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Original Article

Prophylactic Preoperative Application of Intraaortic Balloon Pump (IABP) Support in Surgery for Severe Valvular Heart Disease in the Elderly

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Abstract: Sixteen elderly patients (over 50 years of age) underwent valvular heart surgery between May, 1984 and October, 1988 at our hospital. We evaluated and validated the concepts of elective, prophylactic and preoperative application of IABP to preserve the impaired cardiac, renal and other organ perfusion during induction of anesthesia and/or before induced cardiac arrest and total cardiopulmonary bypass.

Elective and preoperative use of IABP was applied to seven patients whose early and late results were satisfactory. Two other patients required IABP support immediate after cardiopulmonary bypass decreased, one in early and the other in late postoperative period. No complication related to IABP insertion was encountered in any case.

We recognize the advantage of elective, preoperative application of IABP in the elderly to avoid perioperative hemodynamic disarrangement, especially in valvular heart surgery for patients with severe aortic valve stenosis, for elderly (over 65 years) patients with mitral valve lesions in which left ventricular rupture possibly complicates immediate mitral valve replacement and also for patients with moderate or severe cardiac dysfunction complicated with or without coronary diseases. We also recommend preoperative IABP which is used more commonly in order to improve survival with trivial iatrogenic morbidity, because of its generally accepted method, effectiveness and safety.

Key words: Valvular heart surgery, prophylactic intraaortic balloon pumping, elderly patient

Introduction

Because of advancements in cardiovascular surgery, surgeons have become more aggressive in extending various procedures to the older population. In particular, the ability to provide better protection of the heart with cardioplegia and the application of mechanical circulatory support (for example, intraaortic balloon pump and/or left ventricular assist device), have allowed cardiac operations in patients with severe heart diseases, even in the elderly.

The use of intraaortic balloon pumping (IABP) for management of cardiogenic shock is a generally established and accepted procedures, especially in coronary heart surgery.

Indications for its use in surgery of severe valvular heart diseases, however, are still evolving and remain controversial. The surgical results of valvular heart diseases, requiring "postoperative" IABP support, remain unsatisfactory in many institutions[1-5]. That is, in many instances, the very serious

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problem of multiorgan failure developed, leading to a postoperative low cardiac output state.

Therefore, conclusive proof of therapeutic benefit in patients after valve replacement has not been demonstrated. On the other hand, the validity of prophylactic, "preoperative" use of IABP has not been discussed[6-7].

The purpose of this paper is to evaluate and validate the concepts of elective, prophylactic preoperative application of IABP by a review of our experience in severe valvular heart surgery in elderly patients at Yamanashi Medical College Hospital.

Patient material and methods

During the period from May, 1984 to October, 1988, 24 patients underwent valvular heart surgery for aortic, mitral, tricuspid and combined lesions by the method of valvuloplasty and/or valve replacement under cardiopulmonary bypass at Yamanashi Medical College Hospital. Of the 24 patients, 16 (67%) were over 50 years of age, which was defined as elderly. The average age of these 16 patients was 62 years (range 51 to 75 years) and the sex distribution was 6 men and 10 women (Table 1).

Table 1. Surgical results for valvular heart disease in each decade of life. (May, 1984–October, 1988. Yamanashi Medical College Hospital)

Age distribution	No. case	Death	
		early	late
over 70 years	3	1	0
60–70	7	0	1
50–60	6	0	1
40–50	5	0	0
30–40	2	0	1
20–30	0	0	0
10–20	1	0	0
	24	1	3

The 16 elderly patients undergoing valvular heart surgery were categorized into three separate groups according to the timing of IABP support. However, the criteria of IABP support were not always defined in each case in this study.

Group A. This group consisted of 7 patients in whom a low cardiac output syndrome might have appeared postoperatively because of their moderate or severe left ventricular dysfunction. They were in the New York Heart Association Class III to IV. Therefore IABP was instituted prior to the induction of anesthesia and sternotomy, or induction of cardio-pulmonary bypass, in which an application of IABP was defined as "elective preoperative use". IABP was continued throughout the operation and into the postoperative period.

Group B. The 2 patients in this category were either in coronary spasm or in immediate left ventricular rupture, in which cardiopulmonary bypass could not be discontinued after surgery. Instead a combined use of inotropic agents and vasodilators was used. Thereafter, therapeutic use of IABP was needed postoperatively.

Group C. This group consisted of 7 patients with relatively well tolerated cardiac function. Therefore, IABP support was not necessary in any pre- or postoperative course.

The intraaortic balloon was passed through the common femoral artery of the extremity and was positioned just distal to the left subclavian artery. The Contron System was used to drive the intraaortic balloon. Pumping was influenced by the R wave of the electrocardiogram during spontaneous or pacemaker cardiac beats (Fig. 1.A and C), but from internal mode during total cardiopulmonary bypass (Fig. 1.B).

By comparison of these three groups, we evaluated and validated the concept of elective preoperative application of IABP in valvular heart surgery in the elderly.

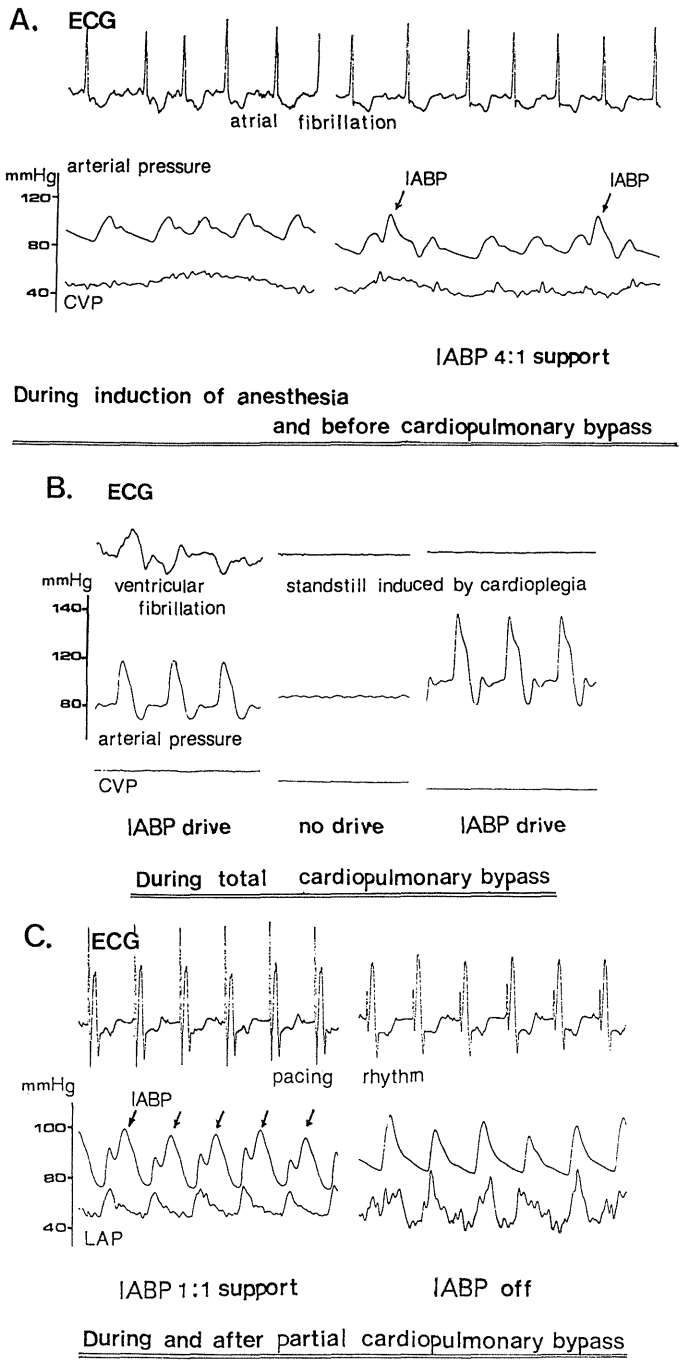

Fig. 1. Serial data from the perioperative use of IABP in a 68-year-old man who underwent AVR for ASr (Case 3).
A: Application of IABP during induction of anesthesia. Immediately after induction of anesthesia, systemic blood pressure fell and then IABP support with 4:1 assist drived was introduced.
B: IABP support during total cardiopulmonary bypass. Pulsatile flow during cardiac operation results in better retention of organ function than nonpulsatile flow of conventional bypass.
C: Postoperative use of IABP during and after partial cardiopulmonary bypass. During and after cardiac resuscitation, IABP support with 1:1 assist drive allowed him to be easily weaned from cardiopulmonary bypass.

Table 2. Successful applications of IABP for several conditions
(May, 1984–October, 1988. Yamanashi Medical College Hospital)

Applications	Preoperative use		Postoperative use	Rate of success
	elective	therapeutic	therapeutic	
Valve surgery	7/7	0	1/2	8/9 (89%)
Coronary surgery	3/3	0	0/1	3/4 (75%)
VSP surgery	—	0/4	0	0/4 (0%)
AMI (shock)	—	2/3	—	2/3 (67%)
Acute myocarditis	—	0/1	—	0/1 (0%)
Rate of success	10/10 (100%)	2/8 (25%)	1/3 (33%)	13/21 (62%)

Abbreviations: VSP: ventricular septal perforation; AMI: acute myocardial infarction.

Results

I. Our experience of the use of IABP for several cardiac conditions (Table 2).

We experienced a total of twenty-one patients who indicated the use of IABP as either elective or therapeutic, and pre- or postoperative. Of the 21 patients, the elective preoperative use of IABP was instituted in seven valvular patients and in three undertaking coronary bypass surgery.

All were weaned from IABP without any complication. But of the three patients requiring therapeutic postoperative use of IABP at the time of valvular and coronary bypass surgery, only one was successfully weaned. However, poor results in patients requiring therapeutic preoperative use of IABP support were shown in conditions complicated by acute myocardial infarction, especially those with ventricular septal perforation. In the present study we found that of the 21 patients indicated to IABP support, the rate of successful weaning from IABP retained 62%. No patients under 50 years of age required IABP in any type of cardiac operation.

II. Surgical details and their results in 16 elderly patients with severe valvular heart diseases (Table 3).

Group A. The 7 patients in this group were assisted for an average of one hour (range 0.5 to 2 hours) prior to open heart surgery and were also assisted for an average of 28 hours postoperatively (range 23 to 44 hours). All of the 7 patients could easily be taken off IABP support. Their postoperative hemodynamic states were not eventful. However, one patient (Case 4) died three months postoperatively from multiorgan failure, following postoperative acute renal failure which resulted from severe hemolysis due to prosthetic valve dysfunction.

Group B. The 2 patients in this category were assisted postoperatively for the following reasons: In one case (Case 7), cardiopulmonary bypass could not be discontinued because of coronary spasm, and in the other (Case 8) because of immediate left ventricular rupture. The former required IABP support for 48 hours postoperatively, however, she died suddenly one year later. The latter died on the operating table because of technical problem in the repair of the left ventricular rupture.

Group C. This group consisted of 7 patients who did not require IABP support before or after cardiac operations. All of them improved both clinically and hemodynamically.

III. Preoperative hemodynamic details in 15 elderly patients and indication for IABP support (Table 4).

Table 3. Surgical details and its results in 16 elderly valvular heart patients

Case	Sex	Age	Diagnosis	Coronary lesion	Procedures	Aorta clamp time / total bypass time	IABP time: preope	IABP time: postop	Result
Group A. Preoperative use of IABP (7 cases)									
1 J N	M	54	ASr	none	AVR	203 min / 296 min	1 hr	44 hrs	good.
2 K A	M	58	ASr	none	AVR in semiemergency	84 / 116	1.5	25	AV block Pacemaker implant, good.
3 T O	M	68	ASr	none	AVR in semiemergency	120 / 144	0.5	24	mediastinitis, good.
4 F I	F	65	MSr, TR OMI LA thrombi	RCA 50%	MVR, TAP	98 / 164	2	23	hemolysis, ARF-MOF, death 3 months later.
5 B D	F	51	MSr, TsR	none	OMC, TAP	21 / 83	1.5	24	good.
6 Y H	F	60	MS LA thrombi	—	MVR in semiemergency	103 / 121	0.5	22	good.
7 T T	F	70	MR (MVP)	none	MVR (modified)	103 / 138	1	26	good.
Group B. Postoperative use of IABP (2 cases)									
8 K S	F	55	ASR, MSR TR	none	AVR, MVR TAP	114 / 238	—	48	cerebral infraction, sudden death, one year later.
9 MM	F	72	MRS, TR LA thrombi	—	MVR, TAP in semiemergency	139 / 171	—	4	LV rupture, DOT.
Group C. No use of IABP (7 cases)									
10 H I	M	59	ASR, MSR	none	AVR, OMC	55 / 104	—	—	Wallenberg syn. fair
11 K S	F	69	ASR	none	AVR	118 / 163	—	—	good.
12 MN	M	75	AR (IE)	none	AVR	90 / 98	—	—	mediastinitis, good.
13 MN	F	54	MS	RCA 25% CX 50%	OMC	42 / 65	—	—	good.
14 T H	F	64	MSr, LA thrombi	none	MVR	97 / 122	—	—	good.
15 HM	M	60	MS post OMC	none	MVR	108 / 125	—	—	good.
16 K O	F	64	thrombosed M prosthesis	—	MVR redo	84 / 101	—	—	Sick sinus syn. pacemaker implant. good.

Abbreviations: AR: aortic regurgitation; ARF: acute renal failure; AS: aortic stenosis; AVR: aortic valve replacement; IE: infective endocarditis; MOF: multi-organ failure; MR: mitral regurgitation; MS: mitral stenosis; MVR: mitral valve replacement; OMC: open mitral commissurotomy; TAP: tricuspid anuloplasty; TR: tricuspid regurgitation; OMI: old myocardial infarction; DOT: death on table; MVP: mitral valve prolapse.

Table 4. Preoperative clinical and hemodynamic details in 16 elderly patients

Case	Age	Diagnosis	NYHA	CTR (%)	Af	Echography		
						LVDd (mm)	LVDs (mm)	EF (%)
1 J N	54	ASr	III	53	−	58	50	32
2 K A	58	ASr	IV	64	−	60	47	51
3 T O	68	ASr	IV	50	±	38	28	60
4 F I	65	MSr, TR OMI	III	70	+	56	47	41
5 E O	51	MSr, TsR	III	74	+	33	27	44
6 Y H	60	MS	II	59	+	54	38	56
7 T T	70	MR	III	58	+	59	29	88
8 K S	55	ASR, MSR TR	III	70	+	60	39	63
9 MM	72	MSR, TR	III	66	+		good	
10 H I	59	ASR, MS	II	50	+	43	22	86
11 K S	69	ASR	III	64	−	45	16	82
12 MN	75	AR	III	50	−	53	32	77
13 MN	54	MS	II	56	+	39	33	39
14 TH	64	MSr	III	76	+	43	35	46
15 HM	60	MS	III	50	+	51	39	55
16 K O	64	thrombosed MVR	IV	63	+	42	11	85

Abbreviations: Af: atrial fibrillation; CI: cardiac index; CTR: cardiothoracic ratio; EF: ejec- LVEDP: left ventricular end-diastolic pressure; LVEDVI: left ventricular end-diastolic volume classification; PAP: pulmonary arterial pressure; PAWP: pulmonary arterial wedge pressure.

Group A. This group consisted of 7 patients whose cardiac dysfunction were moderate or severe resulting from severe calcified aortic valve stenosis (Case 1 to 3), mitral tight stenosis with severe tricuspid regurgitation with or without large left atrial thrombi (Case 4 to 6) and acute onset of severe mitral regurgitation following rupture of the chorda tendinea (Case 7).

Group B. Two patients in this group had several retrospective problems. That is, one (Case 8) involved triple valvular lesions and the other (Case 9) necessitated an urgent operation because of free large thrombi in the left atrium. Therefore, their preoperative hemodynamic data could not be obtained or examined accurately. Preoperative IABP support should be indicated retrospectively.

Group C. This group consisted of 7 patients, almost all of whom had one valvular lesion and showed mild or moderate cardiac dysfunction preoperatively. In one patient (Case 16) preoperative invasive cardiac evaluations could not be performed because of thrombosed mitral prosthesis to avoid multiple embolism during cardiac catheterization, as shown in Case 9.

with valvular heart diseases.

Angiography			Catheterization			
LVEDVI (ml/m²)	LVESVI (ml/m²)	EF (%)	PAWP (mmHg)	PAP (mmHg)	LVEDP (mmHg)	CI (ml/min/m²)
157	117	25	18/13 (15)	36/16 (23)	27	2.2
159	117	27	29/21 (25)	70/30 (42)	30	2.4
53	27	49	(8)	27/ 9 (15)		
102	86	16	15/11 (13)	39/17 (27)	7	1.5
179	110	39	23/18 (21)	66/29 (41)	5	3.0
		—not examined—				
102	34	74	46/20 (25)	50/20 (31)	22	2.8
140	42	70	14/11 (13)	28/18 (22)	—	1.9
		—not examined—				
114	50	57	10/ 6 (8)	22/ 5 (11)	10	2.0
75	27	64	9/ 4 (6)	32/12 (21)	—	2.5
135	56	59	15/ 6 (8)	28/10 (17)	36	3.1
	—not examined—		29/25 (27)	41/28 (32)	4	3.1
70	45	36	30/20 (26)	58/28 (40)	5	2.4
100	29	72	19/12 (16)	45/25 (35)	3	1.9
		—not examined—				

tion fraction; LVDd: left ventricular diastolic dimension; LVDs: left ventricular systolic dimension; index; LVESVI: left ventricular end-systolic volume index; NYHA: New York Heart Association

The average preoperative hemodynamic data of groups A and C are summarized and compared in Table 5. Although a significant statistical difference was not observed in any hemodynamic parameter, there was a tendency for cardiac dysfunction to be worse in group A than C. Although our sample size was small, LVESVI and LVDs may be better parameters for the evaluation of preoperative cardiac dysfunction. Calculation of LVEF by echocardiographic analysis seemed to over-estimate the results when compared to angiographic study.

Discussion

Since the clinical introduction of the intraaortic balloon pump (IABP) in 1968, it has been a useful tool in the management of cardiogenic shock, in particular after acute myocardial infarction. It is generally and pathophysiologically accepted that with the employment of IABP systolic impedance ("afterload") decreases, diastolic aortic pressure increases, cardiac output rises, coronary blood flow increases, left ventricular size decreases and myocardial metabolism improves in both experimental and clinical

Table 5. Retrospective analysis of preoperative clinical and hemodynamic data in comparison between group A and C according to the timing of IABP induction.

Clinical data	Group A	Group C	P value
	preoperative use of IABP	no use of IABP	
total cases	7	7	
age (years)	61 ± 8	64 ± 7	NS
NYHA (grade)	3.3± 0.5	2.9± 0.7	NS
CTR (%)	62 ±10	58 ±10	NS
by echographic analysis			
LVDd (mm)	51 ±12	45 ± 5	NS
LVDs (mm)	38 ±11	27 ±11	$p<0.05$
LVEF (%)	53 ±20	67 ±20	NS
by angiographic analysis			
LVEDVI (ml/m^2)	125 ±48	99 ±27	NS
LVESVI (ml/m^2)	82 ±41	41 ±13	$p<0.05$
LVEF (%)	38 ±21	58 ±13	NS
by catheterization analysis			
mean PAWP (mmHg)	18 ± 7	15 ± 9	NS
mean PAP (mmHG)	30 ±10	26 ±11	NS
LVEDP (mmHg)	17 ±11	12 ±14	NS
CI (L/min/m^2)	2.3± 0.6	2.4± 0.4	NS

studies. Therefore, preoperative and postoperative IABP may be of particular value in three groups of patients with ischemic heart diseases: Those with the clinical syndrome of acute coronary insufficiency, those with critical left main coronary stenosis, and those with impaired left ventricular function.

Moreover, as the results of open-heart operations have progressively improved, the indications for operation have been extended toward the extremes of age. In fact, valve replacement and necessary related procedures can be accomplished in elderly patients with an acceptable operative mortality[8-13].

IABP has also often been used in severe valvular heart surgery, in which cardiopulmonary bypass could not be discontinued after operation because of a low cardiac output syndrome. Indications for the use of IABP in surgery for valvular heart diseases are evolving but remain controversial. In fact, the surgical results of those who required postoperative IABP support remain unsatisfactory in many institutions. In previous reports, the survival rate was between 37% and 68%[1-5]. The intraoperative mortality rate was high in all subgroups and accounted for the greatest number of deaths.

Certainly, there is little doubt that IABP augments cardiac output for a period of time, but there is no evidence that short-term balloon support is capable of restoring myocardial damage by chronic volume overload and diffuse fibrosis coupled with the added injury of cardiopulmonary bypass and myocardial anoxia[14,15]. On the other hand, the intraaortic balloon is one method of introducing pulsatility into a standard cardiopulmonary bypass circuit. Pulsatile flow during the operation results in better retention of organ function than the non-pulsatile flow of conventional bypass[16].

Although it is generally not possible to

Table 6. Criteria of preoperative elective use of IABP (Bolooki (6)).

1. Severe left ventricular dysfunction (CI<1.8, EF<30%, EDP>22 mmHg)
2. Presence of moderate left ventricular dysfunction (CI>2.2, EF<40%, EDP>18) in patient with:
   A. Severe aortic stenosis (gradient>80 mmHg)
   B. Acute myocardial infarction or its complications
   C. Intermediate coronary syndrome (especially due to LMC)
   D. Valvular heart disease and coronary obstruction

examine the differences of availability between pre- and postoperative use of IABP in clinical study, we consider it to be more meaningful to use IABP support before operation or prior to the induction of cardiac arrest in order to preserve the impaired cardiac function and other organ perfusion during induction of anesthesia and, before and during cardiopulmonary bypass, and to improve the survival with tribial iatrogenic morbidity.

Bolooki *et al.*[6] recommended "preoperative" use in patients with moderate or severe left ventricular dysfunction. The details of their criteria for preoperative use of IABP is shown in Table 6. The present study showed similar results as Bolooki's. In the discussion of Bolooki's article, Scully strongly supported the principle of preoperative diastolic counterpulsation in patients who have significant left ventricular dysfunction or who are hemodynamically very unstable preoperatively. Daggett also stated in the same paper that he has used the balloon earlier to control ischemic symptoms and signs rather than waiting until patients have established myocardial damage, and has paid particular attention to the dangerous time period starting with induction of anesthesia until cardiopulmonary bypass is instituted.

Downing *et al.*[5] demonstrated that the preoperative variables suggesting postoperative IABP support in valve replacement were age (60 to 70 years), sex (male), pulmonary arterial wedge pressure (over 30 todd), cardiac index (1 to 1.5 L/min/m^2), and that the chance of IABP were 16.0, 12.4, 11.5 and 18.2% respectively. The diagnosis of mitral regurgitation requiring postoperative IABP support occurred more often than mitral stenosis or mixed mitral stenosis and regurgitation. Similarly the diagnosis of aortic stenosis resulted in more frequent IABP use than aortic regurgitation or a mixed aortic lesion. Within each diagnosis, however, there was less than a 10% incidence of balloon use. Independent preoperative variables cannot predict the necessity for IABP. In general, the more complex the operative procedure, the more likely the need for IABP. However, they did not referred to elective, prophylactic and preoperative use of IABP, and then concluded that IABP counterpulsation is a demanding therapeutic modality from the perspective of monetary and personnel resources. It may not be as helpful as is currently believed in patients undergoing valve replacement, and its use in this context should be further assessed. Most importantly, the poor prognosis of this group of patients emphasized the need for more refined clinical guidelines to promote operative intervention earlier in the course of the diseases (especially for patients with mitral or aortic regurgitation), better methods of intraoperative myocardial preservation, and implementation of effective adjunctive postoperative support measures (left or right ventricular assist devices, or both). We agree with their opinion.

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