Risk stratification and prognostic effects of internal thoracic artery grafting during acute myocardial infarction

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Objective: Surgeons are occasionally requested to perform coronary artery bypass grafting during acute myocardial infarction. We intended to test the safety of coronary artery bypass grafting and internal thoracic artery grafting early after myocardial infarction using the Society of Thoracic Surgeons database.

Methods: The database was queried for isolated coronary artery bypass grafting less than 24 hours after a myocardial infarction from 2002 to 2008. By using multivariable logistic regression and classification trees, risk models were created to stratify this group of patients. The independent prognostic effect of internal thoracic artery grafting was examined using standard risk-adjusted mortality comparisons.

Results: A total of 44,141 patients were identified, with an overall operative mortality of 7.9%. Cardiogenic shock occurred in 21%, percutaneous coronary intervention within 6 hours before surgery was performed in 11%, myocardial infarction within 6 hours before surgery occurred in 37%, preoperative intra-aortic balloon pump was used in 50%, and internal thoracic artery grafting was performed in 79% of the patients. Myocardial infarction in less than 24 hours was associated with higher operative mortality (odds ratio, 3.25) and major morbidity (odds ratio, 2.54). Emergency/salvage status (odds ratio, 6.43), age more than 80 years (odds ratio, 4.07), dialysis (odds ratio, 3.08), and cardiogenic shock (odds ratio, 2.79) were independent mortality predictors. Patients with nonemergence salvage status, absence of cardiogenic shock, creatinine less than 1.5 mg/dL, and age less than 70 years represented 48% of the population and exhibited a lower mortality rate of 2%. Internal thoracic artery grafting was independently associated with a lower risk of mortality (odds ratio, 0.52; $P < .0001$) and did not seem to compromise outcomes.

Conclusions: Coronary artery bypass grafting less than 24 hours after myocardial infarction carries a higher operative risk but can be performed safely in selected patients. Although confounding variables may exist, internal thoracic artery grafting was associated with improved outcomes. Internal thoracic artery use in this setting is less than ideal, and taking time to harvest internal thoracic artery grafts in patients with acute myocardial infarction might be encouraged. (J Thorac Cardiovasc Surg 2013;146:78-84)

During the last decade, several randomized and nonrandomized studies and major society guidelines have established percutaneous coronary intervention (PCI) as the first line of treatment for acute myocardial infarction (MI).[1-8] However, situations exist in which coronary artery bypass grafting (CABG) becomes appropriate in patients with acute MI, for example, unsuitable coronary anatomy for PCI, left main disease, severe 3-vessel disease, and failed PCI. It is generally agreed that the operative risk is higher in these patients, but precise risk characteristics have not been defined. Finally, in patients with acute MI and ongoing ischemia, there is controversy whether to spend time harvesting the internal thoracic artery (ITA) versus performing more rapid revascularization with a saphenous vein graft. This study was undertaken within the Society of Thoracic Surgeons (STS) database to investigate these issues.

MATERIALS AND METHODS

Data Source

The STS database is a voluntary program developed in 1986 to provide risk-adjusted outcomes based on the national cardiac surgical experience. It has expanded over the last 2 decades to represent approximately 90% of the cardiac surgery programs in North America.[9,10] Research on the STS database is conducted by the Duke Clinical Research Institute and approved by the Duke University Institutional Review Board. Patient privacy is protected by standard processes in data collection and submission established by the STS and executed by participating institutions. Patients undergoing isolated CABG less than 24 hours after MI were identified from January 2002 to December 2008. Patient selection was limited to an acuity status of urgent, emergency, or emergency/salvage. Records with missing information about age, gender, MI, PCI, acuity status, or cardiogenic shock were excluded (<3% of patients).

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Abbreviations and Acronyms

CABG = coronary artery bypass grafting
IABP = intra-aortic balloon pump
ITA = internal thoracic artery
MI = myocardial infarction
OR = odds ratio
PCI = percutaneous coronary intervention
SHOCK = SHould we emergently revascularize Occluded Coronaries for cardiogenic shocK
STS = Society of Thoracic Surgeons

Study Design and Statistical Analysis

Clinical definitions for all relevant prognostic variables have been established and can be accessed at www.sts.org. Candidate variables and coding were consistent with the STS 2008 cardiac surgery risk models.[9] A variable for "time trend" was included to adjust for temporal changes in specific variables that may occur coincidentally with a decline in mortality rates. To prevent identifying an unwarranted causal inference with mortality, the STS National Coverage Determination uses "date of surgery" in 6-month intervals to adjust for temporal changes in the frequency of explanatory variables and adverse outcomes.

Preoperative, operative, and postoperative variables were compared in patients with and without MI less than 24 hours before surgery. Continuous variables were compared with the Wilcoxon rank-sum test, and categoric variables were compared with the Pearson chi-square test. Missing predictor variables were replaced according to imputation strategies previously established by the STS database.[9] Single-effect and multiple logistic regression analyses were conducted to create risk models of operative mortality, including and excluding ITA grafting. Pair interactions of ITA grafting with age, reoperation, cardiogenic shock, and acuity status were entered in the model and tested by using the Wald statistic.

The group with MI less than 24 hours before surgery was divided into quintiles of increasing predicted risk, and operative mortalities with and without ITA grafting were compared within each quintile. To further exclude the bias of avoiding ITA grafting in more critical patients, this comparison was repeated after excluding cardiogenic shock, emergency/salvage status, and resuscitation. A classification tree was developed from the multivariable analysis to identify subgroups with a similar mortality risk by using clinically relevant variables with the highest discrimination of operative mortality. This approach yielded subgroups with minimal entropy subject to the constraint that each variable was split only once, and patients in a high-risk subgroup were not further subdivided. The selected tree minimizes the sum of entropy in all leaves among all possible trees with the same structure.

RESULTS

Patient Characteristics

From 2002 to 2008, MI less than 24 hours before surgery was present in 7.6% of patients undergoing isolated CABG (44,141/578,398). The baseline characteristics are shown in Table 1. Because of the large sample size, most variables achieved statistical significance between MI in less than 24 hours and other patients undergoing isolated CABG, but clinically, most variables were similar between both groups. Variables reflecting a higher acuity of presentation were more prevalent in the group with an MI in less than 24 hours, such as cardiogenic shock, resuscitation, preoperative intra-aortic balloon pump (IABP), inotropic use, a lower ejection fraction, and a higher acuity status. ITA grafting was used in 79% of the patients with MI in less than 24 hours and 90% of the patients without MI in less than 24 hours.

Outcome Comparisons

Compared with patients who did not have an MI in less than 24 hours before CABG, operative mortality and combined major morbidity and mortality were significantly higher in the group with an MI in less than 24 hours (7.9% vs 2.6% and 33.7% vs 16.7%, respectively). Differences in operative mortality were more pronounced as patients with an MI in less than 24 hours were further divided into (1) MI in 6 hours or less and (2) MI in 6 to 24 hours (10.8% vs 6.3%, $P < .001$). ITA grafting correlated with the priority of CABG, with 70.5% use in the group with MI in 6 hours or less and 83.9% in the group with MI in 6 to 24 hours. Of particular interest were the patients in cardiogenic shock, in whom only 56.9% received ITA grafting. Except for deep sternal wound infection and postoperative MI, operative morbidity was significantly higher in the group with MI in less than 24 hours.

Selected High-Risk Categories and Univariable/Multivariable Risk Models

Operative mortality was significantly higher in emergency/salvage versus urgent status (31.7% vs 5.9%), cardiogenic shock (22.3% vs 4%), age more than 80 years (16.7% vs 7.1%), preoperative dialysis (23.4% vs 4.9%), PCI in less than 6 hours (14.2% vs 7.2%), presence of IABP (10.6% vs 5.2%), and ejection fraction less than 40% (12.9% vs 5.7%). Of note, patients not receiving ITA grafting comprised 21% of the study population and had an approximately 5-fold higher unadjusted mortality compared with those receiving ITA grafting (19.1% vs 5.0%) (Table 2). Univariable analysis revealed age more than 80 years (odds ratio [OR], 3.53), creatinine greater than 1.5 mg/dL (OR, 3.06), congestive heart failure New York Heart Association IV (OR, 3.55), emergency (OR, 2.67) or emergency/salvage status (OR, 13.62), cardiogenic shock (OR, 6.68), preoperative IABP/inotropes (OR, 2.7), ejection fraction less than 30% (OR, 2.41), mitral insufficiency (OR, 2.66), and tricuspid insufficiency (OR, 3.44) to have the highest association with operative mortality. Finally, ITA grafting was strongly associated with lower operative mortality (OR, 0.22).

Multivariable logistic regression excluding ITA grafting identified emergency/salvage status (OR, 6.43), age more than 80 years (OR, 4.07), dialysis-dependent renal failure (OR, 3.08), and cardiogenic shock (OR, 2.79) to have the highest independent association with operative mortality.