15] influence the survival rate after IABP support. Furthermore, in a few reports, differences in surgical procedures were suggested as one such factor[5,21]. When the results of postoperative IABP support are compared between patients with valve replacement and those with CABG, it has been noted that survival tended to be lower in valve replacement patients than in the latter. Concerning this, the following reasons can be considered from the results of this study. First, although not statistically significant, the cardiac function in patients with valve replacement tended to decrease through the pre- and postoperative periods, especially in those who had required postoperative IABP support. This decrease was evidenced in patients with preoperatively depressed cardiac function, which is more frequent in patients with valve replacement[18]. When these patients had been given insufficient myocardial protection perioperatively, they often deteriorated into severe cardiac failure which required IABP support in the immediate postoperative periods. Regarding this point, Dowing et al.[5] reasoned that patients with valvular heart disease and cardiac impairment might not respond to valve replacement with an immediate improvement in cardiac function, unlike patients with ischemic heart disease who might directly and immediately benefit from increased coronary perfusion and reversal of myocardial ischemia as a result of CABG. This might be another reason why the values of the cardiac index after IABP application were not as markedly improved in valve-IABP patients during the early postoperative periods, or why the duration of IABP support in valve-IABP patients who were

weaned or who survived after IABP support tended to be prolonged compared with those in bypass-IABP patients. The outcome was excellent in patients with CABG in whom the IABP was initiated prior to surgery because of crescendo angina. Only one patient in this group died in-hospital after 32 hours of IABP support; he suffered from severe cardiogenic ischemia during cardiac catheterization while undergoing emergency operation, and was included in the patients' category of preoperative depressed cardiac function. This has also been reported by Pennington et al.[19], in that approximately 80% survival was achieved for patients with preoperative IABP insertion for unstable angina in their series.

Our study also clarified that the use of IABP should improve survival not only in patients with preoperatively maintained cardiac function but also in those with depressed cardiac function due to the beneficial effect on the myocardial performance. Although the incidence of IABP support was somewhat increased in valve replacement patients in whom the cause of postoperative cardiac failure was thought to be the preoperatively depressed cardiac function, the effect of IABP on them or on their survival rates was excellent. This point was raised by Goldman et al.[8], where the use of IABP was shown to improve survival and lessen mortality in patients with reversible cardiac function and was thus a valuable adjunct to cardiac surgery in high-risk patients due to its effect on myocardial performance. In addition, a shorter duration of IABP support was needed for these patients; thus almost all of them could be weaned from IABP within 2 or 3 days after the IABP initiation.

Another reason why patients who underwent valve replacement surgery more frequently faced severe postoperative cardiac failure is that there are so many kinds of serious complications during valve replacement surgery, unlike CABG[4]. When patients suffered from such complications, the degree of cardiac damage was very severe and the effect of IABP was poor. This is another reason for the poorer improvement of the postoperative cardiac index in valve-IABP patients. This might be a limitation of IABP as a method of circulatory assistance. No significant effect of IABP can be expected when postoperative cardiac failure has occurred due to definite and serious surgical complications, particularly in valve replacement surgery. The survival rate of patients who required this therapeutic modality was significantly poorer even if they could be weaned from much longer IABP support. To obtain an improved outcome in this group of patients, the proper application of more advanced mechanical support such as left ventricular assist devices or veno-arterial bypass should be considered[7,16].

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