

## Effects of negative T wave in electrocardiography on prognosis of post-myocardial infarction patients

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### Original Article

#### Abstract

**BACKGROUND:** Negative T (NT) wave in electrocardiography (ECG) is one of the important factors in determining short- and long-term outcomes in patients with acute myocardial infarction (MI). In this study, we compared clinical and paraclinical findings in post-MI patients according to presence or absence of NT wave.

**METHODS:** A cross-sectional study was conducted on patients with acute ST elevation MI who presented to Shahid Modares Hospital (Tehran, Iran) during 2009-10. After undergoing streptokinase therapy, demographic characteristics and ECG and exercise test findings of the subjects were compared based on the presence or absence of NT wave.

**RESULTS:** Overall, 116 patients including 69 cases with NT wave (NT group) and 47 cases without NT wave (PT group) were enrolled (mean age:  $53.7 \pm 7.1$  vs.  $54.1 \pm 6.8$  years old). Mortality rate during the first five days was 13% in the NT group and 29% in the PT group ( $P < 0.05$ ). Ejection fraction values of the NT group were significantly higher than the PT group ( $P = 0.005$ ). However, left ventricular end-diastolic diameter of the NT group was significantly less than the PT group ( $P = 0.005$ ). Moreover, ST segment depression was significantly less frequent in the NT group compared to the PT group.

**CONCLUSION:** Patients with ST elevation MI accompanying with NT wave in ECG versus have better prognosis and myocardial function than similar patients without NT wave. Therefore, invasive procedures should be recommended for patients without NT wave.

**Keywords:** Echocardiography, Exercise Test, Myocardial Infarction, Negative T Wave, Echocardiography

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#### Introduction

Myocardial infarction (MI) is one of the main causes of death and disability worldwide. Despite vast improvements in the areas of prevention, diagnosis, and treatment, it is still considered as a health and medical problem, especially in developed and developing countries.<sup>1</sup> Although mortality rates after MI have reduced about 25-30% during the past two decades, MI is currently the first cause of mortality in western societies.<sup>2-4</sup> Reduced in-hospital mortality rate of patients with MI (from 10.4% in 1994 to 6.3% in 2006) may be a result of advances in immediate diagnostic methods and effective therapeutic interventions.<sup>5</sup>

Various factors including age, sex, Killip class, and history of heart failure have been proposed to affect the prognosis and mortality rate after MI.<sup>6,7</sup> Electrocardiographic (ECG) changes and exercise test are also among the factors that determine the outcome and short- and long-term prognosis of patients with MI.<sup>8,9</sup> Various ECG changes, such as ventricular tachycardia and fibrillation, premature ventricular contractions, decreased heart rate variability, delayed potential in ECG signals evaluated with mobile monitoring, prolonged QRS wave, and T wave changes, can influence the prognosis of patients with acute MI.<sup>10-12</sup> Classically but not always accurately, a negative T wave

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represents ischemia and a very long T wave represents MI.<sup>13</sup> Previous studies on negative T wave after acute MI have not reported clear results about its prognostic role and its relationship with paraclinical findings of patients.<sup>7,12,14</sup> Therefore, we compared different paraclinical findings of patients with ST segment elevation MI (STEMI) based on the presence or absence of negative T waves.

### Materials and Methods

This analytical cross-sectional study was conducted on patients admitted to Shahid Modares Hospital (Tehran, Iran) with the diagnosis of MI during 2009-10. At least two 12-lead ECGs were recorded in all patients during the first 24 hours of hospitalization. Using simple random sampling, patients with confirmed STEMI were enrolled in the study after they had provided informed consent.

Within 24 hours after receiving streptokinase, patients were divided into two groups based on the presence or absence of negative T wave in ECG. Various references have defined negative T wave in a range from 1 to 10 mm. Therefore, in order to be more accurate, negative T wave was accepted when T wave had at least five millimeters from the base point of the line adjacent to the TP segment.<sup>13,15,16</sup> Patients with heart rhythm disorders (such as atrial flutter and bundle branch blocks) were excluded. All cases of false positive or negative T wave (stroke, re-infarction, ischemia after infarction) were also excluded.

During the first five days after receiving streptokinase, all patients were assessed by ECG and exercise test. The obtained data in the two groups was analyzed and compared using chi-square and student t tests in SPSS for Windows 16.0 (SPSS Inc., Chicago, IL, USA). P values less than 0.05 were considered significant. In cases of significance, odds ratio (OR) was calculated based on 95% confidence interval (CI).

### Results

In total, 176 patients were examined and 116 patients with confirmed STEMI were included. Among the 116 patients, 69 patients with MI associated with negative T wave (NT) and 47 patients without negative T wave (PT) were studied (mean age:  $53.7 \pm 7.1$  vs.  $54.1 \pm 6.8$  years old,  $P > 0.05$ ). There was not a significant difference between the two groups in terms of sex distribution (66% male in the PT group vs. 63% in the NT group,  $P > 0.05$ ). Other demographic findings did not indicate significant differences between the two groups, either (Table 1).

The mean elevation of ST segment was  $6.1 \pm 2.0$  mV in the NT group and  $5.4 \pm 1.8$  mV in the PT group ( $P < 0.05$ ). The mortality rate during the first five days after MI was significantly higher in the PT group than in the NT group (29% vs. 13%). This difference was significant despite Yates correction which is the sign of a relationship beyond statistical probabilities. Likewise, the incidence of ventricular tachycardia during the first five days was significantly higher in the PT group than in the NT group (47% vs. 28%) (Table 2).

**Table 1.** Baseline characteristics of patients with ST segment elevation myocardial infarction (MI)

Variable	NT Group (n = 69)	PT Group (n = 47)	P
Age (years)	$53.7 \pm 7.1$	$45.1 \pm 6.8$	0.450
Gender (male)	44 (63)	31 (66)	0.924
Past history of MI	17(25)	12 (26)	0.613
Diabetes mellitus	46 (67)	33 (70)	0.133
Smoking	43(62)	28 (59)	0.378

NT: Negative T wave in echocardiogram; PT: Positive T wave in echocardiogram

Values are presented as mean  $\pm$  SD or n (%)

**Table 2.** Echocardiographic findings in patients with ST segment elevation myocardial infarction (MI)

Variable	NT Group (n = 69)	PT Group (n = 47)	P
Ejection fraction	$38.7 \pm 4.8$	$37.0 \pm 4.1$	0.005
LVEDD	$5.1 \pm 3.2$	$6.3 \pm 3.7$	0.005
MR Grade 0	12 (20)	7 (20)	$> 0.05$
MR Grade 1	27 (44)	15 (43)	$> 0.05$
MR Grade 2	20 (33)	11 (31)	$> 0.05$
MR Grade 3	2 (3)	2 (6)	$> 0.05$
Ventricular aneurysm	8 (13)	5 (14)	$> 0.05$
Thrombosis	3 (5)	2 (6)	$> 0.05$

NT: Negative T wave in echocardiogram; PT: Positive T wave in echocardiogram; LVEDD: Left ventricular end-diastolic diameter; MR: Mitral regurgitation

Values are presented as mean  $\pm$  SD or n (%)

According to ECG findings, the two groups were significantly different in terms of mean ejection fraction and left ventricular end-diastolic diameter. However, no significant differences in various degrees of mitral regurgitation, aneurysm,

and ventricular thrombus were found between the two groups (Table 3).

Exercise test results of patients were evaluated and compared according to ST segment changes and exercise capacity [in metabolic equivalents (METs)] during the test. ST segment depression during the exercise test was not detected in 32% of the NT group and 9% of the PT group ( $P < 0.05$ ). Moreover, 45% of the NT group and 24% of the PT group had 1 mm ST segment depression in the exercise test ( $P < 0.001$ ). In addition, 2 mm ST segment depression was more frequent in the PT group than in the NT group (55% vs. 17%;  $P < 0.001$ ) (Table 3).

Patients with an exercise capacity of more than 6 METs constituted 50% of the NT group and 27% of the PT group ( $P < 0.001$ ). There was a significant difference in prevalence of negative T wave and positive T wave among individuals with exercise capacity of 2-6 METs. However, there was no significant difference between the two groups in patients with exercise capacity of 2 METs (Table 4).

### Discussion

According to ECG findings and exercise test results in the present study, cardiac function of patients with MI in the NT group was better than patients in the PT group. Moreover, during a short five-day follow-up period, the mortality rate of the NT group was lower than that of the PT group. Inverted T wave in precordial leads of ECG after ST elevation has long been considered as a symptom of lesions of acute coronary artery stenosis and an indication of the incidence of coronary events and MI.<sup>17,18</sup> However, recent studies have proposed negative T wave as a more accurate marker of improving myocardial function.<sup>19,20</sup>

Elhendy et al. showed the positive role of negative T wave in the prognosis of patients with nontransmural MI.<sup>19</sup> Although the mentioned study failed to establish a significant relation between negative T wave and prognosis of transmural MI,<sup>19</sup> it is considered as one of the first studies in this area. Corbalan et al. indicated an association between the presence of negative T wave and lower mortality rate during the first 24 hours after acute

MI in patients who were on thrombolytic therapy.<sup>20</sup> While the follow-up period was longer and the sample size was smaller in the present study, we obtained similar results. Ramires et al. evaluated patients with non-Q wave heart attack after thrombolytic therapy. They reported higher survival rate among individuals with negative T wave than those without it. However, the researchers only assessed survival rate in a longer timeframe, but did not examine the patients in terms of ST segment elevation or ECG and exercise test findings.<sup>17</sup>

Although the above-mentioned studies emphasized better survival rate of patients with negative T wave, none of them has considered ECG and exercise test findings as two helpful tests in predicting the prognosis and cardiac function of patients. On the other hand, Kusniec et al.<sup>21</sup> and Agetsuma et al.<sup>22</sup> highlighted the positive role of negative T wave in the prognosis of patients through ECG and paraclinical evaluation. They also suggested higher left ventricular ejection fraction (as an indicator of cardiac pump function) in patients with MI and negative T wave compared to those without negative T wave. These findings are not consistent with the results of the present study. This inconsistency may be justified by not excluding false positive cases of negative T wave and also considering deep form of negative T wave in the two mentioned studies. Nevertheless, studies with larger sample size and more accurate sampling seem more logical. Moreover, Karadede et al. stated that patients with STEMI and positive T wave had a worse response to dobutamine stress test.<sup>23</sup> Although we found different results about ejection fraction, their provocation test results were in accordance with our exercise test findings.

Previous studies have also considered negative T wave a sign of good patency of the involved vessel.<sup>24,25</sup> According to the results of the present study, other signs of myocardial performance (except left ventricular end-diastolic diameter) were better in the NT group than in the PT group. It can hence be concluded that reperfusion changes the process of infarction and electrical potentials and causes the incidence of negative T wave.<sup>24,25</sup>

**Table 3.** ST segment elevation in the groups with negative T wave (NT) and positive T wave (PT)

ST segment elevation	PT (n = 33)	NT (n = 60)	Odds Ratio	P
No	3 (9)	19 (32)	1.3	0.020
1 mm	8 (24)	27 (45)	0.87	0.001
2 mm	18 (55)	10 (17)	1.71	0.001
> 2 mm	4 (12)	4 (7)	0.37	> 0.05

Values are expressed as n (%)

**Table 4.** Exercise capacity of the participants in submaximal exercise tolerance test in groups with negative T wave (NT) and positive T wave (PT)

Exercise capacity (METs)	PT (n = 33)	NT (n = 60)	Odds ratio	P
2	6 (18)	4 (7)	1.88	> 0.05
2-4	12 (36)	5 (8)	1.78	0.001
4-6	6 (18)	21 (35)	0.88	0.005
6	9 (27)	30 (50)	0.93	0.005

METs: Metabolic equivalents  
Values are expressed as n (%)

Szydlo et al. demonstrated greater interruption of blood supply and longer repolarization duration in the group of patients with acute STEMI without negative T wave than subjects with negative T wave. These factors may provoke arrhythmias and sudden death despite similar ECG findings in the two groups (which is in contrast with the present study).<sup>25</sup>

Ando et al. reported the risk of in-hospital death after MI to be three times higher in patients with negative T wave in previous ECG than in those without a similar history.<sup>26</sup> This finding is inconsistent with ours probably because Ando et al. only evaluated negative T wave in previous ECG of patients.<sup>26</sup>

With advances in techniques of reperfusion, the role of ECG findings in selecting patients and determining the success rate after intervention has received more attention. Sorensen et al. showed significantly lower delayed microvascular reperfusion in patients with STEMI and negative T wave than patients with positive T wave.<sup>27</sup> This specifies the importance of negative T wave in predicting recovery after MI. In a study on patients after STEMI, Altun et al. demonstrated that normalization of negative T wave is a stronger predictor of viability and consequently myocardial performance in myocardial perfusion single-photon emission computed tomography (SPECT) than negative T wave itself.<sup>28</sup> Therefore, not only the presence of negative T wave, but also alternations in T wave (especially toward its negative) have been particularly proposed as prognostic factors for survival of in patients with some degrees of ventricular failure due to cardiac ischemia.<sup>29,30</sup> However, further studies in this regard are warranted.

### Conclusion

Based on our findings and previous studies, it can be concluded that prognosis and myocardial tissue performance of patients with STEMI with negative T wave in the initial ECG are more favorable than patients without negative T wave. Thus, more accurate and aggressive follow-up for patients without negative T wave seems to be necessary.

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### Conflict of Interests

Authors have no conflict of interests.

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