

## Complexity of coronary artery disease affects outcome of patients undergoing coronary artery bypass grafting with impaired left ventricular function

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**Objective:** To determine whether the SYNTAX score can predict the outcomes of patients with left ventricular dysfunction undergoing coronary artery bypass grafting.

**Methods:** We studied a consecutive series of 191 patients (mean age,  $67 \pm 10$  years) with a left ventricular ejection fraction of 40% or less who were undergoing isolated coronary artery bypass grafting. All patients were stratified according to their SYNTAX score, indicating coronary artery disease complexity: low, 0 to 22; intermediate, 23 to 32; and high, 33 or more. The primary outcome was all-cause mortality. Secondary outcomes included the late occurrence of major adverse cardiac and cerebrovascular events, left ventricular function, and New York Heart Association functional class.

**Results:** The mean SYNTAX score was  $32 \pm 13$ , and the mean preoperative left ventricular ejection fraction was  $35\% \pm 6\%$ . At a median follow-up of 43 months, the primary outcome had occurred in 46 of 191 patients (24%). Kaplan-Meier analysis showed a survival of  $81\% \pm 15\%$  for low,  $77\% \pm 7\%$  for intermediate, and  $53\% \pm 7\%$  for high coronary artery disease complexity ( $\chi^2$ , 29.4;  $P = .001$ ). The rate of major adverse cardiac and cerebrovascular events was significantly greater in patients with a SYNTAX score of 33 or more ( $P = .002$ ). Greater degrees of left ventricular ejection fraction improvement were found in patients with a SYNTAX score of 32 or less ( $+15\% \pm 10\%$  vs  $+4\% \pm 11\%$ ;  $P = .17$ ) and translated into a better New York Heart Association functional class among patients with a lower SYNTAX score ( $P = .01$ ). Receiver operating characteristic curve analysis showed the SYNTAX score (area under the curve, 0.70; 95% confidence interval, 0.63-0.77) to have the best predictive power for late mortality with respect to the preoperative left ventricular ejection fraction (area under the curve, 0.59; difference,  $P = .04$ ) and incomplete revascularization (area under the curve, 0.55; difference,  $P = .02$ ).

**Conclusions:** The results of the present study have shown a direct relationship between coronary artery disease complexity and late outcomes of patients with left ventricular dysfunction who are undergoing coronary artery bypass grafting. Additional studies are needed to confirm these findings. (*J Thorac Cardiovasc Surg* 2013;146:656-61)

Left ventricular (LV) dysfunction in patients with coronary artery disease (CAD) is not always an irreversible process related to previous myocardial infarction, because LV function has been shown to improve substantially in many patients and can even normalize after coronary artery bypass grafting (CABG).<sup>1-4</sup> The realization that a large proportion of patients with heart failure owing to CAD have viable, but dysfunctional, myocardium has led logically to attempts to resuscitate stunned or hibernating myocardium using revascularization techniques.<sup>5,6</sup> This

approach has been based on substantial, although largely anecdotal, evidence that revascularization, usually by CABG, can improve contractile function of viable, but dysfunctional, myocardium.<sup>7</sup> A meta-analysis of observational studies suggested that revascularization might reduce mortality by 80% in patients with an extensive amount of viable myocardium but would have no effect in those without extensive viability.<sup>3,8</sup> Recently, 2 randomized, controlled trials, the Surgical Treatment for Ischemic Heart Failure trial<sup>9</sup> and Heart Failure Revascularisation Trial,<sup>5</sup> failed to show a substantial benefit from revascularization. In particular, the subgroup of patients with few viable segments appeared to benefit from CABG, the exact opposite of the previously cited observational data.<sup>3</sup> In their recent editorial on this topic, Cleland and colleagues<sup>8</sup> stated that this suggests that revascularization might be best reserved for patients with rather few viable segments, whether or not the function of these segments is impaired, if subtended by coronary lesions amenable to revascularization, to save what little surviving myocardium is left.

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### Abbreviations and Acronyms

AUC	= area under the curve
CABG	= coronary artery bypass grafting
CAD	= coronary artery disease
LV	= left ventricular
LVEF	= left ventricular ejection fraction
PCI	= percutaneous coronary intervention
ROC	= receiver operating characteristic

Therefore, not only is restoring an appropriate blood supply to the stunned or hibernating myocardium a key factor for achieving postoperative LV functional recovery, but also the results of CABG in patients with LV dysfunction could rely on the CAD complexity. The SYNTAX score is an angiographic tool to measure the complexity of CAD. It has recently been shown to predict the outcome in patients undergoing percutaneous coronary intervention (PCI).<sup>10</sup> Investigations testing the predictive power of the SYNTAX score on patients undergoing CABG surgery have not shown unequivocal results.<sup>10-16</sup> To date, no similar studies have been published of using the SYNTAX score specifically for a subgroup of patients with LV dysfunction undergoing surgical revascularization.

The aim of the present investigation was to assess the predictive power of the SYNTAX score in patients with LV dysfunction due to CAD who were undergoing myocardial revascularization by CABG.

## PATIENTS AND METHODS

The Institutional Review Board of the University of Rome reviewed and approved the present study, and a waiver of consent was granted.

### Patients

We studied a consecutive series of 191 patients amenable to CABG (mean age,  $67 \pm 10$  years) with a LV ejection fraction (LVEF) of 40% or less at 1 institution from May 2004 to May 2010. All operations were performed at Ospedale Sant' Andrea, "Sapienza" University (Rome, Italy). The inclusion criterion was isolated on-pump CABG. The exclusion criteria were previous cardiac surgery, combined procedures, PCI within 6 months of surgery, and off-pump CABG.

The SYNTAX score algorithm, which has been previously described in full<sup>10</sup> (available from the SYNTAX score Web site: [www.syntaxscore.com](http://www.syntaxscore.com)), was used to retrospectively score all coronary lesions deemed to have a percentage diameter stenosis of 50% or more, in vessels 1.5 mm or greater. All angiographic variables pertinent to SYNTAX score calculation were computed by 2 experienced interventional cardiologists (F.M., R.Ser.) on diagnostic angiograms obtained before the procedure. In the case of disagreement, the opinion of a third analyst (R.Sin.) was obtained, and the final decision was by consensus. The analysts were unaware of the procedural data and clinical outcomes. The final score was calculated on a patient basis from the individual lesion scores, which were saved in a dedicated database, and were not made available to the analysts until after study completion. The patients were divided into 3 groups according to the measured extent of CAD using their SYNTAX score to indicate CAD complexity: low, 0 to 22; intermediate, 23 to 32; and high, more than 33.

### Operative Details

All patients, after a full median sternotomy, underwent on-pump CABG using standard techniques. Cardiac arrest was obtained by antegrade cold blood cardioplegia, repeated every 15 minutes. The left internal mammary artery was always used to graft the left anterior descending artery, and revascularization was completed using saphenous vein grafts to the right coronary and left circumflex artery segments.

### Follow-up

The data were prospectively collected and recorded in an electronic database, and clinical follow-up was completed with routine outpatient clinic visits. Patients who did not present at their follow-up visit were interviewed by telephone. All symptoms, mortality, and any complications that occurred during follow-up were recorded. The clinical and echocardiographic assessments were performed before CABG and at 6-month intervals postoperatively and then annually. At each visit, all patients underwent a complete M-mode, bidimensional, and Doppler transthoracic echocardiographic assessment using a Sonos 7500 system (Philips Medical Ultrasound; Philips Healthcare, DA Best, The Netherlands). All echocardiographic studies were reviewed in core laboratory and independently reviewed by 2 cardiologists. The LVEF was calculated using Simpson's biplane method.

### Statistical Analysis

Statistical analysis was performed using the Statistical Package for Social Sciences, version 11.0 (SPSS, Chicago, Ill). Continuous data are expressed as the mean  $\pm$  standard deviation and categorical data as percentages. Comparisons were made using the 2-sample *t*-test and the  $\chi^2$  or Fischer exact test, respectively. Differences in continuous variables among the 3 groups of patients were calculated using the analysis of variance test.

Actuarial estimates of survival were made using the Kaplan-Meier method, and differences in time-related events were analyzed using the log-rank test. The survival time of a patient started at the point of surgery and ended at death (event) or the last follow-up visit (censoring).

The primary outcome was all-cause mortality during follow-up after revascularization. Secondary outcomes included a composite of all-cause mortality, myocardial infarction, cerebrovascular events, and repeat revascularization (MACCE), LV function, and New York Heart Association functional class. Mortality was defined as death from any cause, cardiac and noncardiac. Myocardial infarction was defined as cardiac enzyme levels 3 times or more the upper normal limit of normal and associated with the presence of ischemic symptoms or new electrocardiographic changes. A cerebrovascular accident was defined as stroke, transient ischemic attack, or coma.

The predictive power for late mortality of the SYNTAX score, preoperative LVEF, and completeness of revascularization was tested by receiver operating characteristic (ROC) curve analysis.

## RESULTS

The baseline characteristics of the study population stratified by the SYNTAX score are listed in Table 1. The SYNTAX score ranged from 1 to 42 (mean,  $32 \pm 13$ ; median, 10). The LVEF ranged from 29% to 40% (mean,  $35\% \pm 6\%$ ; median, 36%). Male gender was prevalent (163/191, 85%). The preoperative creatinine level was  $1.4 \pm 1$  mg/dL, the mean logistic European System for Cardiac Operative Risk Evaluation was  $19\% \pm 10\%$ , and 48 of the 191 patients (25%) underwent urgency or emergency surgery. The mean number of diseased vessels was  $2.6 \pm 0.4$ , and the mean number of anastomoses was  $2.7 \pm 0.8$ . The operative characteristics and postoperative complications are listed in Table 2.

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