Diagnostic value of standard electrocardiogram in acute right ventricular myocardial infarction

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Abstract

Myocardial infarction (MI) (i.e., heart attack) is the irreversible death (necrosis) of heart muscle secondary to prolonged lack of oxygen supply (ischemia) which accounts for a large number of deaths in the hospital. Diagnosis of myocardial infarction is confirmed based on clinical manifestations and electrocardiographic changes along with increased cardiac enzymes. Electrocardiogram (ECG) is one of the safest and easiest methods in the first place. Therefore, this study aimed to investigate the diagnostic value of standard electrocardiogram in the diagnosis of acute right ventricular infarction following lower cardiac infarction. This research was carried out at a time interval of one and a half years to diagnose acute primary infarction. In this method, the diagnostic value of ST↓ in lead I, ST↓ in lead aVL and I ST↓ + aVL, compared with ST↑ in lead V4R was investigated for diagnosis of right ventricular infarction. ST↑ in the lead V4R is a gold standard for the detection of right ventricular MI. All the patients who had the inclusion criteria were allowed to participate in the study. A total of 66 patients participated in the study. Accordingly, 58 (87%) were male and 8 (13%) were female. The mean age of the population was 54.9 ± 11.41. According to the ST↑ standard in lead V4R, 26 patients (39%) had right ventricular myocardial infarction. There was no significant relationship between angina pectoris and premature infarction (P-Value = 0.869). In this study, the right ventricular was most commonly involved in right coronary artery (78%). There was no significant relationship between the occlusion of right coronary artery and right ventricular infarction in 60 patients (P-Value = 0.94). The results showed that electrocardiogram manifestations help determine the occlusion site and the area at risk (ST↓ in lead aVL and aVL + I, sensitivity = 96%). In myocardial infarction, symptoms such as the ST-Segment elevation in lead aVR and ST-Segment depression in the lower leads are possible. Accordingly, in the lower infarction, ST changes in the leads V1-V6 are helpful in detecting patients at risk. Thus, the use of electrocardiogram in acute myocardial infarction helps detect more invasive patients and prevents extensive myocardial damage and other complications.

Key Words: Electrocardiogram, myocardial infarction, right ventricle

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Myocardial infarction (MI) is the irreversible death (necrosis) of heart muscle secondary to prolonged lack of oxygen supply (ischemia) which accounts for a large number of deaths in the hospital.[1] Some of the main risk factors of MI include diabetes, hypertension, hyperlipidemia, tobacco, alcohol, obesity, family history, and gender. Given the increasing prevalence of the disease in developed and developing countries, the average age of patients suffering from MI is decreasing.[2] In Iran, heart disease accounts for about 46% of all deaths.[3] Diagnosis of MI is confirmed based on clinical manifestations and electrocardiographic changes along with increased cardiac enzymes in the blood. An electrocardiogram (ECG) is a medical test that detects heart problems by measuring the electrical activity generated by the heart as it contracts.[4]

Over the past two decades, several studies have investigated the involvement of myocardial infarction with right ventricle (RV) and its accompaniment with more complications and increased mortality in these patients.[5] According to studies, 18 to 84% of the cases of MI are associated with right ventricular myocardial infarction (RVMI).[6] The incidence of RVMI complicates the prognosis. The mortality rate of RVMI and MI is 25%-30%, while MI accounts for 6%.[7] Patients with inferior MI who also have RV myocardial involvement are at increased risk of death, shock and arrhythmias. This increased risk is related to the presence of RV myocardial involvement itself rather than the extent of left ventricular (LV) myocardial damage. Ischemia and RVMI-related right ventricular dysfunction can be treated upon timely diagnosis. This illustrates the importance of quick and timely diagnosis of RVMI. Accurate and timely diagnosis of these patients is essential in order to improve their final outcome. The American Heart Association introduces ECG as a useful and accessible tool for the diagnosis of right ventricular MI, which reflects RVMI-related changes. Abnormalities detected by ECG help doctors determine the type of treatment needed. The abnormalities on ECG also help show where the heart muscle was damaged. If a person has had previous heart problems, which can alter the ECG, the most recent damage may be harder for doctors to detect. This tool can also be used for clinical examinations, laboratory tests and those with suspected acute heart disease.[8] Using ECG, patients with myocardial infarction and suspected of having acute heart problems are provided with valuable information on the initial assessment and severity of risk.[9] If ECG changes in favor of reducing heart rate, usually a person is admitted to the coronary care unit (CCU). Otherwise, the doctor will decide, depending on the examinations and patient history. ECG has its own limitations and should not be used as the sole means of diagnosing heart disease because many heart diseases cannot be detected by the ECG.[10] Typically, about 50% of patients with unstable angina (UA) and non-ST elevation myocardial infarction (NSTEMI) do not show any changes in the ECG in the first place. UA and the closely related condition of NSTEMI are very common manifestations of this disease. Therefore, it is necessary to obtain a precise history of the patient. Likewise, the correct selection of each diagnostic device for every patient is of utmost importance.[11] Therefore, this study aimed to evaluate the diagnostic value of electrocardiogram in the diagnosis of acute right ventricular infarction.

Materials and Methods

This research was carried out at a time interval of one and a half years to diagnose acute primary myocardial infarction., which was carried out at the Tehran Heart Center. In this method, the ST elevation ST value ↓ was tested on lead I, ST↓ in the aVL lead and ST↓ in the I + aVL lead compared to ST↑ in the V4R lead for right ventricular MI diagnosis. ST↑ in the lead V4R is a gold standard for the detection of right ventricular MI. The sample included all the patients who were allowed to participate in the study. Inclusion and exclusion criteria are listed in Table 1. The sample size included 73 patients who participated in the study with the initial diagnosis of myocardial infarction. Accordingly, 7 patients were excluded. In this study, all patients who were suspected of acute myocardial infarction underwent an electrocardiogram. In the case of ST↑ (more than 1 mm) in the adjacent II, III avf, patients underwent additional electrocardiograms. The enzyme changes were recorded in order to confirm the diagnosis. According to the AHA/ACC Guidelines of the American College of Cardiology, coronary angiography was performed. After collecting the indexes, the electrocardiograms were individually read by the cardiologist and the emergency medicine specialist and the changes were recorded in encoded forms. The ST was measured at 60 msec from the J point and values less than 0.5 mm were assumed as isoelectric. Then, according to the standard criteria (ST↑ in lead V4R), patients were divided in two groups with right ventricular involvement and without right ventricular involvement. Finally, diagnostic tests (ST↓ in lead I, ST↓ in lead aVL and ST↓ in lead I + aVL) were investigated in two groups and compared with the original ST↑ standard in lead V4R. The patients were examined for angina pectoris before infarction once during the admission by a specialist and again during the first 2 days of admission to the CCU by a cardiologist. During the admission, the patients underwent angiography according to the American Heart Association (AHA), and the degree and occlusion site of coronary artery were determined. The findings were compared with the initial diagnosis of right ventricular infarction (based on chest pain for more 30 minutes and enzyme changes and ST↑ in lead V4R in more than 1 mm). Finally, sensitivity, specificity, positive predictive value and negative predictive value were calculated.

Table 1. *Inclusion and exclusion criteria*

Inclusion criteria
No previous history of myocardial infarction
The onset of symptoms less than 6 hours
Sinusoidal rhythm in electrocardiogram
No Bundle Blok and ST↑ (more than 1 mm) in the adjacent leads II, III, avf
Exclusion criteria
Incomplete case
A previous history of myocardial infarction

Ethical Ethical considerations

This study was approved by the ethics committee of Tehran University of Medical Sciences (code # IRTC.1386.12.12). In this study, no intervention was made in the diagnosis and admission of patients.

Table 2. *Relationship between angina pectoris before infarction and right ventricular involvement*

		ST↑ in lead V_4R	
		+	-
History of angina pectoris	+	7 (14%)	8 (16%)
	-	15 (30)	19 (39%)

Table 3. *Relationship between occlusion of proximal RCA and right ventricular MI*

		ST↑ in lead V_4R	
		+	-
Proximal right coronary artery involvement	+	19 (32%)	21 (35%)
	-	5 (8%)	15 (25%)

Results

66 patients participated in the study. 58 patients (87%) were male and 8 (13%) were female. The participants were 54.9 ± 11.41 years old on average. According to the ST↑ standard, in lead V_4R, 26 patients (39%) had right ventricular myocardial infarction. Likewise, 40 patients (61%) had problems only in the heart muscle. Of 26 patients with right ventricular involvement, 24 patients had ST↓ in lead I, (1 mm <). Moreover, of 40 patients without right ventricular involvement, 31 patients did not show ST↓ in lead I (1 mm ≤). According to the ST↑ standard, the following results were obtained: ST↓ in lead I (1mm ≤), sensitivity = 92.3%, specificity = 77.5%, positive predictive value = 72.73%, negative predictive value = 93.94%, positive likelihood ratio = 4 and negative likelihood ratio = 0.1. Of 26 patients with right ventricular involvement, 25 patients had ST↓ in lead avl (mm ≤ 1). Of 40 patients without right ventricular involvement, 18 patients did not show ST↓ in lead avl. Finally, based on V4R, the following results were obtained: ST↓ in lead avl (1 mm ≤), sensitivity = 96.15%, specificity = 45%, positive predictive value = 53.19%, negative predictive value = 94.74%, positive likelihood ratio = 1.7 and negative likelihood ratio = 0.08. Finally, of 26 patients with right ventricular involvement, 25 patients had ST↓ in lead aVL + I (2 mm ≤). Likewise, of 40 patients without right ventricular involvement, 33 patients did not show ST↓ in lead aVL + I (2 mm ≤). Finally, based on the ST↑ criterion, the following results were obtained: ST↓ in I + avL (2 mm ≤), sensitivity = 96.15%, specificity = 82.5%, positive predictive value = 78.13%, negative predictive value = 96.06%, positive likelihood ratio = 5.4 and negative likelihood ratio = 0.048. Table 2 investigates the relationship between angina pectoris and right ventricular involvement in 49 patients with myocardial infarction in Tehran Heart Center (P-value = 0.869). There was no significant relationship between the absence of chest pain 72 hours prior to acute myocardial infarction (AMI) and right ventricular infarction, indicating that chest pain in all cases was not associated with acute myocardial infarction and right ventricular infarction. Table 3 investigates the relationship between the occlusion of proximal right coronary artery (RCA) and right ventricular myocardial infarction in 60 patients referring to the Tehran Heart Center. Although the most common case of right ventricular involvement following obstruction was proximal RCA (78%) (P-value = 0.94), there is no significant relationship between right ventricular involvement and proximal RCA involvement. Table 4 investigates the relationship between the ratio of ST↓ in

Table 4. *Relationship between ST↓ in V3 and ST↑ in lead III in showing the site of coronary artery involvement*

III ST↑ / V3 ST↓					Total
		<0.5	0.5-1.2	>1.2	
Angiography	Proximal right coronary artery	29	4	7	40
	Right distal coronary	6	1	1	8
	Circumflex	6	2	4	12
Total		41	7	12	60

lead V3 and ST↑ in Lead III in 60 patients diagnosed with acute myocardial infarction. There was no significant relationship between the ST↓ in lead V3 and ST↑ in lead III (P-value = 0.60); particularly in the occluded coronary artery: peripheral, distal and circumflex.[12] Therefore, proximal RCA, right distal coronary artery and circumflex artery are not involved. Table 4 investigates the relationship between the ratio of ST↓ in lead V3 and ST↑ in Lead III in 60 patients diagnosed with acute myocardial infarction. There was no significant relationship between the ST↓ in lead V3 and ST↑ in lead III (P-value = 0.60); particularly in the occluded coronary artery: peripheral, distal and circumflex.[12] Therefore, proximal RCA, right distal coronary artery and circumflex artery are not involved.

Discussion

Myocardial infarction often occurs as a result of sudden coronary artery failure, causing necrosis and inappropriate cardiac muscle function.[13] Treatment is often a percutaneous coronary intervention,[14] but an early and precise ECG diagnosis is mandatory. RVMI indicates damage to the right ventricular muscle. It should be noted that right ventricular involvement is rare. The 12-lead ECG paints a picture of the left ventricle, while the right ventricle can be evaluated to a very small extent in the standard ECG.[15] The standard 12-lead electrocardiogram is one of the most commonly used medical studies in the assessment of cardiovascular disease. It is the most important test for interpretation of the cardiac rhythm, detection of myocardial ischemia and infarction, conduction system abnormalities, pre-excitation, long QT syndromes, atrial abnormalities, ventricular hypertrophy, pericarditis, and other conditions. Therefore, ECG was used to diagnose acute right ventricular myocardial infarction. A total of 66 patients (58 males and 8 females) participated in the study. The incidence of right ventricular myocardial infarction was 39%. Although acute right ventricular MI can occur due to the involvement of any main coronary artery, it is often attributed to right coronary artery. In this study, 22 males and 4 females suffered from right ventricular MI involvement, which was similar to that of Aygul, Hosseini et al.[16,17] Turhan et al. concluded that ST↓ in aVL was greater than 1 mm with a sensitivity of 87% and a specificity of 91%. Rashduni et al. observed in 22 patients with acute myocardial infarction that ST↓ in aVL (1mm ≤) had a sensitivity of 100% and a specificity of 57%. In this study, ST↓ in aVL (1mm≤) had a sensitivity of 96%, a specificity of 45%, a positive predictive value of 53% and a negative predictive value of 94.5% (based on the ST↑ in V_4R). However, Turhan et al. showed a higher sensitivity and a lower specificity. It can be attributed to the fact that we included 1mm≤ in this study, but they considered more than 1mm.[18,19] In this study, the ST↓ in lead I (1mm≤) had a sensitivity of 92%, a specificity of 77%, a positive predictive value of 72%, and a negative predictive value of 93%. Likewise, lead I may be the only lead in the standard ECG which reflects the changes in the right ventricle. Although many attempts have been made to diagnose RVMI based on ST changes in the 12-lead ECG, few studies have focused on 12-lead ECG.[20,21] However, in all patients with myocardial infarction, ST changes in lead I should be considered. Mittal et al. examined 24 patients and concluded that ST↓ in lead I and aVL has a high sensitivity in the diagnosis of right ventricular MI, which is in good agreement with this study.[22] Pu SY, et al. examined 50 patients with acute right ventricular myocardial infarction and concluded that aVL+ I had a sensitivity of 96% and a specificity of 89% in the diagnosis of acute right ventricular myocardial infarction. This research aimed to increase the sensitivity and negative predictive value. The results showed that aVL+I (2mm ≤) had a sensitivity of 96.15%, a specificity of 82%, a positive predictive value of 78% and a negative predictive value of 97.06%. The sample size of this study was about 30% greater than that of Pu SY et al. (66 versus 50). The specificity of this study was lower than that of Pu SY et al., which could be attributed to the fact that this study aimed to achieve a higher sensitivity and higher negative predictive value.[23] The relationship between proximal RCA involvement and right ventricular myocardial infarction was also investigated, despite that fact the most common cause of right ventricular involvement was the occlusion of right coronary artery (78%). Although isolated right ventricular MI is usually seen in patients suffering from chronic lung disease together with right ventricular hypertrophy, it can occur in patients suffering a transmural infarction of the inferior-posterior wall which extends to involve the right ventricular wall as well. Right ventricular MI is most commonly caused by obstruction of the proximal right coronary artery and is frequently associated with right bundle branch block. Furthermore, only 5% - 10% of patients suffer from hemodynamic symptoms. However, right ventricular myocardial infarction occurred in 22% of cases as a result of the occlusion of other arteries. This result was in good agreement with that of William et al. Of 40 patients with the occlusion of proximal RCA, only 19 cases resulted in right ventricular myocardial infarction. It should be noted that right ventricular myocardial infarction occurs commonly as a result of pulmonary hypertension. Therefore, the occlusion of proximal RCA does not necessarily cause right ventricular myocardial infarction.[24] The present study also aimed to investigate the relationship between angina pectoris and right ventricular myocardial infarction. This was not in good agreement with Shiraki et al. It is not possible to obtain a precise and reliable biographical report, given the special emergency conditions. Thus, it is not possible to comment on this with certainty.[25] The results showed that electrocardiogram manifestations help to determine the site of the obstruction and the area at risk (ST↓ in aVL and aVL + I with a sensitivity of 96%). Myocardial infarction is associated with

symptoms such as ST-Segment elevation in aVR and ST-Segment depression in the lower leads. ST changes in V1-V6 may help detect patients at risk. Therefore, otherwise unexplained systemic arterial hypotension or diminished cardiac output, or marked hypotension in response to small doses of nitroglycerin in patients with inferior infarction, should lead to the prompt consideration of this diagnosis. Successful reperfusion of the right coronary artery significantly improves right ventricular mechanical function and lowers in-hospital mortality in patients with right ventricular infarction. In conclusion, ECG helps to detect the more critical patients with acute myocardial infarction and to prevent extensive myocardial damage and other complications..

List of acronyms

AMI - acute myocardial infarction
CCU – coronary care unit
ECG - electrocardiogram
LV – left ventricul
MI - myocardial infarction
NSTEMI - non–ST-segment elevation MI
RCA - right coronary artery
RV – right ventricular
UA - unstable angina

Authors contributions

All authors played a substantial role in the conception and/or study design, data acquisition and/or analysis, as well as drafting of the manuscript, approval of the final version to be published.

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Conflict of Interest

The authors declare they have no conflicts of interest.

Ethical Publication Statement

We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

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