Risk scores for predicting mortality after surgical ventricular reconstruction for ischemic cardiomyopathy: Results of a Japanese multicenter study

Satoru Wakasa, MD, PhD,[a] Yoshiro Matsui, MD, PhD,[a] Tadashi Isomura, MD, PhD,[b] Shuichiro Takanashi, MD, PhD,[c] Atsushi Yamaguchi, MD, PhD,[d] Tatsuhiko Komiya, MD,[e] Yasunori Cho, MD, PhD,[f] Junjiro Kobayashi, MD, PhD,[g] Hitoshi Yaku, MD, PhD,[h] Kiyokazu Kokaji, MD, PhD,[i] Hirokuni Arai, MD, PhD,[j] and Yoshiki Sawa, MD, PhD[k]

Objectives: Surgical ventricular reconstruction has been believed to be beneficial for those with ischemic cardiomyopathy. However, the effectiveness of surgical ventricular reconstruction was not proved by a large-scale trial, and no report has clearly demonstrated the exact indications and limitations of surgical ventricular reconstruction. The purpose of this study was to elucidate predictive factors of mortality after surgical ventricular reconstruction and to develop a prognostic model by calculating risk scores.

Methods: The study subjects were 596 patients who underwent surgical ventricular reconstruction for chronic ischemic heart failure in 11 Japanese cardiovascular hospitals between 2000 and 2010. Potential predictors of postoperative mortality were assessed using the Cox proportional hazards model, and a risk score was calculated.

Results: Forty-one patients died before discharge, and 81 patients died during a mean follow-up time of 2.9 years. Four independent predictors of mortality were identified: age, Interagency Registry for Mechanically Assisted Circulatory Support profile, left ventricular ejection fraction, and severity of mitral regurgitation. Each variable was assigned a number of points proportional to its regression coefficient. A risk score was calculated using the point scores for each patient, and 3 risk groups were developed: a low-risk group (0-4 points), an intermediate-risk group (5-6 points), and a high-risk group (7-12 points). Their 3-year survivals were 93%, 81%, and 44%, respectively (log-rank $P < .001$). Harrell's C-index of the predictive model was 0.69.

Conclusions: A simple prognostic model was developed to predict mortality after surgical ventricular reconstruction. It can be useful in clinical practice to select treatment options for ischemic heart failure. (J Thorac Cardiovasc Surg 2014;147:1868-74)

ACD

Supplemental material is available online.

Indications for ischemic heart failure treatments vary depending on the severity of the patient's condition. Surgical ventricular reconstruction (SVR) has been believed to be beneficial for those with ischemic cardiomyopathy.[1-3] However, the Surgical Treatment for Ischemic Heart Failure (STICH) trial concluded that SVR plus coronary artery bypass grafting (CABG) had no further beneficial effect on survival compared with CABG alone.[4] However, the STICH results are controversial because this large-scale trial enrolled patients with less severe disease than in the previous studies supporting the effectiveness of SVR.[5] In contrast, implantable ventricular assist devices (VADs) have become more common in the treatment of severe heart failure and are filling a gap between medical treatment and heart transplantation.[6] However, VAD therapy has inherent unresolved problems,[7,8] such as neurologic dysfunction, bleeding, device failure, pump thrombosis, and lower cost-effectiveness, which may not be associated with SVR. Therefore, SVR could be more beneficial for appropriately selected patients compared with CABG alone or VAD therapy. We hypothesized that risk stratification for SVR could make it possible to identify the responders to this procedure and therefore help with appropriate patient selection, which in turn would

From the Department of Cardiovascular and Thoracic Surgery,[a] Hokkaido University Graduate School of Medicine, Sapporo, Japan; Division of Cardiovascular Surgery,[b] Hayama Heart Center, Hayama, Japan; Department of Cardiovascular Surgery,[c] Sakakibara Heart Institute, Tokyo, Japan; Department of Cardiovascular Surgery,[d] Saitama Medical Center, Jichi Medical University, Saitama, Japan; Department of Cardiovascular Surgery,[e] Kurashiki Central Hospital, Kurashiki, Japan; Department of Cardiovascular Surgery,[f] Tokai University School of Medicine, Isehara, Japan; Department of Cardiovascular Surgery,[g] National Cerebral and Cardiovascular Center, Osaka, Japan; Department of Cardiovascular Surgery,[h] Kyoto Prefectural University of Medicine, Kyoto, Japan; Department of Cardiovascular Surgery,[i] Keio University School of Medicine, Tokyo, Japan; Department of Cardiovascular Surgery,[j] Tokyo Medical and Dental University Graduate School of Medicine, Tokyo, Japan; and Division of Cardiovascular Surgery,[k] Osaka University Graduate School of Medicine, Osaka, Japan.

Disclosures: Authors have nothing to disclose with regard to commercial support.
Received for publication Feb 21, 2013; revisions received May 2, 2013; accepted for publication June 27, 2013; available ahead of print Aug 21, 2013.

Address for reprints: Yoshiro Matsui, MD, PhD, Director of the Department of Cardiovascular and Thoracic Surgery, Hokkaido University Graduate School of Medicine, Kita-15, Nishi-7, Kita-ku, Sapporo 060-8638, Japan (E-mail: ymatsui@med.hokudai.ac.jp).

0022-5223/$36.00

http://dx.doi.org/10.1016/j.jtcvs.2013.06.036

Abbreviations and Acronyms

CABG = coronary artery bypass grafting
INTERMACS = Interagency Registry for Mechanically Assisted Circulatory Support
LV = left ventricle
LVEF = left ventricular ejection fraction
LVESVI = left ventricular end-systolic volume index
MR = mitral regurgitation
NYHA = New York Heart Association
STICH = Surgical Treatment for Ischemic Heart Failure
SVR = surgical ventricular reconstruction
VAD = ventricular assist device

contribute to more practical comparisons among different procedures for ischemic heart failure. Therefore, the purpose of this study was to develop a practical prognostic model to predict mortality after SVR for ischemic heart failure by calculating a risk score using a multivariate Cox proportional hazards model.

MATERIALS AND METHODS

Study Design

We conducted a retrospective multicenter study to investigate the outcomes of SVR. Those who underwent SVR for ischemic heart failure from 2000 to 2010 in 11 Japanese cardiovascular hospitals were enrolled in this study. The indications for SVR were aneurysmal and akinetic left ventricle (LV) in 194 patients (31%) and 412 patients (69%), respectively. Participating hospitals were selected on the basis of the number of SVR procedures performed annually. Principally, the hospitals that performed 5 or more SVR procedures annually were selected (n = 7). Although 4 hospitals did not have 5 cases per year on average during the study period, they were selected because they were leading cardiovascular centers in Japan that also perform heart transplantation (n = 2) or because of their recent academic activities (n = 2). The median number of SVR procedures in each hospital during the study period was 52 (range, 17-166) cases. All data were retrospectively collected from medical records and examination reports. Mortality was detected on the basis of medical records or follow-up inquiries to the attending cardiologists that were made in each hospital. The study protocol was approved by the institutional review boards in all of the participating hospitals.

Initially, 627 patients were enrolled in this study. Then those with acute myocardial ischemia, no LV incision, and no follow-up data were excluded. Finally, there were 596 study subjects. The LV sizes and functions were measured using multiple modalities within 2 weeks before surgery. Postoperative imaging studies were repeated before discharge at 0.8 ± 1.8 months after surgery. Echocardiography was performed for all the patients. LV end-diastolic diameter, LV end-systolic diameter, and LV ejection fraction (LVEF) were acquired by B-mode echocardiography. The severity of mitral regurgitation (MR) was graded on the basis of color Doppler images as follows: 1+ = mild, 2+ = moderate, 3+ = moderate-to-severe, and 4+ = severe.[9] The deceleration time was acquired from the transmitral flow analysis. Systolic pulmonary artery pressure data were obtained from the catheter data or estimated using echocardiographic data. The LV end-diastolic volume index, LV end-systolic volume index (LVESVI), and LVEF were collected from the results of left ventriculograms, quantitative gated scintigrams, and magnetic resonance imaging in 288, 82, and 49 patients, respectively. For the patients with multimodality assessments, the modality that was available both preoperatively and postoperatively was selected to compare the values before and after surgery. Complete imaging data sets of preoperative and postoperative values from the same modality were acquired for LV diameters, LVEF, and LV volumes in 542 patients (91%), 515 patients (95%), and 299 patients (50%), respectively.

Statistical Analyses

Continuous variables were expressed as mean ± standard deviation, and categoric variables were expressed as numbers and percentages. The percentage was calculated exclusive of those with missing values. Preoperative and postoperative data were compared using the Wilcoxon signed-rank test. Intergroup comparisons for categoric data were conducted using the chi-square test or Fisher exact test, if appropriate. Postoperative mortality was estimated using the Kaplan–Meier method, and differences in mortality among groups were assessed by the log-rank test. Univariate and multivariate Cox proportional hazards models were used to determine the contributions of potential variables to the mortality. Variables for the multivariate model were selected considering the proportion of patients with missing data (<5%), the results of univariate analyses, their confounding, and the clinical importance. Selection of variables in the multivariate analysis was performed using the backward elimination method ($P < .10$). Finally, to develop a practical prognostic score, we assigned the independent predictors in the final Cox model weighted point scores proportional to the β regression coefficient values (multiplied by a constant and rounded to the nearest integer). A risk score was then calculated for each patient, and the population was divided into 3 categories: patients at low risk, patients at intermediate risk, and patients at high risk for postoperative mortality. The predictive accuracy of the scoring system was examined by calculating Harrell's C-index.[10] All analyses were performed using IBM SPSS Statistics (v20; IBM Corp, Somers, NY).

RESULTS

Baseline Characteristics of Patients

Table 1 shows the patients' baseline characteristics. Their mean age was 63 ± 10 (range, 29-87) years, and 372 (62%) were male. In addition to the New York Heart Association (NYHA) functional class, the Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) profile[11] at the time of surgery was used for the assessment of heart failure status. Those with NYHA functional class I/II were categorized into INTERMACS profile level 7 or more. Most of the patients (81%) presented with NYHA functional class III/IV. Seventy-nine patients (13%) required inotropic support preoperatively; of them, 21 patients (4%) had INTERMACS profile 1.

Surgical Procedures

Table 2 summarizes the operative procedures. There were 5 different SVR procedures performed: end ventricular circular patch plasty,[12] partial left ventriculectomy,[13] septal anterior ventricular exclusion,[14] overlapping left ventriculoplasty,[15] and linear ventriculoplasty. Each procedure was selected on the basis of the surgeons' preferences in each hospital. However, in common, an LV incision was placed at the myocardial scar lesion that was determined according to the findings of magnetic resonance imaging,

ACD