Bypass surgery for left main coronary artery disease

*Reduced perioperative myocardial infarction with preoperative intra-aortic balloon counterpulsation**

STEVEN R TAHAN, ALEXANDER S GEHA, GRAEME L HAMMOND, LAWRENCE S COHEN, RENE A LANGOU

From the Section of Cardiology, Department of Internal Medicine, and Cardiothoracic Division, Department of Surgery, Yale University School of Medicine, New Haven, Connecticut, USA

SUMMARY From July 1975 to December 1977, 91 consecutive patients with left main coronary artery disease defined by cardiac catheterisation as ≥ 50 per cent luminal narrowing underwent coronary bypass surgery. Prospective examination of the preoperative and postoperative clinical course of these patients was performed to determine the incidence of perioperative myocardial infarction. Intra-aortic balloon counterpulsation was instituted preoperatively in 35 patients, and these patients were classed as group A. Fifty-six patients did not receive the intra-aortic balloon pump and were classed as group B. Of 26 demographic, clinical, haemodynamic, and operative descriptors, only two were found to be significantly different between the two groups: the severity and the pattern of angina. Group A had a higher percentage of patients with class IV angina (80% vs 45%) and a greater proportion with unstable angina (37% vs 7%). Despite these differences group A patients had only a 3 per cent incidence of perioperative myocardial infarction while group B had a 23 per cent perioperative infarction rate. It is suggested that perioperative intra-aortic balloon counterpulsation can reduce the risk of perioperative myocardial infarction in patients with left main coronary artery stenosis.

Obstructive lesions involving the left main coronary artery have been associated with a guarded prognosis in patients with ischaemic heart disease.¹⁻³ Early surgical intervention has become increasingly common for this disease, and many centres have reported a substantial relief of symptoms after operation.⁴⁻⁶ Furthermore, in comparing medical and surgical treatment for patients with left main stenosis several studies indicate a prolonged survival in surgically treated groups.⁵⁻⁷

Left main disease is itself a significant risk factor for operative mortality and perioperative myocardial infarction in coronary bypass surgery. Operative mortality has been reported to be two- to fivefold higher and perioperative myocardial infarction over 50 per cent more common in patients with significant left main narrowing.^{3 6 8}

Experience with prophylactic and therapeutic intra-aortic balloon counterpulsation has shown it to be of value for patients with serious left ventri-

cular dysfunction, impending myocardial infarction, or both, who were undergoing cardiac surgery.⁹⁻¹¹ Evaluation of the prophylactic use of the intra-aortic balloon pump for patients undergoing bypass grafting for left main disease comprises the subject of this report. We collected data retrospectively¹² on 91 consecutive patients undergoing bypass surgery for left main coronary obstruction from July 1975 to December 1977 to determine prospectively if preoperative intra-aortic balloon pumping had any effect on the incidence of perioperative myocardial infarction.

Patients and methods

Data were collected on 91 consecutive patients shown to have greater than 50 per cent obstruction of the left main coronary artery who underwent aortocoronary bypass grafting at Yale-New Haven Hospital from July 1975 to December 1977.

Diagnostic cardiac catheterisation consisted of pressure measurements, cardiac output determination, right anterior oblique left ventriculogram for

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analysis of regional wall motion,¹³ mitral regurgitation, and ejection fraction (calculated according to the method of Greene *et al.*),¹⁴ and selective coronary cinearteriography, all performed by standard techniques. A greater than 50 per cent stenosis of the left main coronary artery and a greater than 70 per cent stenosis for other coronary arteries was considered significant.

Coronary bypass surgery was performed within two weeks after angiography in all patients. All grafts to the left circumflex and right coronary arteries were performed using reversed autogenous saphenous veins. The left anterior descending artery was grafted using the left internal mammary artery in 37 patients, aortosaphenous bypass grafts in 45 patients, and double grafts using aortosaphenous vein grafts and the left internal mammary artery in nine patients. Dissection of the left internal mammary artery from the chest wall and proximal anastomoses of saphenous vein grafts were accomplished without cardiopulmonary bypass. Distal anastomoses were performed on full cardiopulmonary bypass with the heart in ventricular fibrillation, and aortic cross-clamping was used only when a dry field could not be obtained by local occlusion of the coronary artery. Each distal anastomosis was probed near its completion to ensure that the anastomotic communication was wider than the grafted coronary artery. The left ventricle was vented in all patients by a catheter passed through the right superior pulmonary vein or the ventricular apex into the left ventricular cavity. All blood aspirated into the extracorporeal circuit from the vent or cardiac suction lines was filtered through a millipore filter* before being returned to the oxygenator.† Whole blood was transfused only if perfusate haematocrit fell below 25 per cent, and serum potassium levels were carefully monitored and appropriately adjusted.

DEFINITION OF VARIABLE STUDIES

Perioperative myocardial infarction was defined as myocardial necrosis occurring within one week postoperatively and identified by serial electrocardiograms, necropsy, or both. All patients had daily standard 12 lead electrocardiograms from the day before operation until the seventh postoperative day with the first postoperative tracing obtained upon arrival in the surgical intensive care unit. Routine precautions were taken to ensure that praecordial electrocardiographic leads were recorded from the same praecordial place before and after

operation. The criterion for acute myocardial infarction was the development on serial electrocardiograms of new significant pathological Q waves, equivalent to class I-1 and I-2 of the Minnesota Code.¹⁵ These new Q waves were considered diagnostic of myocardial infarction if they were recorded from completely different sites from preoperative myocardial infarctions. New intraventricular conduction defects, new bundle-branch blocks, increasing size of previous Q waves, and ST segment or T wave changes without new pathological Q waves were not considered diagnostic of myocardial infarctions. Rises in serum creatine kinase (CK), serum aspartate transaminase (AST), and CK-MB isoenzyme were not considered diagnostic of myocardial infarction. Mortality of perioperative myocardial infarction was considered to be death up to four weeks after coronary surgery.

STATISTICAL METHODS

Contingency table χ^2 and multiple logistic regression model were used to analyse the data.¹⁶ A probability value less than 0.05 was considered statistically significant. When information on a specific clinical characteristic of a patient was not available, that patient was excluded from analysis of the particular variable.

PATIENT GROUPINGS

Thirty-five patients were treated preoperatively with intra-aortic balloon counterpulsation,‡ and these patients were classed in this study as group A. Fifty-six patients did not receive the intra-aortic balloon pump and were classed as group B. The individual clinical decision regarding the insertion of a pump depended largely upon its availability, but maximal effort was made to assist patients with unstable angina with counterpulsation. When used, the intra-aortic balloon pump was introduced under local anaesthesia in the surgical intensive care unit through the common femoral artery via an end-to-side 10 mm 'dacron' graft and advanced into the descending thoracic aorta. When difficulties were encountered or anticipated, a wire-guided central lumen balloon catheter¹⁷ was introduced under direct fluoroscopy and pressure monitoring in the cardiac catheterisation laboratory. Details of introduction and management of the intra-aortic balloon pump have been previously described.¹⁸

In group A patients the balloon pump was inserted before cardiac catheterisation and operation in 18, and before operation in 17. It was removed either at bypass surgery or up to 48 hours postoperatively in the surgical intensive care unit

* Swank Micro-emboli Filter, Pioneer Filter Co, Beaverton, Oregon.

† Temptrol Disposable Blood Oxygenator Model Q100, Bentley Laboratories Inc., Santa Anna, California; or Kolobine Disposable Membrane Oxygenator, Sci-Med, Minneapolis, Minnesota.

‡ Avco Intra-aortic Balloon, Hoffman-LaRoche Inc., Cranbury, New Jersey.

in all cases. In no instance was the intra-aortic balloon pump left on longer than seven days (average four days).

DEMOGRAPHIC CHARACTERISTICS

Table 1 displays variables relating to the past medical history and physical examination of this group of 91 patients with left main stenosis. It can be seen that the following variables were distributed approximately equally between the 35 group A and 56 group B patients: age over 55, sex, history of previous myocardial infarction, history of congestive heart failure, positive family history (ischaemic heart disease in immediate family member before age 55), evidence of peripheral vascular disease, history of smoking, and propranolol dosage and tapering. Sixty-three per cent of the population was over age 55; 80 per cent were male; 43 per cent had a history of previous myocardial infarction; 28 per cent had symptoms of congestive heart failure; 62 per cent had a positive family history; 26 per cent showed signs of peripheral vascular disease; 64 per cent had a positive smoking history; 60 per cent had been on more than 160 mg propranolol per day, and 8 per cent had propranolol therapy abruptly stopped without tapering before operation.

Statistically significant differences between the two groups were found in three of the studied

demographic descriptors: severity of angina pectoris, pattern of angina pectoris, and use of propranolol before surgery for control or attempted control of symptoms. Eighty per cent of group A patients had New York Heart Association (NYHA) class IV angina while only 45 per cent of group B patients had class IV symptoms ($p < 0.05$). Unstable angina (defined as constant chest pain at rest of at least 20 minutes' duration, refractory to medical therapy with beta-blockers and nitrates) was present in 37 per cent of group A patients compared with 7 per cent of group B patients ($p < 0.05$). Propranolol was used before admission for operation in 97 per cent of group A patients compared with 76 per cent of those in group B ($p < 0.02$). Of note is that there was no significant difference in method of cessation of propranolol therapy among patients receiving the beta-blocker in the two groups. These three demographic indices outline, then, a group A population with clinically more severe angina pectoris than group B.

Similarly, radiological, haemodynamic, and angiographic data are shown in Table 2. A comparable distribution between the two groups can be seen for cardiac enlargement (CT ratio $> 50\%$), abnormal ejection fraction, raised left ventricular end-diastolic pressure (LVEDP), evidence of mitral regurgitation, and presence of triple vessel disease and of abnormal segmental wall motion. Eighteen per

Table 1 Demographic characteristics: medical history and physical examination

	Total	Group A (IABP)	Group B (no IABP)	p value
Number of patients	91	35	56	
Age (y)				
< 55	34/91 (37%)	10/35 (29%)	24/56 (43%)	NS
≥ 55	57/91 (63%)	25/35 (71%)	32/56 (57%)	NS
Sex				
M	73/91 (80%)	31/35 (89%)	42/56 (75%)	NS
F	18/91 (20%)	4/35 (11%)	14/56 (25%)	NS
Previous myocardial infarction	37/87 (43%)	16/35 (46%)	21/52 (40%)	NS
History of congestive heart failure	24/87 (28%)	10/35 (29%)	14/52 (27%)	NS
+ Family history	54/87 (62%)	22/33 (67%)	32/54 (59%)	NS
History of hypertension	29/90 (32%)	10/35 (29%)	19/55 (35%)	NS
Peripheral vascular disease	24/91 (26%)	7/35 (20%)	17/56 (30%)	NS
Smoking	58/90 (64%)	21/34 (62%)	37/56 (66%)	NS
Angina				
Severity: Class I (NYHA)	2/91 (1%)	0/35 (0%)	2/56 (3%)	NS
Class II	14/91 (15%)	3/35 (9%)	11/56 (20%)	NS
Class III	22/91 (24%)	4/35 (11%)	18/56 (32%)	NS
Class IV	53/91 (58%)	28/35 (80%)	25/56 (45%)	< 0.05
Pattern: Stable	22/91 (24%)	6/35 (17%)	16/56 (29%)	NS
Progressive	52/91 (57%)	16/35 (46%)	36/56 (64%)	NS
Unstable	17/91 (19%)	13/35 (37%)	4/56 (7%)	< 0.05
Propranolol				
None	14/89 (16%)	1/35 (3%)	13/54 (24%)	< 0.02
< 160 mg daily	22/89 (25%)	6/35 (17%)	16/54 (30%)	NS
≥ 160 mg daily	53/89 (60%)	28/35 (80%)	25/54 (46%)	NS
Propranolol tapering				
No propranolol	14/75 (19%)	1/35 (3%)	13/40 (32%)	< 0.01
Abrupt withdrawal	6/75 (8%)	1/35 (3%)	5/40 (12%)	NS
Tapered or discontinued 48 hours before operation	53/75 (71%)	33/35 (94%)	22/40 (55%)	NS

IABP, intra-aortic balloon pump.

Table 2 Demographic characteristics: chest x-ray and cardiac catheterisation

	Total	Group A (IABP)	Group B (no IABP)	p value
Cardiac enlargement	16/91 (18%)	6/35 (17%)	10/56 (18%)	NS
Vessels diseased				
LMCA only	14/91 (15%)	2/35 (6%)	12/56 (21%)	NS
LMCA + RCA	77/91 (85%)	33/35 (94%)	44/56 (79%)	NS
Ejection fraction				
≥ 0.60	39/75 (52%)	14/29 (48%)	25/46 (54%)	NS
< 0.60	36/75 (48%)	15/29 (52%)	21/46 (46%)	NS
LVEDP				
≤ 12 mmHg	31/84 (37%)	11/34 (32%)	20/50 (40%)	NS
> 12 mmHg	53/84 (63%)	23/34 (68%)	30/50 (60%)	NS
Mitral regurgitation	6/81 (7%)	2/35 (6%)	4/46 (9%)	NS
Abnormal segmental wall motion	53/84 (63%)	25/34 (73%)	28/50 (56%)	NS

LMCA, left main coronary artery; LVEDP, left ventricular end-diastolic pressure; RCA, right coronary artery.

cent of the total population had cardiac enlargement; 48 per cent had an ejection fraction of less than 0.60; 63 per cent had LVEDP of greater than 12 mmHg; 7 per cent had evidence of mitral regurgitation; 85 per cent had disease of the right coronary artery (RCA) in addition to the left system; and 63 per cent had abnormal segmental wall motion on left ventriculogram.

Table 3 displays operative data for the group. An approximately equal distribution of patients receiving the intra-aortic balloon pump and those not was seen for number of major diseased vessels not grafted (incomplete revascularisation), cardiopulmonary bypass time, anoxia time (aortic cross-clamping), and number of grafted vessels. Sixty-seven per cent of the population had complete revascularisation; 58 per cent had a cardiopulmonary bypass time longer than 90 minutes; 41 per cent had anoxia times of greater than 30 minutes; and 69 per cent received three or more grafts. No differences in operative indices were seen between the two groups.

Results

Perioperative myocardial infarction occurred in 15 per cent of the total population of 91 patients with left main disease. An analysis of incidence of perioperative myocardial infarction for previously reported or suggested risk factors is displayed in Table 4. We found no significant association between perioperative myocardial infarction and age over 55, sex, severity or pattern of anginal pain, the presurgical use of beta-blockers, dosage of propranolol if used, method of propranolol discontinuation, cardiac enlargement, mitral regurgitation, abnormal segmental wall motion, abnormal ejection fraction, raised LVEDP, anoxia time, disease of the right coronary artery, or incomplete revascularisation. A significant association was seen, however, between cardiopulmonary bypass time greater than 90 minutes ($p < 0.05$) and suggested for more than three grafts performed ($p < 0.10$). Twenty-three per cent of patients with cardiopulmonary bypass times of longer than 90 minutes infarcted compared

Table 3 Operative history

	Total	Group A (IABP)	Group B (no IABP)	p value
Number of grafts performed				
1	1/91 (1%)	0/35 (0%)	1/56 (2%)	NS
2	26/91 (29%)	4/35 (11%)	22/56 (39%)	NS
3	56/91 (62%)	26/35 (74%)	30/56 (54%)	NS
≥ 4	7/91 (8%)	4/35 (11%)	3/56 (5%)	NS
Diseased vessels not grafted				
None	61/91 (67%)	24/35 (69%)	37/56 (66%)	NS
LAD	2/91 (2%)	1/35 (3%)	1/56 (2%)	NS
LCF	21/91 (23%)	6/35 (17%)	15/56 (27%)	NS
RCA	7/91 (8%)	4/35 (11%)	3/56 (5%)	NS
Cardiopulmonary bypass time				
≤ 90 seconds	38/91 (42%)	13/35 (37%)	25/56 (45%)	NS
> 90 seconds	53/91 (58%)	22/35 (63%)	31/56 (55%)	NS
Anoxia time				
0	27/91 (30%)	11/35 (31%)	16/56 (29%)	NS
0-30 seconds	27/91 (30%)	8/35 (23%)	19/56 (34%)	NS
31-60 seconds	30/91 (33%)	11/35 (31%)	19/56 (34%)	NS
> 60 seconds	7/91 (8%)	5/35 (14%)	2/56 (4%)	NS

I ABP, intra-aortic balloon pump; LAD, left anterior descending coronary artery; LCF, circumflex coronary artery; RCA, right coronary artery.

Table 4 Patients sustaining perioperative myocardial infarctions

	Total	Group A (IABP)	Group B (no IABP)	p value
Incidence	14/91 (15%)	1/35 (3%)	13/56 (23%)	< 0.05
Age (y)				
< 55	5/34 (15%)	0/10 (0%)	5/24 (21%)	NS
≥ 55	9/57 (16%)	1/25 (4%)	8/32 (25%)	NS
Sex				
M	11/73 (15%)	1/31 (3%)	10/42 (24%)	NS
F	3/18 (17%)	0/4 (0%)	3/14 (21%)	NS
Angina				
Severity: Class I (NYHA)	0/2 (0%)	—	0/2 (0%)	NS
Class II	4/14 (29%)	0/3 (0%)	4/11 (36%)	NS
Class III	3/22 (14%)	0/4 (0%)	3/18 (17%)	NS
Class IV	7/53 (13%)	1/28 (4%)	6/25 (24%)	NS
Pattern: Stable	5/22 (23%)	0/6 (0%)	5/16 (31%)	NS
Progressive	8/52 (15%)	1/16 (6%)	7/36 (19%)	NS
Unstable	1/17 (6%)	0/13 (0%)	1/4 (25%)	NS
Propranolol				
None	4/14 (29%)	0/1 (0%)	4/13 (31%)	NS
< 160 mg daily	3/22 (14%)	0/6 (0%)	3/16 (19%)	NS
≥ 160 mg daily	7/53 (13%)	1/28 (4%)	6/25 (24%)	NS
Propranolol tapering				
No propranolol	4/14 (29%)	0/1 (0%)	4/13 (31%)	NS
Abrupt withdrawal	0/6 (0%)	0/1 (0%)	0/5 (0%)	NS
Tapered or discontinued on IABP				
36 hours before operation	7/55 (13%)	1/33 (3%)	6/22 (27%)	NS
Cardiac enlargement	0/16 (0%)	0/6 (0%)	0/10 (0%)	NS
Mitral regurgitation	0/6 (0%)	0/2 (0%)	0/4 (0%)	NS
Abnormal segmental wall motion	6/53 (11%)	1/25 (4%)	5/28 (18%)	NS
Ejection fraction				
≥ 0.60	7/39 (18%)	1/14 (7%)	6/25 (24%)	NS
< 0.60	5/36 (14%)	0/15 (0%)	5/21 (24%)	NS
LVEDP				
≤ 12	6/31 (19%)	1/11 (9%)	5/20 (25%)	NS
> 12	7/53 (13%)	0/23 (0%)	7/30 (23%)	NS
Cardiopulmonary bypass time				
≤ 90 seconds	2/38 (5%)	0/13 (0%)	2/25 (8%)	NS
> 90 seconds	12/53 (23%)	1/22 (5%)	11/31 (35%)	< 0.05
Anoxia time				
0	3/27 (11%)	0/11 (0%)	3/16 (19%)	NS
0–30 seconds	4/27 (15%)	1/8 (13%)	3/19 (16%)	NS
31–60 seconds	6/30 (20%)	0/11 (0%)	6/19 (32%)	NS
> 60 seconds	1/7 (14%)	0/5 (0%)	1/2 (50%)	NS
Vessels diseased				
LMCA (RCA normal)	1/14 (7%)	0/2 (0%)	1/12 (8%)	NS
LMCA + RCA	13/77 (17%)	1/33 (3%)	12/44 (27%)	< 0.05
Number of grafts performed				
1	0/1 (0%)	—	0/1 (0%)	NS
2	5/26 (19%)	1/4 (25%)	4/22 (18%)	NS
3	7/56 (12%)	0/26 (0%)	7/30 (23%)	< 0.05
≥ 4	2/7 (29%)	0/4 (0%)	2/3 (67%)	NS
Diseased vessels not grafted				
All grafted	9/61 (15%)	0/24 (0%)	9/37 (24%)	< 0.05
One diseased vessel not grafted	5/30 (17%)	1/11 (9%)	4/19 (21%)	NS
Specifically: LAD	1/2 (50%)	0/1 (0%)	1/1 (100%)	NS
LCF	3/21 (14%)	1/6 (17%)	2/15 (13%)	NS
RCA	1/7 (14%)	0/4 (0%)	1/3 (33%)	NS
Location of infarcts:				
Anterior	1	0	1	
Lateral	3	1	2	
Posterior	3	0	3	
Inferior	7	0	7	

LAD, left anterior descending; LCF, circumflex coronary artery; LMCA, left main coronary artery; LVEDP, left ventricular end-diastolic pressure; RCA, right coronary artery.

with only 5 per cent of those with cardiopulmonary bypass times of less than 90 minutes. Twenty-nine per cent of patients receiving four or more grafts infarcted compared with 12 per cent with less than four grafts.

In the intra-aortic balloon pump group (group A) only one patient infarcted (1/35, 3%) perioperatively

compared with 13 in the group not receiving the balloon pump (13/56, 23%), $p < 0.05$. We ran a similar analysis of reported risk factors for perioperative myocardial infarction against the results in each group. As with the total population, both groups showed an association of perioperative myocardial infarction with cardiopulmonary bypass

times of greater than 90 minutes ($p < 0.05$). In group B, more than three grafts performed was a suggested risk for perioperative myocardial infarction (67% vs 23%, $p < 0.05$) as was the presence of triple vessel disease (27% vs 8%, $p < 0.05$).

Statistical analysis of the interdependence of risk factors was performed to determine if any combination was additive. Table 5 displays data showing an additive effect for the combination of triple vessel disease and not using the intra-aortic balloon pump and for the combination of cardiopulmonary bypass times longer than 90 minutes and not using the intra-aortic balloon pump. The incidence of perioperative myocardial infarction in triple vessel disease and not using the intra-aortic balloon pump was 27 per cent while the absence of triple vessel disease and using the balloon yielded a nil infarction rate ($p < 0.05$). Similarly, perioperative myocardial infarction was seen in 35 per cent of patients with prolonged cardiopulmonary bypass times not using the intra-aortic balloon pump compared with none with shorter cardiopulmonary bypass times using the balloon ($p < 0.05$). Other combinations of risk factors did not show a significant additive relation to perioperative myocardial infarction.

The overall mortality in this operated series in patients with left main coronary stenoses was 8.7 per cent (8/91). The mortality of perioperative myocardial infarction in this study was 36 per cent (5/14) while patients not sustaining a myocardial infarction had an operative mortality of 3.9 per cent (3/77). Of the three patients who died in the non-infarcted population, one was in group A and two were in group B. All three patients died as a result of left ventricular failure but there was no evidence of perioperative myocardial infarction either by electrocardiographic criteria or by necropsy.

In addition to the 35 successful preoperative insertions of the intra-aortic balloon pump there were four unsuccessful attempts and nine successful intra- or postoperative placements. In three of the unsuccessful attempts the intra-aortic balloon pump could not be advanced beyond the bifurcation

of the abdominal aorta and was withdrawn without complication. The fourth led to an aortic dissection that healed without surgical intervention. There were two postoperative groin infections, and no cases of arterial insufficiency. The overall complication rate was 6 per cent, 3/48 (Table 6).

Discussion

In this study we report on 91 consecutive patients with left main coronary artery disease undergoing bypass surgery. Thirty-five patients received the intra-aortic balloon pump preoperatively and 56 did not. Statistically significant differences between the two groups among 26 demographic, clinical, haemodynamic, and operative descriptors were found only in the severity of angina pectoris, pattern of angina pectoris, and presurgical use of beta-blockers. These three indices outlined the group receiving the intra-aortic balloon pump as consisting of a higher percentage of patients with more severe anginal symptoms.

Perioperative myocardial infarction occurred in 15 per cent of the overall sample using very stringent Q wave electrocardiographic criteria. This is comparable to previously reported series in which the incidence of perioperative myocardial infarction ranged from 10.7 to 37.5 per cent.^{6 19 20} It is likely that this report underestimates the true incidence of perioperative myocardial infarction, since the rigid electrocardiographic criteria employed exclude a significant number of patients with possible, but less striking evidence of myocardial necrosis. In particular, patients sustaining non-transmural myocardial damage would probably be excluded by our criteria, as well as those sustaining transmural lesions in such sites that electrocardiographic changes were obscured by previous infarctions. Furthermore, while transient or permanent intraventricular conduction abnormalities might suggest myocardial damage, we did not consider these changes conclusive evidence for infarction. The use of serial serum enzyme determinations was

Table 5 Perioperative myocardial infarction

	Patients with IABP	Patients without IABP	p value
Vessels diseased			
LMCA only	0/2 (0%)	1/12 (8%)	NS
LMCA + RCA	1/33 (3%)	12/44 (27%)	< 0.05
CPB time			
≤ 90 seconds	0/13 (0%)	2/25 (8%)	NS
> 90 seconds	1/22 (5%)	11/31 (35%)	< 0.05

CPB, cardiopulmonary bypass time; IABP, intra-aortic balloon pump; LMCA, left main coronary artery; RCA, right coronary artery.

Table 6 Complications of intra-aortic balloon placement or attempted placement

Intra-aortic balloon pump insertion	
Before operation	35—Group A
During or after operation	9 Group B
Unsuccessful attempts	4
Total	48
Complications	
Infection (groin or sepsis)	2/48 (4%)
Aortic dissection	1/48 (2%)
Arterial insufficiency	0/48 (0%)
Overall	3/48 (6%)

felt to be an unreliable method for determining perioperative infarction, as serum CK and AST levels are raised during surgery by musculoskeletal trauma,²¹ and CK-MB isoenzyme measurements have been shown to overestimate the incidence of perioperative myocardial infarction after bypass surgery.²²

No correlation was found between infarction and preoperative clinical presentation, haemodynamic factors such as raised LVEDP or abnormal ejection fraction, abnormalities of contraction, or correlation to additional disease of the right coronary artery. There was also no association with incomplete revascularisation or time of aortic cross-clamping. A significant association of perioperative myocardial infarction was found in patients with prolonged cardiopulmonary bypass times and suggested for more than three grafts performed. However, it is difficult to draw conclusions regarding the importance of multiple grafts, because of the few patients in our series having more than three grafts. Several investigators have found bypass time and number of grafts performed to be related to the frequency of perioperative myocardial infarction.^{8 19 23} We recognise, however, that cardiopulmonary bypass times of longer than 90 minutes are frequently associated with technically difficult anastomoses between the graft and extensively diseased vessels. Our series differed from the results of Brewer *et al.*¹⁹ but concurred with others^{8 23} in that severity and pattern of anginal pain were not related to the frequency of perioperative myocardial infarction in the overall group. We also found no correlation of perioperative myocardial infarction to the number of diseased vessels or to incomplete revascularisation, in contrast to previous reports.^{19 20} We feel that some of these differences may well be related to the beneficial effects of the intra-aortic balloon pump as analysis of patients without the pump suggests more parallels to previously reported results.

While group A (intra-aortic balloon pump) had a greater proportion of patients with more severe clinical presentation, we found this group to have a significantly lower incidence of perioperative myocardial infarction than group B (3% vs 23%, $p < 0.05$). Feola and colleagues reported a similar reduction in incidence of perioperative myocardial infarction using the intra-aortic balloon pump before bypass surgery in patients with poor left ventricular function.¹⁰ They found a 30.4 per cent perioperative myocardial infarction rate in the group not assisted with preoperative counterpulsation and only 4 per cent in the assisted group.

Statistical analysis of combinations of risk factors for patients with left main disease showed a

significantly additive risk for perioperative myocardial infarction when the intra-aortic balloon pump was not used in the presence of disease of the right coronary artery. A similar additive risk was seen when the pump was not used and the cardiopulmonary bypass time prolonged.

The mortality of myocardial infarction was 36 per cent in this series, while patients not sustaining perioperative infarction had a mortality of 3.9 per cent. This high rate shows the malignant nature of infarction for patients with left main disease and is in accord with recent reports.²³⁻²⁵

Of 48 attempts at introduction of an intra-aortic balloon pump there were three complications: one aortic dissection that healed without operation and two groin infections. No patient in the intra-aortic balloon pump group suffered peripheral vascular disease as a result of this procedure. This is comparable with the experience of several investigators who have reported a 0 to 17 per cent overall complication rate and a 0 to 15 per cent rate of arterial insufficiency after balloon placement.²⁶⁻²⁹

Our results suggest that the risk of perioperative infarction can be reduced by the preoperative institution of intra-aortic balloon counterpulsation in patients with left main disease undergoing bypass surgery. Even in the clinical setting of mild symptoms and normal or near normal haemodynamics, the perioperative infarction rate is high, and careful preoperative intra-aortic balloon pump introduction can be of significant benefit.

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Requests for reprints to Dr Rene A Langou, Yale University School of Medicine, Cardiology Section, 87 LMP, 333 Cedar Street, New Haven, Connecticut 06510, USA.