Risk Scoring System for Prognosis Estimation of Multivessel Disease Among Patients with ST-Segment Elevation Myocardial Infarction

Kwang Sun Ryu,1 PhD, Jang-Whan Bae,2,3 MD, Myung Ho Jeong,4 MD, Myeong-Chan Cho,3,2 MD and Keun-Ho Ryu,5 PhD and other Korea Acute Myocardial Infarction Registry Investigators

Summary
Multivessel disease (MVD) is an independent risk factor for poor prognosis in acute myocardial infarction patients. Although several global risk scoring systems (RSS) are in use in clinical practice, there is no dedicated RSS for MVD in ST-segment elevation myocardial infarction (STEMI). The primary objective of this study is to develop a novel RSS to estimate the prognosis of patients with MVD in STEMI.

We used the Korean Acute Myocardial Infarction Registry (KAMIR) to identify 2,030 STEMI patients with MVD who underwent appropriate percutaneous coronary intervention (PCI). Their data were analyzed to develop a new RSS. The prognostic power of this RSS was validated with 2,556 STEMI patients with MVD in the Korean Working Group on Myocardial Infarction Registry (KORMI).

Six prognostic factors related to all-cause death in STEMI patients with MVD were age, serum creatinine, Killip Class, lower body weight, decrease in left ventricular ejection fraction, and history of cerebrovascular disease. The RSS for all-cause death was constructed using these risk factors and their statistical weight. The RSS had appropriate performance (c-index: 0.72) in the KORMI validation cohort.

We developed a novel RSS that estimates all-cause death in the year following discharge for patients with MVD in STEMI appropriately treated by PCI. This novel RSS was transformed into a simple linear risk score to yield a simplified estimate prognosis of MVD among STEMI patients.

Key words: Obesity paradox, Percutaneous coronary intervention

Risk scoring systems (RSSs) for patients with acute coronary syndrome (ACS) were developed to estimate clinical prognosis.1–4 These systems are useful to identify high-risk populations and decide on the intensity of cardiovascular monitoring during the early phase of ACS and on treatment modalities including antiplatelet agent regimen and duration. Patients with high scores should receive more aggressive monitoring and treatment compared to lower risk patients in the cases of ACS.

The Global Registry of Acute Coronary Events risk scores (GRACE 1.0 and 2.0) estimate the risk of in-hospital and 6-month mortality rates of ACS patients.2,5 The GRACE model was evaluated in various populations and using diverse primary endpoints. Prediction of long-term mortality by the GRACE model was verified in one study using 1,443 consecutive patients with ACS in New Zealand.5 Another study confirmed the diagnostic discrimination of the GRACE model for in-hospital and 1-year mortality in 412 consecutive ST-segment elevation myocardial infarction (STEMI) patients in Japan.5 The predictive accuracy of the GRACE score was evaluated in terms of in-hospital combined endpoint that was comprised of all causes of death and non-fatal myocardial infarction for 235 ACS patients.5 The GRACE model showed good discrimination in the 3 different populations. The Canada Acute Coronary Syndrome (C-ACS) risk system was developed to permit early-risk stratification of patients with ACS.5 This RSS features simple risk estimating factors consisting of age, Killip class, systolic...
blood pressure (SBP), and heart rate. The model is simple to memorize, calculations are made easily, and performance is appropriate.\textsuperscript{41} Kim, \textit{et al.} developed an RSS based on the Korean Acute Myocardial Infarction Registry (KAMIR) in Korea. It was shown to predict the 1-year mortality of patients with acute myocardial infarction (AMI) after hospital discharge.\textsuperscript{41} This RSS was constructed using 6 independent variables: age, Killip class, serum creatinine, no in-hospital PCI, left ventricular ejection fraction (LVEF), and admission glucose. The researchers opined that this RSS supports identification of high-risk patients.\textsuperscript{41}

Van der Schaaf, \textit{et al.} and the authors of this manuscript independently showed that multivessel disease (MVD) was significantly related with higher mortality compared to single vessel disease (SVD) in STEMI patients.\textsuperscript{8,11} Therefore, we surmised that a practical and comparable to single vessel disease (SVD) in STEMI patients.\textsuperscript{8-11} Therefore, we surmised that a practical and meaningful RSS for MVD with STEMI should be introduced in clinical practice to reduce major adverse cardiac events (MACEs) in this high-risk population. Even though considerable numbers of RSSs for ACS patients have been developed and are in use, little is known regarding the risk score of MVD with STEMI. Consequently, the objective of our study was to develop a novel RSS to estimate the clinical prognosis of patients with MVD in STEMI.

\section*{Methods}

\textbf{Patient population and study design:} The data in the study were from KAMIR from November 2005 to January 2008, and the Korean Working Group on Myocardial Infarction Registry (KORMI) from February 2008 to June 2012.\textsuperscript{12-14} These databases were designed to identify characteristics of Korean AMI patients, and to determine better treatment options to improve patient survival. The cohort was comprised of STEMI patients who underwent percutaneous coronary intervention (PCI) after hospital arrival. The patients fulfilled MACE data for 1 year after discharge. Major exclusion criteria were non-ST-segment elevation myocardial infarction (NSTEMI) patients, age younger than 18 years, not treated using PCI, SVD in STEMI, and significant missing data of baseline characteristics or follow-up during the year after discharge.

\begin{table*}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
Characteristics & SVD & MVD \\
\hline
Age (years) & 63.9 ± 12.1 & 60.0 ± 13.2 \\
Killip Class (I) & 79.8 ± 11.7 & 74.1 ± 11.7 \\
SBP (mmHg) & 198 ± 41 & 166 ± 64 \\
Diabetes mellitus & 4.2 vs. 2.6\% & 5.0 vs. 4.9\% \\
Cerebrovascular disease & 6.7 vs. 3.2\% & 6.0 vs. 3.0\% \\
Other cause death & 3.1 vs. 1.7\% & 1.9 vs. 1.4\% \\
\hline
\end{tabular}
\caption{Baseline characteristics of the patients.}
\end{table*}

\textbf{Definition terminology and primary endpoint:} STEMI was defined as > 1 mm elevation of ST-segments in at least two consecutive leads and reciprocal ST segment depression accompanied by at least 30 minutes of typical ischemic chest pain and typical form of myocardial enzyme elevation.\textsuperscript{59} Among these patients, we defined MVD as the presence of 50\% diameter stenosis of two or more coronary vessels in coronary artery angiography.

\textbf{Statistical analyses:} To compare the clinical outcomes of SVD against the results of MVD, continuous variables were described as the mean ± standard deviation, and categorical variables were described as percentages (\%). We used the t-test based analysis for continuous variables, and chi-square based approach for categorical variables. In the experiment of risk model development, a univariate Cox regression approach analyzed all potential univariate correlations (P < 0.20) in order to generate the multivariate Cox regression model that includes prognosis predictor variables.\textsuperscript{43} These models were evaluated by Harrell’s C-index in R studio environment.\textsuperscript{77} All analyses were performed using SPSS version 23.0 software (SPSS Inc. Chicago, IL, USA) and R language version 3.3.1.

\section*{Results}

\textbf{Clinical characteristics and outcomes of SVD and MVD:} The baseline clinical characteristics of the patients are summarized in Table I. Patients with MVD were older (63.9 ± 12.1 versus 60.0 ± 13.2 years, P = 0.01), and had higher glucose levels upon emergency room arrival (175.8 ± 78.8 versus 166.3 ± 67.4 mg/dL, P = 0.01) as compared to those with SVD. Body mass index (BMI) (19.5 ± 2.9 versus 19.8 ± 4.1 kg/m\(^2\), P = 0.03), weight (64.1 ± 11.3 versus 65.2 ± 11.2 kg, P = 0.01), and diastolic blood pressure (DBP) (77.5 ± 11.7 versus 78.9 ± 17.4 mm Hg, P = 0.01) were significantly lower in the MVD patients in contrast to those with SVD. MVD showed significantly higher prevalence in terms of previous angina (4.2 versus 2.6\%, P = 0.01), hypertension (51.7 vs. 37.8\%, P = 0.01), diabetes mellitus (28.6 vs. 18.7\%, P = 0.01), and cerebrovascular disease (CVD; 6.7 versus 3.2\%, P = 0.01), as compared to the SVD group.

The MVD group displayed significantly higher ratios, compared to the SVD group, in Killip Class II (14.5 versus 11.7\%, P = 0.01), Killip Class II (6.6 versus 5.0\%, P = 0.04), and Killip Class IV (4.9 versus 3.5\%, P = 0.02) groups. The SVD group had a higher ratio in the Killip Class I (79.8 versus 74.1\%, P = 0.01) group than the MVD group. Pre-PCI thrombolysis in myocardial infarction (TIMI) grade 0 was higher in the SVD group compared to the MVD group (59.5 versus 55.8\%, P = 0.02). Pre-PCI TIMI grade 1 (10.0 versus 10.8\%, P = 0.41), grade 2 (13.5 versus 15.1\%, P = 0.16), and grade 3 (17.0 versus 18.4\%, P = 0.27) were comparable between the two groups. Post-PCI TIMI grades were comparable between the two groups concerning post-PCI TIMI 0 (1.5 versus 0.9\%, P = 0.06), TIMI 1 (0.7 versus 0.6\%, P = 0.85), and TIMI 3 (94.2 versus 93.6\%, P = 0.43). However, the SVD group showed a lower frequency of post-PCI TIMI grade 2 (3.6 versus 4.9\%, P = 0.04). The MVD group showed a significantly higher rate of MACE (11.4 versus 6.0\%, P = 0.01) at 1 year after hospital discharge. All-cause death (3.1 versus 1.7\%, P = 0.01), any cause of revascularization (7.9 versus 3.9\%, P = 0.01), and re-PCI (7.6 versus 3.8\%, P = 0.01) were higher in MVD, but myocardial infarction (MI; 0.4 versus 0.3\%, P = 0.80) and coronary artery bypass graft (CABG; 0.3 versus 0.1\%, P = 0.18) were comparable in both groups (Table II).

\textbf{Development of the MVD risk model for death:} Univariate analysis revealed several clinical and laboratory factors had significant power to predict 1-year mortality. These were age in years (Hazard ratio [HR] 2.16, 95\% confidence interval [CI] 1.64 to 2.85, P = 0.01), serum creatinine (HR 1.60, 95\% CI 1.24 to 2.06, P = 0.01), Killip Class (HR 1.75, 95\% CI 1.41 to 2.17, P = 0.01), lower body weight in kg (HR 1.70, 95\% CI 1.32 to 2.17, P = 0.01), decreased left ventricular ejection fraction (LVEF, \%; HR 1.55, 95\% CI 1.23 to 1.96, P = 0.01), previous angina (HR 3.01, 95\% CI 1.37 to 6.61, P = 0.01), history
Table I. Baseline Characteristics of Study Groups

| Variable                                      | SVD  | MVD  | P value |
|----------------------------------------------|------|------|---------|
| Demographic Factors                          |      |      |         |
| Age (years)                                   | 60.0 ± 13.2 | 63.9 ± 12.1 | 0.01    |
| BMI (Kg/m²)                                   | 19.8 ± 4.1  | 19.5 ± 2.9  | 0.03    |
| Weight (Kg)                                   | 65.2 ± 11.2 | 64.1 ± 11.3 | 0.01    |
| Female (%)                                    | 23.0 | 27.5 | 0.01    |
| Clinical Factors                              |      |      |         |
| Heart rate (beats/min)                        | 76.4 ± 18.2 | 76.0 ± 24.5 | 0.62    |
| SBP (mm Hg)                                   | 128.1 ± 27.7 | 126.9 ± 28.4 | 0.16    |
| DBP (mm Hg)                                   | 78.9 ± 17.4  | 77.5 ± 17.2  | 0.01    |
| LVEF (%)                                      | 51.1 ± 11.2 | 50.4 ± 11.5 | 0.07    |
| Glucose on admission (mg/dL)                  | 166.3 ± 67.4 | 175.8 ± 78.8 | 0.01    |
| Serum creatinine (mg/dL)                      | 1.09 ± 1.2  | 1.1 ± 1.1   | 0.11    |
| Killip Class                                  |      |      |         |
| Killip Class I (%)                            | 79.8 | 74.1 | 0.01    |
| Killip Class II (%)                           | 11.7 | 14.5 | 0.01    |
| Killip Class III (%)                          | 5.0  | 6.6  | 0.04    |
| Killip Class IV (%)                           | 3.5  | 4.9  | 0.02    |
| Pre TIMI flow grade                           |      |      |         |
| TIMI 0 (%)                                    | 59.5 | 55.8 | 0.02    |
| TIMI 1 (%)                                    | 10.0 | 10.8 | 0.41    |
| TIMI 2 (%)                                    | 13.5 | 15.1 | 0.16    |
| TIMI 3 (%)                                    | 17.0 | 18.4 | 0.27    |
| Post TIMI flow grade                          |      |      |         |
| TIMI 0 (%)                                    | 1.5  | 0.9  | 0.06    |
| TIMI 1 (%)                                    | 0.7  | 0.6  | 0.85    |
| TIMI 2 (%)                                    | 3.6  | 4.9  | 0.04    |
| TIMI 3 (%)                                    | 94.2 | 93.6 | 0.43    |
| Hypertension (%)                              | 37.8 | 51.7 | 0.01    |
| Diabetes mellitus (%)                         | 18.7 | 28.6 | 0.01    |
| Dyslipidemia (%)                              | 8.5  | 8.5  | 1.00    |
| Family history of cardiovascular disease (%)  | 6.8  | 6.9  | 1.00    |
| Previous medical history                      |      |      |         |
| Angina (%)                                    | 2.6  | 4.2  | 0.01    |
| AMI (%)                                       | 2.3  | 3.3  | 0.06    |
| PCI (%)                                       | 3.7  | 4.5  | 0.21    |
| Comorbidities                                 |      |      |         |
| CVD (%)                                       | 3.2  | 6.7  | 0.01    |
| Chronic lung disease (%)                      | 1.6  | 2.1  | 0.30    |
| Renal disease (%)                             | 0.9  | 1.1  | 0.63    |
| Peripheral vascular (%)                       | 0.9  | 0.8  | 0.74    |
| Heart failure (%)                             | 0.5  | 1.0  | 0.07    |

Data are expressed as number of patients (percentage) or mean ± SD. SVD indicates single vessel disease; MVD, multiple vessel disease; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; LVEF, left ventricular ejection fraction; TIMI, thrombolysis in myocardial infarction; AMI, acute myocardial infarction; PCI, percutaneous coronary intervention; and CVD, cerebrovascular disease.

of diabetes mellitus (HR 1.70, 95% CI 1.02 to 2.82, P = 0.04), peripheral vascular disease (HR 4.35, 95% CI 1.06 to 17.78, P = 0.04), renal disease (HR 6.69, 95% CI 2.43 to 18.44, P = 0.01), chronic lung disease (HR 3.30, 95% CI 1.20 to 9.10, P = 0.02), and cerebrovascular disease (CVD; HR 3.08, 95% CI 1.61 to 5.91, P = 0.01) (Table III). In multivariate analysis, age in years (HR 1.70, 95% CI 1.25 to 2.30, P = 0.01), serum creatinine (mg/dL; HR 1.45, 95% CI 1.13 to 1.85, P = 0.01), Killip Class (HR 1.45, 95% CI 1.16 to 1.81, P = 0.01), lower body weight in kg (HR 1.31, 95% CI 1.00 to 1.72, P = 0.05), decreased LVEF (%; HR 1.33, 95% CI 1.05 to 1.67, P = 0.02), and CVD (HR 2.19, 95% CI 1.13 to 4.23, P = 0.02) correlated with 1-year mortality (Table IV).

The simplified RSS model was created using relevant clinical and laboratory factors affecting 1-year mortality, with risk scores calculated based on HRs. In the case of a continuous variable, the variable was divided by quartiles; the part with a value smaller than the first quartile was assigned 1 point as a reference, with the risk scores of the other parts increasing according to the HR. For example, the HR of age was 1.70, so patients < 55 years of age were assigned 1 point, those 55 ≤ to < 65 years were assigned 17 points, those 65 ≤ age < 73 years were assigned 34 points, and those 73 ≤ years were assigned 51 points. In the case of nominal attribute, the risk score was set to
Table II. One-Year Clinical Outcomes in SVD and MVD Patients

| Variable                          | SVD (n = 2029) | MVD (n = 2030) | P value |
|-----------------------------------|---------------|---------------|---------|
| MACE (%)                          | 6.0           | 11.4          | 0.01    |
| All cause of death (%)            | 1.7           | 3.1           | 0.01    |
| Myocardial infarction (%)         | 0.3           | 0.4           | 0.80    |
| Any cause of revascularization (%)| 3.9           | 7.9           | 0.01    |
| Re-PCI (%)                        | 3.8           | 7.6           | 0.01    |
| CABG (%)                          | 0.1           | 0.3           | 0.18    |

Data are expressed as number of patients (percentage) or mean ± SD. SVD indicates single vessel disease; MVD, multiple vessel disease; MACE, major adverse cardiac event; Re-PCI, recurrence of percutaneous coronary intervention; and CABG, coronary artery bypass graft.

Table III. Univariate Analysis for Predictors of 1-Year Mortality

| Variable                               | Interval Value | B     | HR (95%CI) | P value |
|----------------------------------------|----------------|-------|------------|---------|
| Age (years)                            | A < 55         | 55 ≤ A < 65 | 65 ≤ A < 73 | 73 ≤ A | 0.77 | 2.16 (1.64-2.85) | 0.01 |
| Glucose on admission (mg/dL)           | G < 124        | 124 ≤ G < 153 | 153 ≤ G < 204 | 204 ≤ G | 0.08 | 1.09 (0.87-1.36) | 0.46 |
| Serum creatinine (mg/dL)               | S < 0.9        | 0.9 ≤ S < 1.0 | 1.0 ≤ S < 1.2 | 1.2 ≤ S | 0.47 | 1.60 (1.24-2.06) | 0.01 |
| Heart rate (minutes)                   | H < 63         | 63 ≤ H < 74 | 74 ≤ H < 87 | 87 ≤ H | 0.09 | 1.09 (0.87-1.37) | 0.44 |
| Killip Class                           | I              | II               | III               | IV              | 0.56 | 1.75 (1.41-2.17) | 0.01 |
| Lower body weight (kg)                 | 71 ≤ W         | 64 ≤ W < 71 | 56 ≤ W < 64 | W < 56 | 0.53 | 1.70 (1.32-2.17) | 0.01 |
| Decrease in SBP (mm Hg)                | 144 ≤ S        | 130 ≤ S < 144 | 110 ≤ S < 130 | S < 110 | 0.15 | 1.16 (0.93-1.46) | 0.19 |
| Decrease in DBP (mm Hg)                | 90 ≤ D         | 80 ≤ D < 90 | 68 ≤ D < 80 | D < 68 | 0.67 | 1.19 (0.96-1.47) | 0.12 |
| Decreased LVEF (%)                     | 58 ≤ L         | 50 ≤ L < 58 | 43 ≤ L < 50 | L < 43 | 0.44 | 1.55 (1.23-1.96) | 0.01 |
| Pre TIMI flow grade                    | 0              | 1               | 2               | 3              | 0.11 | 1.14 (0.94-1.39) | 0.18 |
| Post TIMI flow grade                   | 0              | 1               | 2               | 3              | 0.06 | 1.06 (0.53-2.11) | 0.87 |
| Female                                 |                | 0.16            | 0.17 (0.68-2.01) | 0.57    |
| Previous angina                        |                | 1.10            | 3.01 (1.37-6.61) | 0.01    |
| Previous AMI                          |                | −3.05           | 0.05 (0.00-22.33) | 0.33    |
| Previous PCI                          |                | 0.63            | 1.88 (0.75-4.69) | 0.18    |
| History of hypertension               |                | 0.13            | 1.14 (0.69-1.88) | 0.61    |
| History of diabetes mellitus          |                | 0.53            | 1.70 (1.02-2.82) | 0.04    |
| History of dyslipidemia               |                | −0.30           | 0.74 (0.27-2.03) | 0.56    |
| Family history of cardiovascular disease |            | −0.37           | 0.69 (0.22-2.21) | 0.54    |
| Peripheral vascular disease           |                | 1.47            | 4.35 (1.06-17.78) | 0.04    |
| Renal disease                         |                | 1.90            | 6.69 (2.43-18.44) | 0.01    |
| Heart failure                         |                | 0.44            | 1.55 (0.22-11.19) | 0.66    |
| Chronic lung disease                  |                | 1.20            | 3.30 (1.20-9.10) | 0.02    |
| CVD                                   |                | 1.13            | 3.08 (1.61-5.91) | 0.01    |

B indicates beta coefficient; HR, hazard ratio; SVD, single vessel disease; MVD, multiple vessel disease; SBP, systolic blood pressure; DBP, diastolic blood pressure; LVEF, left ventricular ejection fraction; TIMI, thrombolysis in myocardial infarction; AMI, acute myocardial infarction; PCI, percutaneous coronary intervention; and CVD, cerebrovascular disease.

Table IV. Multivariate Analysis for Predictors of 1-Year Mortality

| Variable                               | Interval Value | B     | HR (95%CI) | P value |
|----------------------------------------|----------------|-------|------------|---------|
| Age (years)                            | A < 55         | 55 ≤ A < 65 | 65 ≤ A < 73 | 73 ≤ A | 0.53 | 1.70 (1.25-2.30) | 0.01 |
| Serum creatinine (mg/dL)               | S < 0.9        | 0.9 ≤ S < 1.0 | 1.0 ≤ S < 1.2 | 1.2 ≤ S | 0.37 | 1.45 (1.13-1.85) | 0.01 |
| Killip Class                           | I              | II               | III               | IV              | 0.37 | 1.45 (1.16-1.81) | 0.01 |
| Lower body weight (kg)                 | 71 ≤ W         | 64 ≤ W < 71 | 56 ≤ W < 64 | W < 56 | 0.21 | 1.31 (1.00-1.72) | 0.05 |
| Decreased LVEF (%)                     | 58 ≤ L         | 50 ≤ L < 58 | 43 ≤ L < 50 | L < 43 | 0.28 | 1.33 (1.05-1.67) | 0.02 |
| CVD                                   |                | 0.78            | 2.19 (1.13-4.23) | 0.02    |

B indicates beta coefficient; HR, hazard ratio; LVEF, left ventricular ejection fraction; and CVD, cerebrovascular disease.

1 point if the value was no; otherwise the score increased based on the HR. For instance, CVD had a HR of 2.19 hazard ratio, so patients with CVD were assigned 22 points and the other patients were assigned 1 point (Figure A). Furthermore, we defined the nomogram-based logistic function to automatically estimate patient mortality (Figure B), which takes the sum of the scores identified from the MVD death risk scoring table. For example, pa-
A. MVD Death Risk Scores

| Age (A) | Point | Weight (W) | Killip Class |
|---------|-------|------------|--------------|
| A<55    | 1     | 71≤W       | I            |
| 55≤A<65 | 17    | 64≤W<71    | II           |
| 65≤A<73 | 34    | 56≤W<64    | III          |
| ≥73     | 51    | W≥56       | IV           |
| Serum Creatinine (S) | LVEF (L) |
| S<0.9   | 1     | 58≤L       |              |
| 0.9≤S<1.0 | 15   | 50≤L<58   |              |
| 1.0≤S<1.2 | 30   | 43≤L<50   |              |
| ≥1.2    | 45    | L<43       |              |

B. Calculation of MVD Death Risk Scores

Calculation formula: \[ y = 1/(0 + 4.6916956982831426 \times 0.9784401597003933^x) \]

C. Distribution and Discrimination for Death model

| Total Risk Scores | All cause of Death 1 year (%) |
|-------------------|------------------------------|
| <110              | 1.1%                         |
| 110-140           | 3.1%                         |
| 140-170           | 7.1%                         |
| 170-200           | 14.5%                        |
| 200≤               | 33.3%                        |

| Number | Total Risk Scores |
|--------|-------------------|
| (%)    | (KAMIR) Development cohort | (KORMI) Validation cohort |
| 1286   | (63.3%)           | (76%)                     |
| 418    | (20.0%)           | (24%)                     |
| 226    | (11.1%)           | (1.2%)                    |

C-index: 0.78 (KAMIR) 0.72 (KORMI)

Figure. Prediction model for 1-year mortality in STEMI patients with MVD in CAG. STEMI indicates ST-segment elevation myocardial infarction; MVD, multiple vessel disease; CAG, coronary angiography; and LVEF, left ventricular ejection fraction.

tient A is 74 years of age, weighed 52 kg, had a LVEF of 56%, Killip class II, serum creatinine 1.3 mg/dL, and CVD corresponding to respective risk scores of 51, 39, 13, 15, 45, and 22 points. The cumulative risk score for patient A is 185 points. The mortality of 12.0% is indicative of a higher probability of an adverse clinical event. In contrast, patient B is 68 years of age, weighs 76 kg, has a LVEF of 46%, Killip class III, serum creatinine 1.0 mg/
Discussion

RSS in patients with ACS is important for effective medical care and improved patient survival. The GRACE 1.0 risk score was developed to estimate the in-hospital mortality.\(^1\) This model was adjusted to GRACE 2.0 to estimate the risk of 6-month death after hospital discharge.\(^2\) The C-ACS risk score model estimates short- and long-term mortality in patients with ACS using simple prognostic variables.\(^3\) Kim, et al. developed an RSS based on the KAMIR database that predicts long-term mortality for patients with AMI.\(^4\) These RSS showed an adequate goodness of fit and good receiver operating characteristic curves for cardiac adverse events.

As compared to previous RSS cohorts, our population comprised fewer patients and data were collected in one only country. Nevertheless, our model concentrated on a specific population, namely STEMI patients with MVD who underwent PCI. Previous RSS studies centered on patients with ACS and STEMI. In our experimental results, patients with MVD displayed a variety of adverse indicators including higher prevalence of previous angina, hypertension, diabetes mellitus, CVD, older age, higher glucose on admission, lower body weight, lower DBP, and higher frequency of Killip Class II, III, and IV as compared to patients with SVD. Those with MVD in particular showed significantly higher rates of MACE, all-cause death, and any cause of revascularization at 1 year after discharge, as compared to SVD patients. With this background, we focused on STEMI patients with MVD treated using PCI, with the goal of establishing a novel RSS dedicated to STEMI patients with MVD treated with PCI. The novel RSS reported here estimates high-risk STEMI patients with MVD who underwent PCI.

Conflicts of interest: None.

References

1. Granger CB, Goldberg RJ, Dabbous O, et al. Predictors of hospital mortality in the global registry of acute coronary events. Arch Intern Med 2003; 163: 2345-53.
2. Eagle KA, Lim MJ, Dabbous OH, et al. A validated prediction model for all forms of acute coronary syndrome: estimating the risk of 6-month post discharge death in an international registry. JAMA 2004; 291: 2727-33.
3. Hyunh T, Kouz S, Yan AT, et al. Canada Acute Coronary Syndrome Risk Score: a new risk score for early prognostication in acute coronary syndromes. Am Heart J 2013; 166: 58-65.
4. Kim HK, Jeong MH, Ahn Y, et al. Hospital discharge risk score system for the assessment of clinical outcomes in patients with acute myocardial infarction (Korea Acute Myocardial Infarction Registry [KAMIR] score). Am J Cardiol 2011; 107: 965-71.
5. Tang EW, Wong CK, Herbison P. Global Registry of Acute Coronary Events (GRACE) hospital discharge risk score accurately predicts long-term mortality post acute coronary syndrome. Am Heart J 2007; 153: 29-35.
6. Fujii T, Suzuki T, Torii S, et al. Diagnostic accuracy of Global Registry of Acute Coronary Events (GRACE) risk score in ST-elevation myocardial infarction for in-hospital and 360-day mortality in Japanese patients. Circ J 2014; 78: 2950-4.
7. Prabhudesai AR, Srilakshmi MA, Santosh MJ, et al. Validation of the GRACE score for prognosis in Indian patients with acute coronary syndromes. Indian Heart J 2012; 64: 263-9.
8. Van der Schaal RJ, Vis MM, Sjauw KD, et al. Impact of multivessel coronary disease on long-term mortality in patients with ST-elevation myocardial infarction is due to the presence of a chronic total occlusion. Am J Cardiol 2006; 98: 1165-9.
9. Ryu KS, Park HW, Park SH, et al. Comparison of clinical outcomes between culprit vessel only and multivessel percutaneous coronary intervention for ST-segment elevation myocardial infarction patients with multivessel coronary diseases. J Geriatr Cardiol 2015; 12: 208-17.
10. Lee WC, Wu BJ, Fang CY, et al. Timing of Staged Percutane-
ous Coronary Intervention for a Non-Culprit Lesion in Patients with Anterior Wall ST Segment Elevation Myocardial Infarction with Multiple Vessel Disease. Int Heart J 2016; 57: 417-23.
11. Watanabe Y, Sakakura K, Taniguchi Y, et al. Determinants of in-hospital death in acute myocardial infarction with triple vessel disease. Int Heart J 2016; 57: 697-704.
12. Sim DS, Jeong MH, Cho KH, et al. Effect of early statin treatment in patients with cardiogenic shock complicating acute myocardial infarction. Korean Circ J 2013; 43: 100-9.
13. Jeong YA, Jeong MH, Jeong HC, et al. Impact of smoking on clinical outcomes in female patients with acute myocardial infarction. Korean Circ J 2015; 45: 22-7.
14. Hwang KK, Eom SY, Lee ST, et al. Atrial fibrillation on admission is related with higher mortality in ST-segment elevation myocardial infarction patients. Int Heart J 2017; 58: 486-94.
15. Hur SH, Won KB, Bae JH, et al. Comparison of 2-year clinical outcomes between diabetic versus nondiabetic patients with acute myocardial infarction after 1-month stabilization: Analysis of the prospective registry of DIAMOND (DIabetic acute myocardial infarctioN Disease) in Korea: an observational registry study. Medicine (Baltimore) 2016; 95: e3882.
16. Im MS, Kim HL, Lim WH, et al. Different prognostic factors according to left ventricular systolic function in patients with acute myocardial infarction. Int J Cardiol 2016; 221: 90-6.
17. Kang WY, Jeong MH, Ahn YK, et al. Obesity paradox in Korean patients undergoing primary percutaneous coronary intervention in ST-segment elevation myocardial infarction. J Cardiol 2010; 55: 84-91.
19. Bucholz EM, Rathore SS, Reid KJ, et al. Body mass index and mortality in acute myocardial infarction patients. Am J Med 2012; 125: 796-803.
20. Mehta L, Devlin W, McCullough PA, et al. Impact of body mass index on outcomes after percutaneous coronary intervention in patients with acute myocardial infarction. Am J Cardiol 2007; 99: 906-10.
21. Nikolsky E, Stone GW, Grines CL, et al. Impact of body mass index on outcomes after primary angioplasty in acute myocardial infarction. Am Heart J 2006; 151: 168-75.
22. Bucholz EM, Beckman AL, Krumholz HA, et al. Excess weight and life expectancy after acute myocardial infarction: The obesity paradox reexamined. Am Heart J 2016; 172: 173-81.
23. Li YJ, Rha SW, Chen KY, et al. Clinical characteristics and mid-term outcomes of acute myocardial infarction patients with prior cerebrovascular disease in an Asian population: Lessons from the Korea Acute Myocardial Infarction Registry. Clin Exp Pharmacol Physiol 2010; 37: 581-6.
24. Tanne D, Gottlieb S, Caspi A, et al. Treatment and outcome of patients with acute myocardial infarction and prior cerebrovascular events in the thrombolytic era: The Israeli Thrombolytic National Survey. Arch Intern Med 1998; 158: 601-6.
25. Cotter G, Cannon CP, McCabe CH, et al. Prior peripheral arterial disease and cerebrovascular disease are independent predictors of adverse outcome in patients with acute coronary syndromes: are we doing enough? Results from the Orbofiban in Patients with Unstable Coronary Syndromes-Thrombolysis In Myocardial Infarction (OPUS-TIMI) 16 study. Am Heart J 2003; 145: 622-7.