"Tombstoning" of ST segment in acute myocardial infarction – effect on clinical course

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Abstract

Introduction: There are many reports evaluating the effects of the amplitude of ST segment elevation in acute myocardial infarction with ST segment elevation (STEMI) on infarction zone and course. There are, however, few publications dealing with the effects of ST segment elevation shape in STEMI patients on their clinical course and prognosis.

Aim: Assessment of the rate of "tombstoning" of ST segment (TOMB-ST) in STEMI patients and the effects on their clinical outcome.

Methods: The study involved 207 consecutive patients with STEMI hospitalised in the period 2000-2002 analysed with respect to the in-hospital complication rate.

Results: On admission, TOMB-ST was observed in 55 (26.1%) subjects. TOMB-ST was more common in anterior MI (39.8%) than in inferior MI (10.6%). Patients with TOMB-ST compared to non-TOMB-ST ones had a significantly higher mortality rate (38.2% *vs* 9.9%, p <0.001), heart failure (45.6% *vs* 28.3%, p <0.026), ventricular fibrillation (18.1% *vs* 6.4%, p <0.016), and lower left ventricular ejection fraction (40.9% *vs* 48.6%, p <0.001). The sum of amplitudes of ST segment deviations (ΣST) >20 mm was indicative for the subgroup of patients with TOMB-ST and trend towards higher mortality (40% *vs* 30%, NS). However, in patients without TOMB-ST, ΣST >20 mm identified two subgroups with significantly different mortality rates (20% *vs* 4%, p=0.001).

Conclusions: TOMB-ST was observed in one fourth of patients with STEMI. This abnormality was associated with an increased mortality rate, higher incidence of heart failure and ventricular fibrillation as well as decreased left ventricular ejection fraction. In the population with TOMB-ST, increased mortality was independent of the total amplitude of ST segment displacement; this relation was, however, observed in patients with STEMI without TOMB-ST.

Key words: "tombstoning" of ST segment, myocardial infarction, STEMI, in-hospital complications

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Introduction

Electrocardiography remains crucial for the diagnosis of acute myocardial infarction (MI) [1]. An elevation of ST segment is one of the earliest electrocardiographic signs of MI. The amplitude of ST elevation is influenced by the myocardial area and other factors, such as constitution of the chest or the electrode to myocardial zone distance [2]. Wimalaratna [3] and Guo et al. [4] described the characteristic tombstone shape of ST segment elevation in patients with acute MI (TOMB-ST).

The study aimed to evaluate the rate of TOMB-ST and its effect on the prognosis and clinical course of ST segment elevation MI (STEMI) patients. Also, the relationship between ST segment elevation of this type and quantitative changes of ST segment was analysed.

Methods

The study included 207 consecutive patients with STEMI and myocardial chest pain of up to 12 hours duration, hospitalised and treated in our department from 2000 to 2002.

Myocardial infarction was diagnosed based on the duration of pain (>30 min.), elevated levels of necrosis markers – phosphocreatine kinase (CK) and cardiac fraction (CK-MB) by twice the upper normal limit in two

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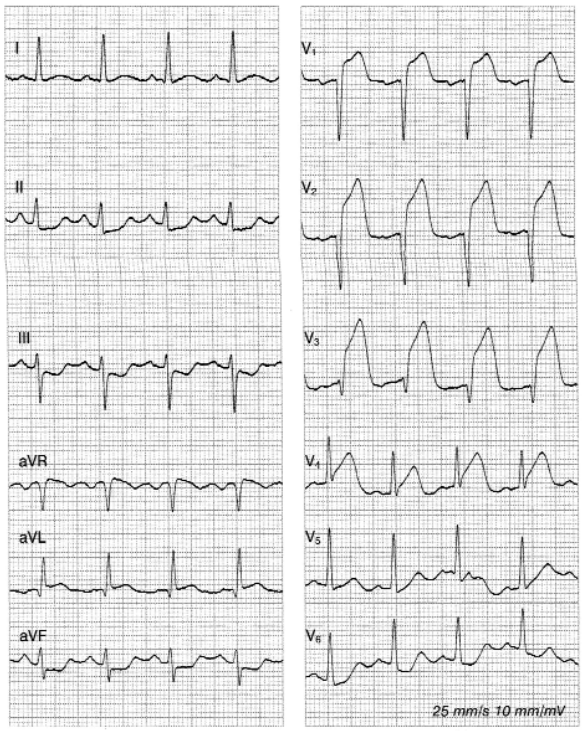

Figure 1. Example of original ECG with "tombstoning" of ST segment

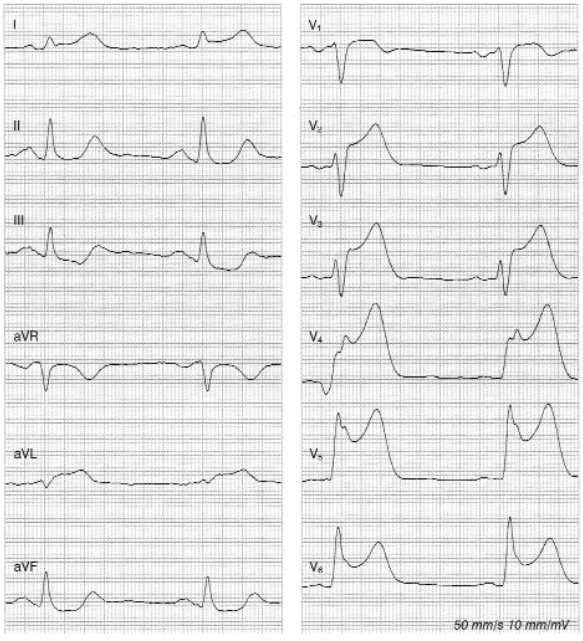

Figure 2. ST segment elevation not meeting the criteria for a tombstone shape (without TOMB-ST)

subsequent tests, and elevation of ST segment in two adjacent leads of at least 1 mm, measured 60 ms after the J point. Standard 12-lead ECG was recorded in all patients on admission at chart speed of 50 mm/sec and sensitivity of 1 mV/10 mm. These records were further analysed. Phosphocreatine kinase and CK-MB were shown as maximum CK level obtained in 3 consecutive blood samples collected every 8 hours after admission.

Echocardiography was performed within the first 48 hours after admission to the intensive cardiologic care unit. Simpson's method was used for the left ventricular ejection fraction calculation (EF%).

The patients were divided into two groups: with TOMB-ST (Figure1) and without TOMB-ST (Figure 2).

Following Wilmalaratna's recommendations [3], further amended by Guo et al. [4], TOMB-ST was defined as follows:

1) no R waves or significantly reduced R wave amplitude and less than 40 ms duration, no waves beneath isoelectric line following the R wave;
2) convex ST segment blurred with the ascending arm of the R wave or the ascending arm of the QRS/QR complex;
3) peak of convex ST segment higher than the R wave amplitude;
4) convex ST segment blurred with the ascending arm of the T wave.

The above changes had to be present in at least two adjacent ECG leads.

Also, the sum of amplitudes of ST segment elevations and depressions in all leads of standard ECG was calculated and the mean sum of amplitudes of ST displacement in the study group (20 mm) was accepted as the cut-off value.

Clinical assessment

During hospitalisation patients were followed up to record mortality, rate of non-fatal reinfarctions, ventricular fibrillation, left or right ventricular heart failure and cardiogenic shock.

Reinfarction was defined as the reoccurrence of angina with a recurrent increase of CK levels (50% above the result of the last test or greater than twice the upper normal limit if prior normalisation was observed) and/or new ECG changes (ST segment elevation, left bundle branch block, new Q waves).

Cardiogenic shock was defined as the systolic blood pressure <90 mmHg for at least 30 min. (or the need to use catecholamine support) and clinical signs of poor tissue perfusion.

Thrombolytic treatment (streptokinase) was administered in all patients without contraindications.

Statistical analysis

Continuous variables of normal distribution are presented as the mean ± standard deviation. Statistical

Table I. Clinical characteristics and in-hospital complications

	Total n=207	TOMB-STn=55	Non-TOMB-STn=152	P
Age	66.9±12.2	68.9±10.8	66.2±12.7	NS
Males	132 (59.4%)	34(61.8%)	91(59.9%)	NS
Thrombolysis	89 (42.3%)	29(52.7%)	60(39.5%)	NS
Diabetes mellitus	37 (16.6%)	13(22.4%)	24 (14.6%)	NS
Chest pain (hours)	4.9±3.4	4.7 ±3.9	4.9±3.2	NS
Deaths	36 (17.3%)	21 (38.2%)	15 (9.9%)	0.001
Cardiogenic shock	31 (14.9%)	12 (21.8%)	19 (12.3%)	NS
Pulmonary oedema	23 (11.1%)	8 (14.5%)	15 (9.6%)	NS
Ventricular fibrillation	20 (9.7%)	10 (18.1%)	10 (6.4%)	0.016
Heart failure	69 (33.3%)	25 (45.6%)	44 (28.3%)	0.026
EF [%]	46.9±12.6	40.9±10.1	48.6±12.7	0.001
Peak CK [IU/L]	1581±1331	1598.9±1361	1575.3±1347	NS

EF – left ventricular ejection fraction; peak CK – peak level of phosphocreatine kinase

significance of differences between such variables was analysed with Student's t-test for independent and dependent samples. Parametric variables are presented as counts and percentages, and compared using the Chi-square test and Fisher's exact test. A p value $p<0.05$ was considered significant.

Results

Clinical characteristics of the studied population are shown in Table I. Patients were admitted at mean 4.9±3.4 hours of duration of chest pain. During hospitalisation a total number of 36 deaths (overall mortality of 17.3%), 6 reinfarctions (2.9%), 3 ischaemic strokes (1.4%), 31 cardiogenic shocks (14.9%), including 15 shocks present on admission (7.2%), 20 episodes of ventricular fibrillation (9.6%) and 23 pulmonary oedema (11.1%) episodes were noted. Thrombolytic treatment was administered in 89 (42.9%) subjects.

Anterior MI (Ant MI) was diagnosed in 111 patients, while inferior MI (Inf MI) – in 96 patients.

"Tombstoning" of ST segment

In the entire study population, TOMB-ST was found in 55 (26.6%) patients, more often in Ant MI – 44 (39.6%) cases than in patients with Inf MI – 11 (11.4%) cases.

Thrombolytic treatment tended to be used more frequently in patients with TOMB-ST than in those without (NS).

The mortality rate was significantly higher in the TOMB-ST patients compared to the non-TOMB-ST ones. This was observed both in patients with Ant MI (TOMB-ST – 17 (38.8%) *versus* non-TOMB-ST – 9 (13.4%); p=0.001) and in subjects with Inf MI (TOMB-ST – 36.4% *versus* non-TOMB-ST – 7.0%; p=0.001). The TOMB-ST group had a reduced EF in comparison to the group without TOMB-ST.

In-hospital complications such as ventricular fibrillation and heart failure occurred more frequently in the TOMB-ST patients (Table I).

"Tombstoning" of ST segment and sum of amplitudes of ST segment displacement

The mean sum of dislocations (elevations/depressions) of ST segments (ΣST) on resting ECG was 19.5 mm ± 10.4, and mean ST segment elevation was 12.6 mm ± 8.36. In the TOMB-ST patients, ΣST was significantly higher, as compared to the non-TOMB-ST group. Additionally, the elevation of ST segments only was also higher in patients with TOMB-ST than in the non-TOMB-ST group (Table II). In patients with ΣST >20 mm (96 subjects) 28 deaths were recorded, whereas in the group with ΣST <20 mm (111 patients)

Table II. Quantitative changes of ST segments with respect to tombstoning ST segment presence

	TOMB-ST (n=55)	NON-TOMB-ST(n=152)	P
ΣST	25.14±8.6 mm	17.5±8.2 mm	0.005
Sum of ST segment elevation amplitudes	18.94±10.3 mm	10.3±7.0 mm	0.0007

ΣST – sum of ST segment elevations/depressions

Table III. In-hospital mortality with respect to tombstoning ST segment and quantitative displacement of ST

	TOMB-ST		Non-TOMB-ST	
	(ΣST) ≥20	(ΣST) <20	(ΣST) ≥20	(ΣST) <20
n =	42	13	54	98
Death	17	4	11	4
Mortality	40.5%	30.7%	20.4%	4.1%
p	0.52	0.001		

8 deaths occurred. Using qualitative estimation of ST segment displacement (ΣST) and shapes, patients were divided into 4 groups (Table III). The highest mortality rate was observed in patients with TOMB-ST, regardless of ΣST value. Following the application of ΣST=20 mm as a cut-off value, two subgroups were selected with mortality rates of 40.5% and 30.7% (NS). Mortality was lower in the group without TOMB-ST, and ΣST=20 mm divided patients into two subgroups marked by a significant difference in mortality rates: 20.4% *vs* 4.1%, (p=0.001).

Discussion

There are only a few reports available on the effects of the shape of ST segment elevation on the clinical outcome or prognosis in patients with STEMI. Wilmalaratna [3] first reported a typical and rapidly progressing convex elevation of ST segment reminiscent of a tombstone. This shape of ST segment was associated with an increased rate of in-hospital complications. TOMB-ST signs were observed in the study of Wilmalaratna [1] in 10% of patients with acute MI, whereas Guo et al [4] reported it in 19% of subjects, and Balci and Yesildag [5] – in 22% of patients with acute AntMI.

In our study mortality reached 26% and was 4 times higher in patients with anterior (39%) than inferior (11%) MI. Two studies involving less numerous groups of patients (63 and 147 subjects) showed a higher rate of complications in patients with TOMB-ST [3, 6]. Balci and Yesildag noted that in 23 patients with TOMB-ST the incidence of death (26% *vs* 2%), cardiogenic shock (22% *vs* 2%) and ventricular fibrillation (30% *vs* 5%) was higher than in the group without TOMB-ST [5]. Our study also revealed that patients with a "tombstoning" of ST segment were at a higher risk of ventricular fibrillation and heart failure, and (tended to have more frequently) cardiogenic shock. Patients with such an ST segment pattern typically had more extensive cardiac damage and hence significantly reduced EF.

Furthermore, our analyses confirmed that qualitative changes of the ST segment, in addition to quantitative evaluation, affected mortality of patients with STEMI. "Tombstoning" of ST segment increases mortality regardless of the sum of amplitudes of ST segment displacement. The mentioned quantitative changes of ST segments (ΣST) unquestionably determined mortality in the group without TOMB-ST (20% *vs* 4 %). When considering the electrocardiogram, the stratification of death risk in patients with STEMI should first include an assessment of the shape of ST segment elevation and then quantitative changes, for example the sum of amplitudes of ST segment displacements.

What are the potential causes of tombstoning ST segment elevation?

There are many hypotheses. One of them was proposed by Guo et al.[4], who associated TOMB-ST with the proximal occlusion of the left anterior descending coronary artery with common concomitant (chronic) occlusion of other coronary arteries. Therefore, these authors suggested that TOMB-ST arises from poorly developed collateral circulation and/or disseminated atherosclerotic lesions in all major coronary arteries. On the other hand, Balci and Yesildag noted that preinfarction angina was observed less frequently in patients with TOMB-ST (only in 39%) as compared to 64% of patients without TOMB-ST [5]. According to this concept, the absence of preinfarction angina and, consequently, cardiac preconditioning before MI results in more extensive ischaemic cardiac damage and in rapidly progressing high convex ST segment elevations observed on ECG.

Wimalaratna, who was the first to highlight the negative prognostic value of "tombstoning" of ST segment, put forward a proposal that this phenomenon is associated with an extensive and extremely rapid process of myocardial damage [3].

Our study involving over 200 STEMI patients confirmed the findings of previous investigations conducted in smaller groups of patients, indicating that TOMB-ST present in the early phase of MI (regardless of its localisation) is associated with unfavourable prognosis due to more extensive injury of the myocardium (expressed as a decrease in EF) and serious in-hospital complications. For this reason, patients with this type of ST segment elevation require more aggressive, invasive treatment. Further studies are needed to investigate the

effect of percutaneous coronary interventions on the clinical outcome of patients with TOMB- ST.

Conclusions

TOMB-ST was observed in one fourth of STEMI patients. This finding was associated with increased mortality, rate of heart failure and ventricular fibrillation and reduced left ventricular ejection fraction. Increased mortality of patients with TOMB-ST was independent of the sum of amplitudes of ST segment displacements; such a relationship was, however, noted in patients with STEMI without TOMB-ST.

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Uniesienie odcinka ST typu kamienia nagrobnego w świeżym zawale mięśnia sercowego – wpływ na przebieg kliniczny

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Streszczenie

Wstęp: Istnieje wiele doniesień oceniających wpływ wielkości uniesienia odcinka ST w świeżym zawale serca z uniesieniem odcinka ST(STEMI) na rozległość zawału i jego przebieg. Niewiele doniesień dotyczy natomiast wpływu kształtu uniesienia odcinka ST na przebieg kliniczny czy rokowanie w STEMI.

Cel pracy: Celem pracy była ocena częstości występowania i wpływu na przebieg wewnątrzszpitalny uniesienia odcinka ST typu kamienia nagrobnego (*tombstoning*; TOMB-ST) w STEMI.

Metody: Badaniem objęto 207 kolejnych chorych ze STEMI hospitalizowanych w latach 2000-2002.

Wyniki: U 55 (26,1%) chorych obserwowano przy przyjęciu TOMB-ST. TOMB-ST występowało częściej w zawale ściany przedniej (39,8%) aniżeli dolnej (10,6%). W grupie z TOMB-ST znamiennie częściej niż w grupie bez TOMB-ST wystąpiły: zgon (38,2% *vs* 9,9%, p<0,001), niewydolność serca (45,6% *vs* 28,3%, p<0,026) oraz migotanie komór (18,1% *vs* 6,4%, p<0,016). Ponadto pacjenci z TOMB-ST charakteryzowali się mniejszą frakcją wyrzutową lewej komory (40,9% *vs* 48,6%, p<0,001). Suma amplitudy przemieszczeń odcinków ST (ΣST) >20 mm wyodrębniła podgrupę chorych z TOMB-ST z nieistotnie większą śmiertelnością (40% *vs* 30%, p=ns). Natomiast w grupie pacjentów bez TOMB-ST ΣST >20 mm pozwoliła wyodrębnić 2 podgrupy z istotną różnicą w śmiertelności (20% *vs* 4%, p=0,001).

Wnioski: W STEMI zjawisko TOMB-ST występuje u jednej czwartej chorych. Objaw ten jest związany ze zwiększoną śmiertelnością, częstszym występowaniem niewydolności serca i migotania komór oraz mniejszą frakcją wyrzutową lewej komory. W grupie pacjentów z TOMB-ST większa śmiertelność nie zależy od sumy amplitudy przemieszczeń ST, natomiast związek taki zachodzi u chorych ze świeżym zawałem serca i uniesieniem ST bez TOMB-ST.

Słowa kluczowe: uniesienie odcinka ST typu kamienia nagrobnego, zawał serca, STEMI, powikłania zawału

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