



## T-wave inversion in patients with acute pulmonary embolism: Prognostic value



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### ABSTRACT

**Introduction:** T-wave inversion (TWI) is a common ECG finding in patients with acute pulmonary embolism (APE).

**Objectives:** To determine the prevalence of TWI in patients with APE and to describe their relationship to outcomes.

**Methods:** Retrospective study of 437 patients with APE. TWI patterns were described in two distributions: inferior (II, III, aVF) and precordial (V1–V6).

**Results:** TWI was observed in 258 (59%) patients. The mortality rate was significantly higher in the group with TWI in the inferior AND precordial leads compared to the group without TWI (OR: 2.74;  $p = 0.024$ ) and the group with TWI in the inferior OR precordial leads (OR: 2.43;  $p = 0.035$ ). As compared those with TWI in <5 leads, patients with TWI in  $\geq 5$  leads experienced significantly higher rates of death (17.1% vs. 6.6%, OR: 2.92;  $p = 0.002$ ) and complications.

**Conclusions:** TWI and the quantitative assessment thereof can be useful to risk stratify patients with APE.

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### Introduction

Acute pulmonary embolism (APE) is among the leading causes of cardiovascular death. Mortality in high-risk patients has been estimated to be as high as 15%.<sup>1</sup> The 12-lead electrocardiogram (ECG) has traditionally been viewed as insensitive for diagnosing APE, however it remains one of the first tests performed on hospital presentation for patients complaining of chest pain and/or dyspnea. Recognition of specific ECG changes may increase diagnostic suspicion of APE, leading to a more rapid diagnosis and treatment as well as potentially improved prognosis. In addition to

more classic ECG patterns such as right heart strain and the S1Q3T3 sign,<sup>2</sup> our group has identified a number of ischemic ECG patterns that can help predict the prognosis of patients with APE.<sup>3,4</sup> T-wave inversion (TWI) is a common ECG finding in patients with APE, but occurs in many other conditions and is by no means specific for APE.

The aim of the study was to determine the prevalence of various TWI patterns in patients with APE and to describe their relationship to clinical outcomes.

### Methods

#### Study population

This was a retrospective chart review of consecutive patients who were diagnosed with APE and were hospitalized in 7 tertiary/

Abbreviations: APE, acute pulmonary embolism; CI, confidence interval; ECG, electrocardiogram; OR, odds ratio; TWI, T-wave inversion.

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secondary hospitals between 2005 and 2012. The study population consisted of 437 patients (267 female, 170 male), aged 17–89 years, with a mean age of age 67.4 ( $\pm 19$ ) years. Clinical characteristics of the study group are described in Table 1. APE was diagnosed by computed tomography with angiography of the pulmonary arteries in 417 patients (95.4%), echocardiography in 18 patients (4.1%) with cardiogenic shock and autopsy in 2 patients (0.5%).

### ECG analysis

The ECGs were obtained in standard format as described previously.<sup>3</sup> TWI was defined as a T-wave with a net negative deflection and an absolute amplitude of at least 0.5 mV. The presence of TWI in all ECG leads except lead aVR was determined on the first ECG recorded following presentation to hospital. TWI presumed to be secondary to left bundle branch block or LV hypertrophy were excluded. TWI patterns were described in two separate electro-anatomical distributions: inferior leads (II, III and aVF) and precordial leads (V1–V6). The absolute number of leads with TWI was also recorded. The patients were divided into two groups based on the number of leads with TWI; Group TWI  $\geq 5$ :  $\geq 5$  leads with TWI and Group TWI  $< 5$ :  $< 5$  leads with TWI. Finally, the sum of amplitude of all TWI was calculated by adding the absolute value of the amplitude of the deepest TWI in each lead. The patients were divided into two groups based on the sum of the absolute amplitude of the deepest TWI in each lead: “High-sum T wave amplitude” (H-group): Total sum of TWI in all leads  $\geq 5$  mm and “Low-sum T wave amplitude” (L-group): Total sum of TWI in all leads  $< 5$  mm.

Outcomes that were included in the analysis included: all cause in-hospital mortality and in-hospital complications (cardiac arrest, cardiogenic shock, treatment with vasopressors or inotropes and positive pressure ventilation).

### Statistical analysis

Categorical variables were expressed as numbers and percentages, and continuous variables as means and standard deviations. The statistical significance of differences between two groups was assessed by the use of a univariate logistic regression model in which the direction and strength of association between grouping variable and predictor was summarized by an odds ratio (OR) with a 95% confidence interval (CI). The performance of binary decision rules was described using the following measures (with 95% confidence interval): diagnostic accuracy, sensitivity, specificity, positive and negative predictive value, likelihood ratio of a positive and negative test. A two-tailed *p* value less than 0.05 was considered

**Table 1**  
Clinical characteristic of a study population of 437 patients with acute pulmonary embolism.

Parameter	
Mean Age	67 (+ 15.0)
Female	267 (61%)
Angina	164 (37.4%)
Syncope	109 (24.9%)
Obesity	116 (26.5%)
Immobilization	106 (24.2%)
Deep vein thrombosis	172 (39.3%)
Hemoptysis	12 (2.7%)
Cancer	43 (9.8%)
Oral contraception	9 (2.0%)
Heart failure NYHA II – IV	62 (14.2%)
Chronic obstructive pulmonary disease	36 (8.2%)
Inflammation	48 (10.9%)

statistically significant. Statistical analysis was performed using a ‘BDT comparator’ program and a code written in R 3.0.<sup>5,6</sup>

### Results

Out of 437 consecutive patients, admission ECGs were of appropriate technical quality to correctly assess the presence of TWI and the sum of TWI amplitudes in 430 (98.4%) and 427 patients (97.7%), respectively. TWI was observed on the first ECG following presentation to hospital in 258 (59.0%) patients. TWI was observed in both the inferior limb leads AND precordial leads in 110 (25.1%) patients (Group T2). TWI was observed in only one region, inferior limb leads OR precordial leads in 148 patients (33.9%) (Group T1). TWI was absent in 179 patients (41.0%) (Group T0). Echocardiographic data from admission was available in 385 (88%) patients, including 100 (91%) patients in Group T2, 132 (89%) patients in Group T1 and 153 (86%) patients in Group T0. Echocardiographic RV overload was observed in 99 (65%) patients in Group T0, in 98 (74%) patients in Group T1 and in 92 (92%) patients in group T2.

### Mortality and complications

In-hospital mortality of the entire APE patient cohort was 9.1%, and was 12.7%, 11.5% and 5.0% in groups T2, T1 and T0, respectively (Table 2). The mortality rate was significantly different between groups T2 and T0 (OR: 2.74; *p* = 0.024) and between groups T1 and T0 (OR: 2.43; *p* = 0.035). The rates of complications were 29.1%, 20.9% and 16.8% in groups T2, T1 and T0, respectively. The complication rate was significantly different between groups T2 and T0 (OR: 2.03; *p* = 0.015) (Table 2).

Compared to patients in groups T0 and T1, a significantly higher proportion of the patients in group T2 received fibrinolytic therapy

**Table 2**

The frequency of death, complications, and the treatment with vasopressor/inotropes or fibrinolysis in patients with APE by presence or absence of T-wave inversions in the inferior and precordial leads.

	TWI Absent (T0)	TWI in inferior OR precordial leads (T1)	OR, 95% CI	<i>p</i> -Value
Complications	30 (16.8%)	31 (20.9%)	1.31 [0.75–2.31]	0.338
Death	9 (5.0%)	17 (11.5%)	2.43 [1.06–5.92]	<b>0.035</b>
Fibrinolysis	8 (4.5%)	11 (7.4%)	1.70 [0.66–4.58]	0.268
Vasopressor/ Inotropes	12 (6.7%)	21 (14.2%)	2.28 [1.09–4.98]	<b>0.028</b>
Elevated cTnT	57 (40.4%)	71 (57.7%)	2.00 [1.23–3.29]	<b>0.005</b>
	TWI Absent (T0)	TWI in inferior AND precordial leads (T2)	OR, 95% CI	<i>p</i> -Value
Complications	30 (16.8%)	32 (29.1%)	2.03 [1.15–3.61]	<b>0.015</b>
Death	9 (5.03%)	14 (12.7%)	2.73 [1.14–6.85]	<b>0.024</b>
Fibrinolysis	8 (4.5%)	17 (15.5%)	3.85 [1.63–9.87]	<b>0.002</b>
Vasopressor/ Inotropes	12 (6.7%)	18 (16.4%)	2.70 [1.25–6.04]	<b>0.011</b>
Elevated cTnT	57 (40.4%)	64 (73.6%)	4.06 [2.29–7.40]	<b>&lt;0.001</b>
	TWI in inferior OR precordial leads (T1)	TWI in inferior AND precordial leads (T2)	OR, 95% CI	<i>p</i> -Value
Complications	31 (20.9%)	32 (29.1%)	1.55 [0.87–2.75]	0.137
Death	17 (11.5%)	14 (12.7%)	1.13 [0.52–2.41]	0.762
Fibrinolysis	11 (7.4%)	17 (15.5%)	2.26 [1.02–5.22]	<b>0.046</b>
Vasopressor/ Inotropes	21 (14.2%)	18 (16.4%)	1.18 [0.59–2.36]	0.632
Elevated cTnT	71 (57.7%)	64 (73.6%)	2.03 [1.12–3.73]	0.019

OR: odds ratio, CI: confidence interval, TWI: T-wave inversions, cTnT: cardiac troponin plasma concentration. *p* values  $< 0.05$  appear in bold.

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