Myocardial viability and cardiac dyssynchrony as strong predictors of perioperative mortality in high-risk patients with ischemic cardiomyopathy having coronary artery bypass surgery

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Objective: Myocardial viability and left ventricular dyssynchrony are important predictors of long-term outcomes in patients with ischemic left ventricular dysfunction. The objective of this study was to test the hypothesis that assessment of myocardial viability and left ventricular dyssynchrony will predict perioperative mortality in high-risk patients with ischemic left ventricular dysfunction having coronary artery bypass surgery.

Methods: The study consisted of 79 consecutive patients with ischemic cardiomyopathy (age 65 ± 9 years; 81% men; ejection fraction 30% ± 6%) and logistic European system for cardiac operative risk evaluation > 10% having coronary artery bypass surgery. Myocardial viability was assessed by delayed contrast-enhanced magnetic resonance imaging. Left ventricular dyssynchrony was calculated using tissue Doppler from measurements of regional electromechanical coupling times in left ventricular basal segments before coronary artery bypass surgery.

Results: Twenty (25.3%) patients died within 30 days following coronary artery bypass surgery. Survivors (n = 59) showed a larger extent of viable myocardium (6.9 ± 3.6 viable segments vs 3.4 ± 3.3 viable segments, $P < .001$) and smaller left ventricular dyssynchrony (75 ± 5 ms vs 179 ± 83 ms, $P < .001$) than nonsurvivors. The presence of significant dyssynchrony (≥105 ms) and absence of myocardial viability (<5 viable segments) independently predicted 30-day mortality with hazard ratio 3.26, 95% confidence interval 1.61 to 8.33 ($P < .01$) and hazard ratio 1.72, 95% confidence interval 1.59 to 1.89 ($P < .01$), respectively. All but 2 patients (94.1%) with viable myocardium and without left ventricular dyssynchrony survived coronary artery bypass surgery as compared with only 12 (52.2%) patients with nonviable myocardium and severe dyssynchrony ($P < .001$).

Conclusions: In high-risk patients with ischemic left ventricular dysfunction having coronary artery bypass surgery, both myocardial viability and left ventricular dyssynchrony are important predictors of perioperative outcome. Assessment of myocardial viability and left ventricular dyssynchrony should be a routine part of the preoperative evaluation of these patients.

Myocardial revascularization using coronary artery bypass surgery (CABG) is associated with improved long-term survival in some patients with coronary artery disease and severe left ventricular (LV) dysfunction compared with conservative management.[1,2] However, in these patients, the potential long-term benefits of revascularization must be weighed against the high periprocedural risks.[1-3] The European system for cardiac operative risk evaluation (EuroSCORE) is a widely accepted scoring system used to predict immediate postoperative outcomes after CABG.[4,5] High EuroSCORE levels have been associated with high perioperative mortality. However, in patients with severe LV dysfunction, additional factors not integrated in the EuroSCORE system, such as the extent of viable myocardium or cardiac dyssynchrony, may be important determinants of perioperative outcomes.[1-3,6] Several studies[1,2,6] have demonstrated a strong relationship between the amount of myocardial viability and survival following CABG surgery in patients with ischemic LV dysfunction. In one of our recent studies,[3] the presence of severe LV dyssynchrony prior to CABG was significantly associated with elevated 30-day mortality in patients having moderate systolic heart failure. This suggests that the predictive accuracy of the EuroSCORE may be lower in patients with ischemic LV dysfunction compared with patients with normal systolic function. The reduced predictive value of the EuroSCORE in patients with LV dysfunction may complicate clinical decision making, particularly in critically ill patients at high perioperative risk.

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Abbreviations and Acronyms

CABG = coronary artery bypass surgery
CI = confidence interval
EuroSCORE = European system for cardiac operative risk evaluation
HR = hazard ratio
LV = left ventricular
NYHA = New York Heart Association
ROC = receiver operating characteristics
STS = Society of Thoracic Surgeons mortality risk score

Therefore, the objective of the present study was to test the hypothesis that assessment of myocardial viability and LV dyssynchrony will predict perioperative mortality and will improve the predictive accuracy of the EuroSCORE in high-risk patients with ischemic LV dysfunction having CABG.

METHODS

Patients

Between January 1, 2005 and December 31, 2005, 1252 patients had CABG at our institutions. The prospective study consisted of 79 (6.3%) consecutive patients (age 65 ± 9 years; 81% men) having isolated CABG who met the following criteria: (1) stable LV dysfunction (LV ejection fraction < 40%, for at least 3 months; to be eligible for the study, the presence of qualifying LV dysfunction had to be already documented at least 3 months before enrollment); (2) standard (≥3 months) heart failure medication including angiotensin-converting enzyme/AT1 inhibitors and ß-blockers if tolerated; (3) logistic EuroSCORE >10%. Patients with acute coronary syndrome or hospitalization for worsening heart failure in the previous 3 months; any valvular heart disease requiring surgery, pacemakers, or internal defibrillators; and contraindications for magnetic resonance were excluded from the study. All patients recruited for the study had CABG surgery as the sole procedure. None of the patients had concomitant LV remodeling, aneurysmectomy, mitral valve repair, or the MAZE procedure. The study was approved by the ethical committee. All patients gave a written informed consent prior to participation.

Protocol

In the week leading up to CABG surgery, each patient had assessment of myocardial viability through contrast enhanced magnetic resonance imaging; LV dyssynchrony was evaluated using pulsed-wave tissue Doppler. Perioperative risk was calculated using the logistic EuroSCORE. Patients were then followed for 30 days postsurgery to assess 30-day mortality.

Assessment of Myocardial Viability by Magnetic Resonance Imaging

Delayed contrast-enhanced electrocardiogram-gated magnetic resonance images (1.5-T scanner Siemens Symphony, Erlangen, Germany) were acquired using a phased-array receiver coil during breath-holds.[7] Short-axis images were acquired every 5 mm from base to apex. Imaging was done 20 minutes after intravenous injection of a gadolinium-based contrast agent (for dose of 0.2 mmol/kg). Images were analyzed off-line by an independent operator. The extent of hyperenhanced tissue was assessed in each segment (16-segment model) of the left ventricle. Segments with ≤50% of transmural hyperenhancement were considered viable.[6]

Assessment of LV Dyssynchrony by Tissue Doppler Echocardiography

Echocardiograms were performed using a standard commercial ultrasound system equipped with tissue Doppler imaging (Vivid 7, Vingmed-General Electric, Horten, Norway). Tissue Doppler was performed in pulsed-wave mode. In brief, in 3 apical (4-, 3-, and 2-chamber) views, longitudinal myocardial velocities were recorded in 6 basal segments of the left ventricle.[3] Gain and filters were adjusted to obtain an optimal tissue signal. Myocardial velocities were recorded at end expiration at a sweep speed of 100 mm/s. All recordings were stored both in digital (raw data) format and on S-VHS videotape for off-line analysis. The mean from 3 consecutive beats was taken for each measurement. Echocardiographers were blinded to clinical follow-up data.

To assess the extent of LV dyssynchrony, the time delay between the onset of QRS complex on the surface electrocardiogram and the onset of the systolic velocity waves on the tissue Doppler imaging recordings were assessed in each basal LV segment.[8] Dyssynchrony was calculated as the difference between the shortest and the longest time delay in the 6 basal segments. Hence, LV dyssynchrony represents a delay in the onset of contraction between the segment with the earliest and the segments with the latest systolic wall motion. Intra- and interobserver variability for the assessment of LV dyssynchrony was 7.1% and 8.2%, respectively.

EuroSCORE

EuroSCORE is a risk stratification system for the prediction of early mortality in patients having cardiac surgery.[5] It has been in use since 1999. The EuroSCORE has a total of 17 factors, consisting of 9 patient-related factors, 4 factors reflecting the preoperative cardiac status, and 4 factors that depend on the timing and nature of the surgical procedure. Together, the scores predict an approximate percentage for mortality.

Statistical Analysis

Data are presented as mean ± standard deviation. Two-sided unpaired Student *t* test was used as appropriate. The Fisher exact test was used to compare categorical variables. The receiver-operating characteristics (ROC) curves were constructed to assess optimal cutoff values for the number of dysfunctional viable segments and LV dyssynchrony to predict the 30-day mortality. Independent predictors of the 30-day mortality were identified using the Cox proportional hazard model and expressed as a hazard ratio (HR) and 95% confidence interval (CI). All analyses were conducted using SPSS software (version 13).

RESULTS

Baseline Characteristics

Twenty (25.3%) patients died within 30 days following CABG (in-hospital deaths). All patients died of pump failure leading to low-output syndrome, multiorgan failure, or sepsis. No patient died of arrhythmias. Table 1 shows baseline characteristics in survivors and nonsurvivors. All patients had left main (19%) or 3-vessel disease (81%). The majority (86%) of included patients showed symptoms of congestive heart failure and 47.8% had severe heart failure (New York Heart Association [NYHA] class III–IV). Angina pectoris was an indication for CABG in 72% of patients, and isolated heart failure symptoms in 28% of patients. Prior to CABG, survivors had milder heart failure symptoms and higher LV ejection fractions (both $P < .05$) and tended to have lower systolic pulmonary artery pressure ($P = .051$) than patients who died. Also, survivors had significantly