Primary Angioplasty for the Treatment of Acute Myocardial Infarction: Experience at Two Community Hospitals Without Cardiac Surgery

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OBJECTIVES
We sought to establish the safety and efficacy of primary percutaneous transluminal coronary angioplasty in patients with acute myocardial infarction (AMI) at two community hospitals without on-site cardiac surgery.

BACKGROUND
Though randomized studies indicate that primary angioplasty in AMI may result in superior outcomes compared with fibrinolytic therapy, the performance of primary angioplasty at hospitals without cardiac surgery is debated.

METHODS
Three experienced operators performed 506 consecutive immediate coronary angiograms with primary angioplasty when appropriate in patients with suspected AMI at two community hospitals without cardiac surgery, following established rigorous program criteria.

RESULTS
Clinical high risk predictors (Killip class 3 or 4, age ≥75 years, anterior AMI, out-of-hospital ventricular fibrillation) and/or angiographic high risk predictors (left main or three-vessel disease or ejection fraction <45%) were present in 69.6%. Angioplasty was performed in 66.2%, with a median time from emergency department presentation to first angiogram of 94 min and a procedural success rate of 94.3%. The in-hospital mortality for the entire study population was 5.3%. Of those without initial cardiogenic shock, the in-hospital mortality was 3.0%. Of 300 patients who were discharged after primary angioplasty, only four died within the first 6 months, with 97.7% follow-up. No patient died or needed emergent aortocoronary bypass surgery because of new myocardial jeopardy caused by a complication of the cardiac catheterization or angioplasty procedure.

CONCLUSIONS
Immediate coronary angiography with primary angioplasty when appropriate in patients with AMI can be performed safely and effectively in community hospitals without on-site cardiac surgery when rigorous program criteria are established. (J Am Coll Cardiol 1999;33:1257–65) © 1999 by the American College of Cardiology

Primary percutaneous transluminal coronary angioplasty has been advocated for treatment of acute myocardial infarction (AMI) for over 15 years (1,2). A meta-analysis of 10 multicenter randomized trials indicates that primary angioplasty in AMI lowers the rates of death, stroke, recurrent ischemia and reinfarction compared with fibrinolytic therapy (3). In addition, for low risk patients with AMI, the mortality of primary angioplasty can be very low (<0.5%), and hospital costs can be decreased (4,5). Furthermore, most AMI patients are not candidates for fibrinolytic therapy, either because they have bleeding risks or shock, or do not have diagnostic electrocardiograms (ECGs) (6–8). These subgroups of patients may be at higher risk than those eligible to receive fibrinolytic therapy. The invasive approach can be applied to almost all of these patients at capable centers. Moreover, primary angioplasty may be more cost-effective than fibrinolytic therapy (9–13). Thus it becomes increasingly important for both clinical and economic reasons to address the question of whether this interventional approach to the treatment of AMI can be extended safely and effectively to a larger number of hospitals.

Most patients with AMI do not present to hospitals with cardiac surgical capability. Yet approximately 840 hospitals in the U.S. without cardiac surgery have cardiac catheterization laboratories (14). Many of these laboratories are staffed by experienced interventionalists who regularly perform elective intervention at surgical centers. Although the
Methods
Operator, laboratory and institutional requirements. We established the following standards for the performance of primary angioplasty for operators, laboratories and institutions at our two community hospitals without cardiac surgery, approved by the ethics committees at both hospitals:

1. The operators must be experienced interventionalists who regularly perform elective intervention at a tertiary surgical center.
2. The nursing and technical catheterization laboratory staff must be experienced in handling acutely ill patients and comfortable with interventional equipment. They must have acquired experience in dedicated angioplasty laboratories at a surgical center. They participate in a 24-h 365-day call schedule.
3. The catheterization laboratory itself must be well equipped, with optimal imaging systems, resuscitative equipment and intra-aortic balloon pump (IABP) support, and must be well stocked with a broad array of interventional equipment.
4. The cardiac care unit nurses must be adept in hemodynamic monitoring and IABP management.
5. The hospital administration must fully support the program and enable the fulfillment of the above institutional requirements.
6. There must be formalized written protocols in place for immediate and efficient transfer of patients to the nearest cardiac surgical facility.
7. Primary intervention must be performed routinely as the treatment of choice around the clock for a large proportion of patients with AMI, to ensure streamlined care paths and increased case volumes.
8. Case selection for the performance of primary angioplasty must be rigorous. Criteria for the types of lesions appropriate for primary angioplasty and for selection for transfer for emergent aortocoronary bypass surgery are listed under “Selection for angioplasty” and “Emergent aortocoronary bypass surgery,” below.
9. There must be an ongoing program of outcomes analysis and formalized periodic case review.

Study population. During the first three years of this analysis (1991 to 1994), intervention was performed primarily in patients with contraindications to fibrinolytics and in those who were clinically at high risk (Killip class 3 or 4, age >75 years, anterior AMI). Over the last three years of this analysis (1994 to 1997), the invasive approach was used by our group in 98% of all patients presenting with AMI. Fibrinolytic therapy was used only in the rare instances when the catheterization laboratory or the interventionalist was not available or when the patient refused catheterization.

The study population included patients with a clinical impression of AMI: over 30 min of ischemic pain not controlled by conventional medications (aspirin, nitroglycerin, beta-adrenergic blocking agents and heparin, but not fibrinolytic agents) or an ECG demonstrating ≥2.0 mV of ST segment elevation in two or more contiguous leads. There was no time cutoff if the clinical impression suggested ongoing myocardial necrosis (ongoing chest pain and ST deviation with preserved R waves in two or more infarct leads). A small fraction of our patients (3.6%) presented with 12 to 24 h of continuous chest pain with ST elevation on ECG, and an even smaller fraction (2.2%) presented with over 24 h of continuous pain and ST elevation. These groups were included in this analysis. We did not include patients who presented more than 12 h after onset of pain if they were symptom-free on emergency department (ED) arrival.

All patients with cardiogenic shock surviving the ED were included. Also included were all patients with out-of-hospital ventricular fibrillation who had successful cardioversion in the field, regardless of acute mental status on arrival. Patients with reversal of shock after angioplasty generally had multivessel disease and were sent for urgent aortocoronary bypass surgery before IABP removal. Not included in this report are patients with ventricular septal rupture or papillary muscle rupture, who were taken to the catheterization laboratory for stabilization and IABP before emergent transfer.

Techniques. Three experienced operators and two experienced catheterization laboratory teams provided 24-h 365-day coverage at two community hospitals without cardiac surgery. Aspirin (325 mg chewed) was given in the ambulance or immediately upon ED arrival along with heparin...
Cardiogenic shock was defined as a sustained systolic with ST segment reelevation and angiographic reocclusion. The activated clotting time was kept above 350 s (between 200 and 300 s if stents or abciximab were used) with supplemental heparin as needed. The occurred infarct-related artery (IRA) was identified and dilated; ventriculography was deferred only in patients who were hemodynamically unstable. For patients in shock, an IABP was inserted before angiography via the opposite groin. The IABP was also utilized after the procedure (via the same femoral access site that was used for angiography) for some patients with ongoing hemodynamic instability or high risk anatomy. Nurses from the ED or the intensive care unit and respiratory therapists were called to the catheterization laboratory to assist with the more critical patients as needed, especially during nights and weekends, when only two of the catheterization laboratory team were available on-call.

Selection for angioplasty. Angioplasty was not performed if there was Thrombolysis in Myocardial Infarction (TIMI) grade 3 flow (24) in the IRA in hemodynamically stable asymptomatic patients, or if there was significant (≥60%) stenosis of an unprotected left main coronary artery upstream from an acute occlusion in the left coronary system that might be disrupted by the angioplasty catheter. Angioplasty was also avoided in extremely long or angulated infarct-related lesions with TIMI grade 3 flow, infarct-related lesions with TIMI grade 3 flow in stable patients with three-vessel disease (25,26), infarct-related lesions of small or secondary vessels and lesions in other than the IRA (unless they appeared to be flow-limiting in patients with hemodynamic instability or ongoing symptoms).

Emergent aortocoronary bypass surgery. Patients were transferred emergently for aortocoronary bypass surgery after angioplasty of occluded vessels if they had high grade residual left main or multivessel coronary disease with clinical or hemodynamic instability. The transport time by ambulance to the nearest surgical center is 45 min from one hospital and 55 min from the other. Time intervals of as short as 62 min from leaving the catheterization laboratory to entering the operating room were documented.

Stents and abciximab usage. Stents and abciximab were used only during the last several months of the data collection period, when the results of angioplasty were suboptimal.

Definitions. Angioplasty success was defined as TIMI grade 3 flow and ≤50% residual stenosis (27). Reocclusion was defined as greater than 90% restenosis with TIMI grade 0–1 flow. Reinfarction was defined as creatinine kinase MB fraction reelevation above its previous nadir or chest pain with ST segment reelevation and angiographic reocclusion. Cardiogenic shock was defined as a sustained systolic arterial pressure of <90 mm Hg for over 30 min despite fluids or requiring pressors, with a pulmonary wedge pressure of >18 mm Hg or clinical evidence of elevated left heart filling pressures, and signs of poor tissue perfusion (oliguria, decreased mentation), without bradycardia, hypovolemia or other correctable causes of hypotension.

Data collection. Clinical data were collected at both hospitals by a single experienced cardiology research nurse-coordinator (author NSM) who had participated in previous multicenter studies of AMI and whose reliability had been verified in the site visits that were part of these studies. Data were collected over a period of 74 months, from mid-1991 through mid-1997. A 239-field computerized relational database was developed for data entry and analysis in 1993 and was completed for all procedures, retrospectively in 1991 and 1992 (187 cases), and prospectively since 1993 (319 cases). The potential for underreporting of adverse outcomes was minimized by conducting a final review of all records from all hospitals, including the surgical records, for each patient several weeks after discharge. Six-month follow-up by personal or telephone contact was attempted in all patients who received primary angioplasty.

RESULTS

Five hundred six immediate coronary angiograms with angioplasty standby were performed in 489 consecutive patients with suspected AMI. Fifteen of these patients had a second emergent procedure for reocclusion or recurrent AMI on the same admission, and two of these had a third emergent procedure for the same reasons. Clinical and angiographic characteristics are shown in Table 1. Clinical high risk predictors (Killip class 3 or 4, age ≥75 years, anterior AMI, out-of-hospital ventricular fibrillation) (28) were present at 272 procedures (53.7%) (Fig. 1). Angiographic high risk predictors (≥50% stenosis of the left main coronary, ≥70% stenosis of all three major epicardial coronary arteries or ejection fraction <45%) were found in 246 (48.6%). Only 154 (30.4%) had none of these clinical or angiographic high risk features. Three hundred ten (61.3%) were considered poor candidates to receive fibrinolytic therapy, because of age ≥80 years, the presence of bleeding risks, shock or prior bypass surgery, the lack of ST segment elevation on ECG or symptom duration over 6 h. Primary angioplasty was performed during 335 of the 506 immediate coronary angiograms (66.2%). It was not performed in 171, or 33.8%, because: a) TIMI 3 flow was present in 25.9% after the high dose heparin that was used; b) the lesion was judged technically unsuitable in 6.1%, and c) the infarct artery was unclear in 1.8%.

Outcomes. The median duration of chest pain before ED arrival was 90 min. Angioplasty success was achieved in 94.3% of procedures (Table 2) at a median time from ED arrival to first angiogram of 94 min (25th percentile = 74 min, 75th percentile = 134 min). A median of 15 more
minutes elapsed before the first balloon inflation in those undergoing angioplasty. The median time from pain onset to reperfusion was 199 min. As seen in Table 2, the mortality rate was relatively low for patients receiving primary angioplasty, whether or not cardiogenic shock was present.

In-hospital outcomes for the entire study population are shown in Table 3. Rates of reocclusion and reinfarction were relatively low. Stroke or transient ischemic attack occurred in only two patients out of the entire population. There were no occurrences of intracerebral bleeding. The overall in-hospital mortality was 5.3%, including postoperative mortality. In 56 patients who presented with cardiogenic shock the mortality was 23.2%, and in patients without shock it was 3%. Patients who presented with out-of-hospital ventricular fibrillation treated with successful countershock in the field had an in-hospital mortality of 11.4% (four of 35 patients). Of the 171 patients who had primary angioplasty deferred because of initial TIMI grade 3 flow in the IRA, including 14 patients with shock, reinfarction occurred in 1.8%, death in 3% and stroke in none.

To more directly compare these outcomes with those of other primary angioplasty and fibrinolytic studies, we analyzed the subgroup of 226 patients who presented with ST segment elevation of at least 2 mV in two or more contiguous leads or with left bundle branch block within 6 h

Table 1. Clinical and Angiographic Characteristics for 506 Immediate Coronary Angiography Procedures in Patients With Suspected AMI

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean Value ± SD or % of Procedures</th>
</tr>
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<tbody>
<tr>
<td>Age (yr)</td>
<td>61 ± 13</td>
</tr>
<tr>
<td>Age ≥70</td>
<td>25.3%</td>
</tr>
<tr>
<td>Female</td>
<td>28.9%</td>
</tr>
<tr>
<td>Prior AMI</td>
<td>21.3%</td>
</tr>
<tr>
<td>Prior bypass surgery</td>
<td>7.3%</td>
</tr>
<tr>
<td>Prior stroke or TIA</td>
<td>4.5%</td>
</tr>
<tr>
<td>Hypertension</td>
<td>48.8%</td>
</tr>
<tr>
<td>Diabetes</td>
<td>20.8%</td>
</tr>
<tr>
<td>Fibrinolytic eligible</td>
<td>38.7%</td>
</tr>
<tr>
<td>Killip class 3</td>
<td>13.4%</td>
</tr>
<tr>
<td>Cardiogenic shock*</td>
<td>11.3%</td>
</tr>
<tr>
<td>Out-of-hospital ventricular fibrillation†</td>
<td>6.9%</td>
</tr>
<tr>
<td>Diseased vessels (≥70% stenosis)</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>5.5%</td>
</tr>
<tr>
<td>1</td>
<td>36.0%</td>
</tr>
<tr>
<td>2</td>
<td>28.1%</td>
</tr>
<tr>
<td>3</td>
<td>21.3%</td>
</tr>
<tr>
<td>Left main (≥50% stenosis)</td>
<td>9.1%</td>
</tr>
<tr>
<td>Left ventricular ejection fraction (%)</td>
<td>49 ± 16</td>
</tr>
</tbody>
</table>

*Sustained systolic arterial pressure of <90 mm Hg despite fluids or requiring pressors, pulmonary wedge pressure of ≥18 mm Hg, signs of poor tissue perfusion (oliguria, decreased mentation) and absence of bradycardia, hypovolemia or other correctable causes of hypotension. †Patients with documented ventricular fibrillation occurring out of hospital who were successfully cardioverted in the field, regardless of mental status on arrival. Data presented are mean value ± SD or percent of procedures.

AMI = acute myocardial infarction; TIA = transient cerebral ischemic attack.

Figure 1. Incidence of clinical and angiographic predictors of high risk. Clinical high risk predictors were present in 53.7% of 506 procedures (shown in middle layer); angiographic high risk predictors were present in 49.4% (lower layer). Both clinical and angiographic high risk predictors were present in 33.5% (shown in black). Only 30.4% had neither clinical nor angiographic predictors of high risk (upper layer). *Clinical high risk—Killip class 3–4, age ≥75 years, anterior infarction or prehospital ventricular fibrillation. †Angiographic high risk: ejection fraction <45% or left main or three-vessel disease.

Table 2. Outcomes of 335 Primary Angioplasty Procedures

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Mean Value ± SD or % of Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-PTCA TIMI flow grade</td>
<td></td>
</tr>
<tr>
<td>0–1</td>
<td>4.8%</td>
</tr>
<tr>
<td>2</td>
<td>0.9%</td>
</tr>
<tr>
<td>3</td>
<td>94.3%</td>
</tr>
<tr>
<td>Post PTCA % stenosis</td>
<td></td>
</tr>
<tr>
<td>23 ± 22</td>
<td></td>
</tr>
<tr>
<td>PTCA success*</td>
<td></td>
</tr>
<tr>
<td>94.3%</td>
<td></td>
</tr>
<tr>
<td>In-hospital mortality</td>
<td></td>
</tr>
<tr>
<td>Presenting with cardiogenic shock</td>
<td></td>
</tr>
<tr>
<td>(n = 44)</td>
<td></td>
</tr>
<tr>
<td>25.0%</td>
<td></td>
</tr>
<tr>
<td>Presenting without shock</td>
<td></td>
</tr>
<tr>
<td>(n = 291)</td>
<td></td>
</tr>
<tr>
<td>3.8%</td>
<td></td>
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</table>

*≥50% stenosis and TIMI grade 3 flow. Data presented are mean value ± SD or percent of procedures.

PTCA = percutaneous transluminal coronary angioplasty; TIMI = Thrombolysis in Myocardial Infarction.
Vascular occlusion or pseudoaneurysm
Stroke or TIA 0
Acute renal failure 0.6%
Cardiogenic shock developing in lab 0
Anaphylaxis 0
Pulmonary edema 0.8%
Respiratory arrest 0.4%
Aspiration 0
Ventricular fibrillation 2.7%
Asystole or heart block requiring pacemaker 3.9%
Any complication 7.1%
Death due to cath lab complication 0

Data presented are percent of patients.

Table 3. In-Hospital Outcomes in Patients Undergoing Immediate Coronary Angiography

<table>
<thead>
<tr>
<th>Complication</th>
<th>% of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>5.3%</td>
</tr>
<tr>
<td>Reinfarction*</td>
<td>2.5%</td>
</tr>
<tr>
<td>Recurrence†</td>
<td>3.3%</td>
</tr>
<tr>
<td>Stroke or TIA (none hemorrhagic)</td>
<td>0.4%</td>
</tr>
<tr>
<td>Total</td>
<td>(n = 489)</td>
</tr>
<tr>
<td>Cardiogenic Shock</td>
<td></td>
</tr>
<tr>
<td>Death</td>
<td>23.2%</td>
</tr>
<tr>
<td>Recurrence†</td>
<td>1.8%</td>
</tr>
<tr>
<td>Stroke or TIA (none hemorrhagic)</td>
<td>1.8%</td>
</tr>
<tr>
<td>Without Shock</td>
<td>(n = 433)</td>
</tr>
</tbody>
</table>

*Creatinine kinase, MB fraction, reevaluation or chest pain with ST segment reelevation and angiographic reocclusion. †Greater than 90% restenosis with Thrombolysis in Myocardial Infarction 0–1 flow. Data presented are percent of patients. TIA = transient ischemic attack.

of pain onset and without cardiogenic shock. Initial TIMI grade 3 flow was present in 57 (25.2%). Primary angioplasty was performed in 166 patients (73.5%), with success in 158 (95.2%). The in-hospital mortality was 3.1% (seven of 226) for this group.

Complications. Table 4 lists the incidence of complications occurring in the catheterization laboratory. Thirty-six procedures (7.1%) had at least one in-laboratory complication, 35 of which had no long-term sequelae. The single in-laboratory death occurred in a patient who developed electromechanical dissociation at the time of arrival at the catheterization laboratory, 32 min after ED admission, before attempted intervention. No patient died or needed emergent aortocoronary bypass surgery because of new myocardial jeopardy caused by a complication of the procedure.

Bleeding after catheterization requiring transfusion occurred in 48 patients (9.8%); 34 patients (6.9%) had bleeding associated with the catheter access site, 3 of whom developed retroperitoneal hematomas. The others had gastrointestinal, nasotracheal (after intubation) or genitourinary bleeding. Over the last year of this study, the rate of bleeding requiring transfusion fell to 5.9%.

Use of emergent aortocoronary bypass surgery. Twenty-seven patients (5.3%) were transferred for and received emergent aortocoronary bypass surgery within 12 h of presentation because of initial shock (eight patients) or critical multivessel disease (19 patients), none because of new myocardial jeopardy caused by a procedural complication. Nineteen of the 27 were transferred with an open IRA after successful primary angioplasty or spontaneous reperfusion. Of the other eight without reperfusion, seven had anatomy judged unsuitable for angioplasty and one had angioplasty that failed to open a totally occluded artery. Twenty-five of the 27 survived. No complication occurred during interhospital transfer.

Use of stents and abciximab. Seventeen stents were deployed over the last few months of the study, all with procedural success. Abciximab was used in 12 patients.

Six-month mortality. Six-month follow-up is available in 293 of 300 patients (97.7%) who were discharged after primary angioplasty. Of this group of 293 patients, 98.6% were alive at 6 months after discharge.

DISCUSSION

Rationale. The chief limitation to the widespread application of primary angioplasty is the availability of qualified hospitals and operators. Approximately 840 community hospitals in the U.S. that have cardiac catheterization laboratories do not have cardiac surgery (14). Many of these hospitals are staffed by experienced and active interventionists. In view of the potential advantages of primary angioplasty, the question of whether the interventional approach in the treatment of AMI can be extended safely and effectively to these primary care hospitals must be addressed.

We reasoned that the main surgical risk of elective angioplasty, that of causing a patent vessel to close, need not pertain to patients with AMI, where culprit vessels already have occluded. We expected that the performance of immediate coronary angiography in patients with AMI could provide additional benefit through risk stratification and triage (4). Further, we felt that our results could be optimized if we committed to primary angioplasty as first-line treatment; we reasoned that this would increase institutional and operator experience and could streamline care paths, shorten times to intervention and improve outcomes. Finally, we felt that this approach should not be limited to
those patients who fulfilled the usual criteria for inclusion in fibrinolytic studies, since many high risk patients with AMI and acute coronary occlusion do not present with diagnostic ECGs or within 6 h of symptom onset, and since these groups may be at higher risk (6–8).

The present study. This series represents the largest single-group experience of primary angioplasty in hospitals without on-site cardiac surgery ever reported to our knowledge. The overall rates of successful angioplasty, reinfarction, stroke and death in our population compare very favorably with the outcomes of large, high volume surgical centers reported in the literature (Fig. 2) (4,5,25,26,29). Moreover, our excellent low mortality rate in patients having primary angioplasty is sustained at six months after discharge.

Cardiogenic shock. The in-hospital mortality rate of 23.2% in 56 consecutive patients presenting in cardiogenic shock is remarkable, being considerably lower than has been reported (30,31). However, patients with cardiogenic shock who are treated with prompt balloon counterpulsation and early revascularization in some studies have mortality rates that are similarly low (32–36). The low mortality in our series might be explained by several factors: 1. immediate balloon counterpulsation and effective angioplasty revascularization may improve outcomes; 2. the short duration of symptoms before ED arrival in this series (median 78 min) should increase the likelihood of salvageable myocardium, and 3. selection bias may in part account for the improved outcomes reported in patients with shock who are treated with intervention (37). In our series, however, all patients who presented with shock and who survived the ED are included. The management of cardiogenic shock at community hospitals is being addressed by ongoing studies. Our approach may improve the effectiveness of the initial treatment of the shock patient at the point of first presentation, and can avoid the delays and risks that are associated with the interhospital transfer of unsupported patients in shock.

Angioplasty rate. The rate of performance of primary angioplasty of 66.2% in all patients taken to the catheterization laboratory and 73.5% in patients with ST segment elevation is lower than that in other primary angioplasty studies (25,26). This is because of rigorous case selection for intervention; to avoid creating a surgical emergency at nonsurgical hospitals by causing acute closure of an already open IRA, primary angioplasty of vessels with initial TIMI grade 3 flow was withheld in stable, pain-free patients. This proved to be a very safe approach. A large proportion of this group with initial TIMI grade 3 flow had subsequent revascularization at a tertiary hospital. Another reason for the lower angioplasty rate is that immediate coronary angiography with primary angioplasty standby was performed on a broader population often not included in other studies, including patients presenting over 12 h after pain onset and patients without diagnostic ECGs. In this population, where immediate angiography was used for diagnosis and triage as well as an antecedent to primary angioplasty, we expected and found a higher percentage with TIMI grade 3 flow.

Limitations. The patients in this series were not randomized. Although our experience demonstrates outcomes that can be achieved at community hospitals without cardiac surgery, these data provide no indication of whether alternative treatments (using fibrinolytics when possible) might have led to similar outcomes. The interventional approach in AMI, however, can be applied to a much broader population than fibrinolytic therapy. Any randomized comparison with fibrinolytic therapy would exclude a very important large and high risk population (6–8) of fibrinolytic ineligible patients. One value of this study is that it includes, and demonstrates excellent outcomes in, patient

Figure 2. Comparison of the outcomes of primary percutaneous transluminal coronary angioplasty (PTCA) in the 231 patients in our series who had acute myocardial infarction with ST segment elevation but without cardiogenic shock with a similar population of 245 patients undergoing primary PTCA in the Primary Angioplasty Registry (25), which required ST segment elevation and excluded patients with shock. The median times from emergency department (ED) arrival to reperfusion and the rates of PTCA success, reinfarction, stroke or transient ischemic attack (TIA), and in-hospital mortality were similar in the two groups. Black bars: Exeter and Portsmouth primary PTCA patients presenting with ST elevation without shock (n = 231). White bars: Primary Angioplasty Registry PTCA patients (n = 245).
groups often excluded from randomized studies of fibrinolytic therapy.

Another limitation is that these results may not be replicable at other community hospitals. The outcomes of primary angioplasty for AMI are very much dependent on operator expertise and institutional commitment. We believe, however, that results similar to ours can be achieved by cardiologists and institutions that establish programs which adopt rigorous standards such as those we propose (see Methods). Preliminary data from the Primary Angioplasty in Myocardial Infarction—No Surgery on Site Registry supports this view (21,22).

A further limitation is that these data were collected retrospectively on the first 187 patients, which could have resulted in an inadvertent selection bias. The decision on which patients to include retrospectively in this series was made by the cardiology research nurse–coordinator, who independently reviewed the catheterization laboratory logs and the hospital charts for over 300 urgent procedures to find these 187 patients with AMI. Decisions were made by reviewing ED notes, admission and progress notes and ECGs, specifically without regard to patient outcomes.

The study is also limited by the fact that stents or abciximab were not used in 95.8% of procedures. Recent studies of these agents in patients undergoing high risk or primary angioplasty suggest their potential to improve outcomes (38–42). Thus these two new modalities may further improve the safety and efficacy of primary angioplasty and could provide an extra measure of safety at hospitals without cardiac surgery.

Finally, there is no core laboratory analysis of the cineangiograms. The diameter of stenoses and the TIMI flow grades were visually estimated. Thus the self-reported rates of angioplasty success might be overly optimistic, and might be expected to decrease somewhat after core laboratory quantitative coronary angiography analysis (43). It should be noted, however, that the visual estimate of TIMI flow grade and lesion diameter is the usual basis on which interventional decisions are made in the catheterization laboratory. Moreover, visual assessment of the immediate change in percent stenosis after angioplasty has been shown to be superior to quantitative coronary angiography in predicting symptom-free survival at 1 year (44).

Conclusions. These outcomes indicate that immediate coronary angiography with primary angioplasty when appropriate in patients with acute myocardial infarction can be performed safely and effectively at community hospitals without cardiac surgery, with excellent outcomes in a large, high risk population. By establishing rigorous standards for operators, staffing, laboratories, equipment and case selection, and maintaining ongoing outcomes analysis and case review, primary angioplasty can be performed consistently, rapidly and with success and complication rates similar to those of large experienced surgical centers. Moreover, early knowledge of coronary anatomy enabled informed thera-

peutic decisions, including early selection of highest risk patients for aortocoronary bypass surgery and early recognition of a large subgroup of patients who had patent vessels after aspirin and high dose heparin, whose initial management could be more conservative.

These results should not be understood to mean that infarct angioplasty can or should be done at every hospital with cardiac catheterization facilities. But this report does suggest that the lack of cardiac surgery backup, per se, need not limit the application, safety or efficacy of this valuable modality in the treatment of a broader spectrum of patients with acute myocardial infarction. Multicenter studies of primary angioplasty at hospitals without cardiac surgery are needed to help assess the feasibility, safety and efficacy of this approach on a large scale nationwide. At least two such studies are now ongoing (21).

Acknowledgments
We thank the nursing, technical and paramedical staffs, the emergency department and attending physicians and the hospital administrations at Exeter and Portsmouth Regional Hospitals, without whose enthusiastic support this work would not have been possible. We particularly wish to acknowledge the invaluable contributions of the catheterization laboratory teams of Exeter and Portsmouth Hospitals, whose dedicated service and commitment to an intensive call schedule were integral to the success of our program. We also wish to express appreciation to Mr. Peter Corbett and to Dr. Terry Mixter of Exeter Hospital for their help in the development of our database.

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