Emergency Coronary Artery Bypass Surgery in the Contemporary Percutaneous Coronary Intervention Era

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Background—Since the advent of percutaneous coronary interventions (PCIs), technological advances, adjunctive pharmacotherapy, and increasing operator experience have contributed to lowering the occurrence of major complications. However, emergency coronary artery bypass surgery (CABG) for failed PCI is still associated with important morbidity and mortality, even in the era of coronary stenting. We sought to determine the prevalence, indications, predictors, and complications of emergency CABG after PCI in the past decade.

Methods and Results—We reviewed 18,593 PCIs performed from 1992 through 2000. There was a need for emergency CABG in 113 (0.61%) cases. The major indications were extensive dissection (n=61, 54%), perforation/tamponade (n=23, 20%), and recurrent acute closure (n=23, 20%). Prevalence of emergency CABG decreased from 1.5% of PCIs in 1992 to 0.14% in 2000 (P<0.001). Independent predictors of the need for emergency CABG included the worst ACC/AHA scoring of the intervened lesion (P<0.001) and female sex (P=0.028), whereas history of prior bypass surgery and use of stents resulted in a decreased need for emergency CABG (P<0.001 for both). In patients undergoing emergency CABG, there were 17 (15%) in-hospital deaths, 14 (12%) perioperative Q-wave myocardial infarctions, and 6 (5%) cerebrovascular accidents.

Conclusions—The need for emergency CABG has considerably decreased over time. Risk factors include female sex and a higher ACC/AHA score of the intervened lesion. However, morbidity and mortality of emergency CABG remain high even in the new millennium. (Circulation. 2002;106:2346-2350.)

Key Words: coronary disease • bypass • grafting • stents • angioplasty

Since the advent of percutaneous coronary interventions (PCIs) in 1977, there has been a significant decline in the occurrence of major complications, perhaps as a result of technological and pharmacological advances such as stenting and use of platelet glycoprotein IIb/IIIa inhibitors. Despite this, emergency coronary artery bypass surgery (CABG) is still associated with a significant in-hospital morbidity and mortality.2-9 We sought to determine the prevalence, indications, predictors, and in-hospital complications of emergency CABG after PCIs in the stent era.

Methods

Study Population
From 1992 through 2000, 18,593 PCI procedures were performed at the Cleveland Clinic Foundation. Information was obtained from a computerized database that included demographics, detailed clinical history, and procedural data entered at the time of the PCI and updated by an independent auditor at the time of hospital discharge. In addition, a medical chart review was performed on all patients sent for emergency CABG. Our cardiothoracic surgical database was also interrogated to ensure all cases of emergency CABG were captured.

Definitions
Emergency CABG was defined as need for surgery after PCI for the following reasons: extensive dissection causing ischemia or threatened ischemia, recurrent acute closure, perforation or tamponade, hemodynamic instability, and other indications warranting CABG that was not electively scheduled.

In-hospital death was defined as death after emergency CABG during the index hospitalization. Perioperative Q-wave myocardial infarction was defined as the appearance of new Q waves (≥0.4 ms) in at least 2 consecutive leads after emergency CABG. Cerebrovascular accidents were defined as new neurological deficits or radiological evidence of new hemorrhagic or thrombotic intracerebral events after emergency CABG.

Statistical Analysis

Descriptive statistics are summarized for categorical variables as frequencies and percentages and compared using the χ² test. Continuous variables, expressed as mean±SD, were compared using t tests. Univariate logistic regression analysis was performed to determine independent predictors of emergency CABG. Odds ratios and 95% CIs are provided for variables that were found to be significantly associated with emergency CABG (P<0.05). To confirm independent predictive value, a multivariable logistic regression model was formed from all baseline clinical and angiographic variables (Appendix) using a guided stepwise approach. Because of the changes in practice over time (ie, increased use of stents and platelet glycoprotein IIb/IIIa inhibitors), interactions of variables with time were also considered in the analysis. A value of P<0.05 was considered statistically significant for retention of variables in
the final model. All statistical analyses were done using the SAS system (version 8.0).

**Results**

**Prevalence of Emergency CABG**

Of the 18,593 PCIs, 113 (0.6%) cases required emergency CABG according to our definition. The baseline clinical and procedural characteristics of the 113 compared with the 14,411 patients who did not require emergency CABG are shown in Tables 1 and 2, respectively. The prevalence of emergency CABG from 1992 through 2000 is shown in Figure 1. There was a significant >10-fold decline in the prevalence of emergency CABG from 1.5% in 1992 to 0.14% in 2000 (P<0.001). In recent years (1996 onwards), stented patients were less likely to undergo emergency CABG compared with nonstented patients (P<0.001) (see Figure 2).

**Stent and Platelet Glycoprotein IIb/IIIa Inhibitor Use**

The use of stents and platelet glycoprotein IIb/IIIa inhibitors in all patients is shown in Figure 3. Stent and platelet glycoprotein IIb/IIIa inhibitor use increased from 5% (1992) to 56% (1996).
and 0% (1992) to 29% (1996) of all PCIs, respectively. From 1997 to 2000, use of stents and IIb/IIIa inhibitors increased from 62% to 81% and 37% to 88%, respectively.

**Indications for Emergency CABG**

The predominant indications for emergency CABG were extensive dissection, perforation/tamponade, and recurrent acute closure in 61 (54%), 23 (20%), and 23 (20%) cases, respectively. Other indications were hemodynamic instability in 3 (3%), aortic dissection in 2 (2%), and guidewire fracture in 1 (1%).

There were 84 cases of emergency CABG from 1992 through 1996 and 29 cases from 1997 through 2000. Extensive dissection as an indication for emergency CABG fell from 60% to 38% in these two time periods. The occurrence of perforation/tamponade was 19% from 1992 through 1996 and 24% from 1997 through 2000. Recurrent acute closure as an indication for emergency CABG was 19% from 1992 through 1996 and 24% from 1997 through 2000.

**Predictors of Emergency CABG**

Patients who required emergency CABG were more likely to be female \((P<0.01)\), have higher left ventricular ejection fractions \((P<0.002)\), have an acute myocardial infarction as an indication for the PCI \((P=0.01)\), and have an intra-aortic balloon pump inserted before \((<=48\) hours) the PCI \((P<0.003)\) and also to have had a relatively higher number of type C lesions \((P<0.001)\) and a lesser number of type A lesions \((P<0.001)\). In addition, the worst ACC/AHA score of the intervened lesion \((<0.001)\) correlated with the need for emergency CABG. Patients with history of a prior bypass surgery \((P<0.001)\) and those who received stents \((P<0.001)\) and platelet glycoprotein IIb/IIIa inhibitors \((P<0.001)\) were less likely to require emergency CABG (Tables 1 through 3).

In multivariable analysis, the worst ACC/AHA score of the intervened lesion \((P<0.001)\) and female sex \((P=0.028)\) were predictive of the need for emergency CABG. Those with a history of a prior bypass surgery were less likely to undergo emergency CABG \((P<0.001)\). Those who received stents in the recent years (1996 onwards) had a decreased need for emergency CABG \((P<0.001)\) (Table 4).

**Operator Experience and Need for Emergency CABG**

There was no difference in need for emergency CABG following PCIs performed by operators performing >75 cases per year compared with those performing <75 cases per year \((0.77%\) versus \(0.83\%),\) respectively, \(P=0.8)\).

**In-Hospital Complications of Emergency CABG**

There were 40 (35%) additional in-hospital complications in the patients undergoing emergency CABG. There were 17 (15%) deaths, 14 (12%) perioperative Q-wave myocardial infarctions, 6 (5%) cerebrovascular accidents, 2 (2%) patients with respiratory failure postoperatively requiring intubation >5 days, and 1 (1%) patient with hemodynamic instability requiring extracorporeal circulatory support postoperatively. Among 84 patients undergoing emergency CABG from 1992 through 1996, there were 29 (35%) complications (11 deaths, 14 perioperative Q-wave myocardial infarctions, 3 cerebrovascular accidents, and 1 respiratory failure). Among 29 patients undergoing emergency CABG from 1997 through 2000, there were 11 (38%) complications (6 deaths, 3 cerebrovascular accidents, 1 extracorporeal mechanical oxygenation, and 1 respiratory failure).

To determine if sending fewer patients to emergency CABG resulted in a potentially compensatory increased...
incidence of other serious complications, the incidence of Q-wave myocardial infarction and death was assessed over time. Among patients undergoing elective PCI not requiring emergency CABG, there was a significant decline in the incidence of death and Q-wave myocardial infarction from 1992 through 2000 (P<0.001). From 1992 through 1996, there were 48 Q-wave myocardial infarctions (0.7%) and 140 deaths (2.0%) among 6614 patients undergoing elective PCI and not requiring emergency CABG. From 1997 through 2000, there were 15 Q-wave myocardial infarctions (0.2%) and 62 deaths (0.9%) among 6825 patients undergoing elective PCIs and not requiring emergency CABG. Therefore, not only emergency CABG but also all major adverse events have significantly improved over the last decade.

**Discussion**
In this study of 18 593 PCIs performed over a 9-year period from 1992 through 2000, we report a dramatic >10-fold decline in prevalence of emergency CABG after failed PCIs. In parallel, Q-wave myocardial infarction and death also significantly declined over time in patients undergoing elective PCI and not requiring emergency CABG.

Independent risk factors predisposing a patient to emergency CABG included female sex and complex coronary lesions (of those requiring emergency CABG, 5% had type A lesions and 40% had type C lesions). Moreover, use of stents was independently associated with decreased need for emergency CABG, as was the history of prior bypass surgery. Furthermore, in this study, operator experience and use of platelet glycoprotein IIb/IIIa inhibitors did not have a bearing on need for emergency CABG after PCI. Despite the decline in emergency CABG in the era of stents, when required, emergency CABG is still associated with a high risk of major in-hospital adverse events.

Since the first reported case of percutaneous coronary intervention in 1977,^1^ surgical standby has been the norm. In an early experience of 50 cases, emergency CABG was required in 14%.<sup>1</sup> In 2 large series reported by the National Heart, Lung and Blood Institute, emergency CABG was required in 6% of the cases between 1977 and 1981 and in 3% between 1985 and 1986.<sup>10</sup> There has been an additional decline in the reported prevalence of emergency CABG in the 1990s. In a study of 5655 patients undergoing PCIs by Shubrooks et al,<sup>11</sup> emergency CABG was required in 2.2% of the cases in 1992 to 1993 and 0.6% of the cases in 1997. We report a significant decline in the prevalence of emergency CABG from 1.5% in 1992 to 0.14% of all PCIs in 2000 in a single-center tertiary care setting (Figure 1).

The declining need for emergency CABG may be attributable to increased operator and laboratory experience, better percutaneous techniques, technological advances such as stents, and use of adjunctive pharmacotherapy such as platelet glycoprotein IIb/IIIa inhibitors. There could also be a higher threshold for sending patients for emergency CABG. In our study, use of stents was independently associated with a decreased need for emergency CABG. As stents became more widely available after 1995 to 1996, stented patients had a significant decline in the need for emergency CABG.

**TABLE 3. Univariate Correlates of the Need for Emergency CABG After PCIs**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worst ACC/AHA score of the intervened lesion</td>
<td>1.71</td>
<td>1.40 to 2.08</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Stent use</td>
<td>0.35</td>
<td>0.23 to 0.54</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Prior bypass surgery</td>
<td>0.22</td>
<td>0.11 to 0.43</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Increased left ventricular ejection fraction</td>
<td>1.03</td>
<td>1.01 to 1.05</td>
<td>0.002</td>
</tr>
<tr>
<td>Acute myocardial infarction</td>
<td>2.08</td>
<td>1.18 to 3.66</td>
<td>0.01</td>
</tr>
<tr>
<td>Female sex</td>
<td>1.64</td>
<td>1.13 to 2.40</td>
<td>0.01</td>
</tr>
<tr>
<td>Platelet glycoprotein IIb/IIIa inhibitors</td>
<td>0.41</td>
<td>0.26 to 0.65</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Year of procedure*</td>
<td>0.77</td>
<td>0.71 to 0.83</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*Interaction term of time and stent use.

**TABLE 4. Multivariable Logistic Regression Model for Predictors of Emergency CABG After PCIs**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate± SE</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worst ACC/AHA score of the intervened lesion</td>
<td>0.547±0.11</td>
<td>1.73</td>
<td>1.40 to 2.13</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Prior bypass surgery</td>
<td>−1.70±0.35</td>
<td>0.18</td>
<td>0.09 to 0.37</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Female sex</td>
<td>0.42±0.19</td>
<td>1.53</td>
<td>1.05 to 2.24</td>
<td>0.028</td>
</tr>
<tr>
<td>Stent use × year of procedure*</td>
<td>−0.48±0.10</td>
<td>...</td>
<td>...</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Year of procedure</td>
<td>−0.09±0.05</td>
<td>...</td>
<td>...</td>
<td>0.07</td>
</tr>
<tr>
<td>Stent use</td>
<td>2.83±0.65</td>
<td>...</td>
<td>...</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Year 1995</td>
<td>...</td>
<td>1.53</td>
<td>1.33 to 1.75</td>
<td>...</td>
</tr>
<tr>
<td>Year 1997</td>
<td>...</td>
<td>0.58</td>
<td>0.54 to 0.63</td>
<td>...</td>
</tr>
<tr>
<td>Year 2000</td>
<td>...</td>
<td>0.14</td>
<td>0.09 to 0.20</td>
<td>...</td>
</tr>
</tbody>
</table>
compared with the nonstented patients. Before the availability of stents, complications such as coronary dissections would have more frequently resulted in emergency surgery. There was a relatively lower number of emergency CABGs in the stented patients compared with those not receiving stents (Figure 2). Despite the benefit of platelet glycoprotein IIb/IIIa inhibitors in decreasing acute closure, the use of platelet glycoprotein IIb/IIIa inhibitors was not independently associated with a decreased need for emergency CABG in the present study. This likely reflects the analytic issues of a larger registry compared with dedicated placebo-controlled randomized trials. Although increased operator experience has been shown to be associated with better outcomes after PCI, in our study, operator experience did not have a bearing on prevalence of emergency CABG.

In parallel with decreased emergency CABG was a decrease in Q-wave myocardial infarction and periprocedural death in patients undergoing elective PCI and not requiring emergency CABG. Thus, the decreased utilization of emergency CABG did not result in a trade off of more severe adverse events of other categories. Rather, the data suggest that the overall safety of PCI has dramatically improved in the last decade.

Despite the low prevalence of emergency CABG in our institution, there was a high occurrence of in-hospital complications after emergency CABG. Several large studies from the mid 1980s to early 1990s have reported perioperative Q-wave myocardial infarction in 21% to 57% of patients and in-hospital mortality ranging from 3% to 19%. In the stent era, in-hospital complications after emergency CABG have remained high. In the study by Shubrooks et al., mortality and nonfatal Q-wave myocardial infarctions occurred in 29% and 14% of the cases, respectively, in 1997. In our study, in-hospital mortality and Q-wave myocardial infarction were 21% and 0%, respectively, from 1997 through 2000 compared with 13% and 17%, respectively, from 1992 through 1996.

Our study has some important limitations. It is an observational clinical study. There may have been a bias against taking patients with prior bypass surgery for an emergency reoperation, likely because of high occurrence of postoperative complications in emergency reoperations. Indeed, only 8% of the patients in the emergency CABG group had a history of prior bypass surgery compared with 29% in patients not requiring emergency CABG. However, fewer patients with a prior bypass surgery may experience tamponade from coronary perforations attributable to pericardial adhesions. In addition, the benefit of stents was likely overestimated, because our analysis did not take into consideration those patients in whom stents were intended to be used but could not be deployed.

In conclusion, we report a highly significant >10-fold decline in prevalence of emergency CABG from 1992 to 2000. Female sex and worse ACC/AHA score of the intervened lesion were independent predictors of the need for emergency CABG. Use of stents has resulted in a decreased need for emergency CABG. Despite this, however, emergency CABG is associated with a significant risk of major in-hospital adverse events, even in the new millennium.

Appendix
The following variables (and transformations of them) were considered in the multivariable analysis as possible predictors of emergency coronary bypass surgery: Age, sex, height, weight, NYHA class, acute myocardial infarction, unstable angina, history of recent myocardial infarction, history of prior myocardial infarction, recent positive stress test, angina class, heart rate and systolic blood pressure before the procedure, worst ACC score of any intervened lesion, left ventricular ejection fraction, degree of mitral regurgitation, restenotic lesion, history of prior bypass surgery, family history of heart disease, hypertension, diabetes, prior cerebrovascular accident or transient ischemic attack, renal insufficiency, chronic obstructive pulmonary disease, peripheral vascular disease, serum cholesterol, triglycerides, and high-density lipoprotein, present/former smoker, number of diseased vessels, intraaortic balloon pump use before the procedure (<48 hours), heparin use, thrombolytic treatment (<48 hours), drugs received <24 hours before the procedure (ACE inhibitors, class-I antiarrhythmics, aspirin, β-blockers, calcium channel blockers, oral/topical or intravenous nitrates, diuretics, and lipid-lowering agents), abiximab before or after procedure, any IIb/IIIa inhibitor use, balloon angioplasty alone, rotatable use, laser, stent, bailout stent, lesion location (such as proximal left anterior descending, mid/distal left anterior descending, and right coronary and circumflex), number of treated sites, longest lesion treated, average diameter of the treated lesion, and date of procedure. The interactions between date of procedure and age, stent, and platelet glycoprotein IIb/IIIa inhibitor use were also taken into consideration.

References
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