A Prospective, Randomized Evaluation of Prophylactic Intraaortic Balloon Counterpulsation in High Risk Patients With Acute Myocardial Infarction Treated With Primary Angioplasty

GREGG W. STONE, MD, FACC, DOMINIC MARSALESE, MD,* BRUCE R. BRODIE, MD, FACC,† JOHN J. GRIFFIN, MD, FACC,‡ BRYAN DONOHUE, MD, FACC,§ COSTANTINO COSTANTINI, MD,|| CARLOS BALESTRINI, MD,¶ THOMAS WHARTON, MD, FACC,# PAOLO ESENTE, MD, FACC,** MICHAEL SPAIN, MD, FACC,†† JEFFREY MOSES, MD, FACC,‡‡ MASAKIYO NOBUYOSHI, MD,§§ MIKE AYRES, MD, FACC,|| || DENISE JONES, RN, BSN,* DENISE MASON, RN, BSN,* LORELEI GRINES, PhD,* WILLIAM W. O'NEILL, MD, FACC,* CINDY L. GRINES, MD, FACC,* ON BEHALF OF THE SECOND PRIMARY ANGIOPLASTY IN MYOCARDIAL INFARCTION (PAMI-II) TRIAL INVESTIGATORS¶¶

Objectives. **A large, international, multicenter, prospective, randomized trial was performed to determine the role of prophylactic intraaortic balloon pump (IABP) counterpulsation after primary percutaneous transluminal coronary angioplasty (PTCA) in acute myocardial infarction (AMI).**

Background. **Previous studies have suggested that routine IABP use after primary PTCA reduces infarct-related artery reocclusion, augments myocardial recovery and improves clinical outcomes.**

Methods. **Cardiac catheterization was performed in 1,100 patients within 12 h of onset of AMI at 34 clinical centers. Clinical and angiographic variables were used to stratify patients undergoing primary PTCA into high and low risk groups. High risk patients were then randomized to 36 to 48 h of IABP (n = 211) or traditional care (n = 226). The study had 80% power to detect a reduction in the primary end point from 30% to 20%.**

Results. **There was no significant difference in the predefined primary combined end point of death, reinfarction, infarct-related artery reocclusion, stroke or new-onset heart failure or sustained hypotension in patients treated with an IABP versus those treated conservatively (28.9% vs. 29.2%, p = 0.95). The IABP strategy conferred modest benefits in reduction of recurrent ischemia (13.3% vs. 19.6%, p = 0.08) and subsequent unscheduled repeat catheterization (7.6% vs. 13.3%, p = 0.05) but did not reduce the rate of infarct-related artery reocclusion (6.7% vs. 5.5%, p = 0.64), reinfarction (6.2% vs. 8.0%, p = 0.46) or mortality (4.3% vs. 3.1%) and was associated with a higher incidence of stroke (2.4% vs. 0%, p = 0.03). IABP use did not result in enhanced myocardial recovery as assessed by paired admission to predischarge and 6-week rest and exercise left ventricular ejection fraction.**

Conclusions. **In contrast to previous studies, a prophylactic IABP strategy after primary PTCA in hemodynamically stable high risk patients with AMI does not decrease the rates of infarct-related artery reocclusion or reinfarction, promote myocardial recovery or improve overall clinical outcome.**

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With the publication of randomized trials demonstrating that primary percutaneous transluminal coronary angioplasty (PTCA) results in improved patency rates and clinical outcomes compared with thrombolytic therapy (1–5), PTCA has been established as a superior method for the early reperfusion of patients with an acute myocardial infarction (AMI) at experienced centers. However, patients with adverse high risk features continue to have excessive morbidity and mortality, especially in the first 48 h after symptom onset, despite effective reperfusion therapy (5–14). Previous studies (15–18) have suggested that the routine use of intraaortic balloon pump (IABP) counterpulsation after PTCA in AMI may reduce the rate of infarct-related artery reocclusion, augment

From the Division of Cardiology, El Camino Hospital, Mountain View, California; *Division of Cardiology, William Beaumont Hospital, Royal Oak, Michigan; †Division of Cardiology, Moses Cone Hospital, Greensboro, North Carolina; ‡Division of Cardiology, Virginia Beach General Hospital, Virginia Beach, Virginia; §Division of Cardiology, Allegheny General Hospital, Pittsburgh, Pennsylvania; ||Division of Cardiology, Hospital Santa Case de Misericordia, Curitiba, Brazil; ¶Division of Cardiology, Instituto Modelo de Cardiologia, Cordoba, Argentina; #Division of Cardiology, Exeter and Portsmount Regional Hospitals, Exeter, New Hampshire; **Division of Cardiology, St. Joseph's Hospital, Syracuse, New York; ††Division of Cardiology, St. Francis Hospital, Tulsa, Oklahoma; ‡‡Division of Cardiology, Lenox Hill Hospital, New York City, New York; §§Division of Cardiology, Kokura Memorial Hospital, Kitakyushu, Japan; || ||Division of Cardiology, Fort Sanders Regional Medical Center, Knoxville, Tennessee. ¶¶A complete list of participating investigators and institutions for the PAMI-II trial appears in the Appendix. Funding for this study was provided in part by unrestricted grants from Advanced Cardiovascular Systems, Inc., Santa Clara, California; Mallinkrodt Medical, Inc., Saint Louis, Missouri; Datascope Corporation, Montvale, New Jersey; St. Jude Medical, Chelmsford, Massachusetts; and Siemens Corporation, Iselin, New Jersey.

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Address for correspondence: Dr. Gregg W. Stone, The Cardiovascular Institute, 2660 Grant Road, Mountain View, California 94040.

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Abbreviations and Acronyms

AMI	=	acute myocardial infarction
CABG	=	coronary artery bypass graft surgery
CK-MB	=	creatine kinase, MB fraction
ECG	=	electrocardiographic
IABP	=	intraaortic balloon pump
LVEF	=	left ventricular ejection fraction
PAMI	=	Primary Angioplasty in Myocardial Infarction
PTCA	=	percutaneous transluminal coronary angioplasty
TIMI	=	Thrombolysis in Myocardial Infarction

myocardial recovery and improve clinical outcomes, with an acceptable safety profile. Such a strategy would be expected to be most effective in high risk patients with AMI.

We hypothesized that in patients with AMI undergoing acute cardiac catheterization, readily available clinical and angiographic variables could prospectively be used to stratify patients into groups at high and low risk for early morbidity and mortality and that high risk patients, so identified, might benefit from a routine IABP strategy after primary PTCA.

Methods

Clinical centers and patients. A total of 34 institutions in North and South America, Europe and Japan participated in the Primary Angioplasty in Myocardial Infarction (PAMI)-II trial. Study sites were diverse and included academic and community hospitals in urban and rural settings, with a wide range in annual total PTCA volume for the hospitals (60 to 3,318/year) and individual operators (22 to 507/year).

Patients were enrolled with ongoing chest pain up to 12 h in duration, with electrocardiographic (ECG) evidence of AMI (ST segment elevation ≥1 mm in two contiguous leads). Patients with ST segment depression, left bundle branch block or other nondiagnostic ECG patterns were included if acute catheterization demonstrated an occluded vessel with regional left ventricular dysfunction. Exclusion criteria included cardiogenic shock; bleeding diathesis prohibiting the use of aspirin or heparin; and precatheterization administration of thrombolytic therapy. Written informed consent was obtained from all patients.

Catheterization and PTCA procedure. Patients who met enrollment criteria were treated in the emergency room with 324 mg of chewable soluble aspirin, a 5,000- to 10,000-U bolus of intravenous heparin, intravenous nitroglycerin and, in the absence of contraindications, intravenous followed by oral beta-blockade. Patients were taken emergently to the cardiac catheterization laboratory, where left ventriculography and coronary arteriography were performed. Ionic contrast agents were used to minimize the risk of thromboembolic complications (19,20). After angiography, PTCA was deferred if spontaneous reperfusion was found with an infarct stenosis <70% or if a small vessel was occluded that would best be treated conservatively. Primary coronary artery bypass graft surgery was recommended rather than PTCA for patients with unprotected left main stenosis >60%, severe triple-vessel disease with a patent infarct-related vessel or features unfavorable for PTCA. Before PTCA, additional heparin was given to maintain the activated clotting time (Hemochron) >350 s. PTCA was performed in the infarct-related vessel only, with the goal of obtaining a <50% residual stenosis and restoring brisk anterograde flow. Stenting (1.3%) and atherectomy (1.2%) were rarely used during the time period of this study.

Acute risk stratification and randomization. After catheterization, patients were stratified into high and low risk groups on the basis of clinical and angiographic variables. Patients were considered to be *high risk* if one or more of the following criteria were met: age >70 years, three-vessel disease, left ventricular ejection fraction (LVEF) ≤45%, vein graft occlusion, persistent malignant ventricular arrhythmias or a suboptimal PTCA result. If none of these criteria were present, the patient was stratified as *low risk*.

Patients stratified as high risk were considered eligible for randomization unless an IABP was contraindicated because of peripheral vascular disease, aortic aneurysm or aortic valve insufficiency or if an IABP was required because of clinical or hemodynamic instability. At the completion of the PTCA procedure, high risk eligible patients were randomized to either placement of an IABP for 36 to 48 h (inserted percutaneously using the same femoral entry site that had been used for PTCA) or conservative, traditional care. Low risk patients were randomized into accelerated discharge and traditional care groups. As previously reported (21), in-hospital and postdischarge outcomes were similar in both arms of the low risk study. High risk patients not eligible for randomization were treated clinically as appropriate and followed up in a registry.

Hospital course. After catheterization, high risk patients were admitted to the coronary care unit. Intravenous heparin was maintained ≥72 h to keep the prothrombin time 1.5 to 2.0 times control levels, then tapered over 12 h to avoid a rebound hypercoagulable state (22). The heparin infusion was interrupted when appropriate to remove the femoral sheaths or IABP, or both, after which the drip was reinstituted. Per protocol, patients were treated with soluble aspirin (325 mg orally every day), intravenous nitroglycerin for 24 h and beta-blockade in the absence of contraindications. Angiotensin-converting enzyme inhibition was recommended for left ventricular dysfunction or hypertension.

In the absence of contraindications, predischarge catheterization was performed in high risk patients for assessment of infarct-related artery patency and left ventricular function. Patients were discharged when clinically stable. Six weeks after discharge, rest and exercise radionuclide ventriculography was recommended to further assess myocardial recovery.

Definitions. *Successful PTCA* was defined as a <50% residual stenosis with Thrombolysis in Myocardial Infarction (TIMI) grade 2 or 3 flow. *Reinfarction* was defined as recurrent clinical symptoms in association with any increase in creatine kinase, MB fraction (CK-MB) above its previous nadir. *Recur-*

rent ischemia was defined as clinical symptoms associated with either new ECG ST segment or T wave changes, hypotension, new murmur, CK-MB elevation or necessity for urgent repeat PTCA or coronary artery bypass graft surgery (CABG). *Congestive heart failure* was defined as Killip class 2 to 4 heart failure. *Sustained hypotension* was defined as systolic blood pressure <90 mm Hg for >30 min or requiring intravenous vasopressors.

Data collection and statistical analysis. Clinical data were collected prospectively at each site by a research nurse. For quality control, an independent study monitor traveled to each site to cross reference case report forms and medical records. After confirmation, data were entered into a computerized data base. Independent core laboratory angiographic analysis was performed by a technician in blinded manner with regard to the randomization scheme. *Residual stenosis* was determined by electronic calipers and TIMI flow grades by visual assessment (23). Global LVEF was calculated by the area–length method (24), and regional wall motion was determined by the centerline chord method (25).

The *primary end point* in high risk patients was prespecified as the combined incidence of in-hospital death, reinfarction, infarct-related artery reocclusion, stroke or postadmission new onset congestive heart failure or sustained hypotension. The study was powered such that for 310 high risk patients enrolled and randomized, it would be able to detect a two-tailed reduction in the primary end point from 35% to 20% with 80% likelihood at a significance level of p = 0.05, considered a clinically relevant reduction. Unless otherwise stated, analysis was made on an intention to treat basis. Categoric variables were compared by chi-square analysis or Fisher exact test. Continuous variables are presented as mean value ± SD and were compared by Student *t* test or Mann-Whitney *U* test. All p values are two-tailed. An independent Data and Safety Monitoring Board reviewed the interim results after 400 and 800 patients were enrolled and recommended that the study continue.

Results

Patient enrollment and baseline features. Between September 1993 and January 1995, acute angiography was performed in 1,100 patients with an AMI at 34 clinical centers, 982 of whom (89%) underwent primary PTCA. After clinical, hemodynamic and angiographic assessment, 908 patients were considered eligible for randomization, whereas 192 patients were followed up in the registry. After PTCA, randomizable patients were risk stratified into high risk (n = 437) and low risk groups (n = 471). As seen in Table 1, among randomizable patients, the risk-stratification process identified a cohort of patients with significantly increased rates of in-hospital death, reinfarction, recurrent ischemia, new onset of heart failure or sustained hypotension, need for CABG and prolonged hospital stay.

High risk patients were subsequently randomized to receive an IABP for 36 to 48 h (n = 211) versus conservative care (no IABP, n = 226). There were no significant differences in the rates of high risk qualifying features, baseline demographic and angiographic characteristics or outcome of primary PTCA between high risk patients randomized to IABP versus conservative care (Table 2).

Table 1. In-Hospital Outcomes of 908 Randomized Patients Risk Stratified Into High Risk and Low Risk Groups

	High Risk Group (n = 437)	Low Risk Group (n = 471)	p Value
Death (%)	3.7	0.4	0.0002
Reinfarction (%)	7.1	2.8	0.001
Recurrent ischemia (%)	16.5	7.6	< 0.0001
Stroke (%)	1.1	0.9	0.75
Postadmission new-onset HF or hypotension (%)	21.5	5.3	< 0.0001
CABG (%)	11.2	1.9	< 0.0001
Length of hospital stay (days)	10.3 ± 7.9	5.6 ± 4.0	< 0.0001

Data presented are mean value ± SD or percent of patients. CABG = coronary artery bypass graft surgery; HF = heart failure.

Randomization and protocol compliance. After PTCA, IABP counterpulsation was established in 182 (86.3%) of 211 patients randomized to an IABP. In 29 patients, an IABP was not placed because of peripheral vascular disease (n = 8), IABP malfunction (n = 8), IABP unavailability (n = 3), patient refusal (n = 3), physician preference (n = 3) or other (n = 4). In patients in whom the device was placed, the mean (±SD) duration of IABP counterpulsation was 47.9 ± 28.0 h. In 26 (11.5%) of 226 patients assigned to conservative treatment, an IABP was required for hemodynamic instability (n = 18), persistent ischemia (n = 7), abrupt vessel reocclusion (n = 3) or severe dissection or thrombosis (n = 3).

Predischarge repeat catheterization was completed in 330 (85%) of 389 eligible patients, including 165 randomized to an IABP and 165 assigned to conservative treatment. Forty-eight patients were ineligible for the predischarge study because of death (n = 16), CABG (n = 21) or major illness or contraindications to repeat angiography, including renal impairment, stroke or confusion (n = 11).

In-hospital outcome. As seen in Figure 1, when the 437 randomized high risk patients in an intention to treat analysis were considered, there were no significant differences in major clinical adverse events or occurrence of the predefined primary end point in patients assigned to a prophylactic IABP strategy versus traditional care, except for a slightly higher incidence of stroke in patients assigned to IABP. The findings were similar when only the 382 randomized patients who actually received the assigned treatment were considered. Secondary clinical end points are shown in Table 3, and also did not vary between the two groups, except for a somewhat lower incidence of persistent chest pain and recurrent ischemia in patients randomized to IABP, with an associated reduction in the necessity for unscheduled predischarge catheterization.

Vascular and bleeding complications (Table 4). Hemorrhagic complications were more frequent in patients assigned to routine IABP usage, primarily because of an increased

Table 2. Baseline Demographic and Angiographic Characteristics and Coronary Angioplasty Outcomes in 437 High Risk Patients Randomized to Intraaortic Balloon Counterpulsation Versus Conservative Care

	IABP (n = 211)	No IABP (n = 226)	p Value
Demographic features			
Age (yr)	64.7 ± 11.9	63.7 ± 13.0	0.69
Female gender (%)	25.1	24.8	0.93
Hypertension (%)	54.8	55.7	0.86
Hypercholesterolemia (%)	37.2	35.9	0.78
Diabetes mellitus (%)	21.3	14.6	0.07
Current cigarette smoking (%)	33.5	30.8	0.55
Prior peripheral vascular disease (%)	5.0	3.2	0.34
Prior MI (%)	21.4	21.7	0.94
Prior CABG (%)	7.5	5.9	0.52
Prior CHF (%)	3.5	3.2	0.86
Admission Killip class ≥2 (%)	21.7	22.2	0.95
Admission HR (beats/min)	79 ± 17	81 ± 36	0.51
Admission SBP (mm Hg)	130 ± 26	129 ± 25	0.52
Time from symptom onset to hospital arrival (min)	149 ± 139	146 ± 140	0.83
Time from symptom onset to angiography (min)	262 ± 167	257 ± 154	0.54
Angiographic features (%)			
1 VD (%)	43.6	51.8	
2 VD (%)	24.2	20.8	0.23
3 VD (%)	32.2	27.4	
Acute LVEF (%)	49.4 ± 12.5	50.1 ± 11.3	0.58
IRA			
LAD (%)	52.3	49.8	
LCx (%)	11.3	10.1	0.67
RCA (%)	36.4	40.1	
Initial infarct lesion stenosis (%)	96 ± 8	97 ± 7	0.47
Initial TIMI flow grade 0–1	80.6	81.1	0.89
High risk qualifying features			
Age >70 yr	35.6	39.4	0.41
LVEF ≤45%	58.6	51.8	0.16
3 VD	32.2	27.4	0.29
Saphenous vein graft angioplasty	4.3	3.6	0.70
Refractory ventricular arrhythmias	7.1	6.8	0.86
Suboptimal angioplasty result	13.3	14.2	0.77
Outcome of primary PTCA			
Post-PTCA infarct lesion stenosis (%)	29 ± 14	29 ± 14	0.93
PTCA successful (%)	97.3	96.2	0.55
TIMI grade 3 flow restored (%)	92.6	91.2	0.78

Data presented are mean value ± SD or percent of patients. CABG = coronary artery bypass graft surgery; CHF = congestive heart failure; HR = heart rate; IABP = intraaortic balloon pump counterpulsation; IRA = infarct-related artery; LAD = left anterior descending coronary artery; LCx = left circumflex coronary artery; LVEF = left ventricular ejection fraction; PTCA = percutaneous transluminal coronary angioplasty; RCA = right coronary artery; SBP = systolic blood pressure; TIMI = Thrombolysis in Myocardial Infarction; VD = vessel disease.

incidence of access site bleeding. However, there was no difference in the rate of blood transfusion or fall in hematocrit during the hospital period. Similarly, major vascular complications occurred rarely and were not increased by the IABP strategy.

Myocardial salvage. Paired acute and predischarge left ventriculography was available for 217 patients. In patients randomized to IABP, LVEF rose from 47.2% ± 9.7% during the acute infarction study to 49.8% ± 9.1% during predischarge catheterization (p = 0.002). In patients treated conservatively, LVEF rose from 48.5% ± 11.2% to 50.7% ± 9.8%, respectively (p = 0.02). As shown in Figure 2, there were no significant differences in the improvement in global LVEF and infarct zone regional wall motion between patients randomized to IABP versus conservative care.

Radionuclide ventriculography was performed 6 weeks after hospital discharge in 183 patients. No significant treatment-related differences were present in either rest or exercise LVEF (Figure 3).

Outcomes of high risk randomized versus registry patients. Among the 192 nonrandomized patients followed up in the registry, 144 (75%) would have met criteria for high risk. The reasons for no randomization of these patients are shown in Table 5. Compared with high risk randomized patients, high risk registry patients had a lower mean acute LVEF (44% ± 15% vs. 50% ± 12%, p < 0.0001), were more likely to have triple-vessel disease (51.4% vs. 29.8%) and to require in-hospital CABG (43.1% vs. 11.2%, p < 0.0001); they also had a higher in-hospital mortality rate (9.0% vs. 3.7%, p = 0.02). PTCA was performed in 66 high risk registry patients (45%), 9 of whom (13.6%) died. An IABP was clinically required in 58 high risk registry patients (40%) (in the catheterization laboratory in 33 patients and later in the hospital course in 25 patients). As seen in Table 6, in-hospital outcomes in high risk registry patients who clinically required an IABP were significantly worse than in those who were able to be managed conservatively.

Discussion

IABP counterpulsation after primary PTCA—results of previous studies. Reocclusion of the infarct-related artery has been documented in 8% to 20% of patients after successful primary PTCA for AMI and results in blunted myocardial recovery (26–29). Approximately 50% of infarct-related artery reocclusions result in clinical reinfarction (29,30), which is the second most common cause of death after successful reperfusion (31). Adjunctive pharmacologic and mechanical strategies have therefore been sought to prevent infarct-related artery reocclusion after successful reperfusion.

Experimental and clinical studies with IABP counterpulsation in patients with AMI and after PTCA have demonstrated augmented proximal coronary blood flow velocity (32–34), suggesting that infarct-related artery reocclusion may be reduced by IABP use after mechanical reperfusion in AMI. Furthermore, the beneficial hemodynamic effects of IABP counterpulsation in reducing preload and afterload may also promote ventricular recovery after AMI (35). Ishihara et al. (15) studied the outcomes of 114 patients with AMI undergoing PTCA with or without antecedent thrombolytic therapy in two consecutive time periods. Compared with 66 patients

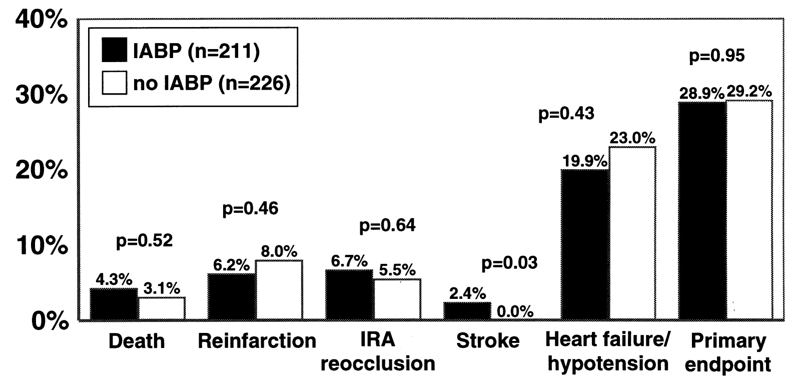

Figure 1. In-hospital major adverse outcomes in 437 high risk patients with AMI randomized to prophylactic IABP counterpulsation versus conservative care after reperfusion by primary PTCA. IRA = infarct-related artery. Heart failure/hypotension = new onset of post-admission congestive heart failure or sustained hypotension.

treated with conventional therapy, patients who received an IABP for 25 ± 8 h after reperfusion had a lower rate of infarct-related artery reocclusion (2% vs. 18%, $p = 0.03$) and reinfarction (0% vs. 7%, $p = 0.04$) and greater improvement in serial LVEF (9.2 ± 13.0% vs. 4.5 ± 12.2%, $p = 0.08$).

Ohman et al. (16), in a retrospective analysis of four thrombolytic trials, found that the rate of infarct-related artery reocclusion was reduced, and recovery of noninfarct zone regional wall motion was enhanced in patients nonrandomly treated with IABP counterpulsation for clinical deterioration. On the basis of these observations, a randomized, multicenter trial was performed in which 182 patients within 24 h onset of AMI who achieved successful reperfusion by either primary PTCA, rescue PTCA after failed thrombolysis on intracoronary thrombolysis or who had documented triple-vessel disease with a patent infarct-related vessel were randomized to 48 h of IABP counterpulsation or traditional care (17). Patients randomized to IABP had a lower rate of infarct-related artery reocclusion (8% vs. 21%, $p < 0.03$), recurrent ischemia (4% vs. 21%, $p = 0.001$) and emergency PTCA (2% vs. 11%, $p < 0.02$). The reduction in infarct-related artery reocclusion afforded by IABP counterpulsation was particularly pronounced in the subgroup of patients undergoing primary PTCA without antecedent thrombolysis (4% vs. 18%).

Table 3. Secondary In-Hospital Outcomes in 437 Randomized High Risk Patients

	IABP (n = 211)	No IABP (n = 226)	p Value
Persistent/recurrent chest pain and ischemic end points			
Persistent postangioplasty chest pain (%)	3.3	7.5	0.05
Recurrent chest pain w/o ECG changes (%)	10.4	15.0	0.15
True recurrent ischemia (%)	13.3	19.6	0.08
Nonprotocol predischarge cath (%)	7.6	13.3	0.05
Nonprotocol predischarge IRA PTCA (%)	4.7	4.0	0.70
Hemodynamic end points			
CHF (%)	17.5	19.5	0.60
Pulmonary edema (%)	6.6	9.3	0.31
Transient hypotension (%)	4.7	8.9	0.09
Sustained hypotension (%)	7.1	8.9	0.50
Vasopressor use (%)	22.0	25.1	0.54
Cerebrovascular end points			
Hemorrhagic stroke (%)	1.0	0	0.23
Nonhemorrhagic stroke (%)	1.4	0	0.11
TIA (%)	0.5	0	0.48
Arrhythmic end points			
VT (%)	5.2	5.3	0.96
VF (%)	1.4	2.7	0.51
Symptomatic bradyarrhythmias (%)	5.7	4.4	0.55
Other end points			
Intubation (%)	8.1	5.3	0.25
Dialysis (%)	1.9	0.4	0.20
CABG (%)	11.9	10.7	0.70
Hospital days	10.5 ± 7.4	10.0 ± 8.3	0.50

Data presented are mean value or percent of patients. cath = catheterization; ECG = electrocardiographic; TIA = transient ischemic attack; VF = ventricular fibrillation; VT = ventricular tachycardia; other abbreviations as in Table 2.

Table 4. Vascular and Hemorrhagic Complications in the Study Cohort

	IABP (n = 211)	no IABP (n = 226)	p Value
Any hemorrhagic complication (%)	36.0	27.4	0.05
Access site hemorrhage (%)	20.9	13.3	0.03
Retroperitoneal hemorrhage (%)	1.0	0.9	1.0
Gastrointestinal hemorrhage (%)	6.6	5.3	0.56
Genitourinary tract hemorrhage (%)	3.8	6.6	0.18
Cerebrovascular hemorrhage (%)	1.0	0	0.23
Postoperative hemorrhage (%)	7.6	4.9	0.24
Undetermined source (%)	6.2	7.6	0.56
Other (%)	2.4	3.5	0.64
Fall in hct (from admission to nadir) (%)	10.7 ± 6.4	10.2 ± 7.1	0.30
Any blood transfusion (%)	19.9	17.7	0.56
From access site or retroperitoneal bleed (%)	4.7	2.6	0.18
Loss of peripheral pulse (%)	0	0.9	0.50
Pseudoaneurysm or arteriovenous fistula (%)	1.4	1.3	1.0
Deep venous thrombosis (%)	0	1.3	0.25
Sepsis (%)	0.9	0.9	1.0
Vascular surgical repair (%)	0.5	0.4	1.0

Data presented are mean value ± SD or percent of patients. hct = hematocrit; IABP = intraaortic balloon pump counterpulsation.

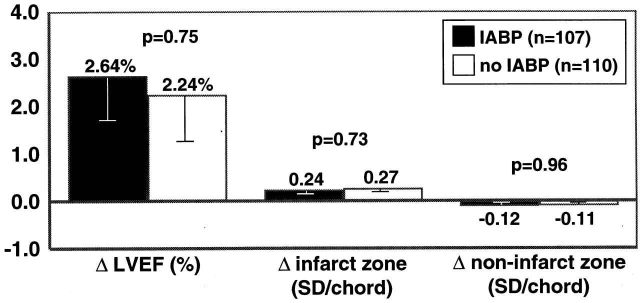

Figure 2. Change in global LVEF, infarct zone regional wall motion and non–infarct zone regional wall motion in patients with paired left ventriculographic studies from admission to predischarge. Results presented are group mean values with standard error bars. A positive value represents improvement in variable from admission to discharge.

Table 5. Reasons for Excluding 144 High Risk Patients From Randomization

Primary PTCA not performed after acute angiography	79 (55%)
CABG planned for LMCA or 3 VD or anatomy unsuitable for PTCA	50
Spontaneous reperfusion with <70% IRA stenosis	19
Large thrombus treated only with intracoronary thrombolysis	5
IRA supplied a small amount of myocardium, left occluded	3
Other	2
IABP required for development of hypotension, shock, acute occlusion or severe dissection after PTCA	33 (23%)
Physician preference	10 (7%)
Peripheral vascular disease or abdominal aortic aneurysm identified contraindicating IABP	8 (6%)
IABP required after failed PTCA before CABG	5 (3%)
Not sure of culprit lesion	2 (1%)
Other	7 (5%)

Data presented are number (%) of patients. LMCA = left main coronary artery; other abbreviations as in Table 2.

The present study. In this trial, clinical and angiographic variables readily obtainable at the time of acute cardiac catheterization were able to prospectively identify patients with an AMI at markedly increased risk for in-hospital mortality, reinfarction, recurrent ischemia, heart failure and hypotension despite effective reperfusion. As previously reported (36), even after all clinical determinants by multivariate analysis were accounted for, the catheterization-derived variables of reduced LVEF, three-vessel disease or failed reperfusion predicted patients with a 3.8-fold increased mortality. The ability to prognostically stratify patients after primary PTCA while still in the cardiac catheterization laboratory is potentially a major advantage of the invasive approach; high risk patients so identified may benefit from adjunctive pharmacologic or mechanical strategies, whereas low risk patients may be safely treated with accelerated discharge (21).

Unfortunately, in contrast to the favorable effects of IABP counterpulsation found in the earlier trials, in the present larger study, the routine use of an IABP for 36 to 48 h after primary PTCA in high risk but hemodynamically stable patients had no significant beneficial effects on preventing infarct-related artery reocclusion or reinfarction or on promoting myocardial recovery either in the infarct zone or noninfarct zone. Modest benefits were seen with the IABP in reducing recurrent ischemia and the subsequent need for urgent repeat catheterization. However, with appropriate management of these events, survival free of reinfarction and late ventricular function were similar in both groups. Furthermore, a statistically significant increase in stroke was present in patients treated with an IABP. This finding may have been due to chance: One stroke was embolic after new-onset atrial fibrillation; one occurred after prolonged hypotension and intubation; one occurred postoperatively; and one, in retrospect, was present on admission; one intracranial hemorrhage developed after a postinfarction patient was hit in the head with a shovel while robbing the hospital nursery. Nonetheless, the possibility that the presence of the large-caliber pulsatile IABP in the vasculature for 48 h contributed to the increased stroke rate cannot totally be disregarded.

The lack of benefit of the IABP strategy in the present trial cannot be attributed to poor outcomes in the IABP arm. Given the high percentage of elderly patients with left ventricular dysfunction comprising the high risk population, the rates of mortality (4.3%), reinfarction (6.2%) and infarct-related artery reocclusion (6.7%) are favorable. Furthermore, the routine use of the IABP for 48 h did not result in an excessive rate of major complications attributable to the device. In contrast to the high incidence of adverse events when IABP counterpul-

Figure 3. Rest and exercise LVEF measured by radionuclide ventriculography 6 weeks after hospital discharge. Format as in Figure 2.

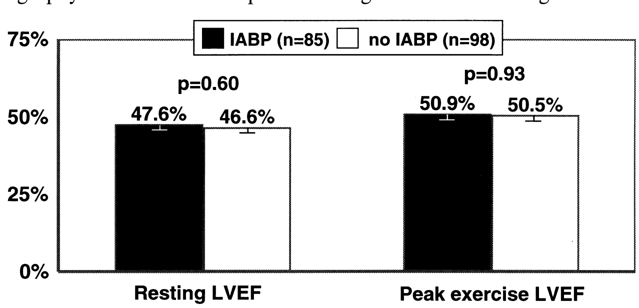

Table 6. Selected Outcomes in High Risk Registry Patients Stratified by Requirement for Intraaortic Balloon Counterpulsation

	IABP Required (n = 58)	IABP Not Required (n = 86)	p Value
Death (%)	15.5	4.7	0.03
Reinfarction (%)	5.2	2.3	0.39
Recurrent ischemia (%)	19.0	7.8	0.03
Hypotension or CHF (%)	70.7	3.5	< 0.0001
CABG (%)	51.7	37.2	0.08
Hospital days	11.4 ± 7.6	7.5 ± 3.8	< 0.0001

Data presented are mean value ± SD or percent of patients. Abbreviations as in Table 2.

sation is required for patients in shock and multisystem failure (37–39), major hemorrhagic, vascular and infectious events in the present study were rare and not increased by the IABP.

The lack of benefit of routine IABP use in PAMI-II compared with previous studies also cannot be attributed to a lower risk cohort being enrolled in the present study. Compared with the previous reports (15,17), patients in the present study were older, more likely to have triple-vessel disease and had similar left ventricular function. Indeed, the risk-stratification process identified a high risk cohort for randomization with a ninefold increased mortality rate compared with that for the nonenrolled low risk patients. Although patients who developed shock, refractory heart failure or severe, persistent ischemia were not randomized for ethical reasons, only 38 (3.5%) of 1,100 patients were excluded on this basis, which also was an exclusion criteria in the randomized trial by Ohman et al. (17).

The more likely explanation for the relative lack of benefit of prophylactic IABP use in the present trial is that the control group had a better than expected outcome. The in-hospital mortality rate of only 3.1% in the conservatively treated high risk patients in this trial is particularly noteworthy given that they were 4 to 8 years older than those in previous studies (15,17). Furthermore, the documented infarct-related artery reocclusion rate of 5.5% in the conservative arm of the present study is significantly lower than the 17.7% and 20.8% rates of reocclusion found in the control patients of the previous studies (15,17). Although the use of thrombolytic therapy before PTCA in a significant proportion of patients in the earlier IABP trials may have increased the rate of reocclusion in the control patients compared with use of a primary PTCA strategy (40,41), 18% of patients undergoing primary PTCA in the multicenter randomized trial also experienced reocclusion. Although speculative, other factors, such as the use of ionic contrast agents (19,20), meticulous attention to anticoagulation status (including precatheterization chewable aspirin and requiring an activated clotting time >350 s at the time of PTCA [42]), avoidance of undersized balloons to obtain the largest minimal lumen diameter possible (43–45) and perseverance until TIMI grade 3 flow was restored (achieved in 92% of patients), may underlie the improved outcome of the patients undergoing primary PTCA without IABP counterpulsation in the present study. Regardless, the equivalent rates of restoration of TIMI grade 3 flow, reinfarction and infarct-related artery reocclusion among patients treated with or without an IABP resulted in similar survival, with a commensurate degree of myocardial recovery in both groups (5,46).

Study limitations. Several potential limitations of this study should be acknowledged: 1) With 437 high risk patients randomized, the study had 80% power to detect a reduction in the primary end point from 30% to 20%. Although lesser degrees of benefit cannot be excluded, the nearly identical 29% occurrence of the primary end point in both arms suggests that major benefits or hazards of routine IABP use are unlikely to exist. 2) Because the lack of major benefit of the IABP strategy in this trial may be explained by the excellent outcomes in the control arm, the results of the present study may not apply to hospitals or operators that cannot recreate these results. However, among the large number of centers and physicians with varying skill levels who participated in PAMI-II, no major differences in outcomes were found on the basis of PTCA experience or hospital setting (47), suggesting that the results of the present study are generalizable to many institutions. 3) It remains possible, albeit presently unproved, that prophylactic IABP counterpulsation may be useful in selected settings, such as in patients with heart failure or hypotension or post-PTCA dissection. The present study also does not exclude a potential role for the IABP after rescue PTCA for failed thrombolysis, wherein reocclusion rates are known to be increased (40). There may also be a role for prophylactic IABP placement before rather than after mechanical reperfusion in selected high risk patients to prevent hemodynamic deterioration (48).

The establishment of IABP counterpulsation has proven utility and is mandatory before catheterization in patients with AMI and cardiogenic shock and is clinically useful in the broad range of high risk patients represented in the PAMI-II registry, including patients with resistant heart failure, mechanical complications of AMI, refractory infarct-related vessel reocclusion and as a bridge to operation (49). However, the 40% to 50% mortality rate of patients with shock despite PTCA and IABP counterpulsation and the adverse outcomes of shock patients without shock requiring an IABP (Table 6), emphasize the continuing need for more effective approaches for the most critically ill patients.

Appendix

Participating Institutions and Investigators for the Second Primary Angioplasty in Myocardial Infarction (PAMI-II) Study

Coordinating center: *William Beaumont Hospital, Royal Oak, Michigan*: Cindy L. Grines, MD, *Principal Investigator*, Lorelei Grines, PhD, Debra Sachs, MS, Denise Jones, RN, BSN, Mariann Graham, RN, BSN, Phyllis McKinney, Holly Jewett, Antoinette Kreis.

Clinical Centers: *William Beaumont Hospital, Royal Oak, Michigan*: Cindy L. Grines, MD, William W. O'Neill, MD, Dominic Marsalese, MD, Marc Brodsky, MD, H. Friedman, MD, V. Gangadharan, MD, L. Goldman, MD, R. Levin, MD, G. Pavlides, MD, R. Ramos, MD, R. Safian, MD, V. Savas, MD, T. Schreiber, MD, S. Ajluni, MD, S. Almany, MD, J. Boatman, MD, Denise Jones, RN, BSN, Denise Mason, RN, BSN; *El Camino Hospital, Mountain View, CA*: Gregg W. Stone, MD, Fred G. St. Goar, MD, C. Bavor, MD, R. Constantino, MD, M. Klughaupt, MD, I. Saah, MD, E. Bough, MD; *Stanford University Hospital, Stanford, California*: Stephen Osterle, MD, Gregg W. Stone, MD, Cheryl McWard, RN; *Moses H. Cone Hospital, Greensboro, North Carolina*: Bruce R. Brodie, MD, Thomas D. Stuckey, MD, Richard A. Weintraub, MD, Tracie Gregory, RN; *Virginia Beach General Hospital, Virginia Beach, Virginia*: John J. Griffin, MD, Denise R. Bondy, BA, RN; *Allegheny General Hospital, Pittsburgh, Pennsylvania*: Bryan Donohue, MD, David M. Lasorda, DO, Richard Begg, MD, Susan Petruolo, RN; *Hospital Santa Case de Misericordia, Curitiba, Brazil*: Costantino Costantini, MD, Eny Goeder, RN; *Instituto Modelo de Cardiologia, Cordoba, Argentina*: Carlos Balestrini, MD, Cesar Serra, MD, Jose Sala, MD; *Exeter and Portsmouth Regional Hospitals, Exeter and Portsmouth, New Hampshire*: Thomas P. Wharton, Jr., MD, James M. Schmitz, MD, Frank A. Fedele, MD, Nancy McNamara, RN; *St. Joseph's Hospital and Health Center, Syracuse, New York*: Paolo Esente, MD, Susan Wagner, RN; *St. Francis Hospital, Tulsa,* *Oklahoma*: Michael G. Spain, MD, Victoria Wagner, RN; *Lenox Hill Hospital, New York, New York*: Jeffrey Moses, MD, Nancy Cohen, RN; *Kokura Memorial Hospital, Kitakyushu, Japan*: Masakiyo Nobuyoshi, MD, Yoshihisa Nakagawa, MD; *Fort Sanders Regional Medical Center, Knoxville, Tennessee*: Mike Ayers, MD, Dan Slutzker, MD, Jane Souther, MD, Vicki Rhule, RN; *Mid America Heart Institute, Kansas City, Missouri*: Thomas Shimshak, MD, Geoffrey O. Hartzler, MD, Patty Eikenberry, LPN, Cheryl Dreiling, RN; *St. Vincent Hospital, Indianapolis, Indiana*: Don Rothbaum, MD, Tom Linnemeier, MD, Susan Gowen, RN; *United Hospital, Grand Forks, North Dakota*: Noah Chelliah, MD, Carolyn Gray, RN; *Hospital General "Gregorio Maranon," Madrid, Spain*: Juan Luis Delcan, MD, Jore Lopez Sandor, MD, Eulogio Garcia, MD; *Lakeland Regional Medical Center, Lakeland, Florida*: Kevin F. Browne, MD, Ronald Vlietstra, MD, Mary Telatnik, RN; *Methodist Hospital, Lubbock, Texas*: Paul Overlie, MD, Karen Davis, RN; *St. Patrick Hospital, Missoula, Montana*: W. Stan Wilson, MD, Katie MacKey, RN; *St. Joseph Medical Center/Elkhart General Hospital, South Bend, Indiana*: Donald Westhausen, Jr., MD, Dawn Edwards, MS, RN; *Guthrie Healthcare System, Sayre, Pennsylvania*: Marcus Sodums, MD, Victoria Schiefen, RN, Kamie Hoey, RN; *Providence Hospital, Portland, Oregon*: Bradley Evans, MD, Karen Rydell, RN; *Florida Hospital South, Orlando, Florida*: Russell Ivanhoe, MD, A. Ralph Rodriguez, MD, Mary Reynolds, RN; *The Heart Institute of St. Joseph Hospital, Atlanta, Georgia*: Christopher Cates, MD, William Knopf, MD, Jan Sheftel, RN; *Eastern Carolina University School of Medicine, Greenville, North Carolina*: A. Kahn, MD; *Riverside Hospital, Columbus, Ohio*: Nathan Kander, MD; *North Shore University Hospital, Manhasset, New York*: Stanley Katz, MD, Lisa Chepurko, RN; *Wake Medical Center, Raleigh, North Carolina*: Joel Schneider, MD; *State University of New York at Stony Brook, Stony Brook, New York*: John P. Dervan, MD; *St. John Hospital, Detroit, Michigan*: Theodore Schreiber, MD, Christine Trevino, RN; *Baptist Memorial Hospital, Memphis, Tennessee*: Joseph Samaha, MD, Barbara Hamilton, RN; *The Heart Center of Fort Wayne, Fort Wayne, Indiana*: Brian Lew, MD; *Hinsdale Hospital, Hinsdale, Illinois*: Jerome Hines, MD.

Data and Safety Monitoring Board: *William Beaumont Hospital, Royal Oak, Michigan*: Gerald Timmis, MD; *University of Michigan Medical Center, Ann Arbor, Michigan*: Bertram Pitt, MD; *Boston University, Boston, Massachusetts*: Thomas J. Ryan, MD.

Core Angiographic Laboratory: *William Beaumont Hospital, Royal Oak, Michigan*: Sandeep Khurana, MD, Mariann Graham, RN, BSN, Ludmilla Mitina.

References

1. Grines CL, Browne KR, Marco J, et al. A comparison of primary angioplasty with thrombolytic therapy for acute myocardial infarction. N Engl J Med 1993;328:673–9.
2. Zijlstra F, DeBoer MJ, Hoorntje JCA, Reiffer S, Reiber JHC, Suryapranata H. A comparison of immediate coronary angioplasty with intravenous streptokinase in acute myocardial infarction. N Engl J Med 1993;328:680–4.
3. Gibbons RJ, Holmes DR, Reeder GS, Bailey KR, Hopenspirger MR, Gersh BJ. Immediate angioplasty compared with the administration of a thrombolytic agent followed by conservative treatment for myocardial infarction. N Engl J Med 1993;328:685–91.
4. Michels KB, Yusif S. Does PTCA in acute myocardial infarction affect mortality and reinfarction rates? A quantitative (meta-analysis) of the randomized clinical trials. Circulation 1995;91:476–85.
5. Stone GW, Grines CL, Browne KF, et al. Predictors of in-hospital and six month outcome after acute myocardial infarction in the reperfusion era: the Primary Angioplasty in Myocardial Infarction (PAMI) trial. J Am Coll Cardiol 1995;25:370–7.
6. Gruppo Italiano per lo Studio della Streptochinasi nell'Infarto Miocardico (GISSI). Effectiveness of intravenous thrombolytic treatment in acute myocardial infarction. Lancet 1986;1:397–402.
7. ISIS-2 (Second International Study Group of Infarct Survival) Collaborative Group: randomized trial of intravenous streptokinase, oral aspirin, both, or neither among 17,187 cases of suspected acute myocardial infarction. Lancet 1988;2:349–60.
8. Wilcox RG, Olsson CG, Skene AM, Von Der Lippe G, Jensen G, Hampton JR. Trial of tissue plasminogen activator for mortality reduction in acute myocardial infarction: AngloScandinavian Study of Early Thrombolysis (ASSET). Lancet 1988;2:525–30.
9. Lee KL, Woodlief LH, Topol EJ, et al. Predictors of 30-day mortality in the era of reperfusion for acute myocardial infarction: results from an international trial of 41,021 patients. Circulation 1995;91:1659–68.
10. Volpi A, De Vita C, Franzosi MG, et al. Determinants of 6-month mortality in survivors of myocardial infarction after thrombolysis: results of the GISSI-2 data base. Circulation 1993;88:416–29.
11. The TIMI Study Group. Comparison of invasive and conservative strategies after treatment with intravenous tissue plasminogen activator in acute myocardial infarction: results of the Thrombolysis in Myocardial Infarction (TIMI) trial, Phase 1 findings. N Engl J Med 1989;320:618–27.
12. The GUSTO Investigators. An international randomized trial comparing four thrombolytic regimens consisting of tissue plasminogen activator, streptokinase, or both for acute myocardial infarction. N Engl J Med 1993;329:673–82.
13. Appleby P, Baigent C, Collins R, Flather M, Parish S, Peto R, for the FTT Collaborative Writing Committee. Indications for fibrinolytic therapy in suspected acute myocardial infarction: collaborative overview of early mortality and major morbidity results from all randomised trials of more than 1000 patients. Lancet 1994;343:311–22.
14. O'Keefe JO, Bailey WL, Rutherford BD, Hartzler GO. Primary angioplasty for acute myocardial infarction in 1000 consecutive patients. Am J Cardiol 1993;72:107G–15G.
15. Ishihara M, Sato H, Tateishi H, Uchida Toshiaki, Dote K. Intraaortic balloon pumping as the post angioplasty strategy in acute myocardial infarction. Am Heart J 1991;122:385–9.
16. Ohman EM, Califf RM, George BS, et al., for the Thrombolysis and Angioplasty in Myocardial Infarction (TAMI) Study Group. The use of intraaortic balloon counterpulsation as an adjunct to reperfusion therapy in acute myocardial infarction. Am Heart J 1991;191:895–901.
17. Ohman EM, George BS, White CJ, et al., for the Randomized IABP Study Group. Use of aortic counterpulsation to improve sustained coronary artery patency during acute myocardial infarction: results of a randomized trial. Circulation 1994;90:792–9.
18. Ishihara M, Sato H, Tateishi H, et al. Intraaortic balloon pumping as adjunctive therapy to rescue coronary angioplasty after failed thrombolysis in anterior wall myocardial infarction. Am J Cardiol 1995;76:73–5.
19. Grines CL, Schreiber TL, Savas V, et al. A randomized trial of low osmolar ionic versus nonionic contrast media in patients with myocardial infarction or unstable angina undergoing percutaneous transluminal coronary angioplasty. J Am Coll Cardiol 1996;27:1381–6.
20. Piessens JH, Stammen F, Vrolix MC, et al. Effects of an ionic versus a nonionic low osmolar contrast agent on the thrombotic complications of coronary angioplasty. Cathet Cardiovasc Diagn 1993;28:99–105.
21. Brodie B, Grines CL, Spain S, et al. A prospective, randomized trial evaluating early discharge (day 3) without non-invasive risk stratification in low risk patients with acute myocardial infarction: PAMI-2. J Am Coll Cardiol 1995;25 Suppl A:430A.
22. Smith AJC, Holt RE, Fitzpatrick K, et al. Transient thrombotic state after abrupt discontinuation of heparin in percutaneous coronary angioplasty. Am Heart J 1996;131:434–9.
23. The TIMI Study Group. The Thrombolysis in Myocardial Infarction (TIMI) trial: Phase 1 findings. N Engl J Med 1985;312:932–6.
24. Dodge HT, Sandler H, Ballew DW, Lord JD. The use of biplane angiography for the measurement of left ventricular volume in man. Am Heart J 1960;60:762–6.
25. Sheehan FH, Bolson EL, Dodge HT, Mathey DG, Schofer J, Woo HW. Advantages and applications of the centerline chord method for characterizing regional ventricular function. Circulation 1986;74:293–305.
26. Rothbaum DA, Linnemeier TJ, Landin RJ, et al. Emergency percutaneous transluminal coronary angioplasty in acute myocardial infarction: a 3 year experience. J Am Coll Cardiol 1987;10:264–72.
27. Miller PF, Brodie BR, Weintraub RA, LeBauer J, Katz JD, Stuckey TD. Emergency coronary angioplasty for acute myocardial infarction. Arch Intern Med 1987;147:1565–70.
28. O'Keefe JH, Rutherford BD, McConahay DR, et al. Early and late results of coronary angioplasty without antecedent thrombolytic therapy for acute myocardial infarction. Am J Cardiol 1989;64:1221–30.
29. Stone GW, Rutherford BD, McConahay DR, et al. Direct coronary angioplasty in acute myocardial infarction: outcome in patients with single vessel disease. J Am Coll Cardiol 1990;15:534–43.
30. Ellis SG, Gallison L, Grines CL, et al. Incidence and predictors of early recurrent ischemia after successful percutaneous transluminal coronary angioplasty for acute myocardial infarction. Am J Cardiol 1989;64:263–8.
31. Ohman EM, Califf RM, Topol EJ, et al. Consequences of reocclusion after successful reperfusion therapy in acute myocardial infarction. Circulation 1990;82:781–91.

32. Kern MJ, Aguirre F, Bach R, Donohue T, Siegal R, Segal J. Augmentation of coronary blood flow by intra-aortic balloon pumping in patients after coronary angioplasty. Circulation 1993;87:500–11.
33. Gurbel PA, Anderson RD, MacCord CS, et al. Arterial diastolic pressure augmentation by intra-aortic balloon counterpulsation enhances the onset of coronary reperfusion by thrombolytic therapy. Circulation 1994;89:361–5.
34. Kern MJ, Aguirre FV, Tatineni S, et al. Enhanced coronary blood flow velocity during intraaortic balloon counterpulsation in critically ill patients. J Am Coll Cardiol 1993;21:359–68.
35. Smalling RW, Cassidy DB, Barrett R, Lachterman B, Felli P, Amirian J. Improved regional myocardial blood flow, left ventricular unloading, and infarct salvage using an axial-flow, transvalvular left ventricular assist device. Circulation 1992;85:1152–9.
36. Grines C, Marsalese D, Brodie B, et al. Acute cath provides the best method of risk stratifying MI patients. Circulation 1995;92 Suppl I:I-531.
37. Alderman JD, Gabliani GI, McCabe CH, et al. Incidence and management of limb ischemia with percutaneous wire-guided intraaortic balloon catheters. J Am Coll Cardiol 1987;9:524–30.
38. Goldberger M, Tabak SW, Shah PK. Clinical experience with intra-aortic balloon counterpulsation in 112 consecutive patients. Am Heart J 1986;111: 497–502.
39. Kantrowitz A, Wasfie T, Freef PS, Rubenfire M, Wajszczuk W, Schork MA. Intraaortic balloon pumping 1967 through 1982: analysis of complications in 733 patients. Am J Cardiol 1986;57:976–83.
40. Ellis SG, Van de Weft F, Riberio-DaSilva E, Topol EJ. Present status of rescue coronary angioplasty: current polarization of opinion and randomized trials. J Am Coll Cardiol 1992;19:681–6.
41. O'Neill WW, Weintraub R, Grines CL, Meany TB, et al. A prospective, placebo-controlled, randomized trial of intravenous streptokinase and angioplasty versus lone angioplasty therapy of acute myocardial infarction. Circulation 1992;86:1710–7.
42. Ferguson J, Dougherty K, Gaos C, Bush HS, Marsh KC, Leachman DR. Relation between procedural activated coagulation time and outcome after percutaneous transluminal coronary angioplasty. J Am Coll Cardiol 1994; 23:1061–5.
43. Badger RS, Brown BG, Kennedy JW, et al. Usefulness of recanalization to luminal diameter of 0.6 millimeter or more with intracoronary streptokinase during acute myocardial infarction in predicting "normal" perfusion status, continued arterial patency and survival at one year. Am J Cardiol 1987;59: 519–22.
44. Sheehan FH, Mathey DG, Schoffer J, Dodge HT, Bolson EL. Factors that determine recovery of left ventricular function after thrombolysis in patients with acute myocardial infarction. Circulation 1985;71:1121–8.
45. Harrison DG, Ferguson DW, Collins SM, et al. Rethrombosis after reperfusion with streptokinase: importance of geometry of residual lesions. Circulation 1984;69:991–9.
46. The GUSTO Angiographic Investigators. The effects of tissue plasminogen activator, streptokinase, or both on coronary-artery patency, ventricular function, and survival after acute myocardial infarction. N Engl J Med 1993;329:1615–22.
47. O'Neill W, Griffin J, Stone G, et al. Operator and institutional volume do not affect the procedural outcome of primary angioplasty therapy. J Am Coll Cardiol 1996;27 Suppl A:13A.
48. Brodie B, Stuckey T, Weintraub R, et al. Timing and mechanism of death after direct angioplasty for acute myocardial infarction. J Am Coll Cardiol 1995;25 Suppl A:47A.
49. Stone GW. Primary PTCA in high risk patients with acute myocardial infarction. J Invasive Cardiol 1995;7:12F–21F.