Iranian Heart Journal; 2024; 25 (2)

Original Article

The Predictive Value of the PRECISE-DAPT Score in Patients With ST-Segment-Elevation Myocardial Infarction After Primary Percutaneous Coronary Intervention

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ABSTRACT

Background: Recent guidelines recommend the use of the predicting bleeding complications in patients undergoing stent implantation and subsequent dual antiplatelet therapy (PRECISE-DAPT) score for bleeding risk stratification and determining the appropriate duration of DAPT following primary percutaneous coronary intervention (PPCI). Our study aimed to assess the predictive value of the PRECISE-DAPT score for not only bleeding complications but also in-hospital and short-term complications, including major adverse cardiovascular events (MACEs) and no-reflow.

Methods: The study included 241 patients diagnosed with STEMI and eligible for PPCI. The patients were divided into 3 groups according to their PRECISE-DAPT score value: low (<17), intermediate (17–24), and high (≥25) score groups. Finally, in-hospital and short-term (180 d) follow-ups for MACEs, no-reflow, and bleeding complications were done.

Results: In-hospital and short-term complications were higher among the high-score group than in the other groups (P<0.001). The high-score group had lower thrombosis in myocardial infarction (TIMI flow<III) than the other groups, which was statistically significant (P= 0.001). The PRECISE-DAPT score had good predictive power for in-hospital complications (AUC=0.64) and short-term follow-up MACEs (AUC=0.80; P=0.004 and P<0.001, respectively), demonstrating good sensitivity and specificity of the PRECISE-DAPT score for the prediction of in-hospital complications, no-reflow, bleeding complications, and follow-up MACEs.

Conclusions: The PRECISE-DAPT score had a strong and independent predictive value for in-hospital, short-term MACEs, no-reflow, and bleeding complications among STEMI patients treated with PPCI. ***(Iranian Heart Journal 2024; 25(2): 35-46)***

KEYWORDS: ST-elevation myocardial infarction, PRECISE-DAPT score, MACEs, No-reflow

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Received: August 15, 2023 **Accepted:** January 16, 2024

ST-elevation-myocardial infarction (STEMI) is a complicated clinical condition that necessitates prompt diagnosis, treatment, and early risk stratification. [1] Despite the extremely low rate of major adverse cardiovascular events (MACEs) with early primary percutaneous coronary intervention (PPCI), some STEMI patients still have a poor prognosis.

The duration of dual antiplatelet treatment (DAPT), particularly after PPCI, is a challenging topic because of the conflict between ischemic and bleeding risks. Hence, early risk stratification is crucial to predicting outcomes among patients with acute myocardial infarction (AMI). [2]

The predicting bleeding complications in patients undergoing stent implantation and subsequent dual antiplatelet therapy (PRECISE-DAPT) score was developed for short-term and 1-year bleeding risk stratification among patients treated with DAPT after PCI. It has 5-point weighted items (age, hemoglobin level, white blood cell count, creatinine clearance, and history of previous spontaneous bleeding) and ranges from 0 to 100. Patients with a minimum score of 25 are considered at a high risk of bleeding, and DAPT duration should be adjusted. [2] Nonetheless, the PRECISE-DAPT score is expected to be beneficial beyond its original field.

Our study aimed to estimate the predictive value of the PRECISE-DAPT score to predict in-hospital and short-term thrombotic complications, including MACEs and no-reflow, among STEMI patients treated with PPCI.

METHODS

Study Design and Population

The present observational prospective cohort study was conducted in a tertiary center. We included 241 patients with STEMI who presented to Assiut University Heart Hospital between September 1, 2020, and December 31, 2021.

All patients were diagnosed with STEMI according to the fourth universal definition of MI [3] and were eligible for PPCI within 12 hours of symptom onset provided that it could be performed expeditiously (ie, within 120 minutes of the STEMI diagnosis).

Exclusion criteria were late presentation with STEMI (either >12 h or a door-to-balloon time >120 min), including rescue PCI, patients with cardiogenic shock (KILLIP IV), patients with autoimmune diseases (eg, vasculitis), platelet count <100,000 IU, prothrombin concentration >60%, and patients treated with triple antithrombotic therapies.

All the included patients underwent full history taking and clinical examination, echocardiography, laboratory investigations, calculation of the PRECISE-DAPT score, coronary angiography, PCI, and follow-up.

Baseline demographic characteristics and related clinical information (eg, age, sex, history of diabetes mellitus, hypertension, history of coronary artery disease, previous COVID-19 infection, and prior spontaneous bleeding) were obtained. Vital signs were assessed with a mercury sphygmomanometer regarding arterial pulse and arterial blood pressure measurement. [4] Weight was estimated, and chest auscultation was done.

All the studied patients were subjected to a resting 12-lead ECG within 10 minutes of their arrival at the hospital. The ECGs were reviewed by a cardiologist.

The study population was examined with 2D transthoracic echocardiography (GE VIVD S5 ultrasound system) by an experienced cardiologist at the CCU.

Blood samples were withdrawn on admission for laboratory investigations, including creatine kinase, cardiac troponin-I, creatinine, hemoglobin, and white blood cell (WBC) count. Creatinine clearance

(mL/min) was estimated according to the Cockcroft-Gault method. [5]

The PRECISE-DAPT score was calculated using a web calculator (http://www.PRECISEdaptscore.com) for each patient.

The patients were divided into 3 groups: a low PRECISE-DAPT score (<17), an intermediate PRECISE-DAPT score (17–24), and a high PRECISE-DAPT score (≥25).

All the patients underwent a coronary angiography and a PPCI within 90 minutes of admission. They also received 300 mg of acetylsalicylic acid. In addition, 236 patients (97.9%) received 180 mg of oral ticagrelor, and 5 (2.1%) received a 300–600 mg oral loading dose of clopidogrel on admission as recommended in the Myocardial Revascularization Guideline of the European Society of Cardiology. [6]

During coronary interventions, a standard intravenous bolus of unfractionated heparin (70–100 IU/kg), and additional doses were given as required to achieve an activated clotting time surpassing 250 seconds. In appropriate patients, stenting of the infarct-related artery with a drug-eluting stent was accomplished effectively immediately after coronary angiography. The diameter, total length, and type of the stents used were also recorded. After discharge, survivors were given aspirin, ticagrelor/clopidogrel, statins, β-blockers, and angiotensin-converting enzyme inhibitors (ACEIs) based on their blood pressure and heart rate.

Follow-up was performed for the patients concerning in-hospital complications, including mortality, bleeding complications, heart failure, life-threatening arrhythmias, and no-reflow, assessed using thrombolysis in myocardial infarction (TIMI [a subjective method to evaluate coronary blood flow]) and [7] TIMI frame count (TFC), defined as the number of cine frames required for contrast to reach a standardized distal coronary landmark in the culprit vessel. The number was expressed based upon a cine filming rate of 30 frames/second [8] and the myocardial blush grade (MBG [a subjective method to assess microvascular perfusion]). [9] The patients underwent follow-up for another 6 months (180 d) for MACEs, composed of total deaths, nonfatal MI, coronary revascularization, stroke, heart failure hospitalization, [10] and bleeding complications, assessed based on the Bleeding Academic Research Consortium (BARC) classification. [11] The patients had follow-ups through telephone calls or hospital visits. Survival time was calculated from the date of hospitalization through the date of death or the last follow-up (Fig. 3).

The study endpoints were MACEs, consisting of a primary MACE composite of heart failure hospitalization, nonfatal MI, nonfatal stroke, and cardiovascular death, and a secondary MACE composite of all-cause mortality and bleeding complications.

Informed written consent was obtained from all the participants after they had received explanations regarding all the study steps. The study was approved by the institutional ethics committee.

Statistical Analysis

Data were verified, coded, and analyzed by the researcher using SPSS (Statistical Package for the Social Sciences, version 24, IBM, and Armonk, NY).

Descriptive statistics, including means, standard deviations, medians, ranges, and percentages, were calculated. Vis-à-vis categorical variables, the χ^2/Monte Carlo exact test was used to compare the frequency between the groups. For continuous variables with more than 2 categories, a one-way ANOVA test was calculated to assess the mean differences of data following a normal distribution. Additionally, a post hoc test was performed using Bonferroni corrections for pairwise comparisons between the study groups. The mortality rate was presented

using the Kaplan-Meier analysis method. Survival vs the time to follow-up curves for the 3 groups were displayed using Kaplan-Meier estimates. Receiver-operating characteristic (ROC) curves depicted the diagnostic accuracy of the PRECISE-DAPT score, analyzed as the area under the curve (AUC), the standard error (SE), and the 95% confidence interval (CI). Validity statistics, comprised of sensitivity, specificity, and positive and negative predictive values, were computed. A *P* value ≤0.05 was considered significant.

RESULTS

During the study period, 315 patients diagnosed with STEMI were assessed for eligibility at Assiut University Heart Hospital. Seventy-four of them were excluded: 3 had cardiogenic shock, 5 were on triple antithrombotic therapy, 5 were older than 85, 45 underwent percutaneous transluminal coronary angioplasty only without stenting, 11 were candidates for coronary artery bypass graft surgery, and 5 were lost to follow-up.

Ultimately, 241 patients were enrolled in our study and followed up for 6 months (Fig. 1). The study population was divided into 3 groups according to their PRECISE-DAPT score: a low score group (<17, n=172), an intermediate score group (17–24, n=33), and a high score group (≥25, n=36).

Baseline Data

The mean age of the study population was 58.12±6.4 years, and the majority (78%) were men. Diabetes mellitus, smoking, and the time from chest pain onset to treatment were statistically different between the 3 groups (*P*=0.037, *P*=0.005, and *P*=0.009, respectively).

Laboratory Data

Patients with a high or intermediate PRECISE-DAPT score had lower levels of hemoglobin and creatinine clearance than those in the low-score group (*P*<0.001 for both). The peak troponin I level was higher in the high-score group (*P*=0.034), whereas the peak creatine kinase level was higher in the intermediate-score group (*P*<0.001).

Echocardiographic and Angiographic Data

Table 1 shows echocardiographic and angiographic findings in the 3 groups. The low-score group had the lowest incidence of a low left ventricular ejection fraction (<40%; *P*=0.019). Regarding angiographic findings, we observed that the incidence of low TIMI flow (<III) was highest in the high-score group (44.5%), followed by the intermediate-score group (42.4%) and the low-score group (18.6%), with the difference constituting statistical significance (*P*=0.001).

As regards TFC (F/30 s), it was highest in the high-score group (28.17±6.6) and lowest in the low-score group (21.91±4.1), which was statistically significant (*P*<0.001). Moreover, MBG was higher in the low-score group (55.2%) than in the other groups, which was statistically significant (*P*=0.045). Additionally, the total stent length was the longest in the high-score group (*P*=0.040).

In-Hospital and Follow-up Complications

In-hospital complications, consisting of mortality, bleeding complications, heart failure, and life-threatening arrhythmias, were highest in the high-score group, followed by the intermediate-score group and the low-score group (52.8% vs 21.2% vs 16.9%; *P*<0.001, respectively). Similarly, short-term follow-up MACEs were highest in the high-score group (*P*<0.001). No-reflow and bleeding complications increased most steeply in the high-score group, followed by the intermediate- and low-score groups (*P*=0.001 and *P*=0.004, respectively) (Fig. 2).

Prognostic Value of the PRECISE-DAPT Score in Predicting in-Hospital and Follow-up MACEs

ROC curves were performed to assess the prognostic value of the PRECISE-DAPT score among the studied patients. The PRECISE-DAPT score had a modest predictive power for in-hospital complications (AUC=0.64) and short-term follow-up MACEs (AUC=0.81) (P=0.004 and P<0.001, respectively), demonstrating good sensitivity and specificity for the PRECISE-DAPT score in predicting in-hospital complications, no-reflow, bleeding complications, and follow-up MACEs. Every 1-point increase in the PRECISE-DAPT score increased the risk of complications. The best cutoff value of the PRECISE-DAPT score to predict in-hospital and short-term follow-up MACEs was 10 (sensitivity =74% and 86%, respectively, and specificity =61% and 72%, respectively), with good positive and negative predictive values (Table 2).

Predictors of MACEs

Figure 4 illustrates the predictive value of the PRECISE-DAPT score in comparison with other score components. Our study showed that the PRECISE-DAPT score was superior to age and creatinine clearance in predicting MACEs without significant differences from WBC and hemoglobin levels (Table 3).

Table 1: Echocardiographic and Angiographic Data of the Studied Patients

Variable	Low (1) (n = 172)	Intermediate (2) (n = 33)	High (3) (n = 36)	*P* value*
LVEF : • 40–55% • <40%	 108 (62.8%) 12 (7%)	 11 (33.3%) 6 (18.2%)	 23 (63.9%) 4 (11.1 %)	= 0.019***
Predilatation	141 (82%)	29 (87.9%)	33 (91.7%)	= 0.288*
Postdilatation	52 (30.2%)	17 (51.5%)	14 (38.9%)	= 0.193*
Stent diameter	3.24 ± 0.4	3.14 ± 0.3	3.11 ± 0.4	= 0.063**
Total stent length	32.79 ± 3.9	35.61 ± 4.3	38.42 ± 4.1	= 0.040**
TIMI Flow : • TIMI 0	 0 (0%)	 1 (3%)	 0 (0%)	= 0.001 *
• TIMI 1	7 (4.1%)	2 (6.1%)	2 (5.6%)	
• TIMI 2	25 (14.5%)	11 (33.3%)	14 (38.9%)	
• TIMI 3	140 (81.4%)	19 (57.6%)	20 (55.6%)	
TFC (F/30)	21.91 ± 4.1	24.03 ± 5.8	28.17 ± 6.6	< 0.001**
MBG				= 0.045*
• MBG 0	10 (5.8%)	3 (9.1%)	3 (8.3%)	
• MBG 1	32 (18.6%)	10 (30.3%)	8 (22.2%)	
• MBG 2	35 (20.3%)	8 (24.2%)	10 (27.8%)	
• MBG 3	95 (55.2%)	12 (36.4%)	15 (41.7%)	

*****The one-way ANOVA test was used to compare means between the groups. **The post hoc test was used for pairwise comparisons. *** The χ^2 test was used to compare the frequency distribution.

LVEF: left ventricular ejection fraction; TIMI: thrombosis in myocardial infarction; TFC: TIMI frame count; MBG: myocardial blush grade

Table 2: Prognostic Value of the PRECISE-DAPT Score in Predicting in-Hospital and Follow-up MACEs in the Studied Patients

Measure	In-Hospital	FU	Bleeding	No-Reflow
1. AUC	0.628	0.703	0.625	0.666
2. 95% CI	588 - 854	611 - 892	524 - 794	517 - 822
3. *P* value	0.004	< 0.001	0.033	0.041

4. Cutoff	10	10	10	10
5. Sensitivity, 95% CI	74% (64-82)	81% (72-88)	75% (65-83)	76% (66-84)
6. Specificity, 95% CI	62% (52-71.5)	75% (65-83)	60% (51-70)	64% (54-73)
7. PPV	66% (60-72)	76.5% (69-82)	65% (59-71)	68% (61-74)
8. NPV	70.5% (61-74)	80% (72-86)	70.5% (62-78)	73% (65-80)
9. Accuracy	68% (60-74)	78% (73-83.5)	67.5% (61-74)	70% (63-76)

MACES: major adverse cardiovascular events; FU: follow-up; AUC: area under the curve; CI: confidence interval; PPV: positive predictive value; NPV: negative predictive value

Table 3: ROC Curve Analysis for the PRECISE-DAPT Score and its Components as Predictors of MACEs

Predictor	AUC	95% CI	*P* value
Age, y	0.756	0.638-0.875	0.001
WBC count	0.615	0.463-0.776	0.150
Hemoglobin	0.614	0.492-0.738	0.149
Creatinine clearance	0.678	0.538-0.817	0.025
PRECISE score	0.775	0.651-0.901	<0.001

MACES: major adverse cardiovascular events; WBC: White blood cells; PRECISE-DAPT: predicting bleeding complications in patients undergoing stent implantation and subsequent dual antiplatelet therapy

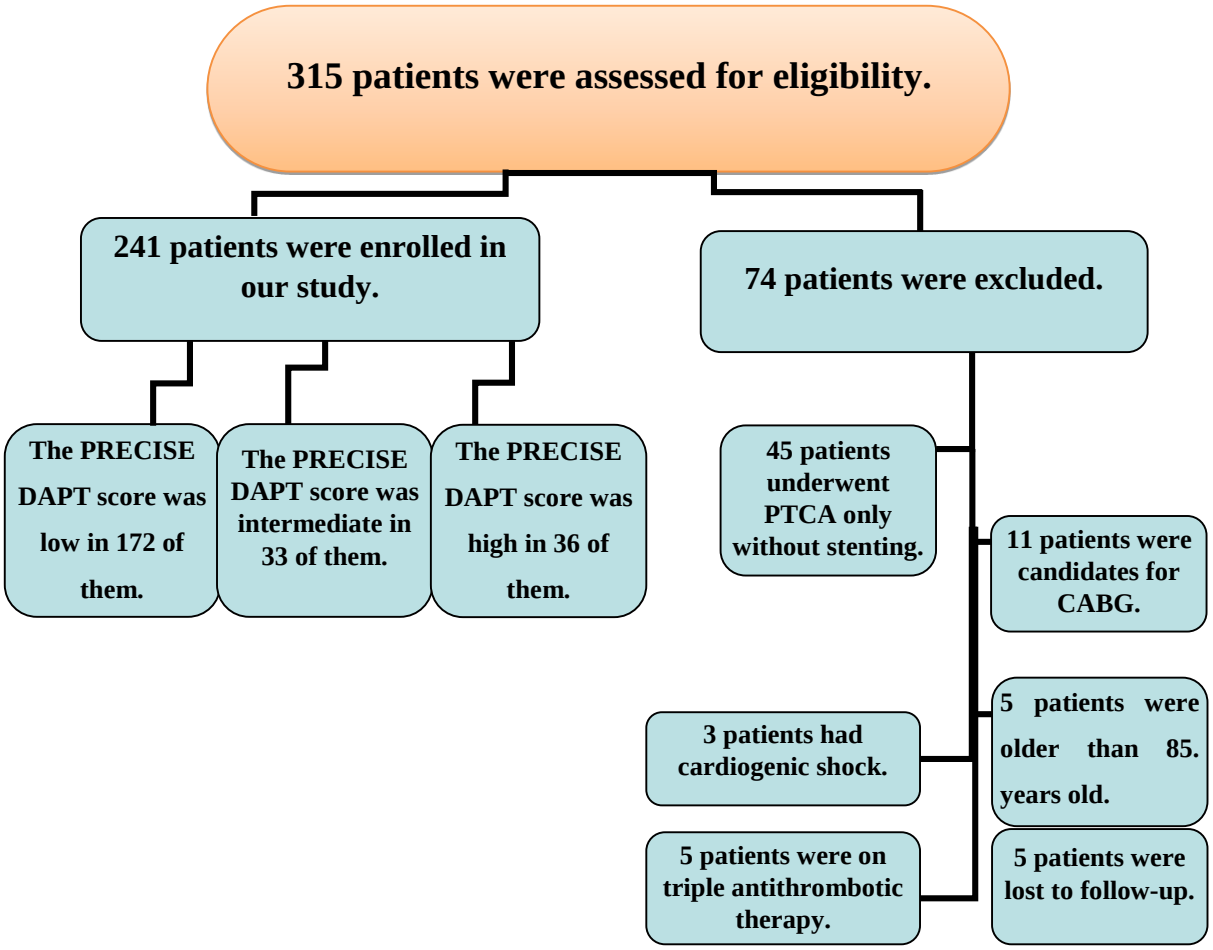

Figure 1: The image depicts the flow chart for our study population.
PRECISE-DAPT: predicting bleeding complications in patients undergoing stent implantation and subsequent dual antiplatelet therapy; CABG: coronary artery bypass graft surgery; PTCA: percutaneous transluminal coronary angioplasty

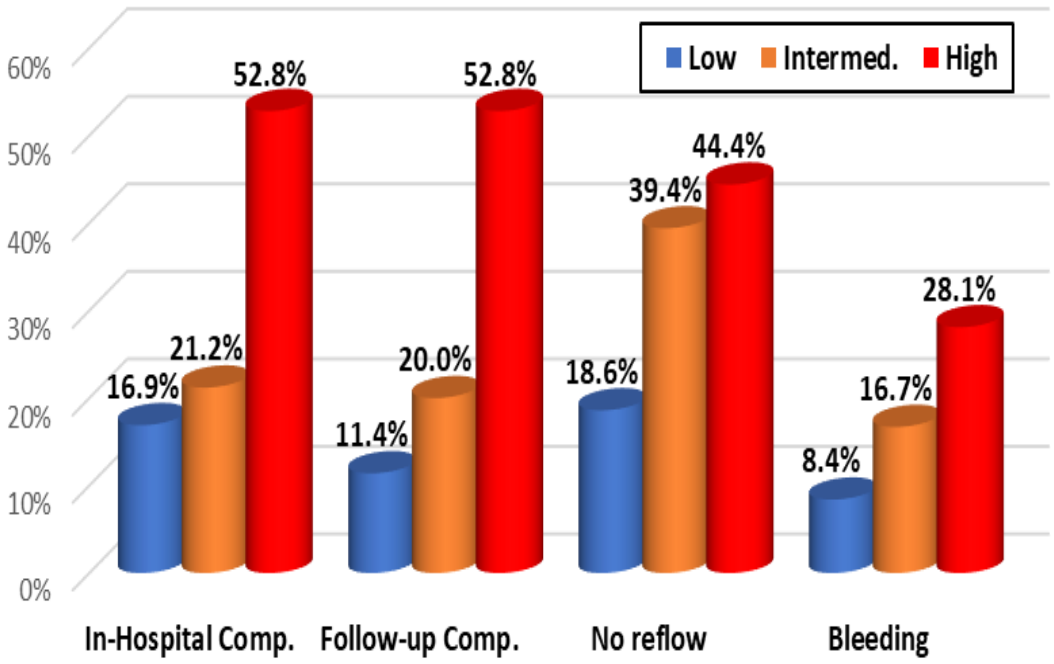

Figure 2: The image illustrates the relationship between the PRECISE-DAPT score and thrombotic and bleeding complications.
PRECISE-DAPT: predicting bleeding complications in patients undergoing stent implantation and subsequent dual antiplatelet therapy; CABG: coronary artery bypass graft surgery

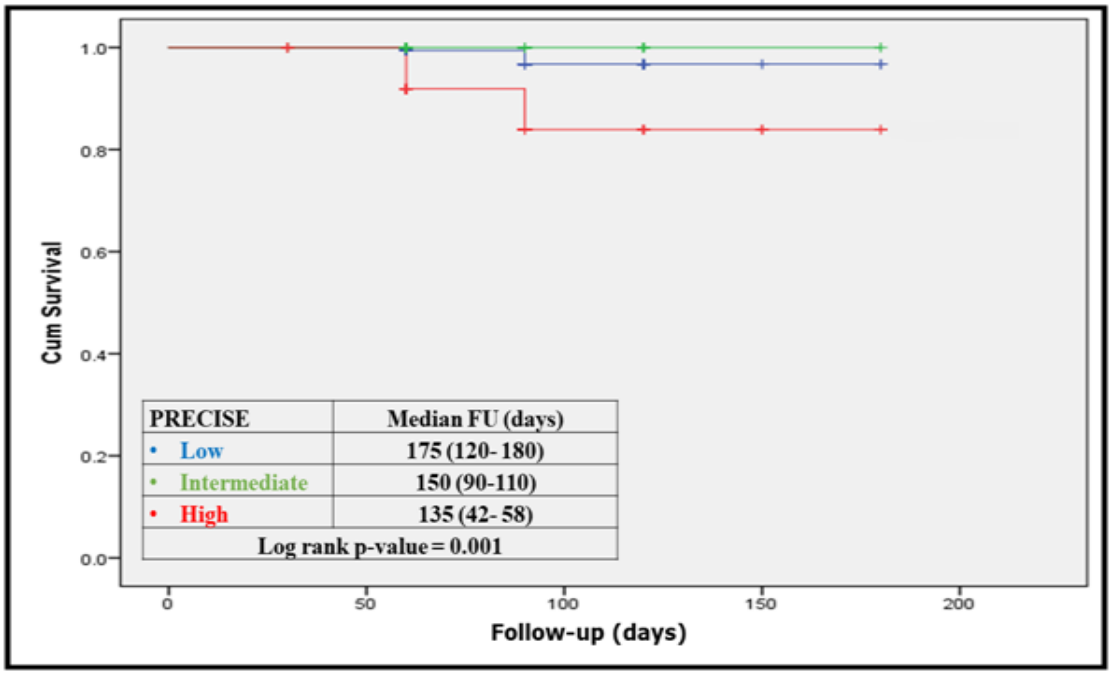

Figure 3: The image provides the pairwise comparison of the ROC curves of the PRECISE-DAPT score, age, white blood cell count, hemoglobin, and creatinine clearance in the prediction of MACEs.
ROC: receiver-operating characteristic; PRECISE-DAPT: predicting bleeding complications in patients undergoing stent implantation and subsequent dual antiplatelet therapy; MACEs: major adverse cardiovascular events

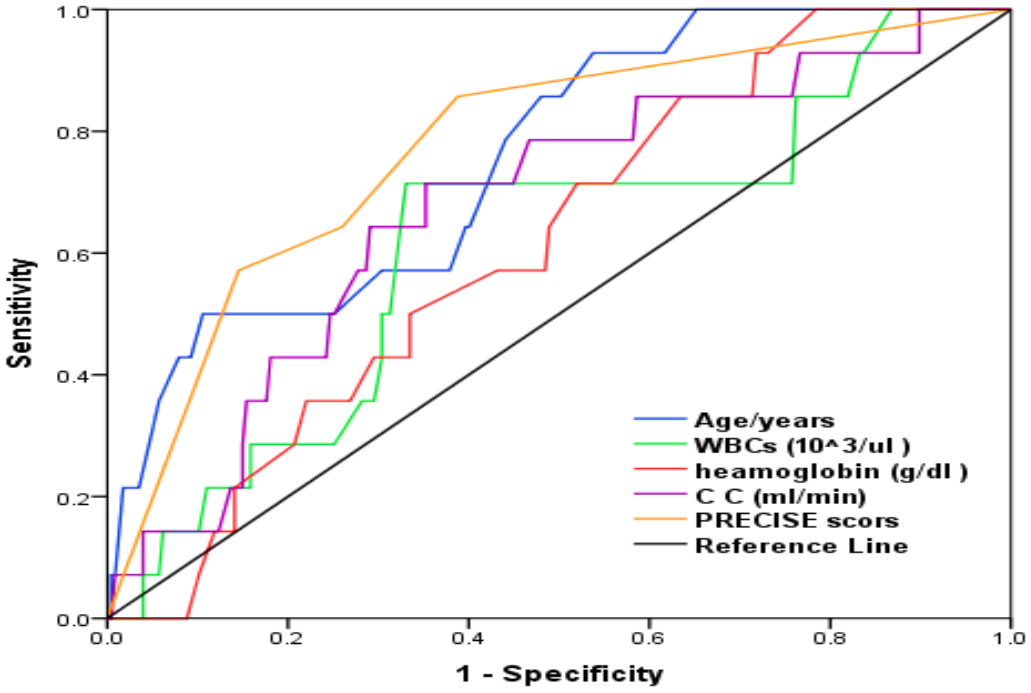

Figure 4: Kaplan-Meier curves for short-term Follow-up MACE in the high, intermediate, and low PRECISE-DAPT score groups.

DISCUSSION

Risk calculation is not always easy in clinical practice, and the use of a rapid and simple risk-scoring system is necessary. The PRECISE-DAPT score is a useful, simple, and rapid objective tool to assess not only bleeding but also thrombotic risks among STEMI patients and to determine DAPT treatment post-PPCI. The feasibility of calculation at the bedside makes the PRECISE-DAPT score advantageous in comparison with other scores.

Our study showed that the PRECISE-DAPT score provided a significant and reliable prognostic value for in-hospital and short-term complications, including MACEs, no-reflow, and bleeding complications, among STEMI patients treated with PPCI. Every 1-point increase in the PRECISE-DAPT score increased the risk of thrombotic complications. Determining high-risk individuals through risk stratification is essential for managing potential long-term issues and developing a treatment plan.

In concordance with our results, Dannenberg et al [12] reported that the PRECISE-DAPT score was easy to use and had a high predictive value for bleeding and MACEs. Tanik et al [13] reported that the PRECISE-DAPT score was a substantial independent predictor of in-hospital mortality among STEMI patients. The higher mortality rate among individuals with high scores may be attributed to ischemic events. The predictive significance of the PRECISE-DAPT score in predicting long-term outcomes post-discharge was also proven by Ando et al. [14] Furthermore, Yildirim et al [15] showed that a high PRECISE-DAPT score was linked to a significant degree of atrioventricular block and atrial fibrillation among STEMI patients who underwent PCI. Arrhythmic complications are a major cause of mortality among STEMI patients, and atrial fibrillation after PCI is a symptom of failed reperfusion and a sign of heart failure.

Many risk scores for thrombotic complications, such as ACTION, GRACE, and TIMI, demonstrate that an increase in age is a risk factor for in-hospital death among STEMI patients. [16,17] Our study showed that patients with high and intermediate PRECISE-DAPT scores were older than the low-score group (P<0.001).

The PRECISE-DAPT score consists of 5 variables: creatinine clearance, hemoglobin level, WBC count, age, and previous spontaneous bleeding. Several studies have demonstrated that each component of the PRECISE-DAPT score exhibits a strong relation with short- and long-term complications among STEMI patients treated with PPCI, which might explain why the PRECISE-DAPT score can predict in-hospital and short–term thrombotic complications, including MACEs and no-reflow. For instance, some studies have demonstrated that impairment in renal function with decreased creatinine clearance is a significant and independent predictor of adverse cardiovascular events among STEMI patients treated with PCI. [18] This finding may be attributed to the fact that chronic kidney disease is associated with arrhythmias, left ventricular hypertrophy and dysfunction, cardiomyopathy (dilated and hypertrophic variants), endothelial dysfunction, and calcification of the coronaries as independent predictors of cardiac morbidity and mortality. [19]

Hemoglobin plays a significant role in supplying oxygen to tissues. Thus, when hemoglobin levels decrease, cardiac output increases to maintain the normal metabolic demands of tissues, which may result in myocardial damage due to the increased workload of the heart. [20]

Accordingly, it is hypothesized that anemia may affect the prognosis of patients with MI by both mechanisms and progress to AMI.

In agreement with previous studies, our study reported that patients with high and intermediate scores had low levels of hemoglobin and creatinine clearance in comparison with the low-score group (P<0.001 for both). Likewise, Sabatine et al [21] revealed that cardiovascular mortality increased for each 1 g/dL decrease in hemoglobin level below 14 g/dL among STEMI patients.

Barron et al [22] reported that WBC count within 24 hours of admission among STEMI patients treated with PPCI was a strong and independent predictor of in-hospital mortality and in-hospital clinical events. The mechanism whereby neutrophils cause this damage is unclear. The pro-inflammatory cytokines released by leukocytes could cause myocyte dysfunction and necrosis. Prior investigations have reported that a progressive leukocyte capillary plugging and the no-reflow phenomenon occur with reperfusion after prolonged ischemia. [21,22] All these findings explain why the PRECISE-DAPT score can predict MACEs and other thrombotic complications among STEMI patients treated with PPCI.

In the current study, we also found that a high PRECISE-DAPT score was independently associated with an increase in stent length, in concordance with Long et al, [23] who reported that the PRECISE-DAPT score was independently correlated with the degree of coronary stenosis among individuals with the acute coronary syndrome.

Apropos no-reflow complications, it has been established that angiographic successful reperfusion is defined as TIMI 3 flow and MBG 2 or 3. MBG is a potent angiographic predictor of mortality. Kaya et al [24] demonstrated that post-procedural MBG 3, in addition to TIMI flow, was a significant predictor of short- and long-term MACE-free survival among patients treated with PPCI rather than TIMI flow alone. This finding may be attributed to the fact that successful rapid reperfusion preserves the

viability of the myocardium and decreases no-reflow complications, associated with reduced ejection fractions, high MACEs, and higher mortality rates.

In the current study, TIMI flow and MBG had lower values among the high-score group, followed by the intermediate- and low-score groups (P=0.001 and P=0.045, respectively). Further, TFC (F/30) values were higher in the high-score group than in the other groups (P<0.001). Accordingly, the PRECISE-DAPT score was considered a good predictor for no-reflow after PPCI in acute cases such as STEMI.

In our study, Kaplan-Meier analysis showed that patients with high scores had a significantly higher incidence of MACEs with a lower survival rate (P=0.05), in agreement with Tanik et al, [13] who demonstrated that the PRECISE-DAPT score was not inferior to the TIMI risk score for predicting in-hospital mortality.

The score is also a useful index that allows clinicians to determine appropriate treatment strategies for antithrombotic therapy, individualized according to thrombotic and bleeding risk for each patient after PCI while considering more intensive monitoring, medical therapy, and close follow-up for patients with a higher PRECISE-DAPT score. In addition, evaluating the risk of no-reflow preoperatively aids in early intervention and the proactive execution of treatment strategies to prevent this complication. However, such evaluations should be conducted with caution to balance the risks of ischemic and bleeding complications for each patient on an individual basis.

Limitations of the Study

Our study is not without limitations. Firstly, our study is limited by the enrollment of a limited number of patients included from a single recruiting medical center. The results, therefore, are preliminary and need to be confirmed and extended in more comprehensive multicenter studies on more patients to obtain more valid and reliable cutoff values and diagnostic impact. Secondly, no comparison analysis was performed between the PRECISE-DAPT score and other risk scores due to a lack of study data. Finally, the rest of the angiographic data were not included in our study. Therefore, further studies with long-term follow-ups are needed to confirm our findings and to demonstrate the exact role of the PRECISE-DAPT score among STEMI patients treated with PPCI.

CONCLUSIONS

The current study showed that the PRECISE-DAPT score provided a significant and reliable prognostic value for in-hospital and short-term complications, including MACEs, no-reflow, and bleeding complications, among STEMI patients treated with PPCI. The PRECISE-DAPT score can play a significant role in early risk stratification, more intense monitoring, and active implementation of treatment strategies among patients with a higher score to prevent thrombotic complications. The success depends on the physician's wisdom regarding DAPT and its duration after PPCI to outweigh bleeding and thrombotic risks.

Funding Resource

This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Funding: None

Conflicting Interest: None

REFERENCES

1. Buccheri S., Capranzano P., Condorelli A., Scalia M., Tamburino C., Capodanno D. Risk stratification after ST-segment elevation

myocardial infarction. Expert Review of Cardiovascular Therapy. 2016; 14(12):1349–1360. doi: 10.1080/14779072.2017.1256201

2. F. Costa, D. van Klaveren, S. James, D. Heg, L. Raber, F. Feres, et al., Derivation and validation of the predicting bleeding complications in patients undergoing stent implantation and subsequent dual antiplatelet therapy (PRECISE-DAPT) score: a pooled analysis of individual-patient datasets from clinical trials, Lancet. 389 (2017) 1025–1034.

3. Fourth Universal Definition of Myocardial Infarction (2018). J Am CollCardiol 2018;Aug 25.

4. Williams B, Mancia G, Spiering W, AgabitiRosei E, Azizi M, Burnier M, Clement DL, Coca A, de Simone G, Dominiczak A, Kahan T. ESC Scientific Document Group. 2018 ESC/ESH Guidelines for the management of arterial hypertension. Eur heart J. 2018 Sep 1;39(33):3021-104

5. Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine.Nephron.1976; 16:31–41.

6. 2018 ESC/EACTS Guidelines on myocardial revascularization

7. Sarkar A, Grigg WS, Lee JJ. TIMI grade flow.StatPearls [Internet]. 2020 Aug 16.

8. Gibson CM, Cannon CP, Daley WL, Dodge JT, Jr., Alexander B, Jr., Marble SJ, et al. TIMI frame count: a quantitative method of assessing coronary artery flow. Circulation. 1996;93(5):879-88. doi: 10.11

9. Vranckx P, White HD, Huang Z, Mahaffey KW, Armstrong PW, Van de Werf F, Moliterno DJ, Wallentin L, Held C, Aylward PE, Cornel JH. Validation of BARC bleeding criteria in patients with acute coronary syndromes: the TRACER trial. Journal of the American College of Cardiology. 2016 May 10;67(18):2135-44.

10. Mrdovic I, Savic L, Krljanac G, Asanin M, Perunicic J, Lasica R, Marinkovic J, Kocev N, Vasiljevic Z, Ostojic M. Predicting 30-day major adverse cardiovascular events after primary percutaneous coronary intervention. The RISK-PCI score. International journal of cardiology. 2013 Jan 20;162(3):220-7

11. Vranckx P, White HD, Huang Z, Mahaffey KW, Armstrong PW, Van de Werf F, Moliterno DJ, Wallentin L, Held C, Aylward PE, Cornel JH. Validation of BARC bleeding criteria in patients with acute coronary syndromes: the TRACER trial. Journal of the American College of Cardiology. 2016 May 10;67(18):2135-44.

12. Dannenberg L, Afzal S, Czychy N, M'Pembele R, Zako S, Helten C, Mourikis P, Zikeli D, Ahlbrecht S, Trojovsky K, Benkhoff M. Risk prediction of bleeding and MACCE by PRECISE-DAPT score post-PCI. IJC Heart & Vasculature. 2021 Apr 1;33:100750.

13. Tanik VO, Cinar T, Arugaslan E, Karabag Y, Hayiroglu MI, Cagdas M, Rencuzogullari I, Uluganyan M. The predictive value of PRECISE-DAPT score for in-hospital mortality in patients with ST-elevation myocardial infarction undergoing primary percutaneous coronary intervention. Angiology. 2019 May;70(5):440-7.

14. Ando T, Nakazato K, Kimishima Y, Kiko T, Shimizu T, Misaka T, Yamada S, Kaneshiro T, Yoshihisa A, Yamaki T, Kunii H. The clinical value of the PRECISE-DAPT score in predicting long-term prognosis in patients with acute myocardial infarction. IJC Heart & Vasculature. 2020 Aug 1;29:100552.

15. Yildirim E, Turkkan C, Ozcan KS, Ceylan US, Zengin A. The predictive value of PRECISE-DAPT score for arrhythmic complications in patients with ST-elevation myocardial infarction. Coronary Artery Disease. 2019 Nov 1;30(7):499-504.

16. Ono M, Kawashima H, Hara H, Gamal A, Wang R, Gao C, O'Leary N, Soliman O, Piek JJ, van Geuns RJ, Jüni P, Hamm CW, Valgimigli M, Vranckx P, Windecker S, Steg PG, Fox KA, Onuma Y, Serruys PW. External validation of the GRACE risk score 2.0 in the contemporary all-comers GLOBAL LEADERS trial. Catheter CardiovascInterv. 2021 Oct;98(4): E513-E522. DOI: 10.1002/ccd.29772. Epub 2021 May 17. PMID: 34000088.

17. Morrow DA, Antman EM, Charlesworth A, Cairns R, Murphy SA, de Lemos JA, Giugliano RP, McCabe CH, Braunwald E. TIMI risk score for ST-elevation myocardial infarction: a convenient, bedside, clinical score for risk assessment at presentation: an intravenous nPA for treatment of infarcting myocardium early II trial substudy. Circulation. 2000 Oct 24;102(17):2031-7.

18. Kim JY, Jeong MH, Ahn YK, Moon JH, Chae SC, Hur SH, Hong TJ, Kim YJ, Seong IW, Chae IH, Cho MC. Decreased glomerular filtration rate is an independent predictor of in-hospital mortality in patients with ST-segment elevation myocardial infarction undergoing primary percutaneous coronary intervention. Korean Circulation Journal. 2011 Apr 1;41(4):184-90

19. Zhao L, Wang L, Zhang Y. Elevated admission serum creatinine predicts poor myocardial blood flow and one-year mortality in ST-segment elevation myocardial infarction patients undergoing primary percutaneous coronary intervention. The Journal of invasive cardiology. 2009 Oct 1;21(10):493-8.

20. Feng QZ, Zhao YS, Li YF. Effect of haemoglobin concentration on the clinical outcomes in patients with acute myocardial infarction and the factors related to haemoglobin. BMC research notes. 2011 Dec;4(1):1-8.https://doi.org/10.1186/1756-0500-4-142

21. Sabatine MS, Morrow DA, Giugliano RP, Burton PB, Murphy SA, McCabe CH, Gibson CM, Braunwald E. Association of hemoglobin levels with clinical outcomes in acute coronary syndromes.Circulation. 2005 Apr 26;111(16):2042-9.

22. Barron HV, Harr SD, Radford MJ, Wang Y, Krumholz HM. The association between white blood cell count and acute myocardial infarction mortality in patients > or ¼65 years of age: findings from the cooperative cardiovascular project. J Am CollCardiol. 2001;38(6):1654-61.

23. Long T, Peng L, Li F, Xia K, Jing R, Liu X, Xie Q, Yang T, Zhang C. Correlations of DAPT score and PRECISE-DAPT score with the extent of coronary stenosis in acute coronary syndrome. Medicine. 2018 Sep;97(39)

24. Kaya MG, Arslan F, Abaci A, Heijden GV, Timurkay-Nak T, Cengel A. Myocardial blush grade: a predictor for major adverse cardiac events after primary PTCA with stent implantation for acute myocardial infarction. Actacardiologica. 2007 Oct 1;62(5):445-51.