The relationship between T-wave polarity and clinical as well as angiographic findings in the early stage of acute myocardial infarction

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Abstract

Background: Restoration of a positive T-wave in the chronic stage of myocardial infarction (MI) is usually seen in patients with a non-Q-wave (non-transmural) MI, where a viable tissue is present. The causes and significance of a positive T-wave in the early phase of acute MI are not clear.

Aim: To investigate angiographic and clinical characteristics of patients with a positive T-wave in the early stage of acute MI.

Methods: We evaluated the clinical and angiographic data in relation to T-wave polarity in 188 patients with acute MI. Coronary risk factors, pre-infarction angina, CK-MB level, left ventricular ejection fraction and angiographic findings were analysed. Death, cardiogenic shock, ventricular tachycardia/fibrillation and high-degree atrioventricular block were regarded as in-hospital complications. All electrocardiograms were divided into two groups, according to the shape of the T-wave, as exhibiting a positive T-wave or negative T-wave.

Results: A positive T-wave was present in 30 (15.9%) patients. None of the patients with a positive T-wave had three-vessel disease compared with 21.5% of patients with a negative T-wave ($p < 0.04$). In-hospital complication rates were similar in both groups.

Conclusions: Patients with a positive T-wave in the early phase of acute MI have significantly less frequently three-vessel disease than patients with a negative T-wave.

Key words: T-wave, myocardial infarction, angiography

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Introduction

In patients with myocardial infarction (MI), negative T-waves usually appear in the infarct-related electrocardiographic leads. In some patients with an initially negative T-wave, a gradual inversion into a positive T-wave may be observed [1]. Tamura et el. reported that patients with T-wave normalisation in the infarct-related leads, occurring between 1 and 6 months after anterior MI, have smaller infarctions, lesser left ventricular (LV) dysfunction and greater improvement in LV wall motion in the infarct area [2]. An autopsy study demonstrated that a positive T-wave in the chronic stage of MI indicates non-transmural infarction containing viable myocardium within the layer of the ventricular wall under the electrodes [3].

However, the causes and significance of a positive T-wave present in the early stage of acute MI have not been clarified. This study was carried out in order to investigate the angiographic and clinical characteristics of patients with a positive T-wave in the early stage of acute MI.

Methods

The study included 188 consecutive patients with acute MI admitted to the coronary care unit of our institution between May 2001 and January 2003. Acute MI was diagnosed when the following criteria were

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met: prolonged chest pain of >30 min duration, diagnostic increase and subsequent decrease of the serum creatine kinase-MB (CK-MB) level, and typical evolution of serial ECG changes in ≥2 adjacent precordial leads. Patients were excluded if they had bundle branch block, T-wave polarity other than a positive or negative T-wave, MI other than Q-wave anterior or inferior, or when they had a history of previous MI. Patients were informed about the aim of the study and agreed to participate.

During hospitalisation, baseline characteristics, preinfarction angina, and coronary risk factors were recorded on standard forms. Admission and discharge electrocardiograms were obtained for future evaluation. LV ejection fraction was measured according to the Teicholz et al. method [4]. Death, cardiogenic shock, complex ventricular arrhythmias (ventricular tachycardia/fibrillation) and high-grade atrioventricular block (second- or third-degree) occurring during the hospital stay were regarded as in-hospital complications.

Standard 12-lead electrocardiograms were recorded before coronary care unit discharge at a speed of 25 mm/s and were calibrated at an amplitude of 1.0 mV/10 mm. The same technician performed all ECG recordings. At the leads where the most prominent ST segment elevation was present, the T-wave was defined as positive when its amplitude exceeded 0.1 mV (Figure 1). All the electrocardiograms were divided into two groups, according to the shape of the T-wave, as exhibiting a positive T-wave or a negative T-wave.

Coronary angiography was performed according to standard methods before hospital discharge. Coronary angiograms were visually assessed by at least two cardiologists who were unaware of the findings of the study. Angiographic findings were quantified according to the American Heart Association classification system [5]. In this system, significant coronary stenosis is defined as a >50% narrowing of a coronary vessel lumen. Patients were classified as having one-, two- or three-vessel disease.

Statistical analysis

Continuous data are expressed as mean ±SD and categorical data as percentages. Continuous data were compared using Student's t-test, and categorical data using the chi-square test. A p value <0.05 was considered significant.

Results

Of the 188 patients, 30 (15.9%) exhibited a positive T-wave in the early stage of acute MI. The remaining 158 patients did not exhibit a positive T-wave. Clinical characteristics of the study population are presented in Table I. There were no differences between the groups regarding age, gender, blood pressure, coronary risk factors, LV ejection fraction, CK-MB level, pre-infarction angina, anterior localisation of MI or the use of thrombolytic therapy.

Figure 1. An example of original ECG with a positive T-wave in patient with inferior infarction

Angiographic findings are presented in Table II. The proportion of patients with single- or two-vessel disease was similar in both groups. None of the patients with a positive T-wave had three-vessel disease, compared with 21.5% of patients without a positive T-wave ($p<0.04$). The in-hospital complication rate was similar in both groups (Table III).

Discussion

T-wave changes occurring after acute MI are attributed to the abnormal prolongation of ventricular action potential in the regions adjacent to the necrotic area, so that the degree of prolonged repolarisation may influence T-wave voltage and polarity [6]. In acute MI, negative T-waves usually appear in the infarct-related leads. In our study, a positive T-wave in the early stage of acute MI was found in 15.9% of patients.

During hospitalisation, only a very small portion of patients with acute MI have a positive T-wave. The negative T-wave can gradually become positive during the evolution of MI. Precordial T-waves convert from negative to positive in 13% of patients up to 3 months after MI, in 33% of patients 3-6 months after MI, and in 47% of patients 6-12 months after MI [1].

In our study, the severity of coronary artery disease was lower in patients with a positive T-wave - none of them had three-vessel disease. The CK-MB level, which indicates infarct size, tended to be higher in patients without a positive T-wave; however, the difference did not reach statistical significance. LV ejection fraction was also similar in both groups.

Table I. Clinical characteristics of the study population

	T-wave		p value
	positive (n=30)	negative (n=158)	
Age (years)	59±10	57±11	0.53
Men [%]	26 (86.7)	130 (82.3)	0.61
SBP [mmHg]	116±16	114±21	0.87
DBP [mmHg]	75±8	71±14	0.61
Hypertension [%]	14 (46.7)	50 (31.6)	0.26
Diabetes [%]	4 (13.3)	36 (22.8)	0.41
Smoking [%]	20 (66.7)	96 (60.8)	0.66
LDL-C [mg/dL]	124±25	126±42	0.83
HDL-C [mg/dL]	36±7	38±11	0.60
Ejection fraction [%]	52±9	48±12	0.28
CK-MB, IU/L	241±200	307±282	0.39
Preinfarction angina [%]	20 (66.7)	80 (50.6)	0.25
Thrombolysis [%]	20 (66.7)	78 (49.4)	0.21
Anterior MI [%]	14 (46.7)	92 (58.2)	0.40

SBP – systolic blood pressure; DBP – diastolic blood pressure; LDL-C – LDL-cholesterol; HDL-C – HDL-cholesterol; CK-MB – creatine kinase-myocardial band

Tamura et el. reported that patients with T-wave normalisation in infarct-related leads between 1 and 6 months after anterior MI have smaller infarcts, lesser LV dysfunction and greater improvement in LV wall motion in the infarct area. These findings suggest that spontaneous normalisation of negative T-waves in infarct-related leads during healing of acute MI represents functional recovery of viable myocardium in the infarct area [2].

Sakata et al. reported that total occlusion of the infarct-related artery in coronary angiograms, obtained within 24 hours after the beginning of acute MI, and the absence of collateral circulation, were more frequent in the negative T-wave group when compared with the positive T-wave group [1]. In the same study, where only patients with anterior MI were enrolled, peak serum CK activity was significantly higher in patients from the T-wave negative group. The LV ejection fraction tended to decrease in those patients in whom negative T-waves were still present during long-term follow-up after MI (up to 1 year).

In our study, the in-hospital complication rate was similar in patients with negative or positive T-waves. The significance of positive T-waves differs depending on when the normalisation of negative T-waves occurs. Sakata et al. reported that 12 months after the onset of MI, most patients with normalised T-waves in leads with Q-waves had better recovery of the regional and global LV function than patients with persistent negative T-waves [1]. However, late normalisation of negative T-waves occurring 12 to 24 months after MI was observed in patients whose parameters of LV function were similar to those with persistent negative T-waves. Therefore, patients with early normalisation of negative T-waves (within 12 months after the onset of MI) have a more favourable clinical outcome than patients with late normalisation of negative T-waves (>12 months after the onset of MI).

Watanabe et al. concluded that restored positive T-waves in Q-wave MI indicate a significantly greater amount of viable myocardium than negative T-waves [7]. They hypothesised that culprit lesion restenosis could cause chronic ischaemia of the myocardium around the infarct area, which would prolong repolarisation of newly ischaemic myocytes and cause restored positive T-waves to invert. Bossimi et al. reported that normalisation of previously inverted T-waves in serial electrocardiograms in the chronic phase of infarctions identifies functional recovery of viable myocardium. Conversely, persistently inverted T-waves and, more importantly, an increase in the number of negative T-waves after discharge indicate greater myocardial damage with more extensive necrotic tissue or less viable myocardium and unfavourable LV remodelling [8].

An autopsy study demonstrated that persistent negative T-waves in leads with Q-waves in the chronic stage of MI indicate the presence of a transmural infarction with a thin fibrotic layer, whereas positive T-waves indicate a nontransmural infarct containing viable myocardium within the layer [3]. The investigators

Table II. Angiographic findings

	T-wave		p<
	positive (n=30)	negative (n=158)	
Single-vessel [%]	14 (46.7)	64 (40.5)	NS
Two-vessel [%]	16 (53.3)	60 (38.0)	NS
Three-vessel [%]	0 (0.0)	34 (21.5)	0.04

Table III. In-hospital complications

	T-wave		p
	positive (n=30)	negative (n=158)	
Death [%]	1 (3.3)	8 (5.1)	NS
Cardiogenic shock [%]	0 (0.0)	10 (6.4)	NS
High-grade atrioventricular block [%]	2 (6.7)	20 (13.5)	NS
Ventricular tachycardia/fibrillation [%]	2 (6.7)	14 (9.3)	NS

speculated that the electrocardiographic findings in the leads with inverted T-waves reflected the activity of the opposite myocardial wall.

Conclusion

Patients with a positive T-wave in the early phase of acute MI have three-vessel disease significantly less frequently than patients with a negative T-wave.

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Związek pomiędzy zwrotem załamka T a klinicznymi i angiograficznymi parametrami u w ostrej fazie zawału serca

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Streszczenie

Wstęp: Powrót dodatnich załamków T po przebyciu ostrej fazy zawału serca (MI) obserwuje się zwykle u chorych, którzy przebyli MI bez załamka Q i mają zachowaną żywotność mięśnia sercowego. Mechanizmy prowadzące do występowania dodatnich załamków T już we wczesnej fazie MI i znaczenie tego zjawiska nie zostały jeszcze dokładnie wyjaśnione.

Cel: Ocena parametrów angiograficznych i klinicznych u chorych z dodatnim załamkiem T stwierdzanym w ostrej fazie MI.

Metodyka: Grupę badaną stanowiło 188 chorych z ostrym MI. Analizowano czynniki ryzyka choroby wieńcowej, obecność bólów wieńcowych przed MI, stężenie CK-MB, frakcję wyrzutową lewej komory i wyniki koronarografii. Podczas obserwacji wewnątrzszpitalnej oceniano występowanie następujących powikłań sercowo-naczyniowych: zgon, wstrząs kardiogenny, częstoskurcz komorowy, migotanie komór lub zaawansowany blok przedsionkowo-komorowy. Chorzy zostali podzieleni na dwie grupy w zależności od dodatniego lub ujemnego wychylenia załamka T.

Wyniki: Dodatnie załamki T w ostrej fazie MI stwierdzono u 30 (15.9%) chorych. Chorobę trzech naczyń stwierdzono u 21.5% chorych z ujemnym załamkiem T i u żadnego chorego z grupy z dodatnim załamkiem T ($p<0.04$). Częstość powikłań wewnątrzszpitalnych była podobna w obu grupach chorych.

Wnioski: U chorych z dodatnim załamkiem T obecnym w ostrej fazie MI stwierdza się mniejsze zaawansowanie choroby wieńcowej niż u chorych z ujemnymi załamkami T.

Słowa kluczowe: załamek T, ostry zawał serca, koronarografia

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