Clinical risk scores predict procedural complications of primary percutaneous coronary intervention

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Abstract

Objective: The predictive value of five risk score models containing clinical (PAMI-PMS, GRACE–GRS, and modified ACEF-ACEFm–scores), angiographic SYNTAX score (SXS) and combined Clinical SYNTAX score (CSS) variables were evaluated for the incidence of three procedural complications of primary percutaneous coronary intervention (pPCI): iatrogenic coronary artery dissection, angiographically visible distal embolization and angiographic no-reflow phenomenon.

Methods: The mentioned scores and the incidence of procedural complications were retrospectively analyzed in 399 consecutive patients with acute ST-elevation myocardial infarction who underwent pPCI.

Results: Coronary dissection, distal embolization and no-reflow occurred in 39 (9.77%), 71 (17.79%), and 108 (27.07%) subjects, respectively. Coronary dissections were significantly associated with higher GRS, ACEFm, and CSS values (all p<0.05). PMS, GRS, ACEFm, and CSS were significantly higher in patients with no-reflow (all p<0.05), while distal embolization was not predicted by any of the calculated scores. In multiple logistic regression models, GRS and ACEFm remained independent predictors of both coronary dissections (OR 3.20, 95% CI 1.56–6.54, p<0.01 and OR 2.87, 95% CI 1.27–6.45, p=0.01, respectively) and no-reflow (OR 1.71, 95% CI 1.04–2.82, p=0.03 and OR 1.86, 95% CI 1.10–3.14, p=0.01, respectively).

Conclusion: Whereas SXS failed to predict procedural complications related to pPCI, two simple, noninvasive risk models, GRS and ACEFm, independently predicted coronary dissections and no-reflow. Pre-interventional assessment of these scores may help the interventional cardiologist to prepare for procedural complications during pPCI. *(Anatol J Cardiol 2017; 17: 276-84)*

Keywords: myocardial infarction, risk assessment, percutaneous coronary intervention, no-reflow phenomenon, dissection

Introduction

Multiple risk predicting models have been proposed to estimate the clinical outcomes after ST-elevation myocardial infarction (STEMI), including clinical, angiographic or combined scores (1–5). Although current clinical guidelines recommend risk stratification in STEMI patients (6), these risk scores are not currently taken into account for immediate clinical decision-making at the time of hospital admission; the recommended treatment for STEMI is emergent reperfusion therapy, preferably by primary percutaneous coronary intervention (pPCI) (6, 7).

Procedural complications such as iatrogenic coronary artery dissections (coronary dissections), the angiographic no-reflow phenomenon (no-reflow), or angiographically visible distal embolization (distal embolization) of atherosclerotic/thrombotic material, increase the incidence of adverse events and mortality after PCI (8–10). Several risk score models have been proved as useful tools in anticipating the occurrence of different periprocedural adverse events. Recent reports indicate that the SYNergy between PCI with TAXUS™ and Cardiac Surgery (SYNTAX) score (SXS), a coronarography-based risk model, can predict no-reflow and distal embolization in STEMI patients (11–13). Despite its obvious value, the calculation of the SYNTAX score requires a strenuous analysis and can only be performed after the patient has undergone coronary angiography. On the other hand, a score based on clinical information that could estimate the risk of such complications based on the information that is available at the initial presentation in the emergency department may help the interventional cardiologist in choosing the most appropriate interventional approach. A specific scoring system was recently validated for the prediction of no-reflow (14), but the clinical and combined risk models currently used for risk

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stratification in acute coronary syndromes have never been tested for this scope. In the current study, we aimed to assess the potential of classical risk scores to predict procedural complications. To achieve this objective, we retrospectively analyzed the data from STEMI patients who were treated by pPCI in our center, and evaluated the relationship between the incidence of three procedural complications: coronary dissections, distal embolization, and no-reflow, and five risk predicting models: the Primary Angioplasty in Myocardial Infarction (PAMI) score (PMS), the Global Registry of Acute Coronary Events (GRACE) score (GRS), the modified Age, Creatinine, and Ejection Fraction score (ACEFm), the SXS, and the Clinical SYNTAX score (CSS). The first three scores include only clinical variables (1, 2, 15), the SXS includes only angiographic parameters (16), while the CSS uses a combination of both clinical and angiographic data (15).

Methods

Study protocol

We retrospectively analyzed the clinical and angiographic data of 399 consecutive STEMI patients treated by pPCI between January 2011 and December 2013 in the catheterization laboratory of a tertiary care cardiovascular center. In this analysis, we included all patients with type I (spontaneous) myocardial infarction (17) who presented to the Emergency Department within the first 12 hours of symptoms onset, or between 12 hours and 24 hours if they had evidence of ongoing ischemia. Applied exclusion criteria were: thrombolytic treatment administered before PCI; left bundle branch block or paced rhythm, making it difficult to assess STEMI-related ECG parameters; history of coronary artery by-pass graft surgery; and insufficient data for calculating the applied scores. All patients received dual antiplatelet therapy with aspirin and clopidogrel administered as a pre-intervention loading dose. Unfractionated heparin was given for periprocedural anticoagulation. Direct stenting and, in case of high thrombus burden, aspiration and stenting were the main therapeutic approaches applied, according to guidelines recommendations at the time. However, the different PCI techniques (balloon pre- and postdilatation, manual thrombus aspiration, stent implantation) and the administration of glycoprotein IIb/IIIa receptor (GPIIb/IIIa) antagonists were performed according to the operator's decision. Only bare-metal stents were used. The research protocol complied with the Declaration of Helsinki and was approved by the local Ethics Committee (decision no. 65/17.09.2014). Every patient/legal representative signed a written informed consent, accepting the procession of personal data for scientific purposes at the moment of hospital admission.

Risk scores

For calculating the risk scores, we only used data that were available at emergency presentation, except the left ventricular ejection fraction, which was measured by echocardiography within the first 24 hours of hospital admission. The PMS (1) and ACEFm (15) were computed as previously described. The GRS for in-hospital death was calculated using the specific software available on-line at http://www.outcomes-umassmed.org/grace/acs_risk/acs_risk_content.html.

The methodology of SXS calculation was described in detail elsewhere (16). Every angiographic film was analyzed by two interventional cardiologists who were blinded to the clinical data of the enrolled cases. The score was calculated before guidewire passage, according to the methodology described by Garg et al. (3). The 2.11 version of the online SXS score calculator (http://www.syntaxscore.com/calc/syntaxscore/frameset.htm) was used. The incidence of procedural complications and the final result of the pPCI procedure were evaluated only after the calculation of the angiographic score.

The CSS was obtained by the simple multiplication of the SXS and ACEFm score values (15).

Additional clinical and procedural parameters

Additional clinical data and noninvasive test results were collected for each patient: current smoking status, the presence or absence of known arterial hypertension, and the ischemic time, defined as the time interval between symptoms onset and the beginning of the pPCI procedure.

We also assessed the presence or absence of a chronic total occlusion (CTO) and the Thrombolysis in Myocardial Infarction (TIMI) flow before the pPCI procedure for each patient. Chronic total occlusion was defined as the absence of anterograde flow in another coronary artery branch than the infarct-related artery, with a diameter of at least 1.5 mm, as previously described (16). The use of balloon pre- and postdilatation, manual aspiration of thrombus, administration of GPIIb/IIIa inhibitors and the number of implanted stents were also noted for each patient.

Procedural complications

The incidence of three procedural complications of pPCI was retrospectively analyzed by reviewing the diagnostic coronary angiogram and the pPCI angiogram. Iatrogenic coronary artery dissection was defined as an angiographically visible, iatrogenic tear of the vascular intima/media, occurring at any moment during PCI as a consequence of guide wire/guiding catheter manipulation or stent implantation/postdilatation ("edge dissection"). Importantly, "usual" dissections caused by routine balloon predilatation were excluded. The presence of at least one of the following criteria was used to describe no-reflow: temporary (during PCI) or post-PCI TIMI flow <3 in the absence of dissection, thrombus, spasm, or high-grade residual stenosis, or in the case of a TIMI flow grade 3 when myocardial blush grade 0 or 1 was observed (18). A filling defect or an abrupt closure of a peripheral branch located distally to the site of PCI was defined as distal embolization (10). Because of the retrospective design of the study, additional diagnostic methods like contrast injection through an over-the-wire balloon or an infusion catheter were not used.

Statistical analysis

All data were introduced in a dedicated database. Data were tested for normality using the Kolmogorov-Smirnoff test. Data with normal distribution were expressed as mean±standard deviation or median and interquartile range. Patients were stratified according to the clinical, angiographic, and combined risk score tertiles in low, medium, and high values, and to the presence or absence of different procedural complications. Each individual variable of the clinical scores, along with the additional clinical and angiographic parameters defined above, were separately evaluated by univariate analyzes as possible predictors of different procedural complications if the respective complications were associated with at least one of the studied risk models. Categorical data were expressed as number (percentage) and were compared using the chi-square test for trend or the Fisher's exact test, as appropriate. Continuous data were summarized as means (standard deviation) or medians (interquartile range), and were compared using the unpaired t test or the Mann-Whitney U test, as appropriate. Receiver-operator characteristic (ROC) curve analysis was used to test and compare the predictive power and to determine the cut-off values of the calculated scores for the incidence of procedural complications. If a significant association was observed between a specific risk model and the occurrence of coronary dissections, no-reflow or distal embolization after univariate analysis, a multiple logistic regression model was constructed to test the independent predictive role of the score in question. Furthermore, we included in these models all the variables, which were not used for the calculation of the respective score, but emerged as possible predictors of periprocedural complications after univariate analysis, with a probability of <0.10. Risk predicting models were introduced in the multiple logistic regression models as binary variables, according to the cut-off values determined for each score in the ROC-curve analysis. Left ventricular ejection fraction was similarly transformed for the multiple logistic regression analysis, using a cut-off value of 40%. A p value of less than 0.05 was considered statistically significant; all tests were two-tailed. The statistical analyzes were performed using the MedCalc Statistical Software version 15.4 (MedCalc Software bvba, Ostend, Belgium; https://www.medcalc.org; 2015).

Results

Clinical and procedural characteristics

The clinical, angiographic, and procedural characteristics of the included patients are listed in Table 1; the calculated score values and the incidence of different procedural complications are presented in Table 2.

Procedural complications

Iatrogenic coronary artery dissections occurred in 39 (9.77%) patients (Table 3). This complication was significantly associated with advanced age (p<0.01), the presence of no-reflow (p=0.02), >1 stent implanted per patient (p<0.001) and the use of balloon postdilatation (p<0.001). Although coronary dissections directly caused by balloon predilatation were excluded from the present analysis, the incidence of this complication was higher in cases in which this technical step was needed during the PCI procedure (p<0.01).

No-reflow was present in 108 (27.07%) subjects and was mainly diagnosed because of impaired post-procedural TIMI flow; a total of 102 (25.56%) patients had suboptimal distal flow at the end of the pPCI procedure–TIMI 0: 2 (0.50%) patients, TIMI 1: 14 (3.51%) patients, TIMI 2: 86 (21.55%) patients. No-reflow was more prevalent in the presence of coronary dissections: 17 vs. 91 patients with and without coronary dissections experienced no-reflow (43.59% vs. 25.28%, respectively; p=0.02). The other univariate predictors of coronary dissections and no-reflow are listed in Table 4. Thrombus aspiration was not associated with a lower

Table 1. Clinical, angiographic and procedural features of the studied patients

Parameter	Value
Age, years	62 (53–70)
Male sex	281 (70.43%)
Weight, kg	78 (70–90)
Diabetes	101 (25.31%)
Hypertension	284 (71.18%)
Active smokers	171 (42.86%)
Serum creatinine, mg/dL	0.99 (0.82–1.19)
Creatinine clearance, mL/min	83.55 (63.67–108.30)
Systolic blood pressure, mm Hg	130 (110–144)
Heart rate, bpm	76 (66–90)
Killip class >1	58 (14.54%)
Cardiac arrest	35 (8.78%)
Elevated cardiac enzymes or biomarkers at presentation	322 (80.70%)
Anterior STEMI	174 (43.61%)
LVEF, %	45.0 (40.0–50.0)
Ischemic time, hours	5.0 (3.5–8.0)
LAD or LM as culprit vessel	178 (44.61%)
Presence of a CTO	52 (13.03%)
Pre-procedural TIMI-flow< 2	311 (77.94%)
>1 implanted stent/patient	92 (23.06%)
Balloon predilatation	136 (34.09%)
Balloon postdilatation	97 (24.31%)
Thrombus aspiration	144 (36.09%)
GPIIb/IIIa inhibitors administered	261 (65.41%)

Values are expressed as medians (interquartile range) or number (percentage). bpm - beats per minute; CTO - chronic total occlusion; GPIIb/IIIa - glycoprotein IIb/IIIa; LAD - left anterior descending coronary artery; LM - left main stem; LVEF - left ventricular ejection fraction; STEMI - acute ST-segment elevation myocardial infarction; TIMI - thrombolysis in myocardial infarction

Table 2. The incidence of complications in the statistical tertiles of the applied risk scores

Risk model	Median (IQR)	Tertiles – N (range)	Incidence of complications – N (%)					
			Coronary dissection		Distal embolization		No-reflow	
PMS	3.00 (2.00–5.00)	Low: 189 (0.00–2.00)	12 (6.35%)	*P*=0.07	29 (15.34%)	*P*=0.26	38 (20.11%)	***P*<0.001**
		Medium: 111 (2.0–5.00)	15 (13.51%)		22 (19.82%)		30 (27.03%)	
		High: 99 (6.00–15.00)	12 (12.12%)		20 (20.20%)		40 (41.40%)	
GRS	146.00 (122.00–168.00)	Low: 132 (67–130)	7 (5.30%)	***P*=0.01**	27 (20.45%)	*P*=0.99	26 (19.70%)	***P*=0.001**
		Medium: 129 (131–158)	12 (9.30%)		16 (12.40%)		31 (24.03%)	
		High: 138 (159–299)	20 (14.49%)		28 (20.29%)		51 (36.96%)	
ACEFm	1.47 (1.17–2.17)	Low: 132 (0.55–1.24)	7 (5.30%)	***P*=0.03**	23 (17.42%)	*P*=0.33	24 (18.18%)	***P*<0.001**
		Medium: 135 (1.25–1.79)	15 (11.11%)		19 (14.07%)		31 (22.96%)	
		High: 132 (1.80–8.15)	17 (12.88%)		29 (21.07%)		53 (40.15%)	
SXS	16.50 (10.50–24.00)	Low: 133 (2.00–13.00)	14 (10.53%)	*P*=0.36	23 (17.29%)	*P*=0.86	31 (23.31%)	*P*=0.74
		Medium:127 (13.5–21.00)	6 (4.72%)		25 (19.69%)		42 (33.07%)	
		High: 139 (21.5–62.5)	19 (13.67%)		23 (16.55%)		35 (25.18%)	
CSS	26.74 (14.14–46.69)	Low: 132 (2.6–18.04)	10 (7.58%)	***P*<0.01**	22 (16.67%)	*P*=0.33	27 (20.45%)	***P*<0.01**
		Medium: 135 (18.05–37.39)	6 (4.44%)		21 (15.56%)		33 (24.44%)	
		High: 132 (37.40–216.60)	23 (17.42%)		28 (21.21%)		48 (36.36%)	

Chi-square test for trend was used. ACEFm - modified age, creatinine, and ejection fraction score; CSS - clinical SYNTAX sore; GRS - Global Registry of acute coronary events (GRACE) score; IQR - interquartile range; PMS - primary angioplasty in myocardial infarction (PAMI) score; SXS - SYNergy between PCI with TAXUS™ and cardiac surgery (SYNTAX) score

Table 3. Producing mechanisms of iatrogenic coronary artery dissection and treatment strategies

Producing mechanism	Incidence – N (%)	Stented – N (%)
Guiding catheter manipulation	3 (0.75%)	3 (0.75%)
Guide wire manipulation	2 (0.50%)	0 (0.00%)
Edge dissection after stenting/postdilatation	34 (8.52%)	27 (6.77%)

Values are expressed as number (percentage)

incidence of no-reflow: the complication occurred in 38 patients (26.39%) with and in 70 patients (27.45%) without this procedural step (p=0.9). The use of a GPIIb/IIIa antagonist was more frequent in case of no-reflow, with borderline statistical significance: 79 patients (73.15%) with no-reflow received this medication vs. 182 patients (62.54%) without this complication (p=0.05).

Angiographically visible distal embolization occurred in 71 (17.79%) patients. None of the examined scoring systems presented statistically significant associations with distal embolization. However, this complication was significantly associated with the use of aspiration thrombectomy (36 patients (25.00%) with, vs. 35 patients (15.91%) without thrombectomy, p<0.01) and with balloon predilatation (34 patients (25.00%) with vs. 37 patients (14.07%, p<0.01) without predilatation), but not with balloon postdilatation (20 patients (20.62%) with vs. 51 patients (16.89%) without postdilatation, p=0.44). Administration of a GPIIb/IIIa antagonist was more frequent in the presence of distal embolization: 56 patients (78.87%) with vs. 205 (62.50%) patients without distal embolization received this medication, p<0.01.

Prediction of procedural complications with the calculated risk scores

While the values of GRS, ACEFm, and CSS risk-predicting models were significantly higher in the presence of both coronary dissections and no-reflow, higher PMS values were associated only with the incidence of no-reflow (Fig. 1). No significant association was observed between coronary dissections or no-reflow and the calculated SXS values (both p>0.05).

Receiver operator characteristic curve analysis also identified the PAMI, GRS, ACEFm, and CSS as significant predictors of coronary dissections and/or no-reflow as detailed in Table 5 and presented in Figure 2. The calculated C-statistic values were not significantly different for the prediction of coronary dissections or for that of no-reflow.

In multiple logistic regression models, which included the GRS, ACEFm, and CSS separately, all scores were found to be independent predictors of coronary dissections, but only high GRS and ACEFm values remained independent predictors of no-reflow (Table 4).

Discussion

The main finding of the present study is that simple clinical risk models can predict two procedural complications of the pPCI: coronary dissections (GRS and ACEFm) and no-reflow (PMS, GRS and ACEFm), independently of angiographic and procedural variables. While the angiographic SXS did not show any association with these complications, the CSS, including combined angiographic and clinical data, had the same predictive

Table 4. Predictors of iatrogenic coronary artery dissections and angiographic no-reflow

	Predictors of iatrogenic coronary artery dissections		Predictors of angiographic no-reflow	
	Univariate *P*	Multiple logistic regression *P*; OR (95%CI)	Univariate *P*	Multiple logistic regression *P*; OR (95%CI)
ACEFm score	<0.01	0.01; 2.87 (1.27–6.45)	<0.001	0.01; 1.86 (1.10–3.14)
GRACE score	<0.01	<0.01; 3.20 (1.56–6.54)	<0.001	0.03; 1.71 (1.04–2.82)
PAMI score	NS	–	<0.001	NS
CSS score	0.01	<0.01; 2.88 (1.39–5.97)	<0.01	NS
Advanced age	<0.01	–	<0.01	–
Smoking	NS	–	<0.001	0.05; 0.59 (0.35–1.00)
Fast HR at admission	NS	–	<0.01	0.02; 1.01 (1.00–1.03)
Long ischaemic period	NS	–	<0.001	NS
Cardiac arrest	NS	–	0.07	NS
LVEF <40%	NS	–	<0.01	0.05; 1.70 (0.98–2.95)
High serum creatinine	NS	–	0.02	0.04; 1.92 (1.02–3.59)
Pre-PCI TIMI-flow <2	NS	–	<0.01	<0.01; 2.78 (1.40–5.51)
Presence of a CTO	NS	–	0.09	0.01; 0.34 (0.15–0.80)
Balloon postdilatation	<0.001	<0.001; 4.58 (2.26–9.30)	NS	–
Balloon predilatation	<0.01	NS	<0.001	<0.01; 2.02 (1.24–3.31)

ACEFm - modified age, creatinine, and ejection fraction score; CI - confidence interval; CSS - clinical SYNTAX score; CTO - chronic total occlusion; GRACE - Global Registry of acute coronary events; HR - heart rate; LVEF - left ventricular ejection fraction; NS - non significant; OR - odds ratio; PAMI - primary angioplasty in myocardial infarction score; PCI - percutaneous coronary intervention; TIMI - thrombolysis in myocardial infarction

Table 5. Receiver-operator characteristic curve analysis of different risk scores for the prediction of iatrogenic coronary artery dissection and angiographic no-reflow

Risk score	Complication	C-statistic	95%CI	Cut-off value	*P*
GRACE	ICAD	0.64	0.59-0.68	166	<0.01
	ANRP	0.62	0.57-0.66	152	<0.01
ACEFm	ICAD	0.63	0.58-0.67	1.4	<0.01
	ANRP	0.63	0.58-0.67	1.77	<0.001
CSS	ICAD	0.62	0.57-0.67	35.25	0.02
	ANRP	0.59	0.54-0.64	33.08	<0.01
PAMI	ICAD	–	–	–	NS
	ANRP	0.61	0.57-0.66	5	<0.001

ACEFm - modified age, creatinine, and ejection fraction score; ANRP - angiographic no-reflow phenomenon; CI - confidence interval; CSS - Clinical SYNTAX score; GRACE - Global Registry of acute coronary events; ICAD - iatrogenic coronary artery dissection; NS - non significant; OR - odds ratio; PAMI - primary angioplasty in myocardial infarction score

ability for coronary dissections as the clinical risk models, but failed to predict the occurrence of no-reflow independently.

Angiographically visible dissections may be identified in up to 40% of coronary balloon angioplasty procedures (19). Since the use of balloon predilatation is an inevitable step in many pPCI procedures, dissections caused by routine lesion predilatation were excluded from the present analysis. In contrast, vessel wall trauma due to aggressive manipulation of catheters/guide wires, or edge dissections caused by stent implantation at high pressures may be potentially preventable; these types of complications were present in almost 10% of the studied population. The presence of residual dissections after stent implantation has been found to be associated with adverse clinical events, mainly due to stent thrombosis, and subsequent target vessel revascularization (8, 20). Therefore, identifying the subset of patients at high risk of developing such complications has the potential to influence the interventional approach. In our study, coronary artery dissections were mainly related to procedural aspects, such as edge dissections after stent implantation. The single clinical variable significantly associated with coronary dissections was older age. This parameter is included in all the evaluated clinical and combined risk scores, but with different weighting factors, also reflected by the results of multiple logistic regression analyzes. In the PMS, age is used only as a categorical variable, representing 1 or 2 of a maximum of 15 points (1). In contrast, the GRS and the ACEFm take into account this variable as a continuous prognostic factor (21). Moreover, age is included twice in the calculation of the ACEFm, as it is also used at the estimation of creatinine clearance according to the Cockroft-Gault formula (15).

The SXS evaluates the complexity of coronary artery lesions causing at least 50% diameter stenosis (16), but not the overall plaque burden of coronary arteries. The atherosclerotic involvement of coronary artery segments increases with advanced age (22). The presence of atherosclerosis at the stent edges was found to be an independent predictor of edge dissection after stent implantation in a recent intravascular optical coherence

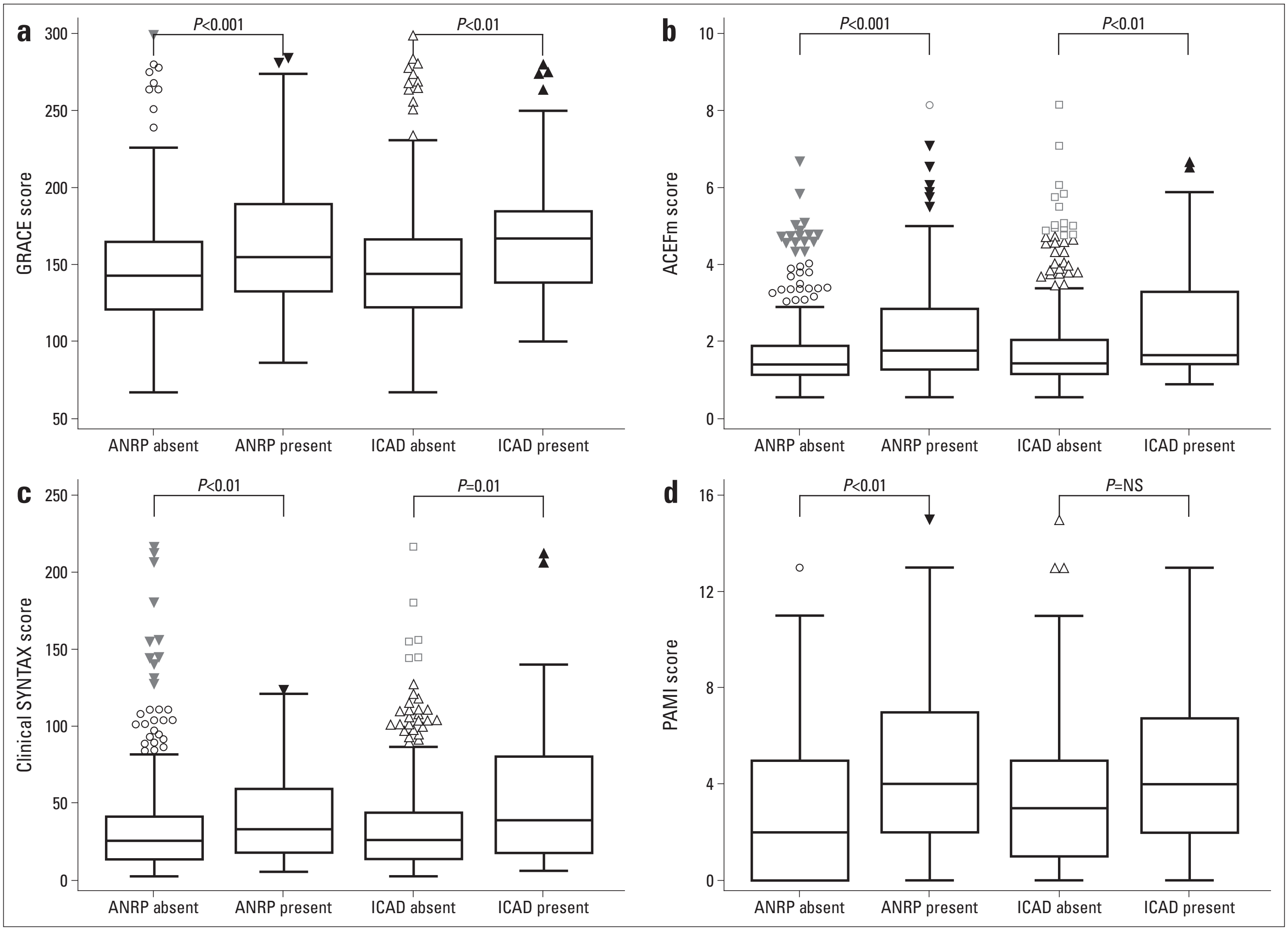

Figure 1. Different risk score values of patients with, vs. without no-reflow and iatrogenic coronary artery dissection: (a) GRACE score; (b) ACEFm score; (c) Clinical SYNTAX score; (d) PAMI score. Mann-Whitney U test was used as follows: The central boxes represent interquartile ranges, the lines inside the boxes the median values, while the different markers of triangles, squares and circles indicate outside and far out cases (with values smaller than the lower quartile minus 1.5, respectively 3 times the interquartile range, or larger than the upper quartile plus 1.5, respectively 3 times the interquartile range)

ACEFm - modified age, creatinine, and ejection fraction; ANRP - angiographic no-reflow phenomenon; GRACE - Global Registry of acute coronary events; ICAD - iatrogenic coronary artery dissection; PAMI - primary angioplasty in myocardial infarction score; SYNTAX - SYNergy between PCI with TAXUS™ and cardiac surgery

tomography study (23, 24). As the SXS was not associated with coronary dissections, we hypothesize that more extensive, but non-occlusive atherosclerosis in the elderly could at least partially explain the relationship between advanced age and coronary dissections. Obviously, in the setting of a retrospective clinical study, without intravascular ultrasound or -optical coherence tomography data, this remains only a speculative idea.

In most cases coronary dissections were successfully treated by additional stent implantation, whereas the higher complexity of the PCI procedure (more stents, additional balloon pre- and postdilatation) led to a higher incidence of no-reflow, another complication associated with adverse outcomes (25, 26).

Angiographic no-reflow occurs in >20–30% of pPCI procedures (18, 27). In the present study, the incidence of no-reflow was 27%, with a significant predominance in the higher tertiles of all the assessed risk scores, except for the SXS. This last observation is in contrast with the recent findings of Magro et al. (11) and Şahin et al. (12). Angiographically visible distal embolization, a strong independent predictor of no-reflow (10), has recently been found to be associated with low SXS values in STEMI patients (13). Although this finding was not confirmed by our results, and there is an obvious possibility of insufficient statistical power, these observations may stress the fact that one of the most important angiographic variables on which no-reflow depends, is thrombus burden (28). The importance of thrombus load is also reflected by the fact that TIMI 0–1 pre-PCI distal flow and the need of balloon predilatation were all independent predictors of no-reflow. Clot burden is not quantitatively reflected in the SXS: the presence of thrombus is included as a categorical variable, adding a single point to the score value of the culprit lesion and so to the overall risk score of a STEMI patient (16). The procedural step of manual thrombus aspiration was performed in

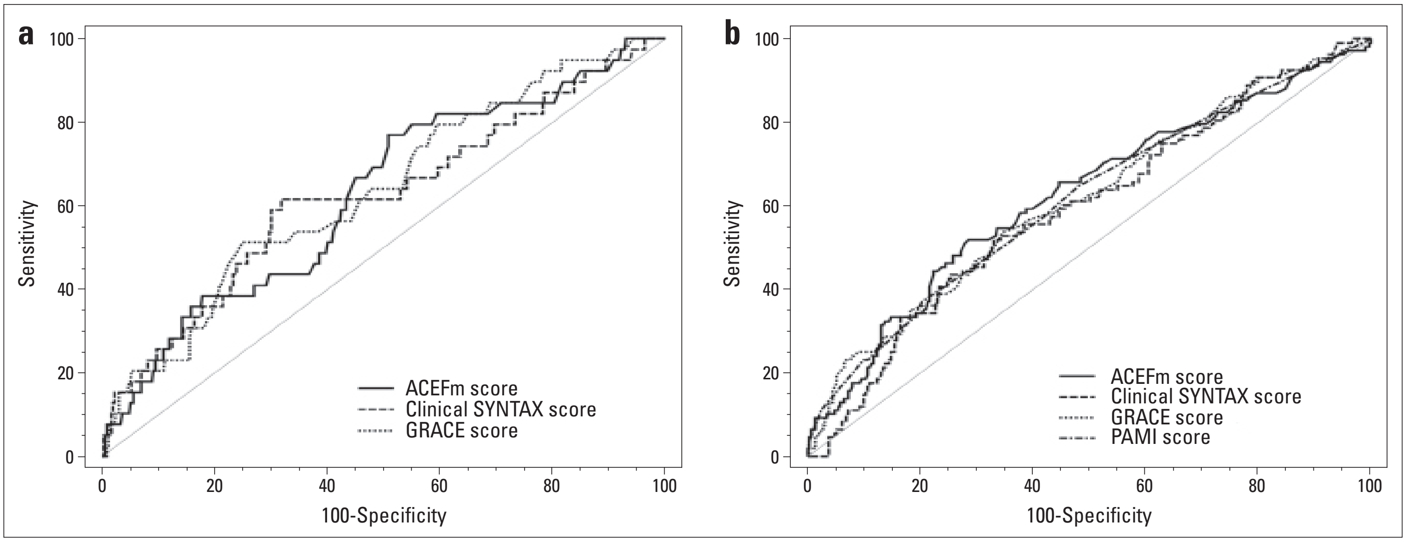

Figure 2. Receiver-operator characteristic curves determined for different risk scores in case of iatrogenic coronary artery dissection (a) and angiographic no-reflow phenomenon (b)

ACEFm - modified age, creatinine, and ejection fraction; GRACE - Global Registry of acute coronary events; PAMI - primary angioplasty in myocardial infarction

more than one third of the included cases. In the studied patients, aspiration thrombectomy did not prevent no-reflow, but was associated with a higher incidence of distal embolization. These results are in line with recent studies suggesting no benefit of manual thrombus aspiration in the setting of acute STEMI (29, 30). Interestingly, the presence of a CTO was associated with a low incidence of no-reflow in our study population, contributing to the relatively low incidence of this complication in the high SXS tertile. This finding may be related to ischemic preconditioning: the presence of a well-developed coronary collateral circulation was found to have a protective role against no-reflow (31, 32).

Numerous studies documented the association between no-reflow and clinical variables such as advanced age (33, 34), absence of smoking (33), faster heart rate (11), presentation with cardiac arrest (11), renal dysfunction (33, 35, 36), poor left ventricular ejection fraction (35), and a longer ischemic period (34). Many of these factors are included in the studied clinical and combined risk models, explaining their predictive ability for this procedural complication: the PMS contains two (age, heart rate) and the GRS four (age, heart rate, cardiac arrest and serum creatinine) of these univariate predictors. All the parameters included in the ACEFm were univariate predictors of no-reflow. While age was not tested separately in multiple logistic regression analysis in the present study, left ventricular ejection fraction<40% and higher serum creatinine values were associated with no-reflow independent of angiographic and procedural parameters.

According to ROC curve analysis, there were no significant differences between the C-statistic values of the tested clinical and combined risk models. However, whilst coronary dissections were predicted by GRS, ACEFm, and CSS, the occurrence of no-reflow was independently predicted only by GRS and ACEFm. Additionally, whereas PMS, GRS, and ACEFm are noninvasive, easy to use clinical risk scores, the determination of CSS is more difficult. Thus, the calculation of simple clinical risk scores such as ACEFm or GRS before the interventional procedure seems to be more useful. Quick pre-procedural risk stratification with one of these widely used, noninvasive scoring systems may provide additional information to the interventional cardiologist regarding the complexity of the pPCI. Less "aggressive" manipulation of catheters and guide wires, careful evaluation of the landing zone before stent implantation, direct stent implantation and less frequent high pressure balloon postdilatation might be considered to minimize the risk of dissection and no-reflow in STEMI patients with high values of these clinical risk scores.

Study limitations

The present study has some limitations, mostly linked to its retrospective nature and the rather low number of patients. Thus, our results should be regarded as hypothesis-generating and interpreted with some caution, due to possibly insufficient statistical power. Although the observed associations between clinical risk scores and angiographic complications are statistically significant, the calculated C-statistic values are <0.7. Therefore, more extensive research should be conducted to validate the results of the current study and to endorse the use of these scores for predicting pPCI-related complications in everyday clinical practice. Given their potential impact for the interventional approach of STEMI patients, current findings deserve to be assessed in larger, prospective clinical trials. Additionally, the authors would like to emphasize that operator-related factors are more important than patient-related factors, for the prevention of coronary artery dissections. The presented data reflects the experience of a single center. However, this reduced the heterogeneity of patient management strategies. Finally, left ventricular ejection fraction values included in ACEFm and CSS were obtained within the first 24 hours of hospital admission, but not necessarily before the pPCI.

Conclusion

Simple, noninvasive risk models–the GRS and the ACEFm–independently predicted the occurrence of two procedural complications of pPCI in STEMI patients: coronary dissections and no-reflow. Pre-interventional assessment of these scores may help the interventional cardiologist to prepare for procedural complications during pPCI. These findings should be confirmed in larger, prospective clinical trials.

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Attending the 5th Cardiology and Cardiovascular Surgery Summit were (left to right) chairman of the Turkish Society of Cardiovascular Surgery, Prof. Dr. Anil Z. Apaydın; Prof. Dr. Bilgin Timuralp; and selected chairman of the Turkish Society of Cardiology, Dr. Mustafa Kemal Erol