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Original Article

Simplified Selvester QRS Score as an Infarct Size Parameter in STEMI Patients Undergoing Pharmacoinvasive or Primary Percutaneous Coronary Intervention

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Abstract

Background: Cardiovascular disease especially acute myocardial infarction (AMI) is one of the highest causes of mortality worldwide. The majority of AMI comes in the form of an ST-elevation myocardial infarct (STEMI) that requires timely diagnosis and revascularization management to restore myocardial circulation. The simple method to estimate infarct size is by using a simplified Selvester QRS Score to electrocardiogram records, which is a tested method that has a good correlation with the gold standard, namely cardiac magnetic resonance imaging.

Objective: To investigate the difference in infarct size with simplified Selvester QRS score parameters between STEMI patients undergoing pharmacoinvasive compared to primary PCI.

Methods: Eighty-two STEMI patients, 41 of pharmacoinvasive and 41 of primary PCI were scored with simplified Selvester QRS score from electrocardiogram recording. Patient data are retroactively taken from Sardjito Cardiovascular Intensive Care (SCIENCE) registry. Scoring simplified Selvester QRS Score was done by two experienced cardiologists blinded to the patient procedure, and results were then measured for interobserver agreement with the Bland-Altman test. A comparison of QRS Scores in pharmacoinvasive and primary PCI groups was done with an independent sample T-test followed by a multivariable linear regression test.

Results: The means of simplified Selvester QRS score in the pharmacoinvasive and primary PCI group is 7.240±3.015 and 8.900±4.188, p=0.043, respectively. Independent sample T-test shows a significant difference in the simplified Selvester QRS score in the pharmacoinvasive and primary PCI groups. The multivariable analysis shows that variables other than the revascularization method independently influence QRS score are onset, anterior segment ST elevation, and ST-segment elevation in more > than 3 leads in the electrocardiogram.

Conclusion: There is a significant difference in infarct size measured by simplified Selvester QRS score between STEMI patients undergoing pharmacoinvasive method compared to primary PCI procedure, which is lower in the pharmacoinvasive group.

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Keywords: infarct size; electrocardiogram; STEMI; pharmacoinvasive; primary PCI.

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Introduction

Management of STEMI patients requires timely and accurate diagnosis and immediate revascularization which aims to minimize myocardial cell damage and complications.[1,2] In general, it is known that the short and long-term prognosis of STEMI patients is directly related to the size of left ventricular infarction.[3,4] Therefore, a reliable method is required to estimate the extent of myocardial infarction.[5] There are studies about the evaluation of several methods aimed at estimating the size of myocardial infarction.[6,7] The gold standard of this measurement is the use of Contrast-Enhanced Magnetic Resonance Imaging, as this method provides precise in vivo estimation of infarct area in a non-invasive manner.[8] However, this examination is difficult to perform because of the limited number of facilities and resources and high cost as well.[9] Another method that is simpler and easier to use at a lower cost is the application of a scoring system by electrocardiogram recording.[10,11]

Our hospital, Dr. Sardjito Hospital is a tertiary center in the region that can carry out revascularization measures for STEMI by using primary PCI and pharmacoinvasive methods. Primary PCI is an attempt to revascularize the coronary artery without the administration of fibrinolysis drugs but with coronary intervention using stents, balloons, or other recommended devices. The pharmacoinvasive method is an attempt to revascularize the coronary artery by giving full doses of fibrinolytic agents, both specific and non-specific, and followed by angiography and PCI within 2 to 24 hours, namely immediate rescue PCI if fibrinolysis fails or angiography evaluation and PCI as appropriate for successful fibrinolysis. Our previous study found that the average time for performing primary PCI was 200 minutes, which was longer than the target of less than 120 minutes.[12] This delay was caused by many factors, both technical and non-technical constraints.[12] There has never been a study comparing the myocardial infarct area in STEMI patients undergoing revascularization with fibrinolysis and primary PCI in our hospital. The study aims to investigate the difference in myocardial infarct area between STEMI patients who received the pharmacoinvasive method and who underwent primary PCI by assessing post-intervention electrocardiogram recordings using the Selvester QRS scoring system. The Selvester QRS score is a scoring system developed by Selvester et al.(1985) using 12-lead electrocardiogram recordings to estimate the extent of myocardial infarct size.[5] It consists of 54 criteria with 32 points based on the criteria for Q and R wave duration, R and S wave amplitude, R/Q and R/S ratio, and QRS notch in 10 of the 12 electrocardiogram leads.[5]

Methods

This research was an observational study. The study design was cross-sectional. The data taken were secondary data of STEMI patients who were treated at RSUP Dr. Sardjito and had been registered in the Sardjito Cardiovascular Intensive Care Registry (SCIENCE registry). The subjects of this study were STEMI patients who were treated at the intensive cardiovascular care unit (ICCU) of Dr. Sardjito Hospital that were registered in the SCIENCE registry starting in July 2019. The sampling was carried out consecutively from the subjects who met the research criteria until the number of subjects was met. The inclusion criteria were (1) patients with male and female sexes, (2) 18 years old or older, (3) patients diagnosed with STEMI with onset < 24 hours, (4) patients underwent revascularization by primary PCI or fibrinolysis and (5) patients were treated at the ICCU of Dr. Sardjito hospital and (6) patients registered in the SCIENCE registry. The exclusion criteria were (1) patients who underwent fibrinolysis and performed angiography in > 24 hours, (2) patients who underwent fibrinolysis but not receiving full-dose fibrinolytic agents, (3) patients with a history of coronary artery bypass surgery, (4) patients with a history of previous infarction, (5) patients with a history of pacemaker insertion, (6) patients with confounding factors from the electrocardiogram recording (bundle branch block, fascicular block, ventricular hypertrophy, and preexcitation), (7) an unreadable quality of electrocardiogram recording, and (8) patients with congenital heart disease and coronary anomalies.

The electrocardiogram recording used was carried out with a standard 12-lead surface electrocardiography, with a voltage configuration of 10mm/mv and a speed of 25mm/s. The electrocardiogram recording was done after the primary PCI procedure in the acute phase, which was 30-60 minutes after the primary PCI procedure was

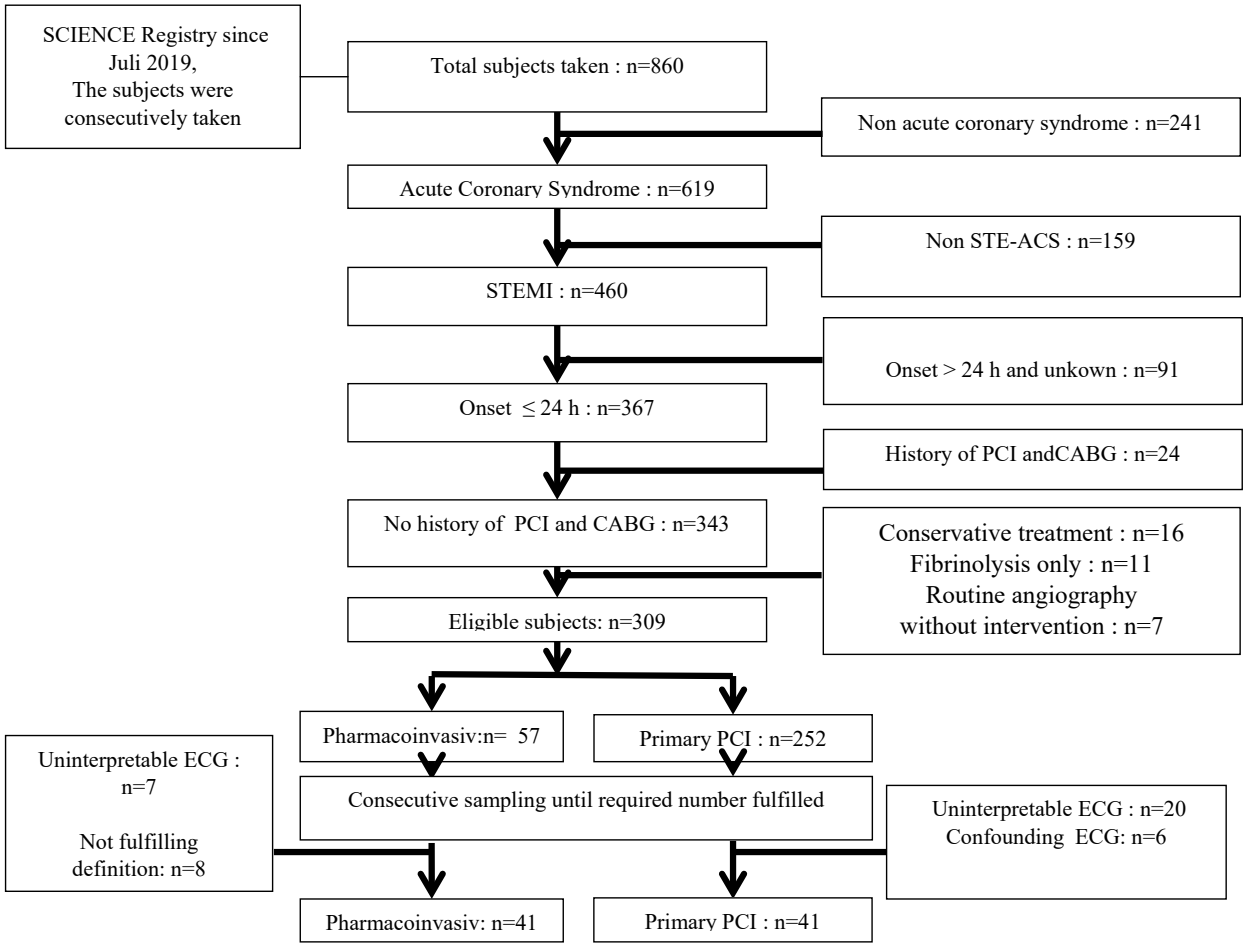

Figure 1. The flow of research subjects enrollment and sample selection.

completed, then the QRS score was calculated using the Simplified Selvester QRS Scoring System method which consisted of 37 criteria and produced a maximum of 29 points. The simplified Selvester QRS score is a simplification of the Selvester QRS scoring system in which qualitative criteria such as the notch and absolute amplitude of the QRS wave deflection are not evaluated, resulting in 37 criteria being applied to 10 ECG leads, resulting in 29 points. The electrocardiogram assessment was carried out by two investigators who were blinded to the patient's procedure. The investigators were experienced cardiologists, who had been educated on how to assess the Selvester Simplified QRS Score. Furthermore, the Bland-Altman test was also carried out to find the interobserver agreement of the numerical calculation results.

The basic characteristic data were presented in frequency and percentage for categorical data and the form of mean and standard deviation for numerical data. The normality of the data will be analyzed by the Shapiro-Wilk test. The comparative analysis for numerical data was performed by an unpaired T-test if the data variance was normal and the Mann-Whitney test if the data variance was not normal. Confounding factor analysis was performed using bivariate analysis followed by multivariate analysis. Bivariate analysis was performed with Pearson's or Spearman's if the variables were numerical. The analysis used an unpaired t-test or Mann-Whitney test if the variables were categorical. The multivariate analysis was performed with multiple linear regression. A p-value <0.05 was set as a statistical significance.

Table 1. Basic characteristics of subjects from the pharmacoinvasive and primary PCI group.

Characteristics	Pharmacoinvasive (n=41)	Primary PCI (n=41)
Age	55 (51-61)	59 (52.2-70)
Gender, n (%)		
Male	36 (87.8)	32 (78.0)
Female	5 (12.2)	9 (22.0)
Onset	4.5 (3-6.5)	7 (4.5-10.5)
Body mass index	23.44 (21.84 – 27.07)	23.78 (21.48 – 25.71)
Risk Factor, n (%)		
Smoker	31 (75.6)	21 (51.2)
Hypertension	16 (39.0)	21 (51.2)
Diabetes mellitus	13 (31.7)	8 (19.5)
Dyslipid	34 (82.9)	36 (87.8)
Vital signs		
Systolic blood pressure	122.65±22.812	136.18±27.011
Diastolic blood pressure	73.55±11.036	78.17±18.140
Heart rate	81.65±17.194	75.22±21.264
ST-elevation location, n (%)		
Anterior	17 (41.5)	27 (65.9)
Inferior	24 (58.5)	15 (36.6)
Posterior	10 (24.4)	6 (14.6)
Lateral	10 (24.4)	8 (19.5)
Dextra	6 (14.6)	8 (19.5)
Diagnostic ST-Elevation electrocariogram, n (%)		
3 Leads	15 (36.6)	13 (31.7)
>3 Leads	26 (63.4)	28 (68.3)
Left ventricle morphology, n (%)		
Normal	9 (22.0)	9 (22.0)
Concentric remodeling	28 (68.3)	25 (61.0)
Eccentric remodeling	4 (9.8)	7 (17.1)
The coronary vessel involved, n (%)		
≤ 1 vessel	21 (51.2)	16 (39.0)
>1 vessel	20 (48.8)	25 (61.0)
Coronary lesion section, n (%)		
Proximal	24 (58.5)	29 (70.7)
Distal	16 (39.0)	12 (29.3)
Unknown	1 (2.4)	0 (0)
Use of anti-hypertension, n (%)		
Yes	8 (19.5)	8 (19.5)
No	33 (80.5)	33 (80.5)
Pre-intervention drugs, n (%)		
Unfractionated/Low molecular weight heparin	17 (41.5)	7 (17.1)
Nitrate	23 (56.1)	21 (51.2)
Inotropic/vasoconstrictor	13 (31.7)	6 (14.6)
Opioid	8 (19.5)	4 (9.8)
Culprit lesion, n (%)		
Left coronary artery	19 (46.3)	27 (65.9)
Right coronary artery	22 (53.7)	14 (34.1)
TIMI risk score, n (%)		
TIMI 0-2	5 (12.2)	6 (14.6)
TIMI 3	36 (87.8)	35 (85.4)

Characteristics	Pharmacoinvasive (n=41)	Primary PCI (n=41)
Laboratorium results		
Haemoglobin, g/dL	13.72 ± 1.68	13.43 ± 1.85
Platelet counts, 103/mm3	242.04±68.8	265.37 ± 71.33
Hs-Troponin I, ng/mL	40000 (3237.97 – 40000)	4733.7 (599.75 – 33486.15)
Fibrinolytic agent, n (%)		
Streptokinase	25 (61.0)	
Alteplase	16 (39.0)	
Percutaneous coronary intervention, n (%)		
Rescue	27 (65.9)	
Routine/evaluation	14 (34.1)	
Hospital ischemic time	159 (125 – 288)	135 (99 – 172.5)
Time until electrocardiogram	8.7 (6.15 – 13.95)	9.1 (7.25 – 13.2)
Ejection fraction by echocardiography	46.94 ± 10.29	43.98 ± 10.762

Value in means±standard deviation or median (interquartile range) for numerical data

Table 2. The difference in the value of the simplified Selvester QRS score between the pharmacoinvasive method and primary PCI groups.

		Mean	Mean	Primary PCI (n=41)
Group	Pharmcoinvasive	7.240	3.015	0.043
	Primary PCI	8.900	4.188	0.043

Table 3. Bivariate analysis of numerical confounding variables using Pearson and Spearman tests.

Numerical variables	Bivariate correlation		
	Pearson	Spearman	p-value
Age		-0.065	0.563
Onset		0.137	0.221
Body mass index		-0.223	0.044
Systolic blood pressure	0.054		0.634
Diastolic blood pressure	0.114		0.313
Heart rate	-0.168		0.133
Haemoglobin	0.099		0.377
Platelet counts	0.097		0.377
Hs-troponin I	0.126		0.264
Hospital ischemic time		-0.037	0.743
Time until electrocardiogram		-0.002	0.987
Left ventricle ejection fraction	-0.107		0.340

Result

The STEMI patients who met the inclusion and exclusion criteria were retrieved consecutively from the SCIENCE registry. From the registry, there were 460 STEMI patients. A total of 91 patients were not included in the study because the onset was more than 24 hours or unknown. From the remaining 367 patients, 58 patients were excluded because they had a history of previous myocardial infarction. After excluding patients whose electrocardiogram recordings could not be interpreted, had confounders, and did not meet the definition (figure 1), consecutive sampling was carried out until the number of subjects was met. Eventually, 41 subjects were enrolled in the pharmacoinvasive group and 41 patients in the primary PCI group. The basic characteristics of subjects were depicted in **Table 1**.

From the results of the Bland-Altman test, the

Table 4. Bivariate analysis of categorical variables with Mann-Whitney test or Independent sample T Test.

Numerical variables		Bivariate
		p-value
Gender[1]		0.668
Risk factors[1]	Smoker	0.421
	Hypertension	0.508
	Diabetes	0.203
	Dyslipidemia	0.731
ST-elevation[1]	Anterior	0.020
	Inferior	0.046
	Posterior	0.846
	Lateral	0.259
	Dextra	0.926
Diagnostic ST Elevation electrocardigram[1]	3 Leads	0.026
	>3 Leads	0.026
	Normal	0.937
Left ventricle morphology[1]	Concentric	0.949
	Eccentric	0.853
	≤ 1	0.895
Involved Vessel[1]	>1	0.895
	Proximal	0.887
Lesion[1]	Distal	0.910
		0.205
Antihypertension Drug[1]	UFH/LMWH	0.857
Pre Intervention Drug[1]	Nitrate	0.818
	Inotropic	0.482
	Opioid	0.273
	LCA	0.036
Culprit Artery[1]	RCA	0.036
TIMI Flow[1]		1.00
Fibrinolytic agent[1]	Alteplase	0.343
	Streptokinase	0.343
Type of PCI[1]	Rescue	0.802
	Routine	0.802
Revascularization Method[2]	Pharmacoinvasive	0.043
	Primary PCI	0.043

1: Categorical Data analyzed with Mann-Whitney Test
2: Categorical Data analyzed with Independent Sample T-Test
PCI: percutaneous coronary intervention, UFH: unfractionated heparin; LMWH: low molecular weight heparin

observers obtained a mean difference of -0.889 with 95% CI -2.2447 to 0.4669 with p-value = 0.169, no statistical difference in mean was observed. Based on these data, the interobserver conformity had a good match and there was no difference in assessing the Simplified Selvester QRS Score.

In this study, the Simplified Selvester QRS Score was tested for data distribution in the pharmacoinvasive and the primary PCI group using the Shapiro Wilk test. The Simplified QRS Score data in both the pharmacoinvasive group (p= 0.055) and the primary PCI group (p= 0.057) indicated a normal distribution.

There was a statistically significant difference in the myocardial infarct size as measured by the Simplified Selvester QRS Score parameter between STEMI patients who received the pharmacoinvasive method and primary PCI (mean score: 7.240±3.015 vs. 8.900±4.188, p=0.043). The myocardial infarct size in the pharmacoinvasive group was significantly smaller than in the primary PCI group, with a mean difference of 1.66 (**Table 2**).

Bivariate analysis showed that body mass index (p=0.44), location of ST-elevation (p=0.02), number of leads with ST-segment elevation on electrocardiogram (p=0.026), and culprit artery (0.026) were significantly associated with Simplified Selvester QRS Score, in addition to the method of revascularization. **Table 3** and **Table 4** show the bivariate analysis for confounding variables and their correlation with the Simplified Selvester QRS Score.

The variables included in the multivariate analysis were variables that have a p-value <0.25 from the bivariate analysis. These variables were body mass index, onset (p=0.221), hypertension medication (p=0.205), diabetes mellitus (p=0.203), location of segment elevation ST in anterior or inferior, number of leads with ST-segment elevation on electrocardiogram, and culprit artery in left coronary (LCA) or right coronary artery (RCA), along with revascularization method. The multivariate analysis showed that onset (p=0.032), location of segment elevation ST in anterior (p=0.044), and several leads with ST-segment elevation on diagnostic ECG >3 (p=0.026) were independently associated with Simplified Selvester QRS Score. The method of revascularization, namely pharmacoinvasive and primary PCI, did not independently associated with the Simplified Selvester QRS Score (p=0.543) (**Table 5**).

Table 5. Results of multivariate analysis of confounding variables using the backward. model.

Variables		Multivariate analysis			
		Difference	β	P Model 1	P Model 6
Onset			0.196	0.098	0.032*
Body mass index			-0.097	0.411	
Risk factor	Diabetes mellitus	0		0.947	
Heart rate			-0.166	0.141	0.062
ST Elevation location	Anterior	3.00		0.038	0.044*
	Inferior	3.00		0.088	0.097
Diagnostic electrocardiogram ST elevation	3 Leads	2.50		0.061	
	>3 Leads	2.50		0.061	0.026*
Antihypertension		2.50		0.414	
Coronary culprit vessel	LCA	3.00		0.419	
	RCA	3.00		0.419	
	Pharmacoinvasive	1.66		0.543	
Revascularization method	Primary PCI	1.66		0.543	

* independent association by multivariate analysis
PCI: percutaneous coronary intervention; LCA: left coronary artery; RCA: right coronary artery

Discussion

This study aimed to compare the simplified Selvester QRS score between STEMI patients who underwent the pharmacoinvasive method and patients who underwent primary PCI. This study showed that the mean simplified QRS Selvester score in the pharmacoinvasive group was significantly smaller than in the primary PCI group. Other than with the revascularization method, the simplified Selvester QRS score significantly correlated with body mass index, location of the ST segment elevation in the anterior and inferior, the number of ST-segment elevations in the electrocardiogram, and the location of the lesions in the LCA or RCA. Further multivariate analysis showed that the method of revascularization, namely the pharmacoinvasive method and primary PCI, did not independently affect the simplified Selvester QRS score. Other confounding variables which influenced the simplified Selvester QRS score were the location of the ST-elevation in the anterior, the onset of STEMI, and the number of ST-segment elevation >3 segments in the electrocardiogram.

The difference in simplified Selvester QRS score between groups receiving pharmacoinvasive versus primary PCI may be influenced by the timing of the electrocardiogram taking, namely in the acute phase within 48 hours of onset. In previous studies, the electrocardiogram taking time used to calculate QRS scores was much longer which is more than 7 days from onset.13,14 This is due to the extent of infarct tissue, and Selvester QRS scores as its parameter can undergo significant changes up to 30 days from the onset of STEMI. The reason is that in the acute post-infarction phase there is still viable myocardial tissue, which undergoes a stunning and hibernating phase, where this tissue has not caused changes in the QRS complex that can be detected by the Selvester QRS scoring system. Myocardial tissue, the majority of which is infarcted tissue, will cause visible changes in the QRS complex, but the electrocardiogram recording and the scoring system cannot distinguish and detect areas consisting of a mixture of necrotic and viable tissue. More complex and sophisticated methods for detecting infarct areas, such as cardiac magnetic resonance imaging, can distinguish and detect these partial differences.[15]

There are not many previous studies have compared the infarct area based on different revascularization methods by using the scoring system of the electrocardiogram recording. Previous studies have generally compared infarct size between conservatively managed versus revascularized patients, with either fibrinolysis or PCI.[16]

In our study, after adjusting with confounding variables, it showed that the difference in the simplified Selvester QRS score between the pharmacoinvasive

group and the primary PCI group was not independent. Other variables affected the QRS score, namely the onset of ischemia, the location of the ST segment elevation in the anterior leads, and the number of leads with ST-segment elevation > 3 leads. This means that the confounding factors mentioned above, such as the onset of STEMI and anterior infarction, will affect the patient's Selvester QRS score, apart from the revascularization procedure of STEMI in patients, both pharmacoinvasive and primary PCI. Following the results of previous studies, where a longer onset means a longer ischemic time which will lead to a wider infarct area, which is reflected in a higher QRS score. The number of ST segment elevations that appear in the ECG leads also indicates the area of ischemia, where the more leads with ST-segment elevation, the larger the area of ischemia and infarction.[6,17]

This research has several limitations. The main limitation of this study was the use of electrocardiogram recordings from medical records or registry data retrospectively so it was not possible to take further patient electrocardiograms at a longer time after the onset. Another limitation was related to the measuring instruments used in the study, namely the electrocardiogram and its QRS scoring system in estimating the area of infarct tissue and distinguishing viable and non-viable myocardial tissue, which was not a gold standard.[18]

Conclusion

There was a significant difference in infarct area measured from the simplified Selvester QRS score between STEMI patients who underwent pharmacoinvasive method compared to primary PCI, which was lower in the pharmacoinvasive group. The association between simplified Selvester QRS score with a different method of revascularization was not independent, since there were confounding variables for this association, namely onset of STEMI, anterior location of infarction, and ST-segment elevation in electrocardiogram recording > 3 leads.

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References

1. 1. Pahlm US, Chaitman BR, Rautaharju PM, Selvester RH, Wagner GS. Comparison of the various electrocardiographic scoring codes for estimating anatomically documented sizes of single and multiple infarcts of the left ventricle. Am J Cardiol. 1998;81(7):809-15..
2. Nijveldt R, van der Vleuten PA, Hirsch A, Beek AM, Tio RA, Tijssen JG, Piek JJ, van Rossum AC, Zijlstra F. Early electrocardiographic findings and MR imaging-verified microvascular injury and myocardial infarct size. JACC Cardiovasc Imaging. 2009;2(10):1187-94..
3. Arso IA, Setianto BY, Taufiq N, Hartopo AB. In-hospital major cardiovascular events between STEMI receiving thrombolysis therapy and primary PCI. Acta Med Indones. 2014;46(2):124-30.
4. Antman, E.M., and Braunwald E., 2008. ST Elevation Myocardial Infarction: Pathology, Pathophysiology and Clinical Feature. Braunwald's Heart Disease: A Textbook of Cardiovascular. McGraw-Hill. New York. U.S.A.
5. Selvester RH, Wagner GS, Hindman NB. The Selvester QRS scoring system for estimating myocardial infarct size. The development and application of the system. Arch Intern Med. 1985;145(10):1877-81..
6. Shiomi H, Kosuge M, Morimoto T, Watanabe H, Taniguchi T, Nakatsuma K, Toyota T, Yamamoto E, Shizuta S, Tada T, Furukawa Y, Nakagawa Y, Ando K, Kadota K, Kimura K, Kimura T; CREDO-Kyoto AMI Investigators. QRS Score at Presentation Electrocardiogram Is Correlated With Infarct Size and Mortality in ST-Segment Elevation Myocardial Infarction Patients Undergoing Primary Percutaneous Coronary Intervention. Circ J. 2017 Jul 25;81(8):1129-1136.
7. Ibanez B, James S, Agewall S, Antunes MJ,

Bucciarelli-Ducci C, Bueno H, Caforio ALP, Crea F, Goudevenos JA, Halvorsen S, Hindricks G, Kastrati A, Lenzen MJ, Prescott E, Roffi M, Valgimigli M, Varenhorst C, Vranckx P, Widimský P; ESC Scientific Document Group. 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: The Task Force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). Eur Heart J. 2018 Jan 7;39(2):119-177..

8. Abreu D, Salomé Cabral M, Ribeiro F. Factors associated with longer delays in reperfusion in ST-segment elevation myocardial infarction. Int J Cardiol Heart Vessel. 2014 Jul 10;4:97-101..
9. Bainey KR, Armstrong PW, Zheng Y, Brass N, Tyrrell BD, Leung R, Westerhout CM, Welsh RC. Pharmacoinvasive Strategy Versus Primary Percutaneous Coronary Intervention in ST-Elevation Myocardial Infarction in Clinical Practice: Insights From the Vital Heart Response Registry. Circ Cardiovasc Interv. 2019 Oct;12(10):e008059.
10. Bang LE, Ripa RS, Grande P, Kastrup J, Clemmensen PM, Wagner GS. Comparison of infarct size changes with delayed contrast-enhanced magnetic resonance imaging and electrocardiogram QRS scoring during the 6 months after acutely reperfused myocardial infarction. J Electrocardiol. 2008 Nov-Dec;41(6):609-13.
11. Carlsen EA, Bang LE, Ahtarovski KA, Engstrøm T, Køber L, Kelbæk H, Vejlstrup N, Jørgensen E, Helqvist S, Saunamäki K, Clemmensen P, Holmvang L, Wagner GS, Lønborg J. Comparison of Selvester QRS score with magnetic resonance imaging measured infarct size in patients with ST elevation myocardial infarction. J Electrocardiol. 2012 Jul-Aug;45(4):414-419..
12. Nugraha IW, Hartopo AB, Taufiq N. wire crossing time correlates with left ventricular end-diastolic pressure in patients with ST segment elevation myocardial infarction undergoing primary percutaneous coronary intervention. Indonesian J Cardiol 2020;41:143-152.
13. Knippenberg SA, Wagner GS, Ubachs JF, Gorgels A, Hedström E, Arheden H, Engblom H. Consideration of the impact of reperfusion therapy on the quantitative relationship between the Selvester QRS score and infarct size by cardiac MRI. Ann Noninvasive Electrocardiol. 2010 Jul;15(3):238-44.
14. Engblom H, Hedström E, Heiberg E, Wagner GS, Pahlm O, Arheden H. Size and transmural extent of first-time reperfused myocardial infarction assessed by cardiac magnetic resonance can be estimated by 12-lead electrocardiogram. Am Heart J. 2005 Nov;150(5):920.
15. Lee DC, Albert CM, Narula D, Kadish AH, Panicker GK, Wu E, Schaechter A, Pester J, Chatterjee NA, Cook NR, Goldberger JJ. Estimating Myocardial Infarction Size With a Simple Electrocardiographic Marker Score. J Am Heart Assoc. 2020 Feb 4;9(3):e014205.
16. Birnbaum Y, Strasberg B. The predischarge electrocardiographic pattern in anterior acute myocardial infarction: relation between evolutionary ST segment and T-wave configuration and prediction of myocardial infarct size and left ventricular systolic function by the QRS Selvester score. J Electrocardiol. 2000;33 Suppl:73-80..
17. Rovers WC, van Boreen MC, Robinson M, Martin TN, Maynard C, Wagner GS, Gorgels AP. Comparison of the correlation of the Selvester QRS scoring system with cardiac contrast-enhanced magnetic resonance imaging-measured acute myocardial infarct size in patients with and without thrombolytic therapy. J Electrocardiol. 2009 Mar-Apr;42(2):139-44.
18. Geerse DA, Wu KC, Gorgels AP, Zimmet J, Wagner GS, Miller JM. Comparison between contrast-enhanced magnetic resonance imaging and Selvester QRS scoring system in estimating changes in infarct size between the acute and chronic phases of myocardial infarction. Ann Noninvasive Electrocardiol. 2009 Oct;14(4):360-5.