Determinants and Prognosis of Myocardial Damage After Coronary Artery Bypass Grafting

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Background. **Myocardial infarction remains a devastating complication after coronary revascularization. Although electrocardiography (ECG) and echocardiography suggest transmural infarction, myocardial damage and the quality of myocardial protection are not recognized unless troponin I (TnI) is assessed. Determinants and prognosis of TnI elevation after coronary artery bypass grafting (CABG) were evaluated.**

Methods. **Data of 776 consecutive patients undergoing CABG between January 2002 and January 2004 were prospectively exposed to univariate and multivariate analysis. We evaluated the prognosis of patients with all the ECG, echocardiographic, and biochemical criteria for acute myocardial infarction and that of patients with only TnI elevation. Twelve-month follow-up survival and freedom from cardiac events (FCE) were accomplished.**

Results. **Troponin I greater than 3.1 μg/L at 12 hours was detected in 6.9% of the population, and correlated with lower in-hospital ($p < 0.001$) and follow-up survival ($p = 0.00001$), and lower FCE ($p = 0.0009$). Twenty-one (38.8%) of these fulfilled ECG-echocardiographic criteria ($p = 0.05$), demonstrating higher TnI values at 12 ($p = 0.001$), 24 ($p = 0.01$), 48 ($p = 0.01$), and 72 ($p = 0.04$) hours, prolonged ventilation time ($p = 0.001$), higher in hospital mortality ($p = 0.003$), lower follow-up survival ($p = 0.023$), and lower FCE ($p = 0.0084$). A EuroSCORE greater than 6, ongoing unstable angina, aortic cross-clamp time greater than 90 minutes, cardiopulmonary bypass time greater than 180 minutes, incomplete revascularization, and intraoperative intraaortic balloon pump were independent predictors of myocardial damage (MD) at multivariate analysis. Combined antegrade and retrograde cardioplegia and postoperative enoximone infusion were associated with a lower TnI elevation.**

Conclusions. **Troponin I greater than 3.1 μg/L at 12 hours defines perioperative MD. Associated ECG-echocardiographic criteria indicate acute myocardial infarction and anticipate a worse outcome. Identification of predictors for MD is important to develop preventative strategies, as antegrade plus retrograde cardioplegia and enoximone infusion.**

(Ann Thorac Surg 2005;79:837–45)

Since the early 1960s, coronary artery bypass grafting (CABG) has evolved from being a rarely performed high-risk operation into a common treatment procedure, owing to improvements in surgical techniques, medications, and patient care. However, perioperative acute myocardial infarction (AMI) after CABG remains a serious complication with a high risk of early and late mortality [1, 2].

Despite attempts to improve the detection of perioperative myocardial necrosis, new Q waves on the electrocardiograph (ECG) and elevated blood levels of the MB isoenzyme of creatine kinase are still used to establish the diagnosis. Moreover, although new Q waves on the ECG suggest transmural infarction, minimal necrosis and damage are not recognized with this approach [3, 4].

Recently cardiac troponin I (TnI) has been shown to be a specific marker of myocardial damage (MD) with a higher sensitivity and specificity and a wider diagnostic window as compared to conventional biochemical enzymes such as creatine kinase, MB isoenzyme, and myoglobin. It is widely accepted that TnI should be able to detect even minor differences of myocardial ischemia, and that TnI greater than 3.1 μg/L at 12 hours also defined perioperative MD in cases without ECG or echocardiographic findings [5]. Moreover, recent reports have defined postoperative TnI as a sensible marker of the quality of myocardial protection and of prognostic value for cardiovascular events at follow-up [6].

During the past few decades, perioperative MD has been the focus of a number of studies, which differed with respect to the time period examined, the surgical strategies, the data elements compared, and the patient population. In fact, the variation in demographic data and in the distribution of risk factors among different ethnic groups, races, and geographical locations has to be considered [7]. Moreover, there have also been tremendous efforts to develop risk stratification models to provide a more accurate risk prediction. Finally, the changing profile of patients undergoing cardiac surgery

Accepted for publication July 23, 2004.

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Published by Elsevier Inc

0003-4975/05/$30.00
doi:10.1016/j.athoracsur.2004.07.060

Abbreviations and Acronyms

ACC = aortic cross-clamp
AMI = acute myocardial infarction
CABG = coronary artery bypass grafting
CCS = Canadian Class Score
CI = confidence intervals
COPD = chronic obstructive pulmonary disease
CPB = cardio-pulmonary bypass
CVA = cardiovascular accident
ECG = electrocardiogram
FCE = freedom from cardiac events
IABP = intraaortic balloon pump
ILVM = indexed left ventricular mass
LMSD = left main stem disease
LVEF = left ventricle ejection fraction
MD = myocardial damage
NYHA = New York Health Association
OR = odds ratios
TnI = troponin I
WMSI = wall motion score index

operations necessitates continuous updating and revision of risk models [1, 2].

However, the prediction of outcome after CABG is still of significant interest to the scientific community. It was the aim of our study to evaluate determinants of perioperative myocardial damage, as defined by TnI elevation, in a double-center population undergoing primary isolated CABG in the last two years.

Material and Methods

A total of 776 consecutive adult patients undergoing primary isolated coronary artery bypass grafting between January 2002 and January 2004 were prospectively enrolled in the study. Fifty-eight perioperative risk factors analyzed by univariate and multivariate stepwise logistic regression are listed in the Appendix.

Of preoperative variables, number and type of diseased vessels were determined based on the angiography of the patient. The left anterior descending, left circumflex, right coronary artery, or posterior descending artery were considered to be diseased only if the stenosis was equal to or greater than 60% of the luminal diameter. The left main coronary artery was classified as diseased if any stenosis equal to or greater than 50% of luminal diameter was reported. Left main disease was also dichotomized in two groups: greater than 50% and less than 75%, and greater than 75%.

Of intraoperative variables, aortic cross-clamp time was categorized as more or less than 90 minutes; similarly, cardiopulmonary bypass time was dichotomized in more or less than 180 minutes. Inotropic support was defined as low dose when enoximone or dobutamine were administered at dosages lower than 5 $\mu g \cdot Kg \cdot min$. A medium dose of inotropic agents was considered when dobutamine or dopamine were at dosages between 5 and 10 $\mu g \cdot Kg \cdot min$ for greater than 6 hours postoperatively. A high dose was defined when epinephrine was added to dobutamine or dopamine infusion greater than 10 $\mu g \cdot Kg \cdot min$.

Of postoperative variables and complications, arrhythmias were considered to be a complication only if they were life-threatening or needed medical treatment; postoperative respiratory failure was defined as the need for mechanical ventilator support for greater than 48 hours; acute renal failure as the need for continuous veno-venous hemofiltration or dialysis.

Patient Population and Surgery

Of the patients, 226 (29.1%) were female; 211 (27.2%) had unstable angina with endovenous infusion of nitrates on hospital admission; 187 (24.1%) had left main stem disease (LMSD) as indication of CABG. Forty-five (5.8%) patients demonstrated severe left ventricular dysfunction (ejection fraction $< 30\%$) on hospital admission; 264 (34%) suffered from diabetes mellitus with oral drugs or insulin therapy; 338 (43.8%) had hypertension with ecochardiographic finding of ventricular hypertrophy; 299 (38.5%) were dyslipidemic.

Surgery was always performed by the same group of surgeons (No. 4) and always through a median sternotomy. One hundred and thirty-three (17.2%) patients underwent off-pump surgery, whereas 643 patients (82.8%) underwent conventional CABG with cardiopulmonary bypass and warm blood cardioplegia; in 369 (57.4%) of these blood cardioplegia was administered only antegrade and in 274 (42.6%) intermittent retrograde delivery was added. One hundred and seventy (21.9%) patients underwent total arterial grafting.

Electrocardiography

Twelve-lead electrocardiographic recordings were performed preoperatively, on admission to the intensive therapy unit postoperatively, and then daily thereafter until hospital discharge or whenever judged necessary. All patients had continuous electrocardiogram monitoring for the first 48 hours postoperatively. The incidence of dysrhythmias, both atrial and ventricular, were recorded together with transient ischemic events (ST segment elevation > 1 mm). The ECG diagnostic criteria for perioperative AMI were new Q waves of greater than 0.04 ms, and/or a reduction in R waves greater than 25% in at least two leads.

Echocardiography

All studies were performed using a transthoracic Acuson Sequoia C256 echocardiography system (Acuson Corporation, Mountain View, CA) with probe 3V2C, always by the same two physicians in a blind manner, preoperatively, at the time of hospital admission, and before hospital discharge. Left ventricular ejection fraction (LVEF), wall motion score index, and indexed left ventricular mass (ILVM) were recorded. A value of ILVM greater than 125 g/m^2 was considered as a marker of left ventricular hypertrophy.