DETERMINANTS OF SUCCESSFUL SURGICAL REVASCULARIZATION FOR FAILED ANGIOPLASTY IN PATIENTS WITH ACUTE MYOCARDIAL INFARCTION AND CARDIOGENIC SHOCK

Ron-Bin Hsu, Robert J. Chen, Shoëi-Shen Wang, and Shu-Hsun Chu

Cardiogenic shock (CS) is the leading cause of mortality in patients with acute myocardial infarction (AMI) [1–3]. Previous nonrandomized studies have reported encouraging results with percutaneous transluminal coronary angioplasty (PTCA) in patients with acute myocardial infarction (AMI) and cardiogenic shock (CS). However, PTCA fails in many patients and the mortality rate associated with the procedure is very high. This study sought to assess the determinants of successful coronary artery bypass grafting (CABG) in patients with AMI, CS and failed PTCA.

Background and Purpose: Previous studies have reported encouraging results with percutaneous transluminal coronary angioplasty (PTCA) in patients with acute myocardial infarction (AMI) and cardiogenic shock (CS). However, PTCA fails in many patients and the mortality rate associated with the procedure is very high. This study sought to assess the determinants of successful coronary artery bypass grafting (CABG) in patients with AMI, CS and failed PTCA.

Materials and Methods: From April 1997 to May 2001, 33 patients with a mean age of 62.9 ± 10.5 years underwent CABG for AMI, CS and failed PTCA. PTCA failed or was not attempted because of primary failure in 13 patients, reocclusion in three, no-reflow in one, and multivessel disease in 18. Patients were initially stabilized with inotropic infusion and mechanical circulatory support. Before June 2000, patients underwent conventional CABG, while after June 2000, patients underwent beating heart CABG. Risk factor analysis was performed using retrospective chart review.

Results: The overall inhospital mortality rate was 30.3% — 33.3% in 24 patients who underwent conventional CABG and 22.2% in nine patients who underwent beating heart CABG. Risk factors for death were unstable hemodynamics (p < 0.001), non-right coronary artery as the infarct-related artery (IRA) (p = 0.012), high inotropic dose (p = 0.013), intubation (p = 0.021), cardiopulmonary resuscitation (p = 0.021), and early bypass (p = 0.050).

Conclusions: CABG was associated with a high inhospital mortality rate in patients with AMI, CS and failed PTCA. Patients with unstable hemodynamics and high inotropic dose before surgery had the worst survival rate.

The efficacy of surgical revascularization in patients with AMI, CS and failed PTCA remains unclear. The aim of this study was to assess the effect of surgical revascularization on survival in patients with AMI, CS and failed PTCA.

Patients and Methods

All patients referred from cardiologists to the Department of Surgery at National Taiwan University

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Hospital for treatment for AMI and CS between April 1997 and May 2001 were included in this study. CS was defined as systolic blood pressure below 90 mmHg that was thought to be secondary to cardiac dysfunction and associated with signs of end-organ hypoperfusion such as cool extremities or oliguria. Patients with CS due to post-infarct mitral regurgitation, ventricular septal rupture, or free wall rupture were excluded.

**Initial stabilization and PTCA**

Patients with CS were initially stabilized with intravenous inotropic infusion (dopamine, dobutamine, epinephrine). Mechanical circulatory support with intraaortic balloon pumping (IABP) or extracorporeal membrane oxygenation (ECMO) was used if patients had persistent shock or angina. Patients were sent to the coronary catheter laboratory immediately for diagnostic cardiac catheterization, and angioplasty was attempted if the coronary artery was occluded. Coronary artery bypass grafting (CABG) was performed if PTCA failed to recanalize the infarct-related artery (IRA).

**CABG**

From April 1997 through June 2000, patients underwent conventional CABG. This was performed in a standard manner with cardiopulmonary bypass and aortic cross-clamp. Internal mammary artery and saphenous vein grafts were used as coronary bypass conduits. Both antegrade and retrograde cold blood cardioplegia with terminal warm shot were used for myocardial protection.

From June 2000, patients underwent off-pump or on-pump beating heart CABG without aortic cross-clamp. Surgery was performed through a median sternotomy. A myocardial coronary artery stabilizer system (Octopus, Medtronic, Minneapolis, MN, USA) was used in all cases [11]. Distal anastomosis was constructed from the most severely occluded coronary artery. Proximal anastomosis of saphenous vein grafts was performed on the partially clamped ascending aorta after careful digital palpation of the aorta. To assist good exposure of inferior and obtuse marginal surfaces of the heart, the patient was placed in a steep Trendelenburg position at a 30 to 60° angle. The table was raised and rotated toward the right. A suitably sized Guidant Flocoil intra-coronary shunt was inserted into the lumen to minimize the amount of ischemia and to reduce bleeding. A carbon dioxide blower was used for anastomosis.

Alpha agents, inotropic agents and IABP were used to maintain blood pressure and cardiac output during manipulation. For patients with severe peripheral arterial occlusive disease or persistent unstable hemodynamics, partial cardiopulmonary bypass was instituted using an ascending aortic perfusion cannula and single right atrial cannula.

**Data collection**

Data were collected from a retrospective review of medical records and categorized into three types: patient factors, surgical factors, and hospital outcome (in-hospital mortality).

Patient factors included age, sex, hypertension, diabetes, history of previous MI, Q or non-Q wave AMI, unstable hemodynamics before surgery, IABP use, ECMO use, cardiopulmonary resuscitation before surgery, preoperative inotropic dose, IRA, and number of diseased coronary arteries. Unstable hemodynamics before surgery was defined as persistent shock despite the use of multiple inotropic drips, IABP or ECMO. Preoperative inotropic dose was classified as low if dopamine infusion was less than 10 µg/kg/minute or high if dopamine infusion was more than 10 µg/kg/minute.

Surgical factors included operative procedure, early bypass, emergency operation and complete revascularization. Early bypass was defined as a CABG procedure performed within 24 hours of AMI.

Patient and surgical factors were compared between non-surviving and surviving patient groups.

**Statistical analysis**

Comparisons between groups were performed using Fisher’s exact test for categorical variables and Whitney-Mann U test for continuous variables. A value of \( p < 0.05 \) was considered statistically significant.

**Results**

**Patient factors**

From April 1997 to May 2001, 33 patients underwent CABG for AMI, CS and failed PTCA. In these patients, PTCA failed to recanalize the IRA because of primary failure in 13, re-occlusion in three, no-reflow in one, and multivessel disease not amenable to angioplasty in 18. There were 25 males and 8 females with a mean age of 62.9 ± 10.5 years. Thirty patients had systemic hypertension, 12 had diabetes mellitus, and 11 had a previous history of MI (Table). Twenty-five patients had Q-wave AMI, 19 required cardiopulmonary resuscitation and endotracheal intubation, 29 required preoperative IABP, and 22 required a high inotropic dose before surgery. Fifteen patients had unstable hemodynamics despite the use of inotropic infusion and mechanical circulatory support and required emergency surgery. The IRA was the left main coronary artery in
Table. Comparison between non-surviving and surviving patients

<table>
<thead>
<tr>
<th>Variables</th>
<th>Non-survivors (n = 10)</th>
<th>Survivors (n = 23)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>61.5 ± 9.0</td>
<td>63.5 ± 11.3</td>
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<tr>
<td>Male</td>
<td>7 (70%)</td>
<td>18 (78%)</td>
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<tr>
<td>Hypertension</td>
<td>9 (90%)</td>
<td>21 (91%)</td>
<td>0.999</td>
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<tr>
<td>Diabetes mellitus</td>
<td>4 (40%)</td>
<td>8 (35%)</td>
<td>0.999</td>
</tr>
<tr>
<td>History of previous infarction</td>
<td>2 (20%)</td>
<td>9 (39%)</td>
<td>0.430</td>
</tr>
<tr>
<td>Q-wave AMI</td>
<td>10 (100%)</td>
<td>15 (74%)</td>
<td>0.071</td>
</tr>
<tr>
<td>Emergency surgery</td>
<td>10 (100%)</td>
<td>18 (78%)</td>
<td>0.291</td>
</tr>
<tr>
<td>High inotropic dose before surgery</td>
<td>10 (100%)</td>
<td>12 (52%)</td>
<td>0.013*</td>
</tr>
<tr>
<td>IABP use</td>
<td>10 (100%)</td>
<td>19 (83%)</td>
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<tr>
<td>ECMO use</td>
<td>4 (40%)</td>
<td>2 (9%)</td>
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</tr>
<tr>
<td>Cardiopulmonary resuscitation</td>
<td>9 (90%)</td>
<td>10 (44%)</td>
<td>0.021*</td>
</tr>
<tr>
<td>Endotracheal intubation</td>
<td>9 (90%)</td>
<td>10 (44%)</td>
<td>0.021*</td>
</tr>
<tr>
<td>Infarct-related artery</td>
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<td></td>
</tr>
<tr>
<td>Left anterior descending artery</td>
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<td>6</td>
<td></td>
</tr>
<tr>
<td>Left circumflex artery</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Right coronary artery</td>
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<tr>
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<td>9</td>
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<tr>
<td>Unstable hemodynamics before surgery</td>
<td>10 (100%)</td>
<td>5 (22%)</td>
<td>&lt;0.001*</td>
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<td>Operative procedures</td>
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<td>Beating heart CABG</td>
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<tr>
<td>Early bypass within 24 hours of AMI</td>
<td>9 (90%)</td>
<td>11 (48%)</td>
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<tr>
<td>Complete revascularization</td>
<td>8 (80%)</td>
<td>18 (78%)</td>
<td>0.999</td>
</tr>
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</table>
| *Indicates statistical significance. AMI = acute myocardial infarction; IABP = intraaortic balloon pumping; ECMO = extracorporeal membrane oxygenation; CABG = coronary artery bypass grafting.

six patients, the left anterior descending artery in 14 patients, the left circumflex artery in two patients, and the right coronary artery in 11 patients.

**Surgical factors**
Twenty-eight patients underwent emergency surgery and five underwent urgent surgery (Table). Twenty-four patients underwent conventional CABG and nine underwent beating heart CABG (2 off-pump, 7 on-pump). Early bypass was performed in 20 patients because of unstable hemodynamics or persistent angina. Complete revascularization was achieved in 26 patients.

**Hospital outcome**
The overall in-hospital mortality rate was 30.3% (10/33). In-hospital mortality was 33.3% in the 24 patients who underwent conventional CABG and 22.2% in the nine patients who underwent beating heart CABG.

**Risk factor analysis**
Age, gender, diabetes mellitus, hypertension, history of MI, Q-wave AMI, operative procedure, emergency surgery, IABP, multivessel disease, and complete revascularization did not have a significant influence on the outcome (Table). Risk factors for mortality were unstable hemodynamics before surgery, non-right coronary artery as the IRA, high inotropic dose, endotracheal intubation, cardiopulmonary resuscitation and early bypass. In the logistic regression model, the significant predictors for survival were IRA and early bypass. The right coronary artery as the IRA had a favorable effect on survival (odds ratio, OR = 16.4; p = 0.034), whereas early bypass had an adverse effect on survival (OR = 0.06; p = 0.034).

**Discussion**
PTCA is a rapid and effective method to establish coronary reperfusion in acute coronary artery occlusion. Previous nonrandomized studies showed that the success rate of early reperfusion using PTCA in AMI and CS is 70 to 90% [4-10, 12-14]. PTCA reduces in-
hospital mortality in patients with AMI and CS from between 70 and 80% to between 25 and 50%, especially when the IRA is successfully recanalized. However, selection bias might have affected the results in these studies [15]. Presumably, the cohort of patients selected to undergo PTCA would have had a favorable prognosis. Shock is usually more severe in patients who undergo conservative treatment than in those who undergo reperfusion therapy. Recent randomized studies have shown that emergency revascularization, using both PTCA and CABG, did not significantly reduce early mortality in patients with AMI and CS [16]. The role of PTCA in AMI with CS is not clear.

Among patients with AMI and CS, PTCA is successful in those with a better chance of survival; i.e., young patients with fewer medical comorbidities, stable hemodynamics, and one- or two-vessel disease. Cardiac surgeons are now increasingly faced with a new cohort of patients; i.e., old patients with unstable hemodynamics, multivessel disease and, most importantly, failed angioplasty. The efficacy of surgical revascularization in patients with AMI, CS and failed PTCA remains unclear.

Before the clinical application of thrombolytic therapy and PTCA, DeWood et al reported that emergency surgical revascularization improved survival in patients with AMI and CS [17]. Better results with improved survival and preserved left ventricular ejection fraction were obtained when surgery was performed within 16 hours. Guyton et al reported an operative mortality rate of 12% in 17 patients with CS, among whom 10 (59%) required preoperative IABP and four (24%) required cardiopulmonary resuscitation [18]. Connolly et al reported an operative mortality rate of 28% in 14 patients with AMI and CS; preoperative IABP was required in nine patients (65%) [19]. After the clinical application of PTCA, Hochman et al reported a 30-day mortality rate of 42.1% among 57 patients who underwent CABG [16]. PTCA was performed in only nine patients (16%). Hirose et al reported an operative mortality rate of 15.8% in 19 patients with refractory shock who underwent surgical revascularization, with no mortality if surgery was performed within 24 hours after AMI [20]. They recommended that patients with shock should undergo primary surgical revascularization instead of spending a lot of time in the coronary catheter laboratory. However, PTCA was performed in only 31.9% of these patients. Thus, the outcome of CABG in patients with AMI, CS and failed PTCA is still unclear. To our knowledge, from sporadic case series [4–10], in-hospital mortality rates of surgical revascularization range from 80 to 100% in patients with AMI, CS and failed PTCA. In our 33 patients who underwent surgical revascularization, PTCA failed in 15 patients and was not attempted in 18 because of multivessel disease not amenable to angioplasty. Preoperative IABP was required in 29 patients (88%) and cardiopulmonary resuscitation in 19 (57%), and 15 patients (45%) had persistent shock before surgery. Compared to Hochman et al’s series, the incidence of cardiopulmonary resuscitation in our series was relatively high (57% vs. 30%) [16]. Our data confirm that patients with AMI, CS and failed PTCA have a worse prognosis than those in previously reported series [16].

In our study, risk factors for mortality were unstable hemodynamics before surgery, non-right coronary artery as IRA, high inotropic dose, endotracheal intubation, cardiopulmonary resuscitation, and early bypass. In the logistic regression model, significant predictors for survival were IRA and early bypass. The right coronary artery as IRA had a favorable effect on survival, whereas early bypass had an adverse effect on survival. The primary determinants of in-hospital death in patients with AMI and CS were patient factors, not surgical factors. Patients with cardiopulmonary resuscitation, endotracheal intubation, non-right coronary artery as IRA, and persistent unstable hemodynamics had the worst prognosis. Donatelli et al recommended that patients with AMI should undergo surgery before the development of CS [21]. Further clinical trials are needed to confirm this suggestion. In addition, our study showed that early bypass had a detrimental effect on survival because patients who required early bypass had severe shock before surgery.

Previous studies have reported encouraging results with off-pump or on-pump beating heart CABG in patients with AMI and high-risk patients for conventional CABG [22–25]. Of our 33 patients, two underwent off-pump beating heart CABG and seven underwent on-pump beating heart CABG. The in-hospital mortality rate was 22.2% in the nine patients who underwent beating heart CABG and 29.2% in 24 patients who underwent conventional CABG. Although there was no significant difference in mortality between the two groups, beating heart CABG with its lower incidence of myocardial injury provided a new and potentially better method of myocardial revascularization in patients with AMI and CS [26, 27].

This study was limited by the small number of patients and its retrospective design. However, it is the first study to assess the determinants of outcomes of surgical revascularization in patients with AMI, CS and failed PTCA.

**Conclusion**

CABG is associated with a high in-hospital mortality rate in patients with AMI, CS and failed PTCA. This study suggests that the primary determinants of clinical outcome are patient factors, not surgical factors, and
that patients with unstable hemodynamics and high inotropic dose before surgery have the worst survival rates.

References