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ORIGINAL PAPER

Comparison of SYNTAX score II efficacy with SYNTAX score and TIMI risk score for predicting in-hospital and long-term mortality in patients with ST segment elevation myocardial infarction

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Abstract

SYNTAX score II (SS-II) has a powerful prognostic accuracy in patients with stable complex coronary artery disease who have undergone revascularization; however, there is limited data regarding the prognosis of patients with ST segment elevation myocardial infarction (STEMI). The aim of this study is to examine both the predictive performance of SS-II in determining in-hospital and long term mortality of STEMI patients and to compare SYNTAX score (SS) and TIMI risk score (TRS). Consecutive 1912 STEMI patients treated with primary percutaneous coronary intervention (p-PCI) retrospectively reviewed, and the remaining 1708 patients constituted the study population after exclusion. The patients were divided into three groups according to increased SS-II value: low (n:562; SS-II $\leq$ 24.6); intermediate (n:563; 24.6 < SS-II < 34.4); and high tertile (n:583; SS-II $\geq$ 34.4). In-hospital and long term mortality rate from all causes (0 vs. 0.5 vs. 10.6% and 1.8 vs. 3.2 vs. 18.1% respectively, $p \leq 0.001$) were significantly increased with SS-II tertiles and SS-II was found to be independent predictor of in-hospital and long term mortality (HR: 1.076 95% CI 1.060–1.092, $p < 0.001$) and (HR: 1.070 95% CI 1.050–1.090, $p < 0.0001$). The predictive power of SS-II, SS, and TRS were compared by ROC curve and decision curve analysis. SS-II surpassed SS and TRS in long-term and in-hospital mortality prediction. SS-II is a powerful tool to predict in-hospital and long-term mortality from all causes in STEMI patients treated with p-PCI.

Keywords SYNTAX score II · SYNTAX score · TIMI risk · In-hospital and long-term mortality · ST segment elevation myocardial infarction · Primary percutaneous coronary intervention

Introduction

ST-elevation myocardial infarction (STEMI) known as a life threatening complication of coronary artery disease (CAD) is one of the leading cause of death worldwide. According to the European Society of Cardiology guidelines, every 14% of women and 16% of men die due to myocardial infarction (MI) [1]. The widespread use of primary percutaneous coronary intervention (p-PCI) has dramatically increased the chances of survival for patients with STEMI over the past decade [2, 3]. However, the survival rates are still not in the desired range. Due to this fact, risk classification remains important in STEMI and is useful in the selection of treatment regimens as well as planning hospital discharge and long-term treatment. Clinical scores such as thrombolysis in myocardial infarction (TIMI) was used for this purpose [4]. On the other hand, anatomical scores used to select the best

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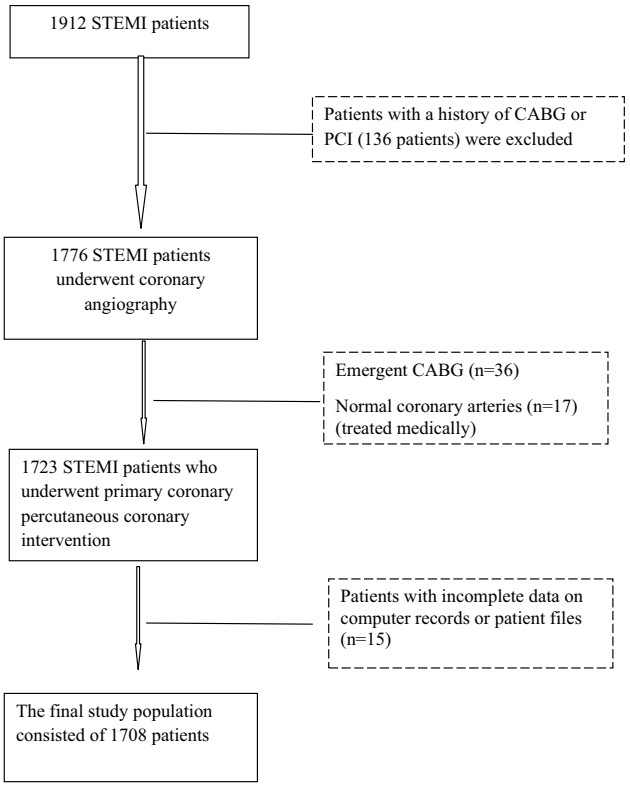
revascularization strategies in patients with stable CAD on the basis of the prognostic information that it provides; have been shown to predict prognosis of STEMI patients in the in-hospital and long-term follow-up [5]. SYNTAX (Synergy between Percutaneous Coronary Intervention with TAXUS and Cardiac Surgery) score (SS), the most commonly used anatomical scoring system worldwide, has been found to be associated with prognosis of patients with STEMI [6–8]. SYNTAX score II (SS-II), a new scoring system containing age, left ventricular ejection fraction (LVEF), estimated glomerular filtration rate (eGFR), peripheral arterial disease, chronic obstructive pulmonary disease (COPD) and left main coronary artery (LMCA) disease alongside SS-II, have been found to be superior to SS in predicting prognosis in patients with complex CAD [9–12]. However, the value of the SS-II in predicting in-hospital and long-term prognosis in patients with STEMI who undergo p-PCI remains unknown. The present study was designed to investigate this question.

Methods

Study population

We thoroughly reviewed 1912 patients with acute STEMI who had p-PCI in our cardiology departments from January 2010 to June 2015. Patients prior history of CABG (coronary artery bypass graft surgery) or PCI, treated only with medical therapy, emergency CABG, and those with incomplete data on computer records or hospital patient files were excluded from the study. Therefore, the remaining number of patients came to be 1708 patients who comprised of the final study population (as in Flowchart 1). All patients were treated with the current standard therapy according to the STEMI guideline consisting of aspirin, clopidogrel, heparin, beta blockers, angiotensin-converting enzyme inhibitors and statins [1]. Our local Ethics Committee approved the study protocol in accordance with the Declaration of Helsinki, and every patient received written approval for the study protocol.

Making use of hospital records, the patients' baseline clinical and demographic characteristics and past histories were obtained. Blood biochemical parameters and complete blood count were measured. Troponin T, creatinine kinase and myocardial band were repeated every 4–6 h and then followed up to discharge with daily creatinine and hemogram levels. The eGFR was calculated using the Cockcroft–Gault formula with the blood sample obtained during admission. The modified Simpson method [13] was used to calculate the LVEF which was defined as EF after the procedure and before discharge.



Flowchart Enrollment and follow-up of study patients

Angiographic analysis

Selective coronary angiography of all patients was performed using Judkins percutaneous transfemoral technique. All patients were routinely treated with 300 mg acetylsalicylic acid and 600 mg clopidogrel loading dose prior to intervention and unfractionated heparin during the intervention. The operator decides glycoprotein IIb–IIIa inhibitor use, thrombus aspiration and which stent type is to be used (bare metal or drug release). After the procedure, it is recommended that 100 mg of aspirin is to be taken by the patient daily for life as well as 75 mg of clopidogrel for at least 12 months. The standard drug regimen after discharge is aspirin, clopidogrel, angiotensin converting enzyme inhibitor or angiotensin receptor blocker, B-blocker, statin therapy and spironolactone all according to New York Heart Association functional class or LVEF.

Coronary angiograms were recorded to digital media for quantitative analysis (Dicom-viewer; MedCom GmbH, Darmstadt, Germany). Digital angiograms were evaluated by two experienced cardiologists who had at least 5 years experience in coronary intervention and were blinded to other patient information. In the case of a disagreement, a third cardiologist's opinion was requested, and the final decision was taken by consensus. The SS was calculated

using the SS calculator for each lesion with a diameter of ≥ 1.5 mm and ≥ 50% stenosis [14]. Patients with STEMI were not included in the SYNTAX trial. For this reason, non-flow IRA vessels before and after the procedure were scored as chronic total occlusion vessels for < 3 months [15]. TIMI was calculated as described earlier [4]. SS-II was calculated using an online calculator consisting of 2 anatomical variables, the SS, LMCA, and six clinical variables, age, CrCl, LVEF, sex, COPD, and PAD [15, 16].

Definition

The definition of STEMI was given as the elevation of 1 mm or more in a minimum of 2 consecutive leads at the ST segment or a left branch block newly developed in the reference electrocardiogram together with 30 min or more chest pain [1]. The TIMI thrombus score was used to analyze the thrombus burden, which is after balloon dilatation and baseline and if the TIMI score is > 4, then it means a high-grade thrombosis [17]. Using the aforementioned methods, the TIMI frame count was examined [18].

Re-infarction was defined as the recurrence of typical clinical symptoms and new electrocardiography (ECG) changes with a new elevation of the CKMB levels > twice the upper normal limit or any rise by at least > 50% of the previously elevated level during in-hospital course [19]. If MI occurred after in-hospital course of incident MI; it was termed recurrent MI. Revascularization can be explained as the continuous bypass or PCI grafting of both infarct and non-infarct related artery, influenced by ischemic symptoms, that is re-infarction or unstable/stable angina, or the use of non-invasive tests to reveal ischemia. Advanced heart failure was found in the left ventricular systolic or diastolic dysfunction was found on the echocardiography in relation with clinical symptoms and signs including dyspnea, orthopnea, S3, jugular venous distention, crepitation at the base of the lungs or alveolar edema needing diuretic therapy. Arrhythmic events during in-hospital and long-term follow-up were defined as documented sustained ventricular tachycardia and ventricular fibrillation.

The long-term follow-up (mean: 40 months) data of patients was gathered from their follow-up visits or in-hospital records of the rehospitalized patients. Furthermore, all the patient whose data were gathered were called up on their telephone. In order to discover if the patients who could not be reached on their telephone were still living. The Birth Registration Office and Statistical Institute records were thoroughly examined. 65 patients who died in hospital were excluded from the long-term follow-up. The primary endpoint of this study as mentioned before was all-cause mortality starting from the beginning of hospitalization.

Statistical analyses

MedCalc trial Version 16.8.4 and SPSS version 22.0 (Inc., Chicago, Illinois) were both utilized to conduct statistical analyses. In respect to their distribution characteristics and normality assessed by Kolmogorov–Smirnov test, mean (± standard deviation) or median (0.25–0.75 percentiles) were used to express continuous variables, and the *t* test (Mann–Whitney *U* test) or analysis of variance was used to compare them. The categorical variables were conveyed as numbers (percentages), and proceeded to be compared with the Fisher exact test or the χ^2-test. The Kaplan–Meier method was used to generate event-free survival curves while the log-rank test was used to compare the dissimilarities among the SS-II tertiles. The risk factors for all-cause mortality were analyzed and derived using Univariate and multivariate Cox proportional hazard analyses, and then the link between the incidence of all-cause mortality and SS-II were assessed. Next, the receiver operating curve (ROC) was utilized to derive and compare the cut-off value of the SS-II together with the TIMI and SS for predicting all-cause mortality. The DeLong et al. method was then used to compare the ROC curve of SS-II, TIMI and SS. A p value that is < 0.05 indicates statistical significance.

The decision curve analysis was used to analyze the clinical usefulness [20]. From the decision curve analyses, the net benefit for the prediction model is approximated to give the individual risk estimates. A given threshold value is set to classify the patients according to their risk level, i.e., high or low risk. The aforementioned net benefit looks at the advantages of the threshold classification, that is, patients rightly separated into the dying within in-hospital and long-term follow-up period classification. In the decision curve analysis, the threshold value is utilized to analyze the number of accurately classified patients as opposed to the wrongly classified patients. Each of the patients was classified with the reference of being either high risk, that is died for both long term follow-up and in-hospital follow up, or as low risk, that is also alive both long term and in-hospital follow up. The decision curve's meaning is that the prediction model which contains the highest net benefit at a specific threshold value is the recommended model.

Results

The study population consisted of 1708 patients (mean age: 57 ± 12 years; 80.5% of which were males and 19.5% female) who had p-PCI for STEMI. The SS-II of the patients ranged from 13 to 80 (median 29.5). The patients were divided into three groups according to their corresponding SS-II values: (a) SS-II low tertile group, 562 patients (SS-II ≤ 24.6); (b) SS-II intermediate tertile, 563 patients (24.6 < SS-II < 34.4);

and (c) SS-II high tertile, 583 patients (SS-II ≥ 34.4). The mean SS-II values were 19.8 ± 3.1, 29.3 ± 2.8 and 45.2 ± 9, 2 for the low, intermediate and high tertiles respectively. Baseline characteristics of patients are shown in Table 1. Age, female gender, diabetes, hypertension, family history, COPD, PAD and Killip class, prior B-blockers and ACEI/ARB usage incidences, systolic blood pressure, heart rate, white blood cell Count, hemoglobin, fasting blood glucose, GFR, creatine kinase-myocardial band and EF values were statistically different between the groups (Table 1).

The angiographic and interventional characteristics are presented in Table 2. The group with high SS-II tertile had a longer door to balloon and symptom to balloon time, low incidence of normal pre and post p-PCI flow, higher corrected TIMI frame count and higher thrombus grade after wiring. Left anterior descending artery and proximal/ostial lesion localization, balloon pre-dilatation, and three-vessel disease more often occurred in patients with high SS-II. Stent length was shorter in the low SS-II group than in the other groups. TIMI, SS, SS-II were higher in the high SS-II tertile. The use of bare metal Stent, LMCA involvement, and balloon post-dilatation frequency were similar among the groups (Table 2).

The mean hospital stay of the patients was 5.2 ± 3.1 days and mean follow-up was 40.1 ± 10.3 months (4–58). 65 patients (3.8%) died in the hospital, and 113 patients (6.8%) died in long-term follow-up. The incidences of both short and long term mortality from all causes (0 vs. 0.5 vs. 10.6% and 1.8 vs. 3.2 vs. 18.1%, respectively, p ≤ 0.001). (Figs. 1, 2), heart failure (0.5 vs. 4.6 vs. 27.8% and 1.8 vs. 4.9 vs. 20% respectively, p ≤ 0.001) and ventricular tachycardia/fibrillation (0.5 vs. 1.3 vs. 5.3%, respectively, p ≤ 0.001) were all significantly higher in the high SS-II tertiles. There was no significant difference with respect to in-hospital reinfarction and the revascularization rates (Table 3).

The risk factors for short and long term mortality by Cox regression model were shown in Tables 4, 5. On multivariable analysis, independent predictors of in-hospital mortality were systolic blood pressure [0.984 (0.976–0.992), p ≤ 0.001], killip class > 1 [2.116 (1.076–4.163), p = 0.03], white blood cell [1.063, (1.016–1.111), p = 0.008], door to balloon time [1.021 (1.004–1.039), p = 0.014]

Table 1 Demographic, clinical, laboratory characteristics of all patients, and SYNTAX score II tertiles with p value

Variable	Syntax II group				
	All patients (n:1708)	≤ 24.6 (n:562)	24.6–34.4 (n:563)	≥ 34.4 (n:583)	p Value
Age (year)	57 ± 12	49 ± 9	56 ± 10	65 ± 11	< 0.001
Male gender [n (%)]	1370 (80.2)	548 (97.5)	476 (84.5)	346 (59.3)	< 0.001
Diabetes [n (%)]	401 (23.5)	31 (5.5)	96 (17.1)	274 (47.0)	< 0.001
Hypertension [n (%)]	694 (40.6)	137 (24.4)	218 (38.7)	339 (58.1)	< 0.001
COPD [n (%)]	88 (5.2)	9 (1.6)	31 (5.5)	48 (8.2)	< 0.001
PAD [n (%)]	273 (16.0)	0 (0.0)	52 (9.2)	221 (37.9)	< 0.001
Hyperlipidemia [n (%)]	688 (40.3)	233 (41.5)	220 (39.1)	235 (40.3)	0.717
Family history of CAD [n (%)]	371 (21.7)	151 (26.9)	120 (21.3)	100 (17.2)	< 0.001
Smoking [n (%)]	936 (54.8)	397 (70.6)	330 (58.6)	209 (35.8)	< 0.001
Previous medication					
ASA [n (%)]	36 (2.1)	12 (2.1)	8 (1.4)	16 (2.7)	0.296
Beta-blocker [n (%)]	115 (6.7)	20 (3.6)	42 (7.5)	53 (9.1)	< 0.001
ACEI/ARB [n (%)]	333 (19.5)	56 (10.0)	100 (17.8)	177 (30.4)	< 0.001
Statin [n (%)]	296 (17.3)	88 (15.7)	94 (16.7)	114 (19.6)	0.195
SBP (mmHg)	131 ± 32	127 ± 24	133 ± 28	134 ± 40	< 0.001
Heart rate (bpm)	77 ± 16	75 ± 13	77 ± 15	79 ± 20	0.195
Killip class > 1 [n (%)]	284 (16.6)	38 (6.8)	68 (12.1)	178 (30.5)	< 0.001
WBC count (/1000)	12.3 ± 3.8	11.9 ± 2.9	12.1 ± 3.5	13.1 ± 4.5	< 0.001
Hemoglobin (g/dL)	13.7 ± 1.8	14.3 ± 1.4	13.8 ± 1.7	13.0 ± 2.1	< 0.001
FBG (mg/dL)	150.4 ± 75.9	119.4 ± 39.5	143.2 ± 65.7	187.3 ± 94.2	< 0.001
eGFR (ml/min)	88.0 ± 26.4	101.6 ± 19.1	92.1 ± 21.6	70.9 ± 27.4	< 0.001
CK-MB (mg/dL)	176 (98–306)	121 (76–189)	187 (104–316)	261 (144–408)	< 0.001
LVEF (%)	47.2 ± 8.2	52.7 ± 5.2	46.9 ± 6.9	42.2 ± 8.4	< 0.001

COPD chronic obstructive pulmonary disease, *PAD* peripheral arterial disease, *ASA* acetyl salicylic acid, *ACEI* angiotensin converting enzyme inhibitor, *ARB* angiotensin II receptor blocker, *SBP* systolic blood pressure, *eGFR* estimated glomerular filtration rate, *WBC* white blood cell, *FBG* fasting blood glucose on admission, *CK-MB* creatine kinase-myocardial band, *LVEF* left ventricular ejection fraction

Table 2 Angiographic and procedural data characteristics of all patients, and SYNTAX score II tertiles with p value

Variable	Syntax II group				
	All patients (n:1708)	≤24.6 (N:562)	24.6–34 (N:563)	≤34.4 (N:583)	p Value
Door-balloon (min)	31.0 ± 9.0	30.3 ± 6.9	29.9 ± 6.2	32.4 ± 10.7	< 0.001
Onset-balloon (min)	199 (126–300)	137 (85–200)	179 (114–260)	212 (138–320)	< 0.001
Infarct-related artery LAD [n (%)]	632 (55.1)	219 (39.0)	288 (51.2)	344 (59.0)	< 0.001
Proximal/ostial lesion for IRA [n (%)]	707 (61.7)	230 (40.9)	322 (57.2)	385 (66.0)	< 0.001
TIMI < 3 before p-PCI [n (%)]	1067 (93.1)	467 (83.1)	510 (90.6)	557 (95.5)	< 0.001
High grade thrombus [n (%)]	826.0 (72.1)	305.0 (54.3)	381.0 (67.7)	445.0 (76.3)	< 0.001
Balloon predilatation [n (%)]	984 (85.9)	403 (71.7)	468 (83.1)	516 (88.5)	< 0.001
Bare metal stent [n (%)]	1048 (95.5)	518 (94.4)	517 (94.9)	531 (96.2)	0.340
Stent length (mm)	22.3 ± 9.3	20.4 ± 7.9	22.1 ± 9.3	22.6 ± 9.2	< 0.001
Stent diameter (mm)	3.1 ± 0.4	3.1 ± 0.4	3.1 ± 0.4	3.1 ± 0.4	0.406
Balloon postdilatation [n (%)]	309 (27.0)	130 (23.1)	146 (25.9)	163 (28.0)	0.170
Corrected TIMI frame count	28 (17–22)	18 (15–23)	22 (17–27)	25 (19–33)	< 0.001
TIMI < 3 after p-PCI [n (%)]	183 (16.0)	13 (2.3)	59 (10.5)	124 (21.3)	< 0.001
LMCA disease [n (%)]	17 (1.5)	6 (1.1)	4 (0.7)	13 (2.2)	0.070
Multi vessel disease [n (%)]	180 (10.5)	33 (5.9)	53 (9.4)	94 (16.1)	< 0.001
Presence of CTO [n (%)]	101 (8.8)	21 (3.7)	35 (6.2)	66 (11.3)	< 0.001
Bazal SYNTAX score	17.5 ± 4.6	14.8 ± 4.2	16.6 ± 4.0	18.4 ± 4.9	< 0.001
TIMI risk score	2.58 ± 2.07	1.41 ± 1.16	2.18 ± 1.39	4.10 ± 2.38	< 0.001
Bazal SYNTAX score II PCI	37.4 ± 10.5	19.8 ± 3.1	293 ± 2.8	45.2 ± 9.2	< 0.001

IRA infarct related artery, *LAD* left anterior descending, *TIMI* thrombolysis in myocardial infarction, *LMCA* left main coronary artery, *CTO* chronic total occlusion

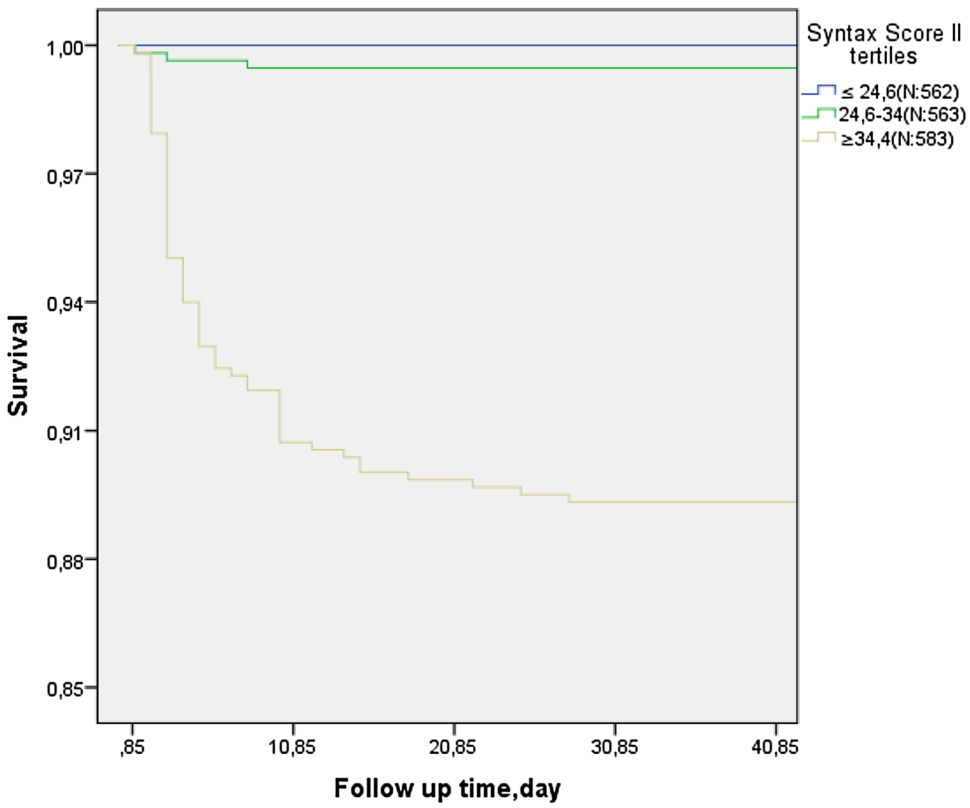


Fig. 1 In-hospital survival curve comparison between the SYNTAX score II tertiles

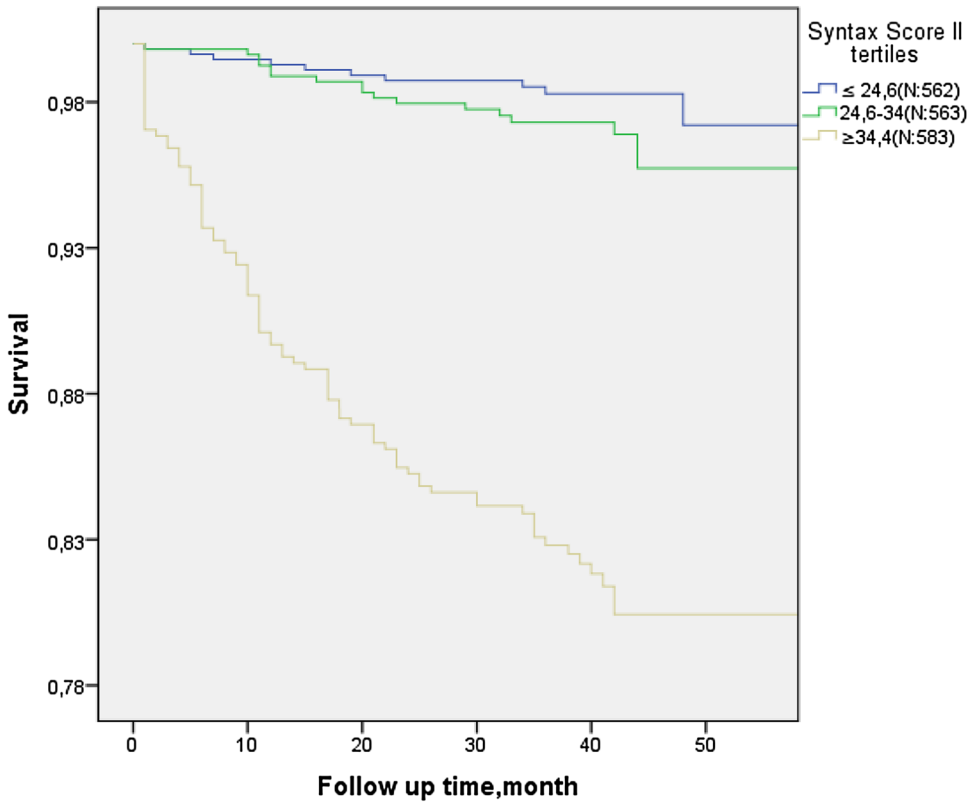


Fig. 2 Long-term survival curve comparison between the SYNTAX score II tertiles

Table 3 In-hospital and long term events according to SYNTAX score II tertiles

	SYNTAX score II tertiles			
	≤24.6 (n:562)	24.6–34 (n:563)	≥34.4 (n:583)	p Value
In hospital				
All cause mortality [n (%)]	0 (0.0)	3 (0.50)	62 (10.6)	<0.001
Reinfarction [n (%)]	1 (0.2)	8 (1.40)	9 (1.5)	0.071
Heart failure [n (%)]	3 (0.50%)	26 (4.60)	162 (27.8)	<0.001
Secondary VT/VF [n (%)]	3 (0.50%)	7 (1.30)	25 (5.3)	<0.001
Long-term				
All cause mortality [n (%)]	10 (1.8)	17 (3.2)	86 (18.1)	<0.001
Recurrent myocardial infarction [n (%)]	9 (1.6)	15 (2.8)	12 (2.5)	0.291
Target vessel revascularization [n (%)]	4 (0.7)	11 (2.0)	10 (1.70)	0.228
Heart failure [n (%)]	10 (1.8)	26 (4.9)	95 (20.0)	<0.001

proximal or ostial lesion location [4.222 (1.275–13.984), p = 0.018], no-reflow [1.758 (1.015–3.046), p = 0.044] and SS-II [1.076 (1.060–1.092), p < 0.001] while independent predictors of long-term mortality were dyslipidemia [1.606 (1.055–2.445), p = 0.027], peak CKMB [1.001 (1.000–1.002), p = 0.004] no-reflow [1.630 (1.402–1.986), p = 0.043] and SS-II [1.070 (1.050–1.090), p < 0.0001].

The cut-off value to show in-hospital mortality for SS-II was 39.24 (sensitivity = 92.0%, specificity = 80%) in ROC curve analysis. The area under curve was 0.927 (p < 0.001 95% CI 0.914–0.939) (Fig. 3). The cut-off value to show long-term mortality for SS-II was 32.82 (sensitivity = 81%, specificity = 69%) in ROC curve analysis. The area under curve was 0.798 (p = 0.013 95% CI 0.777–0.818, Fig. 4). When SS-II, TIMI, and SS were compared in terms of in-hospital and long-term mortality, in-hospital and long-term AUC value of SS-II was significantly higher than that of SS (0.927 vs. 0.775 and 0.798 vs. 0.641 respectively; p < 0.001). The in-hospital mortality AUC value of SS-II was similar to the AUC of TIMI, whereas the long-term mortality AUC value of SS-II was higher than the AUC of TIMI. (0.927–0.917, p = 0.638 and 0.798–0.736, p = 0.003 respectively) (Figs. 3, 4).

Table 4 Adjusted and unadjusted hazards ratios for in-hospital mortality

	Univariate analysis of predictors in-hospital mortality			Multivariate analysis of predictors in-hospital mortality		
	p Value	Hazard ratio	95% CI	p Value	Hazard ratio	95% CI
Diabetes	< 0.001	3.354	1.965–5.725	–	–	–
Family history of CAD	0.003	0.209	0.076–0.579	–	–	–
Smoking	< 0.001	0.245	0.129–0.465	–	–	–
Systolic blood pressure (mmHg)	< 0.001	0.975	0.966–0.983	< 0.001	0.984	0.976–0.992
Heart rate (bpm)	0.017	1.017	1.003–1.031	–	–	–
Killip class > 1 on admission	< 0.001	5.848	3.318–10.307	0.03	2.116	1.076–4.163
WBC count	< 0.001	1.108	1.062–1.156	0.008	1.063	1.016–1.111
Hemoglobin	0.006	0.841	0.744–0.951	–	–	–
Fasting blood glucose on admission	< 0.001	1.005	1.003–1.006	–	–	–
Peak creatine kinase MB	< 0.001	1.002	1.002–1.003	–	–	–
Door-balloon	< 0.001	1.096	1.069–1.123	0.014	1.021	1.004–1.039
Onset-balloon	< 0.001	1.003	1.002–1.005	–	–	–
Proximal/ostial lesion for IRA	< 0.001	15.29	3.725–62.751	0.018	4.222	1.275–13.984
Balloon predilatation	0.027	9.31	1.288–67.301	–		–
Corrected TIMI frame count	< 0.001	1.02	1.010–1.029	–		–
TIMI < 3 before PCI	< 0.001	3.609	2.102–6.198	0.044	1.758	1.015–3.046
Multi vessel disease	< 0.001	1.913	1.317–2.779	–		
Bazal SYNTAX score II/per point	< 0.001	1.091	1.077–1.106	< 0.001	1.076	1.060–1.092

CAD coronary artery disease, *ARB* angiotensin II receptor blocker, *WBC* white blood cell, *CK-MB* creatine kinase-myocardial band, *IRA* infarct related artery, *TIMI* thrombolysis in myocardial infarction, *PCI* percutaneous coronary intervention

Table 5 Adjusted and unadjusted hazards ratios for long term mortality

Variable	Univariate analysis of long term mortality			Multivariate analysis of long term mortality		
	p Value	Hazard ratio	95% CI	p Value	Hazard ratio	95% CI
Diabetes	< 0.001	2.242	1.534–3.277	–	–	–
Hypertension	< 0.001	2.122	1.466–3.071	–	–	–
Hyperlipidemia	0.011	0.588	0.391–0.884	0.027	1.606	1.055–2.445
ACEI/ARB	< 0.001	2.142	1.452–3.160	–	–	–
Statin	0.054	0.567	0.318–1.009	–	–	–
Killip class > 1 on admission	< 0.001	2.731	1.829–4.076	–	–	–
WBC count	0.002	1.079	1.029–1.132	–	–	–
Peak CKMB	< 0.001	1.003	1.002–1.003	0.004	1.001	1.000–1.002
Door-balloon	0.004	1.015	1.005–1.026	–	–	–
Onset-balloon	< 0.001	1.003	1.002–1.004	–	–	–
Infarct-related artery	0.027	0.797	0.652–0.975	–	–	–
Proximal/ostial lesion for IRA	0.039	1.485	1.020–2.163	–	–	–
Corrected TIMI frame count	< 0.001	1.026	1.018–1.034	–	–	–
TIMI < 3 before PCI	< 0.001	3.767	2.460–5.768	0.043	1.63	1.402–1.986
Bazal SYNTAX score II/per point	< 0.001	1.051	1.023–1.080	< 0.001	1.07	1.050–1.090

ACEI angiotensin converting enzyme inhibitor, *ARB* angiotensin II receptor blocker, *WBC* white blood cell, *CK-MB* creatine kinase-myocardial band, *IRA* infarct related artery, *TIMI* thrombolysis in myocardial infarction

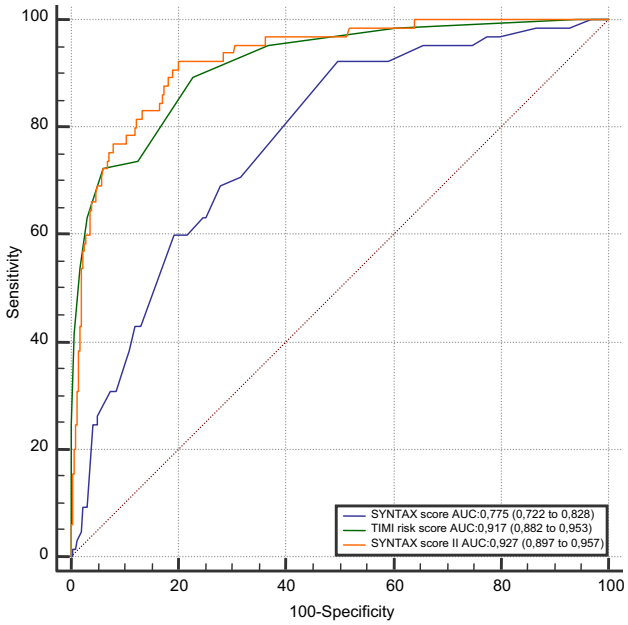


Fig. 3 ROC curves for SYNTAX score II, SYNTAX score, TIMI risk score for in-hospital all cause mortality

The net benefit of the SS-II, TIMI, and SS on in-hospital mortality are shown on the decision curve's y-axis (Fig. 5). The net benefit was highest for the SS-II across all potential threshold values (except 3) of in-hospital mortality. This was followed by the TIMI then the SS.

Discussion

The present study is demonstrated that the SS-II has important prognostic value in STEMI patients treated with p-PCI. To our knowledge our study is the first study to compare usefulness of SS-II values of patients with STEMI to SS and TIMI risk score (TRS) in in-hospital and long term mortality prediction. The main findings of our study can be summarized as follows:

1. During both in-hospital and long-term follow-up; a gradual increase in the frequency of death and cardiac complications was observed throughout increasing SS-II tertiles. However, the re-infarction rate remained unchanged.
2. SS-II is an independent predictor of both in-hospital and long-term mortality.
3. The performance of SS-II, SS, and TIMI in the prediction of in-hospital and long-term mortality was evaluated by ROC curve comparison. SS-II was better than both SS and TIMI in terms of long-term mortality prediction, however, SS-II was better than SS only in terms of in-hospital mortality prediction.
4. Decision curve analysis conducted to compare the clinical usability of SS-II and TIMI revealed that SS-II was superior to TIMI in predicting in-hospital mortality.

Despite rapid improvements in the treatment of STEMI patients in recent years, mortality and major adverse cardiovascular events in short and long-term follow-up have not reached the desired level. Therefore, the aim of risk

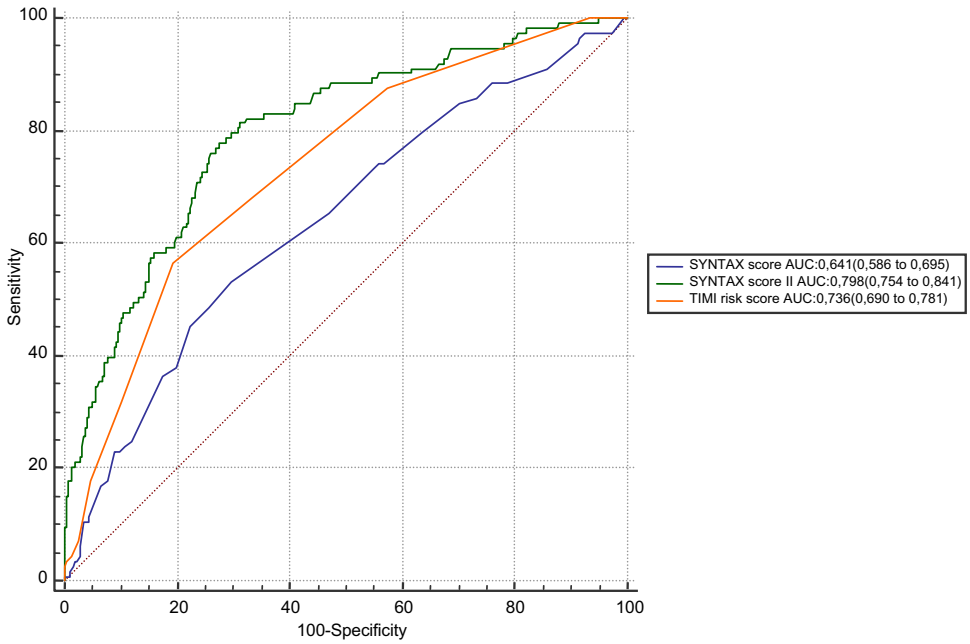


Fig. 4 ROC curves for SYNTAX score II, SYNTAX score, TIMI risk score for long-term all cause mortality

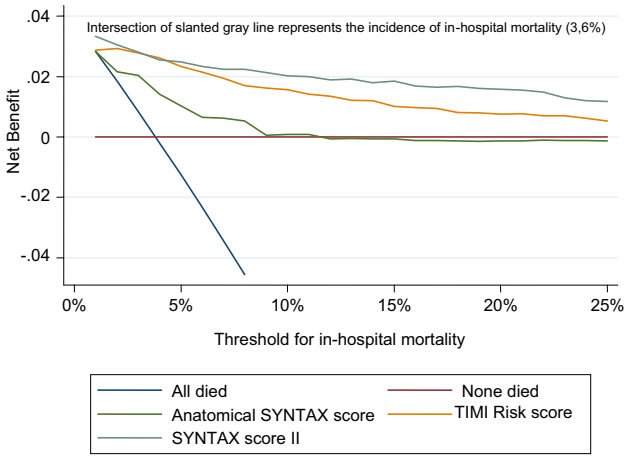


Fig. 5 Decision curves demonstrating identification of patients who will die, based on in-hospital and long term mortality predictions of SYNTAX score II, compared with the SYNTAX score, and logistic clinical SYNTAX score. Threshold values for in-hospital mortality risk are shown on the x-axis. The medical personnel could use the threshold value to categorize patients into the high or low-risk category at a specified value to be able to start something like more medical therapy or patient monitoring. The y-axis, on the other hand, shows the various threshold values of in-hospital mortality risk. The net benefit breakdown is in the value of true positives and is the total number of patients accurately categorized as high risks, that died within in-hospital minus the value of the patients inaccurately classified as high risk, that is the false positives. Patients categorized as high risk are shown by the slanted gray line while those with low risk are represented by the horizontal line with the net benefit value result as 0. The total in-hospital risk in this study, which is 6.4%, is represented by the intersection between the slanted gray line and the y-axis. The prediction models located at the edges of both the horizontal line, that is assuming all are living at in-hospital, and the slanted gray line, that is assuming all died within in-hospital, and that showed the most net benefit value that is the SS-II preceded by the TIMI

assessment for patients with p-PCI is not only to establish appropriate treatment strategy but also to determine the risk of post-PCI adverse cardiac event that may affect discharge planning and long-term follow-up. The present study was concluded to determine the prognostic significance of SS-II in STEMI patients and to compare it to SS and TIMI score using ROC curve comparison and decision curve analysis.

Although SS-II has been developed to determine the prognosis of patients with stable CAD undergone revascularization (CABG or PCI), the results of our study show that; STEMI patients with increased SS II scores are at high risk for all-cause mortality and heart failure in in-hospital and long-term course; secondary VT/VF in in-hospital course. SS-II consists of two anatomical (LMCA and SS) and six clinical (Age, CrCL, LVEF, female gender, COPD, and PAD) variables, are independent predictors of all-causes long-term mortality (4-years), from SYNTAX study involving 1800 patients. Campos et al. and Xu et al. showed that in patients with complex CAD, long-term mortality was better predicted by SS II than SS. Recently, Gang et al. [21] investigated the effects of SS-II on 1-year MACE (major adverse cardiac event), including all-cause mortality, recurrent MI, and TVR of 477 patients with STEMI. The investigators showed that a high SS-II is a predictor of all major adverse cardiovascular events in patients with STEMI who have undergone p-PCI and the rates of MACE increased with high SS-II. The study concluded by Gang et al. have several limitations. Firstly; it had a low mortality rate (n:30) due to low patient numbers and did not give in-hospital and 1-year follow-up MACE (included all cause mortality, TVR, reinfarction) rate separately. Our study included 1917 STEMI patients and 3.8% of them died in in-hospital course, 6.8% of them died in long-term course (5 years); SS-II was found to be an independent predictor of both in-hospital and long-term mortality. Secondly, the effect of SS-II on death has not been assessed separately from MACE. The present study demonstrated that statistically, a significant gradual increase in all-cause mortality was observed through increased SS-II tertiles; however, the increase of reinfarction rate did not achieve statistical significance in in-hospital and long term course. Finally, heart failure and secondary VT/VF were not added to MACE in that study; the present study demonstrated that patients with increased SS-II were at high risk of heart failure in both in-hospital and long term course and secondary VT/VF in in-hospital course.

The second purpose of the present study was to compare the prognostic power of SS-II with SS and TIMI score in predicting all-cause mortality. The SS, the most preferred tool for grading the complexity and severity of CAD, is found to be an independent predictor of cardiac mortality and unwanted events in patients with acute coronary syndrome [22–25]. The TRS for STEMI is a simple arithmetic score which helps to predict short-term mortality based on age and clinical data on admission [26]. Initially, this score was developed and also validated in a randomised controlled trial of patients that are treated with fibrinolysis, however, it has actually shown to be useful in patients that are treated with p-PCI in an observational registry [27]. Consistent with above-mentioned studies, the present study revealed that patients that died in in-hospital and long-term course had a higher SS and TRS. ROC curve comparison was performed to compare the predictive performance of SS-II, SS, and TRS and it was observed that SS II had higher predictive power than SS in terms of both in-hospital and long-term mortality and TRS in terms of long-term mortality. The SS-II and TRS showed fairly high predictive performance and the AUC value of them were similar. However, SS-II provided additional prognostic value than TIMI in in-hospital mortality on decision curve analysis.

Conclusion

Although SS-II has been designed to assess long-term prognosis in patients with stable CAD, it also provides valuable information on the prognosis of STEMI patients according to the results of the present study and previous studies. Compared with the SS alone, SS-II and TIMI can more accurately predict individual in-hospital and long-term mortality in patients presented with ST-segment elevation ACS, undergoing p-PCI. SS-II also provides additional information on TIMI in-hospital and long-term mortality.

Limitation

Our study had some limitations, first of all, was the fact that it was a retrospective study. Secondly, patients with emergency surgical revascularization and those who had thrombolytic agents were not included, this means that there was a potential bias in the patient selection process.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

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