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Coronary Artery Disease

Relationship between ST-Segment Shifts in Lead aVR and Coronary Complexity in Patients with Acute Coronary Syndrome

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Background: ST-segment shifts in lead aVR are associated with increased coronary atherosclerosis. However, there is insufficient data about the relationship between ST-segment shifts in lead aVR and coronary complexity. The aim of this study was to investigate this relationship.

Methods: This prospective, observational study included 236 patients with acute coronary syndrome who underwent coronary angiography. Electrocardiograms on presentation were reviewed in terms of ST-segment shifts in lead aVR. Inter-observer agreement was analyzed using kappa statistics for the presence of aVR lead ST segment shifts. The patients were divided into two groups according to their Syntax (Sx) scores (≤ 22 and > 22).

Results: The mean age of the study population was 62.19 ± 12 years. Eighty-seven patients (37%) had complex coronary artery disease as defined by intermediate-high Sx scores, and 130 patients (55%) had ST-segment shifts in lead aVR. In multivariate logistic regression analysis, ST-segment elevation or depression ≥ 1 mm were independently associated with intermediate-high Sx scores.

Conclusions: In patients with acute coronary syndrome, the presence of ST-segment elevation or depression ≥ 1 mm in lead aVR may indicate coronary complexity.

Key Words: Coronary complexity • Lead aVR • ST-segment shifts • Syntax score

INTRODUCTION

Acute coronary syndrome (ACS) is a major cause of mortality worldwide. Twelve-lead electrocardiography (ECG) is the first step in the diagnosis and risk assessment of ACS.[1] However, several studies have shown that ST-segment shifts in lead aVR provide useful information about coronary anatomy and risk stratification for patients with ACS.[2,3] It is well known that ST-segment shifts in lead aVR are associated with left main and/or three-vessel disease in patients with ACS,[4] however, the aVR lead in ECG is ignored when making a diagnosis and stratifying the risk of ACS in routine practice.[5,6] The SYNergy between percutaneous coronary intervention with Taxus and cardiac surgery (Syntax) scoring system was developed to evaluate lesion complexity including lesion location, tortuosity, chronic total occlusion, presence of heavy calcification and thrombus.[7] The Syntax (Sx) score can help physicians to select revascularization options, and it can predict mortality and morbidity in patients with coronary artery disease.[8,9] Practical and reliable parameters are required to estimate the presence and severity of coronary artery disease to implement effective diagnostic and therapeutic strategies. However, there is currently insufficient data about the relationship between ST-segment shifts in lead aVR and coronary complexity as assessed by Sx score. The aim of this study was to evaluate the association between ST-segment shifts in lead aVR and coronary complexity as assessed by Sx

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score in patients with ACS.

MATERIAL AND METHODS

Patients

Two hundred and thirty-six consecutive patients presenting with ACS were included. Patients with ST-segment elevation at the J-point with cut-off points of ≥ 2 mm in men and ≥ 1.5 mm in women in leads V2-V3 and/or ≥ 1 mm in other leads in ≥ 2 contiguous leads were defined as having ST-elevation myocardial infarction (STEMI). Patients without persistent ST-segment elevation were diagnosed as having non-STEMI or unstable angina pectoris (UAP) based on cardiac-specific troponin tests. Patients with normal troponin levels were classified as having UAP. Patients with high troponin levels were defined as having non-STEMI.[10] Patients with a history of coronary artery disease, cardiopulmonary resuscitation before admission, moderate to severe valve disease, hypertrophic cardiomyopathy and bundle branch block on admission ECG were excluded from the study. Eligible subjects underwent a comprehensive assessment, including documentation of medical history, physical examination and measurement of laboratory variables. Diabetes was defined as currently receiving insulin or oral anti-diabetic drugs and/or diet or fasting blood glucose 7.0 mmol/l (126 mg/dl) or greater. Hypertension was defined as having a history of hypertension diagnosed and/or treated with medications, or systolic blood pressure greater than 140 mmHg or diastolic blood pressure greater than 90 mmHg on at least two occasions. Hyperlipidemia was defined as the use of lipid-lowering drugs. The Institutional Ethics Committee approved the study protocol. All patients gave written informed consent.

Electrocardiography

All ECGs obtained on presentation before percutaneous coronary interventions were reviewed specifically for ST-segment shifts in lead aVR (filter range 0.15 to 100 Hz, 25 mm/s, 10 mm/mV). ST-segment depression in other leads was defined as the presence of 1 mm or more ST-segment depression in two continuous leads, and was classified as anterior (V1 through V4), inferior (II, III, aVF) or lateral (I, aVL, V5, or V6) ST-segment depression. ST-segment shifts in lead aVR were defined as the presence of ST-segment elevation or depression of ≥ 0.5 mm. Measurement of ST-segment deviations from baseline was performed using a magnifying caliper at the J point. Two experienced cardiologists who were blinded to the patient's data evaluated all ECGs. One hundred randomly selected ECGs were independently evaluated for aVR lead ST-segment shifts by the two cardiologists to assess the reliability of aVR lead ST-segment shifts, and the Kappa value was 0.825 ($p < 0.001$).

Echocardiographic examination

Transthoracic echocardiography was performed for all patients within 48 hours after hospitalization. All patients were examined in the left lateral decubitus position using a commercially available system (Vivid 4 GE Medical System, Horten, Norway) with a phased-array 3.5-MHz transducer. The conventional M-mode and B-mode parameters were measured in accordance with the American Society of Echocardiography guidelines. Left ventricular end-diastolic and end-systolic diameters, and posterior and septal wall thicknesses were measured. Left ventricular ejection fraction was measured using the Teichholz method.

Coronary angiography

Coronary angiography was performed in all patients using the standard Judkin's technique (Siemens Axiom Artis zee; Siemens Healthcare, Erlangen, Germany). Coronary lesions with a luminal narrowing of ≥ 50%, in vessels with a size of ≥ 1.5 mm were considered for the calculation of Sx score. All angiographic variables of the Sx score were evaluated by two experienced cardiologists who were blinded to the procedural data and clinical outcomes. In cases of disagreement, the final decision was made by consensus. The latest online updated version of the Sx score calculator was used for all calculations (www.syntaxscore.com).[8] An Sx score of > 22 was defined as an intermediate-high Sx score.

Statistical analysis

Continuous variables were expressed as median and interquartile range, and categorical variables as number and percentage. The distributions of continuous variables across the study groups were tested with the Kolmogorov-Smirnov test. Based on the distribution of the data, continuous variables were compared using the Student's t test or Mann-Whitney U test. Categorical

data were compared using the chi-square test or Fisher's exact test, as appropriate. Univariate and multivariate logistic regression analyses were conducted to assess associations between ST-segment changes in lead aVR and intermediate-high Sx scores. In multivariate regression analysis (enter method), the effect size was adjusted for all potential variables with a univariate significance level of < 0.25. Adjusted odds ratios (ORs) along with their 95% confidence intervals (CI) were presented. A two-tailed p value < 0.05 was considered to be statistically significant. All statistical analyses were performed using IBM SPSS software (IBM SPSS Statistics for Windows, Version 21.0, IBM Corp., Armonk, NY).

RESULTS

A total of 236 patients with ACS (126 with non-STEMI, 89 with STEMI, and 21 with unstable angina) were enrolled, of whom 77% were males. The mean age was 62.19 ± 12 years. The Sx score ranged from 0 to 48.5, with a mean of 19.5 ± 10.2. Eighty-seven patients (37%) had intermediate-high Sx scores, and were defined as having complex coronary artery disease (CAD). One hundred and twenty-nine patients (55%) had ST-segment shifts in lead aVR on admission. Of these, 57 had ST-segment elevation ≥ 0.5 < 1 mm, 34 had ST-segment elevation ≥ 1 mm, 26 had ST-segment depression ≥ 0.5 < 1 mm, and 12 had ST-segment depression ≥ 1 mm. Both an ST-segment elevation of ≥ 1 mm (p = 0.001) and ST-segment depression of 0.5 mm-1 mm (p < 0.001) in aVR lead were associated with ST-segment elevation in other leads. In addition, ST-segment depressions in lateral derivations were associated with 0.5 mm-1 mm ST-segment elevation in aVR lead (p = 0.036). In addition, ST-segment depressions in anterior derivations were associated with ST-segment elevation of ≥ 1 mm in aVR lead (p = 0.023). There was no association between ST-segment depression in inferior leads and ST-segment shifts in aVR lead. Baseline, clinical and angiographic characteristics of the patients according to Sx scores are shown in Table 1. Patients with intermediate-high Sx scores were more likely to be older (60.26 ± 11.5 vs. 65.72 ± 11.28, p < 0.0001). Hypertension (p = 0.021) and ST-segment elevation or depression ≥ 1 mm (p ≤ 0.0001) in lead aVR on admission ECG were more common in the patients with intermediate-high Sx score compared to those with low Sx scores. In addition, diabetes mellitus (p = 0.068), male gender (p = 0.077) and left ventricular hypertrophy (p = 0.086) tended to be more prevalent and the left ventricular diastolic diameter (p = 0.072) was larger in the patients with intermediate-high Sx scores. Moreover, the patients with an intermediate-high Sx score had a significantly higher rate of multivessel coronary artery disease (p < 0.0001). Single, two and three-vessel diseases were detected in 68 (46%), 53 (36%) and 17 (11%) of the patients with low Sx scores, respectively, and 10 (12%), 42 (48%), and 35 (40%) of the patients with intermediate-high Sx scores, respectively. Coronary angiograms were normal in 11 patients.

Table 1. Baseline characteristics

	SYNTAX Score ≤ 22 (n = 149)	SYNTAX Score > 22 (n = 87)	p value
Age (years)	60.3 ± 11.5	65.7 ± 11.3	0.0005
Male, n (%)	121 (81.2)	62 (71.3)	0.077
Body mass index (kg/m^2)	26.6 (5.0)	26.3 (5.1)	0.682
Body surface area (m²)	1.84 ± 0.18	1.87 ± 0.18	0.308
Hypertension, n (%)	71 (47.7)	55 (63.2)	0.021
Diabetes mellitus, n (%)	29 (19.5)	26 (29.9)	0.068
Hyperlipidemia, n (%)	23 (15.4)	16 (18.4)	0.555
Smoking, n (%)	51 (34.2)	33 (37.9)	0.567
Obesity, n (%)	35 (23.5)	16 (18.4)	0.414
Medications, n (%)			
Acetylsalicylic acid	14 (9.4)	9 (10.3)	1.0
Beta blockers	7 (4.7)	4 (4.6)	0.972
ACE Inhibitors	39 (26.2)	31 (35.6)	0.125
Statins	21 (14.1)	11 (12.6)	0.754

Table 1. Continued

	SYNTAX Score ≤ 22 (n = 149)	SYNTAX Score > 22 (n = 87)	p value
ST segment changes in lead aVR, n (%)			
No ST segment changes	92 (61.7)	15 (17.2)	
ST-segment depression ≥ 1 mm	3 (2.0)	9 (10.3)	
ST-segment depression ≥ 0.5 < 1 mm	13 (8.7)	13 (14.9)	< 0.0001
ST-segment elevation ≥ 1.0 mm	9 (6)	25 (28.7)	
ST-segment elevation ≥ 0.5 < 1 mm	32 (21.5)	25 (28.7)	
Anterior ST-segment depression, n (%)	36 (24.2)	30 (34.5)	0.088
Lateral ST-segment depression, n (%)	29 (19.5)	22 (25.3)	0.294
Inferior ST-segment depression, n (%)	22 (14.8)	21 (24.1)	0.072
Echocardiographic parameters			
Left ventricular end-diastolic diameter (mm)	46 (4.0)	48.0 (5)	0.072
Left ventricular end-systolic diameter (mm)	32.0 (5.0)	32.0 (5)	0.132
Left ventricular ejection fraction, (%)	61.0 (13)	61 (10.03)	0.466
Left atrial dimeter (mm)	38.0 (6)	39.0 (7)	0.436
Interventricular septal thickness (mm)	11.0 (2.0)	11.0 (2)	0.860
Posterior wall thickness (mm)	11.0 (2.0)	11 (1)	0.908
Peak E velocity (cm/s)	60.1 ± 15.28	61.29 ± 15.95	0.796
Peak A velocity (cm/s)	70.0 (18.24)	75 (15.25)	0.102
E/A ratio	0.82 (0.43)	0.79 (0.20)	0.510
Deceleration time (ms)	240 (103)	250 (110)	0.504
Left ventricular hypertrophy, n (%)	17 (11.4)	17 (19.5)	0.086
Left ventricular mass (gram)	191 (45)	194 (40)	0.282
Left ventricular mass index (gram/m^2)	103 (30)	104 (19)	0.553
Peak troponin (ng/mL)	18 (46)	29 (46)	0.342
Clinical presentation (%)			
Unstable angina pectoris	14 (9.4)	7 (8)	
Non-ST segment elevation MI	77 (51.7)	49 (56.3)	0.782
ST segment elevation MI	58 (38.9)	31 (35.6)	
Diseased coronary vessels, n (%)			
Left main	4 (2.7)	12 (13.8)	0.001
Left anterior descending	81 (54.4)	69 (79.3)	0.00012
Circumflex	61 (40.9)	64 (73.6)	< 0.0001
Right	80 (53.7)	57 (65.5)	0.0076
Treatment procedures, n (%)			
Percutaneous coronary intervention	117(78.5)	52 (59.8)	0.002
Medical treatment	22 (14.8)	4 (4.6)	0.0016
Coronary artery bypass surgery	10 (6.7)	31 (35.6)	< 0.0001
Numbers of diseased vessel, n (%)			
Normal coronary artery	11 (7.4)	0 (0)	
Single vessel disease	68 (45.6)	10 (11.5)	< 0.0001
Two-vessel disease	53 (35.6)	42 (48.3)	
Three-vessel disease	17 (11.4)	35 (40.2)	
Arrhythmias during hospital stay, n (%)			
Atrial fibrillation	9 (6)	8 (9.2)	0.366
Ventricular tachycardia	3 (2)	4 (4.6)	0.228
Ventricular fibrillation, %	4 (2.7)	3 (3.4)	0.711

Continuous variables are presented as mean ± standard deviation or median (interquartile range). Categorical variables are presented as n (%). ACE, angiotensin converting enzyme; MI, myocardial infarction.

The left main coronary artery was the most common culprit vessel in the intermediate-high Sx score group. In the univariate analysis, there were significant differences between groups with an Sx score > 22 and Sx score ≤ 22 with respect to hypertension, age, number of diseased vessels, and ST-segment changes in lead aVR (Table 2). However, after multivariate logistic regression analysis, ST-segment elevation or depression ≥ 1 mm in the admission ECG were independently associated with intermediate-high Sx scores (Table 3) (Figure 1, Figure 2). The

Table 2. Univariate analysis

	p value	Odds ratio	95% confidence interval
Age	0.001	1.043	1.018-1.068
Male	0.079	0.574	0.309-1.067
Body surface area	0.307	2.166	0.491-9545
Body mass index	0.775	0.991	0.931-1.055
Hypertension	0.021	1.888	1.099-3.245
Diabetes	0.069	0.567	0.307-1.046
Smoking	0.567	1.174	0.678-2.035
Hyperlipidemia	0.556	1.235	0.612-2.489
Medications			
Acetylsalicylic acid	0.813	1.113	0.460-2.689
Beta blocker	0.972	1.023	0.291-3.599
ACE inhibitors	0.126	1.561	0.882-2.763
Statin	0.754	0.882	0.403-1.930
Clinical presentation			
Unstable angina pectoris		Reference category	
Non ST segment elevation MI	0.628	1.273	0.480-3.376
ST segment elevation MI	0.897	1.069	0.391-2.925
Echocardiographic parameters			
Left ventricular end-diastolic diameter	0.136	1.052	0.984-1.125
Left ventricular end-systolic diameter	0.306	1.027	0.976-1.081
Left atrial diameter	0.460	1.025	0.960-1.094
Interventricular septal thickness	0.894	1.015	0.816-1.262
Posterior wall thickness	0.565	0.927	0.715-1.201
E/A ratio	0.384	0.695	0.306-1.579
Deceleration time	0.583	1.001	0.997-1.005
Left ventricular mass index	0.753	1.002	0.990-1.014
Left ventricular ejection fraction	0.668	0.995	0.971-1.019
Anterior ST-segment depression	0.090	1.652	0.925-2.950
Lateral ST-segment depression	0.295	1.401	0.745-2.632
Inferior ST-segment depression	0.074	1.837	0.942-3.582
ST segment change in lead aVR			
No ST change (zero or < 0.5 mm)		Reference category	
≥ 0.5 < 1 mm ST segment depression	< 0.001	6.133	2.389-15.745
≥ 1 mm ST segment depression	< 0.0001	18.400	4.465-75.822
≥ 0.5 < 1 mm ST segment elevation	< 0.0001	4.792	2.250-10.205
≥ 1 mm ST segment elevation	< 0.0001	17.037	6.674-43.492
ST segment change in lead aVR			
No ST change (zero or < 0.5 mm)		Reference category	
≥ 0.5 mm ST segment depression	< 0.0001	8.433	3.626-19.616
≥ 0.5 mm ST segment elevation	< 0.0001	7.480	3.773-14.829
Any ST segment change in lead aVR	< 0.0001	7.747	4.057-14.796

ACE, angiotensin converting enzyme; CI, confidence interval; MI, myocardial infarction.

Table 3. Multivariate analysis

	Regression coefficient	Odds ratio	95% confidence interval
Model 1			
No ST change (zero or < 0.5 mm)		Reference category	
≥ 0.5 < 1 mm ST segment depression	1.814	6.1	2.6-16.7
≥ 1 mm ST segment depression	3.253	25.8	5.6-119.2
≥ 0.5 < 1 mm ST segment elevation	1.715	6.5	2.5-12.6
≥ 1 mm ST segment elevation	2.795	16.3	5.8-45.9
Model 2			
No ST change (zero or < 0.5 mm)		Reference category	
≥ 0.5 mm ST segment depression	1.95	7.1	3.4-14.5
≥ 0.5 mm ST segment elevation	2.1	8.2	3.4-19.5
Model 3			
Any ST segment change (≥ 0.5 mm)	2.0	7.4	3.7-14.6

In all regression models index variable was adjusted for age, male gender, history of hypertension, history of diabetes, use of angiotensin converting enzyme inhibitors, left ventricular end-diastolic diameter, anterior ST-segment depression and inferior ST-segment depression.

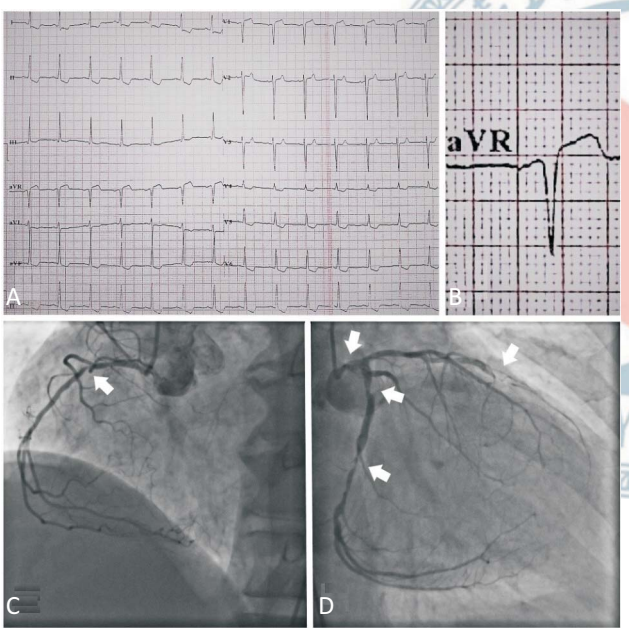

Figure 1. *A 74-year-old female patient admitted with diagnosis of non-STEMI. She had ≥ 1-mm ST-segment elevation in the aVR lead on admission electrocardiography (ECG) and her syntax score was intermediate-high according to the coronary angiography findings (Sx score: 38.5). (A, B) ECG with ≥ 1-mm ST-segment elevation in the aVR lead. (C) Right coronary artery. (D) Left coronary artery system.*

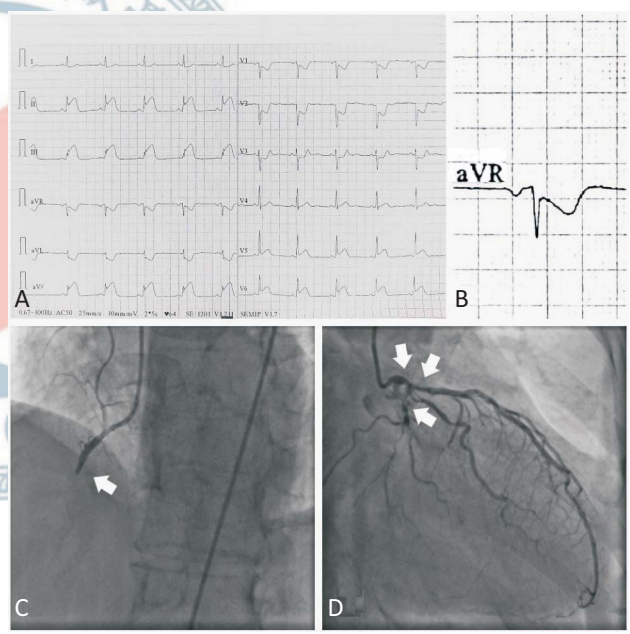

Figure 2. *A 54-year-old male patient admitted with diagnosis of inferior posterior lateral STEMI. He had ≥ 1-mm ST-segment depression in the aVR lead on admission ECG and his syntax score was intermediate-high according to the coronary angiography finding (Sx score: 30). (A, B) ECG with ≥ 1-mm ST-segment depression in the aVR lead. (C) Right coronary artery. (D) Left coronary artery system.*

adjusted ORs of ST-segment elevation ≥ 1 mm and ST-segment depression ≥ 1 mm in lead aVR in the admission ECG for predicting an intermediate-high Sx score were 16.3 (95% CI 5.8-45.9) and 25.8 (95% CI 5.6-119.2), respectively. We also evaluated ST-segment elevation of the aVR lead in combination with ST-segment depression in the anterior, inferior, and lateral leads. Multivariate regression analysis was conducted to determine the variables predicting a moderate-high Sx score, and the ORs were 5.110 (95% CI 2.175-12.006), 7.056 (95% CI 1.827-27.243), 8.980 (95% CI 1.009-79.911) and 2.038 (95% CI 0.466-8.917) for aVR ST-segment elevation alone,

combined with anterior, inferior and lateral ST-segment depression, respectively. The ORs were 5.230 (95% CI 1.294-21.142) and 7.974 (95% CI 0.815-78.019) for aVR lead ST-segment depression alone and combined with other lead ST-segment elevation, respectively.

DISCUSSION

The Sx score plays a pivotal role in making decisions with regards to revascularization in patients with left main and/or three-vessel coronary artery disease. In this study, we found an independent and strong association between intermediate-high Sx score and ST-segment elevation or depression ≥ 1 mm in lead aVR in patients with ACS.

AVR lead has been given the attention it warrants in clinical practice. It is an important indicator of cardiovascular mortality in patients with ACS.[11,12] ST-segment elevation in aVR lead is also indicative of recurrent myocardial infarction, development of heart failure, and the need for coronary bypass surgery.[13] AVR lead is directionally opposite to standard leads I and II and chest leads V5 and V6, and it is non-adjacent to any other lead. ST-segment depressions in the other 11 leads are more frequent in patients with aVR lead ST-segment elevation.[13,14] Consistent with these findings, we found that the prevalence of ST-segment depression in non-aVR leads was more common in patients with ST-segment elevation in lead aVR than in those without ST-segment elevation in aVR lead. Although ST-segment elevation in aVR lead is often associated with ST-segment depression in other leads, it had an independent prognostic value in this study. Wong and colleagues followed 17,073 patients with ST elevation myocardial infarction for 30 days, and found that ST-segment elevation in aVR lead was an important predictor of 30-day cardiovascular mortality independently of ST-segment depression in other leads.[11] In the present study, aVR lead ST-segment elevation was related to Sx score independently of ST-segment depression in other leads. Similarly, Nabati and colleagues found that aVR lead ST-segment elevation alone was associated with coronary atherosclerosis extension and low ejection fraction in patients with ACS.[10] We did not find a meaningful association between ejection fraction and aVR lead ST-segment elevation in this study. However, male gender, left main coronary artery (LMCA) lesions, hypertension and left ventricular hypertrophy were more frequent in the group with ≥ 1 mm ST-segment elevation in aVR lead. Hypertension, diabetes and atrial fibrillation were also higher in the group with ≥ 1 mm ST-segment depression in aVR lead. A previous study investigating the relationship between ST-segment change and Sx score included patients with non-ST elevation myocardial infarction.[14] In contrast, we included all ACS patients including those with non-ST elevation myocardial infarction.

Cardiologists need simple predictors of coronary complexity before coronary angiography to assist in deciding medical treatment, especially antiplatelet therapy. Such simple predictors could be helpful for revascularization decisions and to estimate the difficulty of stent implantation during coronary angiography. They could also be helpful for estimating the prognosis after coronary angiography. ST-segment shifts in the aVR lead have been associated with left main and/or three-vessel coronary artery disease, and been reported to predict cardiovascular mortality and morbidity such as an intermediate-high Sx score.[13,15-17] Supporting the present study, Cerit L et al. retrospectively reviewed admission ECGs of 117 non-STEMI patients, and reported a significant correlation between ST elevation ≥ 0.5 mm in aVR lead and an intermediate-high Sx score[13] Different from Cerit's study, we prospectively included more patients with ACS (STEMI, non-STEMI and USAP). In Cerit's study, ST elevation ≥ 0.5 mm in aVR lead was associated with an intermediate-high Sx score, while ST shifts ≥ 1 mm (either elevation or depression) in aVR lead were associated with an intermediate-high Sx score in our study. This difference may be due to the fact that the study populations consisted of different patient groups.

Identifying high-risk individuals may facilitate the process whereby modifiable risk factors can be controlled in order to prevent coronary heart disease.[18] Several risk scores are used to determine cardiovascular risks, including the Framingham risk score, the Prospective Cardiovascular Münster score, and Systematic Coronary Risk Evaluation risk scores. All of these risk scores have been associated with the Sx score.[18,19] The Sx score is more suitable to determine cardiovascular risks because it is based on coronary anatomy and lesion complexity. The definition of complex lesions includes vessel

bifurcation, trifurcation, the presence of thrombus, involvement of the left main coronary artery and the number of "difficult" lesions that are heavily calcified or diffuse, lesions in vessels with excessive tortuosity, and chronic totally occluded lesions.[20] Coronary complexity is very important to determine the treatment options, and it can provide information about how percutaneous coronary interventions could be difficult.[21] Patients are generally classified into three different risk levels by Sx score. In the present study, we classified the patients into two groups according to Sx score, because patients with a low Sx score could equally be treated with either percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG), whereas those with an intermediate-high Sx score are better treated with CABG.[22] The predictive value of the Sx score has been demonstrated in several studies in patients undergoing PCI for three-vessel CAD and/or unprotected LMCA disease.[23] The 5-year results of the Syntax trial showed a statistically significant relationship between intermediate-high Sx score risk categories and worse outcomes of PCI in patients with multivessel disease compared with CABG,[24] and it was concluded that CABG should remain the standard of care for patients with complex lesions (intermediate-high Sx scores). For the patients with less complex disease (low Sx score) or left main coronary artery disease (low Sx score), PCI is an acceptable alternative. All patients with complex multivessel coronary artery disease should be reviewed and discussed by both a cardiac surgeon and interventional cardiologist to reach a consensus on the optimum treatment.

The Sx score has several benefits in addition to assisting in selecting optimal revascularization options and risk identification. It can also alert interventional cardiologists to potential complication with PCI such as periprocedural myocardial infarction, which is associated with a poor prognosis. In the Twente trial, Tandjung et al. demonstrated that an elevated Sx score is associated with a five-fold higher risk of periprocedural myocardial infarction.[25] In addition, hemorrhagic events after PCI are associated with high rates of morbidity and mortality. Madhavan et al. showed with the Acuity trial that a high Sx score was associated with major bleeding after PCI in patients with non-STEMI ACS. Meanwhile it has been shown that the Sx score can also predict contrast-induced nephropathy after PCI.[26,27] Another complication of PCI is silent embolic cerebral infarction, which is a major complication of coronary angiography and PCI. Deveci et al. reported that Sx score was an independent predictor of silent embolic cerebral infarction after coronary angiography and PCI.[28] The Sx score is a useful risk score for patients with ACS, along with ECG as the first step in the diagnosis of ACS. The present study suggests that with a simple ECG, the Sx score may be estimated using the aVR lead.

Limitations

The present investigation has several limitations. It is a single-center study and includes a small number of patients. Another limitation is that there was no follow-up of the patients, and therefore we could not provide any prognostic data in terms of future cardiovascular events. In addition, the pathophysiological mechanisms could not be confirmed. Finally, the assessment of angiographic findings was limited to visual interpretation.

CONCLUSIONS

In the present study, we found a strong association between ST-segment elevation or depression $\geq$ 1 mm in lead aVR and coronary complexity assessed by Sx score in patients with ACS. Evaluating ST-segment shifts in lead aVR on admission ECG can be useful for making treatment decisions in patients with ACS. Further investigations are necessary to verify our findings.

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None.

CONFLICTS OF INTEREST

None declared.

REFERENCES

1. Liang D, Zhang J, Lin L, Zong W. The difference on features of fragmented qrs complex and influences on mortality in patients with

acute coronary syndrome. *Acta Cardiol Sin* 2017;33:588-95.
2. Nough H, Jorat MV, Varasteravan HR, et al. The value of ST-segment elevation in lead aVR for predicting left main coronary artery lesion in patients suspected of acute coronary syndrome. *Rom J Intern Med* 2012;50:159-64.
3. Kosuge M, Kimura K, Ishikawa T, et al. ST-segment depression in lead aVR: a useful predictor of impaired myocardial reperfusion in patients with inferior acute myocardial infarction. *Chest* 2005; 128:780-6.
4. Rostoff P, Piwowarska W, Konduracka E, et al. Value of lead aVR in the detection of significant left main coronary artery stenosis in acute coronary syndrome. *Kardiol Pol* 2005;62:128-35; discussion 36-7.
5. Pahlm US, Pahlm O, Wagner GS. The standard 11-lead ecg. Neglect of lead aVR in the classical limb lead display. *J Electrocardiol* 1996;29 Suppl:270-4.
6. Chenniappan M, Sankar RU, Saravanan K, Karthikeyan. Lead aVR --the neglected lead. *J Assoc Physicians India* 2013;61:650-4.
7. Serdar Kuyumcu M, Kuyumcu A, Yayla C, et al. The relationship between nesfatin-1 levels and SYNTAX score in patients with non-ST segment elevation myocardial infarction. *Acta Cardiol Sin* 2018;34:386-93.
8. Sianos G, Morel MA, Kappetein AP, et al. The syntax score: an angiographic tool grading the complexity of coronary artery disease. *EuroIntervention* 2005;1:219-27.
9. Scherff F, Vassalli G, Surder D, et al. The syntax score predicts early mortality risk in the elderly with acute coronary syndrome having primary pci. *J Invasive Cardiol* 2011;23:505-10.
10. Smith JN, Negrelli JM, Manek MB, et al. Diagnosis and management of acute coronary syndrome: an evidence-based update. *J Am Board Fam Med* 2015;28:283-93.
11. Nabati M, Emadi M, Mollaalipour M, et al. ST-segment elevation in lead aVR in the setting of acute coronary syndrome. *Acta Cardiol* 2016;71:47-54.
12. Wong CK, Gao W, Stewart RA, et al. AVR ST elevation: an important but neglected sign in st elevation acute myocardial infarction. *Eur Heart J* 2010;31:1845-53.
13. Barrabes JA, Figueras J, Moure C, et al. Prognostic value of lead aVR in patients with a first non-ST-segment elevation acute myocardial infarction. *Circulation* 2003;108:814-9.
14. Cerit L. Chicken or the egg: ST elevation in lead aVR or syntax score. *Cardiovasc J Afr* 2017;28:100-3.
15. Williamson K, Mattu A, Plautz CU, et al. Electrocardiographic applications of lead aVR. *Am J Emerg Med* 2006;24:864-74.
16. Kosuge M, Kimura K, Ishikawa T, et al. Combined prognostic utility of ST segment in lead aVR and troponin t on admission in non-ST-segment elevation acute coronary syndromes. *Am J Cardiol* 2006;97:334-9.
17. Hennings JR, Fesmire FM. A new electrocardiographic criteria for emergent reperfusion therapy. *Am J Emerg Med* 2012;30:994-1000.
18. Tolunay H, Kurmus O. Comparison of coronary risk scoring systems to predict the severity of coronary artery disease using the syntax score. *Cardiol J* 2015.
19. Yalcin M, Kardesoglu E, Aparci M, et al. Cardiovascular risk scores for coronary atherosclerosis. *Acta Cardiol* 2012;67:557-63.
20. Wilensky RL, Selzer F, Johnston J, et al. Relation of percutaneous coronary intervention of complex lesions to clinical outcomes (from the nhlbi dynamic registry). *Am J Cardiol* 2002;90:216-21.
21. Kappetein AP, van Mieghem NM, Head SJ. Revascularization options: coronary artery bypass surgery and percutaneous coronary intervention. *Heart Fail Clin* 2016;12:135-9.
22. Authors/Task Force m, Windecker S, Kolh P, et al. 2014 ESC/EACTS guidelines on myocardial revascularization: the task force on myocardial revascularization of The European Society of Cardiology (ESC) and The European Association for Cardio-thoracic Surgery (EACTS) developed with the special contribution of The European Association of Percutaneous Cardiovascular Interventions (EAPCI). *Eur Heart J* 2014;35:2541-619.
23. Valgimigli M, Serruys PW, Tsuchida K, et al. Cyphering the complexity of coronary artery disease using the syntax score to predict clinical outcome in patients with three-vessel lumen obstruction undergoing percutaneous coronary intervention. *Am J Cardiol* 2007;99:1072-81.
24. Mohr FW, Morice MC, Kappetein AP, et al. Coronary artery bypass graft surgery versus percutaneous coronary intervention in patients with three-vessel disease and left main coronary disease: 5-year follow-up of the randomised, clinical syntax trial. *Lancet* 2013;381:629-38.
25. Tandjung K, Lam MK, Sen H, et al. Value of the syntax score for periprocedural myocardial infarction according to who and the third universal definition of myocardial infarction: insights from the twente trial. *EuroIntervention* 2015;11.
26. Madhavan MV, Genereux P, Rubin J, et al. Usefulness of the syntax score to predict acute kidney injury after percutaneous coronary intervention (from the acute catheterization and urgent intervention triage strategy trial). *Am J Cardiol* 2014;113:1331-7.
27. Liu CW, Liao PC, Chen KC, et al. Syntax score of infarct-related artery other than the number of coronary balloon inflations and deflations as an independent predictor of contrast-induced acute kidney injury in patients with ST-segment elevation myocardial infarction. *Acta Cardiol Sin* 2017;33:362-76.
28. Deveci OS, Celik AI, Ikikardes F, et al. The incidence and the risk factors of silent embolic cerebral infarction after coronary angiography and percutaneous coronary interventions. *Angiology* 2016;67:433-7.