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# Prognostic Value of SYNTAX Scores for Predicting Major Cardiac Adverse Events in Patients with Acute Myocardial Infarction Treated with Primary Percutaneous Coronary Intervention

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ABSTRACT

**Background:** SYNTAX scores (SS) and clinical SYNTAX scores (CSS) together are widely used in clinical practice as predictors for major adverse cardiac events (MACEs) after an elective primary percutaneous intervention (PCI).

**Objectives:** We sought to investigate prognostic values of the combination of SS and CSS in predicting MACEs in a cohort of patients with acute myocardial infarction treated by primary PCI with a 12-month follow-up.

**Methods:** This prospective, longitudinal study included patients from two referral hospitals who had an acute myocardial infarction and underwent primary PCI. SS and CSS were calculated by researchers blinded to patient details using web-based software and clinical factors. SS and CSS were classified into three categories: low/SS1: < 11.75, moderate/SS2: 11.75 – 23.25, or high/SS3 > 23.25, and low/CSS1: < 22.95, moderate/CSS2: 22.95 – 35.95, or high/CSS3: > 35.95. We followed the patients 12 months after the procedure and recorded clinical examination results and MACEs. Data analysis included the chi-squared test (c2), student's t-test, and Cox regression analysis. Cumulative survival rates were estimated through Kaplan–Meier curve analysis.

**Results:** Among 296 subjects, those with a MACE predominated in the SS3 (16.8%) and CSS3 (14.0%) categories. SS had a significant relationship with all-cause mortality (P = 0.015), re-infarction (P = 0.019), cardiovascular death (P = 0.03), and MACE (P = 0.04). CSS had a significant relationship with all-cause mortality (P < 0.001), re-infarction (P = 0.02), cardiovascular death (P = 0.016), and MACE (P = 0.045). The risk of death by 12-month follow-up of the SS3 patient group was 2.99 times higher than that of the SS1 group (HR = 2.99; 95% CI: 1.11 – 7.84; P = 0.029). The CSS3 patient group had a 4.23 times higher risk of death than the CSS1 group (HR = 4.23; 95% CI: 1.94 – 9.36; P < 0.001). According to Kaplan-Meier curve analysis, the difference in survival rates of the three patient groups categorized by SS or CSS was significant. The SS1 group had the highest survival rate of 91.8%, followed by the SS2 (85.0%) and SS3 (77.9%) groups. Regarding CSS, the CSS1 group had the highest survival rate of 93.0%, followed by the CSS2 (85.1%) and CSS3 (73.8%) groups.

**Conclusions:** The classification of SS (low SS1, moderate SS2, high SS3) and CCS (low CSS1, moderate CSS2, high CSS3) has important roles in the risk assessment of patients with ACS treated by primary PCI.

## 1. Background

Acute myocardial infarction (AMI) is a leading cause of death worldwide. Several studies have shown that a primary percutaneous intervention (PCI) effectively reduces mortality (1). However, predicting major adverse cardiac events (MACEs) after a PCI can be challenging. Several clinical models and scoring systems have attempted to predict

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patient outcomes using hemodynamics, the severity of coronary lesions, electrocardiographic features, age, cardiac enzymes, clinical scores, and so on (2-6). However, such instruments may be uncommonly used in clinical practice due to their limitations. The SYNTAX score (SS), a lesion-based angiographic scoring tool, was developed based on previously established systems (7). However, one problem is that this score is independent of the patient's other clinical parameters. Meanwhile, it has been shown that the prognostic value of this system could be improved by considering the clinical characteristics of the patient (8). Hence, the clinical SYNTAX score (CSS) was developed, adding in clinical features such as age, left ventricular ejection fraction, and serum creatinine clearance. The CSS, together with SS, can predict early and late MACEs after PCI (9, 10).

Several studies attempted to predict SYNTAX scores before invasive coronary angiography. Hatamnejad et al. demonstrated that ST elevation in the right side leads (aVR, III, V1) and ST depression in other leads indicate high SYNTAX scores (11). Amirhossein et al. also showed that a HEART score with a cutoff of 6 can predict a SYNTAX score of ≥ 23 (12). Studies have also attempted to define different SS and CSS scores as low, medium, or high (10, 13, 14). However, no consensus seemed to have been reached.

## 2. Objectives

We investigated the prognostic values of SS and CSS cutoff points in predicting MACEs in a cohort of AMI patients who underwent primary PCI and were followed for 12 months.

## 3. Patients and Methods

### *3.1. Study Populations*

This prospective longitudinal study was conducted at two tertiary cardiovascular centers. From May 2015 to February 2020, we were able to follow 296 patients for 12 months. All patients underwent primary PCI at two tertiary hospitals in Hanoi, Vietnam. Our patients met all the criteria for ST-elevation myocardial infarction (STEMI), per the 2012 European Society of Cardiology guidelines (15). All patients provided informed consent to participate in the study. All patients were treated with antiplatelet therapy and were well-controlled for comorbidities. We followed this cohort for 12 months during the post-intervention period.

Data were collected from a hospital database containing information on patients' demographics, angiography characteristics, and methods of coronary intervention. On-call cardiologists performed primary PCI, and the researchers obtained all data at the end of the procedure. We recorded all adverse cardiac events. A MACE was defined as any major adverse event after the procedure, such as all-cause mortality, re-infarction, in-stent thrombosis, stroke, re-intervention, and cardiovascular death.

### *3.2. Calculating the SYNTAX Score (SS) and Clinical SYNTAX Score (CSS)*

The SS was calculated using the SS calculator application version 2.11 from the webpage https://www.syntaxscore.org (16). Input data were based on coronary images after primary PCI. The CSS was obtained via the following formula: CSS = SS x (age/left ventricular ejection fraction) + 1 point for every 10 mL/min reduction in creatinine clearance < 60 mL/min per 1.73 $m^2$ (17). To ensure reproducibility, a cardiologist was asked to check for the variability of measurements in 5% of the participants while blinded to their demographic information.

The SS and CSS cutoffs of the patients were obtained using the receiver operating characteristic curve analysis algorithm. We relied on the Youden index (J = Youden index) with the highest and lowest values to determine the SS and CSS tertiles. The J-index was highest at the SS of 23.25 and lowest at 11.75; for CSS, the J-index was highest at 35.95 and lowest at 22.95. These cutoffs were used to create our study's high and low CSS and SS subgroups: SS1 (< 11.75) and CSS1 (< 22.95) were classified as low, SS2 (11.75 – 23.25) and CSS2 (22.95 – 35.94) as moderate, and SS3 (> 23.25) and CSS3 (> 35.95) as high.

### *3.3. Statistical Analysis*

We used SPSS software (version 21.0, USA) for statistical analysis. To test for the significance of differences across low, moderate, and high cutoff points of SS and CSS, we used the chi-squared test (c2) and student's t-test. Cox regression analysis assessed the association between mortality and SS or CSS. Kaplan–Meier curve analysis estimated cumulative survival rates through follow-up. A P-value < 0.05 was considered statistically significant.

### *3.4. Ethical Considerations*

Ethical approval was received from the Ethics Committee of Bach Mai Hospital and 103 Military Hospital (approval No. 320; date: 04.07.2015). During the recruitment process, written informed consent was obtained from all participants.

## 4. Results

### *4.1. Baseline and Angiography Characteristics and Methods of Coronary Intervention*

Our study included 296 patients (mean age, 65.5 ± 10.9 years). More than two-thirds of patients were males (77.7%). The mean SS for all patients in our cohort was 19.5 ± 9.4. Table 1 shows the baseline characteristics, angiography characteristics, and methods of coronary intervention across the three SS patient groups. There were 61 patients with low SS (< 11.75; SS1), 140 patients with moderate SS (11.75 – 23.25; SS2), and 95 patients with high SS (> 23.25; SS3). Among the risk factors, there were statistically significant relationships between the SS of the three patient groups and a history of hypertension (P < 0.001) or prior PCI (P = 0.036). Regarding angiography characteristics, we found no significant relationships between SS and having complex lesions of the left circumflex or right coronary arteries. Patients with moderate and high SS appeared to have had more drug-eluting stents (135 (97%) and 92 (97.2%), respectively) compared to those with low SS. The relationship between using drug-eluting stents and SS was significant (P = 0.027). Patients with high SS had lower left ventricular ejection fractions measured by echocardiography than those with moderate or low SS (38.8 ± 9.7, 42.1 ± 8.1, and 41.3 ± 9.8, respectively; P < 0.001).

**Table 1.** Baseline Clinical Characteristics Compared across SYNTAX Score (SS) Categories

| | Total (n = 296) | SS1 (n = 61) | SS2 (n = 140) | SS3 (n = 95) | P-value |
|---|---|---|---|---|---|
| Baseline characteristics | | | | | |
| Age, years | 65.5 ± 10.9 | 64.3 ± 17.6 | 58.7 ± 15.9 | 61.5 ± 19.6 | 0.23 |
| Gender - male, n (%) | 230 (77.7) | 83 (79.1) | 105 (75.5) | 42 (80.1) | 0.08 |
| Diabetes mellitus, n (%) | 40 (13.5) | 9 (15.7) | 18 (12.6) | 13 (12.5) | 0.653 |
| Current smoking, n (%) | 128 (43.5) | 28 (46.3) | 60 (43.1) | 40 (42.0) | 0.746 |
| Hypertension, n (%) | 153 (52.0) | 29 (47.8) | 64 (45.7) | 60 (64.8) | **< 0.001** |
| Dyslipidemia, n (%) | 90 (30.5) | 24 (40.5) | 42 (30.0) | 24 (25.2) | 0.673 |
| Stroke, n (%) | 2 (0.3) | 0 (0.0) | 1 (0.4) | 1 (0.6) | 0.15 |
| Chronic pulmonary disease, n (%) | 13 (2.2) | 2 (1.5) | 4 (1.5) | 7 (4.0) | 0.16 |
| Previous MI, n (%) | 9 (1.5) | 0(0.0) | 7(2.6) | 2(1.1) | 0.12 |
| Previous PCI, n (%) | 3 (0.5) | 1 (0.7) | 0 (0,0) | 2 (1.1) | **0.036** |
| Anterior/septal MI, n(%) | 146 (49.3) | 22(37.3) | 76(53.9) | 48(48.9) | **0.014** |
| Inferior/Posterior MI, n(%) | 33 (11.2) | 29 (48.5) | 34 (36.4) | 35 (36.9) | 0.162 |
| Lateral MI, n(%) | 116 (39.3) | 8 (12.7) | 13 (8.9) | 12 (13.6) | 0.302 |
| Ejection fraction (%) | 41.3 ± 9.8 | 46.5 ± 7.8 | 42.1 ± 8.1 | 38.8 ± 9.7 | **< 0.001** |
| Dual antiplatelet, n(%) | 296 (100) | 61 (100) | 140 (100) | 95 (100) | **NA** |
| SS | 19.5 ± 9.4 | | | | |
| Angiography characteristics | | | | | |
| Multi-vessel disease | 16 (5.5) | 2 (3.7) | 4 (3.0) | 10 (10.8) | **< 0.001** |
| Total occlusions | 181 (61.4) | 17 (27.6) | 95 (67.7) | 69 (73.8) | **< 0.001** |
| Bifurcations | 114 (38.8) | 14 (22.4) | 49 (35.7) | 51 (56.3) | **< 0.001** |
| Small vessels/diffuse disease | 104 (35.2) | 15 (23.9) | 33 (24.1) | 56 (60.8) | **< 0.001** |
| Left main | 6 (1.0) | 0(0.0) | 2(0.7) | 4(2.3) | **0.024** |
| Left anterior descending | 140 (47.4) | 22 (37.3) | 74 (53.2) | 44(46.6) | **0.015** |
| Left circumflex | 33 (11.2) | 8 (12.7) | 13 (8.9) | 12 (13.6) | 0.302 |
| Right coronary artery | 116 (39.3) | 29 (48.5) | 34 (36.4) | 35 (36.9) | 0.162 |
| Methods of coronary intervention | | | | | |
| Bare metal stent | 4 (1.2) | 1 (1.5) | 1 (0.7) | 2 (1.7) | 0.418 |
| Drug-eluting stent | 283 (95.8) | 56 (91.8) | 135 (97.0) | 92 (97.2) | **0.027** |
| Bioabsorbable Stent | 4 (1.3) | 2 (3.7) | 1 (0.7) | 1 (1.1) | 0.253 |
| Thrombus suction | 5 (1.7) | 2 (3.0) | 2 (1.4) | 1 (0.6) | 0.103 |

Values are mean ± SD or n (%). Statistical significance of differences across low (SS1), moderate (SS2), and high (SS3) cutoff points of SS were tested using the chi-squared test (c2) or student's t-test. A P-value < 0.05 (bold) was considered significant.
Abbreviations: MI; myocardial infarction, PCI; percutaneous coronary intervention

The mean CSS for all patients (n = 296) was 30.2 ± 18.8. Table 2 shows the baseline characteristics, angiography characteristics, and methods of coronary intervention across the three CSS patient groups. Exactly 115 patients were categorized in the CSS1 group (< 22.95), 74 in the CSS2 group (22.95 – 35.94), and 107 in the CSS3 group (> 35.95). We found significant differences in factors of age (P = 0.035) and hypertension history (P < 0.001) among CSS1, CSS2, and CSS3 patients. No significant relationship was found between the CSS of the three patient groups and complex lesions of left anterior descending, left circumflex, or right coronary arteries. Patients with high CSS had more multiple vessel diseases (8 (7.4%), 3 (4.3%), and 5 (4.3%), respectively) compared to ones with moderate or low CSS; similar results were seen regarding total occlusions, bifurcation and small/diffuse coronary disease (P < 0.001). Patients with high CSS had lower left ventricular ejection fractions measured by echocardiography than those with moderate or low CSS (39.4 ± 6.7; 41.6 ± 7.8 and 45.9 ± 8.4, respectively; P < 0.001).

*4.2. Cumulative outcomes by 12-Month Follow-up*

After the 12-month follow-up, 47 cases of all-cause mortality and 34 MACEs were detected in our cohort (Table 3). A MACE occurred in 16.8%, 9.3%, and 8.2% of patients in the SS3, SS2, and SS1 groups, respectively. Significant relationships were seen between SS and all-cause mortality (P = 0.015), re-infarction (P = 0.019), cardiovascular death (P = 0.03), and MACEs (P = 0.04). As for CSS categorization, the percentage of patients with a MACE was 14.0% for CSS3, 11.3% for CSS2, and 8.1% for the CSS1 patient group. The relationship between CSS and all-cause mortality (P < 0.001), re-infarction (P = 0.02), cardiovascular death (P = 0.016), and MACEs (P = 0.045) was significant.

Through Cox regression analysis, we compared the mortality rates of the three SS and CSS groups (Table 4). The CSS3 patient group had a 4.23 times higher risk of death than the CSS1 group (HR = 4.23; 95% CI: 1.94 – 9.36; P < 0.001). The risk of death in the CSS3 group was 1.96 times higher than that in the CSS2 group, and the risk of death in the CSS2 group was 2.19 times higher than that in the CSS1 group. As for SS, the risk of death by 12-month follow-up of the SS3 patient group was 2.99 times higher than that of the SS1 (HR = 2.99; 95% CI: 1.11 – 7.84; P = 0.029). The SS3 group had a 1.59 times higher risk of death than the SS2 group, and the SS2 group had a 1.85 times higher risk of death than the SS1 group.

**Table 2.** Baseline Clinical Characteristics Compared across Clinical SYNTAX Score (CSS) Categories

| | Total (n = 296) | CSS1 (n = 115) | CSS2 (n = 74) | CSS3 (n = 107) | P-value |
|---|---|---|---|---|---|
| Baseline characteristics | | | | | |
| Age | 65.5 ± 10.9 | 59.3 ± 19.3 | 61.7 ± 14.3 | 67.1 ± 16.6 | **0.035** |
| Gender - male | 230 (77.7) | 99 (86.5) | 53 (72.0) | 78 (71.8) | 0.124 |
| Diabetes mellitus | 40 (13.5) | 17 (15.7) | 9 (12.6) | 14 (12.5) | 0.653 |
| Current smoking | 128 (43.5) | 53 (46.3) | 32 (43.1) | 43 (42.0) | 0.746 |
| Hypertension | 153 (52.0) | 54 (47.8) | 33 (45.7) | 66 (64.8) | **< 0.001** |
| Hypercholesterolemia | 90 (30.5) | 5 (4.5) | 2 (3.0) | 3 (2.8) | 0.673 |
| Stroke | 2 (0.3) | 0 (0.0) | 1 (1.3) | 1 (0.9) | 0.217 |
| Chronic pulmonary disease | 13 (2.2) | 4 (3.4) | 3 (4.0) | 6 (5.7) | 0.352 |
| Previous MI | 9 (1.5) | 0(0.0) | 7 (9.4) | 2 (1.8) | 0.12 |
| Previous PCI | 3 (0.5) | 0 (0.0) | 1 (1.4) | 2 (1.8) | 0.168 |
| Anterior/septal MI, n(%) | 146 (49.3) | 44 (38.7) | 43(58.1) | 59 (58.3) | 0.125 |
| Inferior/Posterior MI, n(%) | 116 (39.3) | 54 (47.4) | 24 (33.5) | 38 (34.6) | 0.438 |
| Lateral MI, n(%) | 33 (11.2) | 14 (12.2) | 6 (8.7) | 13(12.2) | 0.185 |
| Ejection fraction (%) | 41.3 ± 9.8 | 45.9 ± 8.4 | 41.6 ± 7.8 | 39.4 ± 6.7 | < 0.001 |
| Dual antiplatelet, n(%) | 296 (100) | 115 (100) | 74 (100) | 107 (100) | **NA** |
| CSS | 30.2 ± 18.8 | | | | |
| Angiography characteristics | | | | | |
| Multivessel disease | 16 (5.5) | 5 (4.3) | 3 (4.3) | 8 (7.4) | **<0.001** |
| Total occlusions | 181 (61.4) | 52 (45.7) | 51 (68.9) | 78 (74.5) | **<0.001** |
| Bifurcations | 114 (38.8) | 30 (26.1) | 29 (39.8) | 55 (53.7) | **<0.001** |
| Small vessels /diffuse disease | 104 (35.2) | 18 (16.5) | 33 (45.3) | 52 (49.5) | **<0.001** |
| Left main | 6 (1.0) | 0 (0.0) | 2 (2.7) | 4 (3.7) | **0.031** |
| Left anterior descending | 140 (47.4) | 44 (38.7) | 41(55.9) | 55 (54.6) | 0.625 |
| Left circumflex | 33 (11.2) | 14 (12.2) | 6 (8.7) | 13(12.2) | 0.438 |
| Right coronary artery | 116 (39.3) | 54 (47.4) | 24 (33.5) | 38 (34.6) | 0.185 |
| Method of coronary intervention | | | | | |
| Bare metal stent | 4 (1.2) | 1 (0.9) | 1 (1.3) | 2 (1.7) | 0.733 |
| Drug-eluting stent | 283 (95.8) | 110 (95.6) | 68 (91.8) | 105 (98.1) | 0.204 |
| Bioabsorbable Stent | 4 (1.3) | 2 (1.7) | 1 (1.3) | 1 (0.9) | 0.371 |
| Thrombus suction | 5 (1.7) | 2 (1.7) | 2 (2.7) | 1 (0.9) | 0.052 |

Values are mean ± SD and n (%). Statistical significance of differences across low (CSS1), moderate (CSS2), and high (CSS3) cutoff points of CSS were tested using the chi-squared test (c2) or student's t-test. A P-value < 0.05 (bold) was considered significant.
Abbreviations: MI; myocardial infarction, PCI; percutaneous coronary intervention

**Table 3.** Cumulative Clinical Outcomes across Patient Categories by 12-Month Follow-up

| By Syntax score (SS) | Total (n = 296) | SS1 (n = 61) | SS2 (n = 140) | SS3 (n = 95) | P-value |
|---|---|---|---|---|---|
| All-cause mortality | 47 (15.8) | 5 (8.2) | 21 (15.0) | 21 (22.1) | **0.015** |
| Re-infarction | 7 (2.3) | 0 (0.0) | 2 (1.4) | 5 (5.3) | **0.019** |
| In-stent thrombosis | 5 (1.6) | 1 (1.6) | 2 (1.4) | 2 (2.1) | 0.476 |
| Stroke | 3 (1.0) | 1 (1.6) | 1 (0.7) | 1 (1,1) | 0.825 |
| Re-intervention | 11 (3.7) | 2 (3.3) | 3 (2,1) | 6 (6.3) | 0.245 |
| Cardiovascular death | 37 (12.5) | 4 (6.2) | 18 (12.9) | 15 (15.8) | **0.03** |
| MACE | 34 (11.4) | 5 (8.2) | 13 (9.3) | 16 (16.8) | **0.04** |
| **By clinical SYNTAX score (CSS)** | **Total (n = 296)** | **CSS1 (n = 115)** | **CSS2 (n = 74)** | **CSS3 (n = 107)** | **P-value** |
| All-cause mortality | 47 (15.8) | 8 (7.0) | 11 (14.9) | 28 (26.2) | **< 0.001** |
| Re-infarction | 7 (2.3) | 0 (0.0) | 1 (1.4) | 6 (5.6) | **0.02** |
| In-stent thrombosis | 5 (1.6) | 1 (0.9) | 1 (1.4) | 3 (2.8) | 0.365 |
| Stroke | 3 (1.0) | 1 (0.9) | 0 (0.0) | 2 (1,9) | 0.309 |
| Re-intervention | 11 (3.7) | 3 (2.6) | 1 (1.4) | 7 (6.5) | 0.175 |
| Cardiovascular death | 37 (12.5) | 5 (4.3) | 12 (16.2) | 20 (18.7) | **0.016** |
| MACE | 34(11.4) | 6 (8.1) | 13 (11.3) | 15 (14.0) | **0.045** |

Values are n (%). Statistical significance of differences across low, moderate, and high cutoff points of SS and CSS were tested using the chi-squared test (c2). A P-value < 0.05 (bold) was considered significant.
Abbreviations: MACE; major adverse cardiac event

**Table 4.** Cox regression Analysis Comparing Mortality between Different SYNTAX Score (SS) and Clinical SYNTAX Score (CSS) Groups

| | Hazard Risk Ratio (95% Confidence Interval) | | | | | |
|---|---|---|---|---|---|---|
| | **SS1 vs. SS2** | **P-value** | **SS1 vs. SS3** | **P-value** | **SS2 vs. SS3** | **P-value** |
| Mortality by 12-month follow-up | 1.85 (0.69 – 4.90) | 0.217 | 2.99 (1.11 – 7.84) | **0.029** | 1.59 (0.87 – 2.94) | 0.128 |
| | **CSS1 vs. CSS2** | **P-value** | **CSS1 vs. CSS3** | **P-value** | **CSS2 vs. CSS3** | **P-value** |
| | 2.19 (0.88 – 5.44) | 0.092 | 4.23 (1.94 – 9.36) | **< 0.001** | 1.96 (0.97 – 3.85) | 0.061 |

A P-value < 0.05 (bold) was considered significant. SYNTAX scores: low or SS1: < 11.75; moderate or SS2: 11.75 – 23.25; high or SS3: >23.25. Clinical syntax scores: low or CSS1: < 22.95, moderate or CSS2: 22.9 5 – 35.95, and high or CSS3: > 35.95.

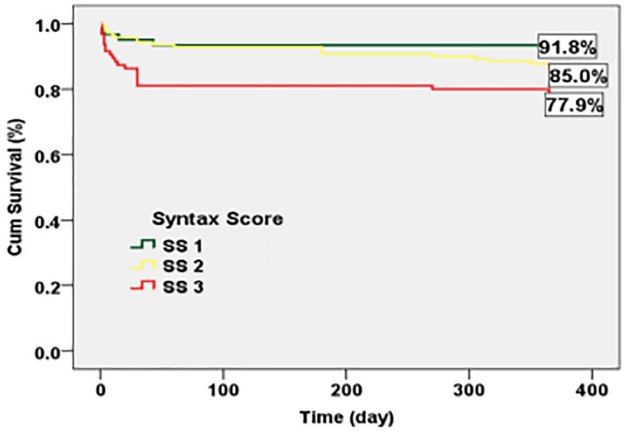


**Figure 1.** Kaplan-Meier Curve for Major Adverse Cardiac Events (MACEs) according to SYNTAX Score (SS) Category.

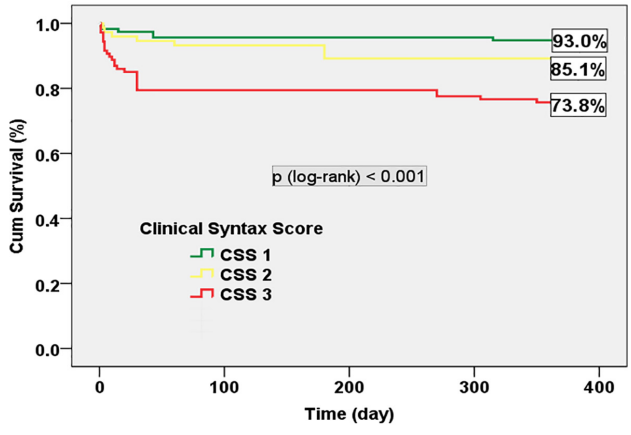


**Figure 2.** Kaplan-Meier Curve for Major Adverse Cardiac Events (MACEs) according to Clinical SYNTAX Score (SS) Category.

After 12 months of follow-up, the difference in the survival rate of three patient groups categorized by SS and CSS were statistically significant per Kaplan-Meier curve analysis. The SS1 group had the highest survival rate of 91.8%, followed by the SS2 patient group at 85.0%, and SS3 group at 77.9% (Figure 1). In terms of CSS, we found that the CSS1 group had the highest survival rate of 93.0%, followed by the CSS2 group at 85.1% and the CSS3 group at 73.8% (Figure 2). The differences were statistically significant at P < 0.001 (log-rank test).

## 5. Discussion

The main finding of our study was new prognostic cutoff values for the classification of SS (low or SS1: < 11.75; moderate or SS2: 11.75 – 23.25; high or SS3: > 23.25) and CCS (low or CSS1: < 22.95, moderate or CSS2: 22.95 – 35.95, and high or CSS3: > 35.95). The SS and CSS have been tested in many trials, which showed that these scores are valuable in risk classification after both primary and elective PCI (17, 18). However, there is still debate on which values are the best to classify risk based on SS and CSS, and we tried to answer this question with our cohort of patients. Based on our findings (MACE) and the Youden index, we identified cutoff values that divided the SS and CSS into low, moderate, and high levels.

Karabag et al. (14) studied 1912 STEMI patients and defined CSS as low (< 24.6), moderate (26.4 – 34.4), and high (> 34.4). They found that in-hospital and long-term mortality rates from all causes were significantly increased with higher SS, and high SS was an independent predictor of in-hospital and long-term mortality. When using our values for clarification, we found that SS and CSS had more accurate prognostic values after 12 months of follow-up (HR= 2.99; 95% CI: 1.11 – 7.84 for SS1 vs. SS3 and HR = 4.23; 95% CI: 1.94– 9.36 for CSS1 vs. CSS3). This can be explained by the fact that their cohort of patients was younger (57 ± 12 years) than our cohort. Garg et al. (9) retrospectively calculated the SS and divided the patients into three groups: low SS < 9, moderate SS: 9 – 15, and high SS > 15. Their cut-off points showed that the primary event occurred earlier in patients with lower SS. In another study including a larger number of patients at the 1-year follow-up (8), all clinical outcomes, including mortality, mortality/re-infarction, MACE (a composite of all-cause death, re-infarction, and target vessel revascularization), and definite, definite/probable, or any stent thrombosis, were significantly higher in patients in the highest SS group. The SS was identified as an independent predictor of mortality, MACE, and stent thrombosis at the 1-year follow-up. The authors also combined the SS and PAMI scores, which led to a net reclassification improvement of 15.7% and 4.6% for mortality and MACE, respectively. Recently published papers did not link gender, diabetes and stents of different sizes with MACEs in patients with diabetes after PCI (19, 20). Smoking makes women more prone to MACEs than men among patients with stable CAD after PCI with a drug-eluting stent (21).

When we followed up 12 months after the intervention, the mortality rate in the high CSS3 group was 26.2%, compared with 14.9% in the moderate CSS2, and 7% in the low CCS1 group. Through Cox regression analysis, we found that CSS3 had a 4.23 times higher risk of death than the CSS1 group (HR = 4.23; 95% CI:1.94 – 9.36, P < 0.001), death in the CSS3 group was 1.96 times higher than that in the CSS2 group, and death in the CSS2 group was 2.19 times higher than that in the CSS1 group (HR = 2.19; 95% CI: 0.88 – 5.44, P = 0.092). On the Kaplan-Meier curve of Figure 2, we found that the CSS3 group had the lowest survival

probability of 85.1% (red line) compared with that of the CSS2 group (93.2%; yellow line) and low SS1 (96.5%; blue line). The difference was statistically significant. Thus, the CSS was an independent predictor of 12-month mortality risk in patients with AMI treated by PCI. Such findings align with Centinkal et al. (22), who reported that CSS > 26 was an independent predictor of the composite of all-cause mortality, myocardial infarction, and stroke (HR = 3.58, 95% CI: 1.68 – 7.60, P = 0.001). Many other studies have also demonstrated that the CSS is an independent predictor of the risk of all-cause mortality and cardiovascular death in patients with coronary artery disease, including those with AMI treated by PCI (23, 24).

### *5.1. Study Limitations*

This study had some limitations. First, the study's sample size was rather small, which is a barrier to generalizing our findings to all patients with ACS. Second, we could not follow up on the patients every month after discharge from the hospital due to limited financial support.

### *5.2. Conclusions*

The new cutoff values of SS (low or SS1: < 11.75; moderate or SS2: 11.75 – 23.25; high or SS3: > 23.25) and CCS (low or CSS1: < 22.95, moderate or CSS2: 22.95 – 35.95, and high or CSS3: > 35.95) have an important role in the risk assessment of patients with ACS treated by primary PCI.

### *5.3. Informed Consent*

Obtained from all participants.

### *5.4. Ethical Approval*

The study was approved by the Ethics Committee of Bach Mai Hospital and 103 Military Hospital under approval number 320 on July 4, 2015.

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**Authors' Contribution**

Study concept and design: T.D.H and N.Q.T; Acquisition of data: T.D.H, N.Q.T; Study supervision: D.V.C; Statistical analysis and interpretation of data: H.T.A. and C.V.P; Drafting of the manuscript: T.D.H and N.Q.T and D.V.C; Critical revision of the manuscript for important intellectual content: T.D.H, N.Q.T, and D.V.C; Administrative, technical, and material support: H.T.A. and C.V.P

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