Catheterization Laboratory Events and Hospital Outcome With Direct Angioplasty for Acute Myocardial Infarction

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To assess the safety of direct infarct angioplasty without antecedent thrombolytic therapy, catheterization laboratory and hospital events were assessed in consecutively treated patients with infarctions involving the left anterior descending (n=100 patients), right (n=100), and circumflex (n=50) coronary arteries. The groups of patients were similar for age (left anterior descending coronary artery, 59 years; right coronary artery, 58 years; circumflex coronary artery, 62 years), patients with multivessel disease (left anterior descending coronary artery, 55%; right coronary artery, 55%; circumflex coronary artery, 64%), and patients with initial grade 0/1 antegrade flow (left anterior descending coronary artery, 79%; right coronary artery, 84%; circumflex coronary artery, 90%). Cardiogenic shock was present in eight patients with infarction of the left anterior descending coronary artery, four with infarction of the right coronary artery, and four with infarction of the circumflex coronary artery. Major catheterization laboratory events (cardioversion, cardiopulmonary resuscitation, dopamine or intra-aortic balloon pump support for hypotension, and urgent surgery) occurred in 10 patients with infarction of the left anterior descending coronary artery, eight with infarction of the right coronary artery, and four with infarction of the circumflex coronary artery. Major catheterization laboratory events (cardioversion, cardiopulmonary resuscitation, dopamine or intra-aortic balloon pump support for hypotension, and urgent surgery) occurred in 10 patients with infarction of the left anterior descending coronary artery, eight with infarction of the right coronary artery, and four with infarction of the circumflex coronary artery. Minor in-laboratory events (brief bolus atropine or pressor, and temporary pacer) occurred in an additional six patients with infarction of the left anterior descending coronary artery, 27 with infarction of the right coronary artery, and six with infarction of the circumflex coronary artery (p<0.001 for right coronary artery). Initial flow was grade 0/1 in 60 of 61 patients with events. Procedural success (alive, ≤40% stenosis, no surgery) was achieved in 96% of patients with infarction of the left anterior descending coronary artery, 98% of patients with infarction of the right coronary artery, and 90% of patients with infarction of the circumflex coronary artery (p=NS). Predischarge angiography demonstrated sustained arterial patency in 95% of 65 patients with infarction of the left anterior descending coronary artery, 90% of 62 with infarction of the right coronary artery, and 81% of 26 with infarction of the circumflex coronary artery. Hospital survival was 93% for patients with infarction of the left anterior descending coronary artery, 96% for those with infarction of the right coronary artery, and 94% for those with infarction of the circumflex coronary artery (p=NS). Thus, major catheterization laboratory events are infrequent during direct infarct angioplasty. Although minor catheterization laboratory events are common, and should be anticipated with right coronary artery infarcts, direct infarct angioplasty results in excellent arterial patency and hospital survival. (Circulation 1990;82:1910–1915)

Evidence indicating that direct infarct angioplasty without antecedent thrombolytic therapy may be the reperfusion strategy of choice during acute myocardial infarction has recently been reviewed.1 Important advantages of emergent catheterization and direct infarct angioplasty include higher patency rates (≥90%) than with thrombolytic agents,1,3–4 applicability to the majority of infarct patients due to the absence of the multiple contraindications that limit the use of

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thrombolytic agents,1,3,5 freedom from the increased rate of intracranial hemorrhage with thrombolytic drugs,6 and early confirmation of the diagnosis before therapy eliminating conditions that masquerade as infarction.7 Impressive recovery of ventricular function and good hospital survival have been reported from our center.2,8,9 Greater use of direct infarct angioplasty has been hampered in part by a lack of information regarding relative safety and ease of the procedure as performed by experienced operators. The purpose of this report is to describe the frequency and outcome of catheterization laboratory events complicating direct infarct angioplasty in many patients.

Methods

Study Patients

Since 1981, all patients treated with coronary angioplasty have been prospectively entered into a computer database. For analysis, patients treated between 1987 and 1989 were selected to provide 100 consecutive patients with infarctions involving the left anterior descending (LAD) artery, 100 consecutive patients with infarctions involving the right coronary artery (RCA), and 50 consecutive patients with infarctions involving the left circumflex artery (LCx). The analysis was limited to these 250 patients due to difficulties in obtaining complete laboratory records from patients treated earlier in our experience. Patients were considered for direct infarct angioplasty if they had 1) chest pain consistent with ongoing myocardial ischemia persisting more than 30 minutes and 2) at least 1 mm ST segment elevation in two or more contiguous electrocardiographic leads. Patients were excluded from this study for the following reasons: 1) treatment with a thrombolytic agent for the infarction in progress, 2) acute coronary occlusion after elective angioplasty, 3) presentation to the emergency room more than 6 hours after the onset of chest pain without clinical or electrocardiographic evidence of ongoing ischemia. Patients with “stuttering” ischemia presenting more than 6 hours but less than 24 hours after pain onset were included. No patient was excluded from balloon angioplasty because of age, cardiogenic shock, bleeding diatheses, or prior or ongoing cardiopulmonary resuscitation. Cardiogenic shock was defined as a systolic blood pressure less than or equal to 80 mm Hg with clinical evidence of systemic hypoperfusion. Patients with prior coronary artery bypass graft (CABG) surgery were excluded from this analysis.

Angioplasty Protocol

Patients received 10,000–20,000 units heparin in the emergency room or the catheterization laboratory. A lidocaine hydrochloride bolus followed by a continuous intravenous infusion was started in the emergency room. Unless contraindicated, routine premedications consisted of 325 mg aspirin orally, 5 mg isosorbide dinitrate sublingually, and 5 mg verapamil intravenously. Patients also received 500 ml intravenous dextran if they had preserved left ventricular function, 100–200 ml if they had moderately depressed function, and no dextran if they had poor function. An additional 5,000 units heparin was given every hour of the angioplasty procedure. Left ventriculography in the 30° right anterior oblique projection was performed in patients without hemodynamic instability, followed by visualization of the non–infarct-related arteries and the infarct-related vessel. In each patient, the infarct-related vessel was determined by the presence of a total or subtotal occlusion in a distribution concordant with the electrocardiographic and ventriculographic site of infarction. The extent of coronary artery disease was graded as one-, two-, or three-vessel disease based on the presence of a 70% or greater reduction of the internal vessel diameter of the main arteries or branches as defined by the Coronary Artery Surgery Study.10

Coronary angioplasty was performed in the majority of patients with a 0.014- or 0.018-in. guidewire and an over-the-wire balloon catheter. Typically, 3–5 inflations lasting 45–120 seconds were performed across the lesion by using pressure sufficient to achieve full balloon expansion. The angioplasty procedure was considered successful if the residual stenosis was less than 40% in all views and no major procedural complications occurred (death or urgent CABG).

After angioplasty, heparin was continued for 36–48 hours with the partial thromboplastin time adjusted to 2.0-fold to 2.5-fold the control value. After discontinuation for sheath removal, the heparin was restarted for an additional 1–3 days. All patients were maintained on 325 mg aspirin three times daily, 75 mg dipyridamole three times daily, and an oral calcium antagonist. Patients demonstrating signs of recurrent ischemia had repeat catheterization before hospital discharge. Predischarge catheterization was also performed in consenting, asymptomatic patients.

Definitions

In all study patients, hospital and catheterization laboratory records were carefully reviewed for catheterization laboratory events and hospital outcomes. Major in-laboratory events during direct infarct angioplasty, defined as new events not present before arrival in the catheterization suite, were 1) death, 2) cardiopulmonary resuscitation, 3) ventricular tachycardia or fibrillation treated with electrical cardioversion, and 4) sustained hypotension, defined as a systolic blood pressure less than or equal to 80 mm Hg requiring the continuous intravenous infusion of dopamine, the therapeutic insertion of an intra-aortic balloon pump, or both. Minor in-laboratory events were defined as 1) transient hypotension, defined as a systolic blood pressure less than or equal to 80 mm Hg requiring intravenous bolus administration of 0.0625–0.125 mg neosynephrine once or twice during the procedure, and 2) bradycardia treated...
with 0.5–1.0 mg intravenous atropine or a temporary transvenous pacemaker. In three patients, an intra-aortic balloon pump was inserted at the operator’s discretion at the end of uncomplicated procedures as a prophylactic measure, and in two patients, prophylactic temporary pacemakers were inserted at the end of uncomplicated procedures. These procedures were not considered as therapeutic catheterization laboratory events.

**Statistics**

Data are reported as mean±SD. Analysis of variance was used for comparison of continuous variables, and the χ² test was used between categorical variables. A p value of 0.05 was considered significant.

**Results**

**Baseline Characteristics**

The baseline clinical and angiographic characteristics of the study patients are presented in Table 1. There were no differences in the age, sex, or time to presentation in the three groups. Forty-nine patients were at least 70 years old (20%). Cardiogenic shock was present in 16 patients (6%). Multivessel coronary artery disease was found in 142 patients (57%).

**In-Laboratory Events**

Major and minor catheterization laboratory events are summarized in Table 2. A total of 61 patients (24%) had events, including 22 patients with major events (9%) and 39 patients with only minor events (15%). In-laboratory events occurred in 60 of 208 patients with Thrombolysis in Myocardial Infarction grade 0 or 1 antegrade coronary flow compared with one of 42 patients with initial grade 2 or 3 coronary flow (p<0.001). Major in-laboratory events occurred in 16 of 16 shock patients (100%) and six of 234 nonshock patients (3%, p<0.001). One in-laboratory death occurred in a shock patient with a proximal LAD occlusion (0.4% of patients). Electrical cardioversion for ventricular tachycardia/fibrillation was required in one LAD and one LCx infarction in patients in shock and in five RCA infarctions. In two of these patients with right coronary infarction, the sustained arrhythmia occurred in the laboratory before the procedure began, and in three it commenced after control injections of the right artery before angioplasty. Intra-aortic balloon pumps were placed in all 16 shock patients at the beginning of the procedure to support the circulation and in two nonshock patients during the procedure for progressive hypotension. There was no difference in the frequency of major in-laboratory events among the patient groups separated by infarct vessel site. Minor in-laboratory events were more frequent in the group of patients with reperfused RCAs (p<0.001). These events consisted predominantly of transient hypotension and bradycardia at the time of reperfusion, which was easily managed. Mean fluoroscopic time required during the procedures was similar for the three infarct arteries.

**Procedural and Hospital Outcome**

The results of the angioplasty procedures and subsequent hospital outcome are summarized in Ta-
ble 3. Successful dilatation of the infarct artery was achieved in 239 of 250 patients (96%), and did not vary according to the infarct artery involved or the initial antegrade coronary flow. There were 14 in-hospital deaths, giving an overall hospital survival of 94%. Eight of the 14 deaths occurred in shock patients, and 97.5% of 234 patients without shock survived to discharge. There was no difference in hospital mortality according to the infarct artery involved. All patients evolved a myocardial infarction by enzyme analysis, and the peak creatinine phosphokinase level was not different among the three groups. Before discharge, significant Q waves were present on the electrocardiograms of 62 patients, each with infarction involving the LADs and RCAs, and 25 patients with infarction involving the LCx (p=NS). Predischarge coronary arteriography was obtained in 153 of 236 hospital survivors (65%). Sustained arterial patency was documented in 139 of these patients (91%) and did not vary by infarct artery.

**TABLE 2. Catheterization Laboratory Events During Direct Infarct Angioplasty in 250 Patients**

<table>
<thead>
<tr>
<th>Major events</th>
<th>LAD infarct (n=100)</th>
<th>RCA infarct (n=100)</th>
<th>LCx infarct (n=50)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (%)</td>
<td>10</td>
<td>8</td>
<td>8</td>
<td>NS</td>
</tr>
<tr>
<td>Death (%)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>...</td>
</tr>
<tr>
<td>Urgent surgery (%)</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>...</td>
</tr>
<tr>
<td>Intra-aortic balloon (%)</td>
<td>10</td>
<td>4</td>
<td>8</td>
<td>...</td>
</tr>
<tr>
<td>Cardioversion (%)</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>...</td>
</tr>
<tr>
<td>Dopamine infusion (%)</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>...</td>
</tr>
<tr>
<td>Total nonshock patients (%)</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>...</td>
</tr>
</tbody>
</table>

**Minor events                  | LAD infarct (n=100) | RCA infarct (n=100) | LCx infarct (n=50) | p   |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (%)</td>
<td>6</td>
<td>27*</td>
<td>12</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Bolus neosynephrine (%)</td>
<td>4</td>
<td>13*</td>
<td>4</td>
<td>0.02</td>
</tr>
<tr>
<td>Atropine (%)</td>
<td>2</td>
<td>19*</td>
<td>6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Temporary pacemaker</td>
<td>2</td>
<td>13*</td>
<td>8</td>
<td>0.01</td>
</tr>
<tr>
<td>Total events</td>
<td>16</td>
<td>35*</td>
<td>20</td>
<td>0.01</td>
</tr>
<tr>
<td>Fluoroscopic time (min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean±SD</td>
<td>16±9</td>
<td>15±7</td>
<td>19±13</td>
<td>0.06</td>
</tr>
<tr>
<td>Range</td>
<td>4–44</td>
<td>4–63</td>
<td>6–47</td>
<td>...</td>
</tr>
</tbody>
</table>

*LAD, left anterior descending coronary artery; RCA, right coronary artery; LCx, left circumflex. *Indicates statistically significant differing value.

**TABLE 3. Procedural and Hospital Outcome in 250 Patients Treated With Direct Infarct Angioplasty**

<table>
<thead>
<tr>
<th>Overall angioplasty success</th>
<th>LAD infarct (n=100)(%)</th>
<th>RCA infarct (n=100)(%)</th>
<th>LCx infarct (n=50)(%)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>96</td>
<td>98</td>
<td>90</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>Initial flow grade 0 or 1</td>
<td>76/79 (96)</td>
<td>82/84 (98)</td>
<td>40/45 (89)</td>
<td>0.08</td>
</tr>
<tr>
<td>Initial flow grade 2 or 3</td>
<td>20/21 (95)</td>
<td>16/16 (100)</td>
<td>5/5 (100)</td>
<td>...</td>
</tr>
<tr>
<td>Peak CPK (IU/ml)</td>
<td>2,362±2,176</td>
<td>1,892±2,975</td>
<td>1,796±1,746</td>
<td>NS</td>
</tr>
<tr>
<td>Hospital survival</td>
<td>93</td>
<td>96</td>
<td>94</td>
<td>NS</td>
</tr>
<tr>
<td>Follow-up angiography (patients)</td>
<td>65</td>
<td>62</td>
<td>26</td>
<td>NS</td>
</tr>
<tr>
<td>Sustained arterial patency</td>
<td>95</td>
<td>90</td>
<td>81</td>
<td>0.09</td>
</tr>
</tbody>
</table>

*LAD, left anterior descending coronary artery; RCA, right coronary artery; LCx, left circumflex; CPK, creatinine phosphokinase.

**Discussion**

This study provides the first detailed analysis of the procedural safety of mobilizing large numbers of patients to the cardiac catheterization laboratory for direct infarct angioplasty without antecedent thrombolytic therapy. The results indicate that major events such as death, life-threatening arrhythmias, and requirements for urgent bypass surgery do occur in patients treated with direct infarct angioplasty but predominantly in patients presenting with cardiogenic shock. Indeed, 97% of the nonshock patients in this study were free of major catheterization laboratory adverse events. Transient hypotension and bradycardia that were readily and effectively treated occurred more frequently, particularly in infarctions involving the RCA. They appeared to be of little significance, however, as the overall angioplasty success rate achieved was 96%, and the total hospital survival including the shock patients was 94%.

Limited information concerning the catheterization laboratory outcomes of acute infarction inter-
ventations is available.\textsuperscript{4,11,12} Several important differences exist between this study and previous reports. With the exception of one study,\textsuperscript{12} this is the only analysis focusing on in-laboratory events during infarct angioplasty, and it provides sufficient detail to critically analyze the procedure. Unlike the other report emphasizing in-laboratory complications,\textsuperscript{12} the present series is large, analyzes a single treatment strategy, includes patients presenting with cardiogenic shock, and includes sufficient patients with infarctions of each of the three coronary arteries to permit comparisons. During the period of study, approximately 96\% of patients with acute myocardial infarction and ST segment elevation presenting to our group were treated with direct infarct angioplasty.\textsuperscript{2} In agreement with the previous report, in-laboratory events were observed more frequently in procedures involving the RCA. In our series, 35\% of infarctions involving the RCA were complicated by in-laboratory events (Table 2). Gacioch and Topol\textsuperscript{12} reported complications in 33\% of procedures involving the RCA. The nature of the events, however, differs greatly in the two series. Only eight of the events in the RCA group in the present report were major, occurring for the most part in patients with cardiogenic shock. Cardiopulmonary resuscitation was required in only one patient (1\%) and ventricular arrhythmias requiring cardioversion occurred in only three nonshock patients (Table 2). In contrast, Gacioch and Topol\textsuperscript{12} observed that cardiopulmonary resuscitation was needed in 16\% of patients and cardioversion was needed in 9\% of their group. Furthermore, important differences were observed in procedural outcome. In this series, infarct angioplasty was successful in 98\% of RCA infarcts and 96\% of patients survived to discharge (Table 3). In contrast, arterial patency was achieved in 87\% of 46 RCA infarcts and only 87\% survived to discharge.\textsuperscript{12} Finally, we observed a 90\% sustained patency rate of the RCA in patients undergoing predischarge angiography, compared with 63\% patency at 7 days reported by Gacioch and Topol.\textsuperscript{12} Explanations for these major differences are not readily apparent. In the prior report, 70 of 83 patients were treated after failed thrombolytic therapy, suggesting that significant biases in the selection may have occurred. Our patients were uniformly treated with intravenous lidocaine before the procedure, which may have reduced the incidence of sustained ventricular arrhythmias. Furthermore, larger doses of heparin and uniform aspirin therapy were used in our study and may have contributed to the superior procedural results. After the procedure, we achieved a greater degree of anticoagulation for a longer duration of time, perhaps contributing to sustained patency and hospital survival.

The overall procedural results and hospital survival in this study compare favorably with our initial report detailing 500 consecutive patients treated from 1981 to 1988.\textsuperscript{2} Although there was overlap of 99 patients between that series and this report, the slightly improved procedural success, hospital survival, and rates of sustained patency reported here probably reflect improvements in equipment, technique, and patient management in our most recent performance of direct infarct angioplasty. Additionally, in comparison with the survival of 95.3\% of patients treated with thrombolytic therapy followed by a conservative “watchful waiting” approach in a recent major trial,\textsuperscript{13} the survival of 97.5\% of nonshock patients in this study, including many elderly patients and patients with multivessel disease, is promising.

The results of this study support the safety and increased use of direct infarct angioplasty in patients with infarctions involving the LAD. These patients are at the highest risk for cardiogenic shock and death. Although major catheterization laboratory events can be anticipated in patients with cardiogenic shock treated with direct infarct angioplasty, the effectiveness of this therapy would appear to justify the risks.\textsuperscript{14} In nonshock patients, procedures were typically brief and uncomplicated. Similarly, procedures in patients with infarctions involving the LCX are uncommonly complicated by major events. Therapy of infarctions in patients involving the RCA warrants further consideration. The opinion has been expressed that patients with inferior infarction be denied both thrombolytic therapy and angioplasty due to limited potential benefits.\textsuperscript{12,15} Critical analysis of the results of multiple trials involving thrombolytic agents in patients with inferior infarction, however, indicates that patency rates comparable with anterior infarctions are achieved and that improvements in regional ventricular function are independent of infarct location.\textsuperscript{16} Significant improvements in regional wall motion in patients with RCA involvement have also been observed after combined thrombolysis and angioplasty.\textsuperscript{17} Our data would support the continued application of direct infarct angioplasty to patients with inferior infarctions. Complications are frequent and must be anticipated, but tend to be minor, brief, and readily treated with pharmacological agents or temporary pacing. Nonetheless, procedural success is high, sustained patency is good, and hospital survival is excellent in patients with RCA involvement.

The decision whether to treat patients with thrombolytic agents or direct angioplasty will depend on patient, physician, and hospital factors. The large group of infarct patients who have contraindications to thrombolytic therapy should be strongly considered for direct angioplasty. Although the expense and logistical demands of transporting patients rapidly to experienced centers with catheterization laboratories are important factors to be studied further, the reperfusion rates of more than 90\% and excellent hospital survival that can be anticipated with this therapy would appear to offset these concerns. In patients eligible for thrombolytic therapy in hospitals with active angioplasty programs, the decision will depend on laboratory availability and physician experience. An ongoing multicenter randomized trial of
tissue plasminogen activator versus direct infarct angioplasty should provide further comparative information about the therapeutic efficacy of these two reperfusion strategies.

References

KEY WORDS • cardiogenic shock • ventricular fibrillation • coronary artery disease • myocardial ischemia
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