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Comparison between Negative T waves characteristics in acute coronary syndrome and pulmonary embolism

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ABSTRACT

Background: Electrocardiogram (ECG) is the first available modality used in patients with chest pain and dyspnea in emergency rooms.
We aimed to study differences between acute coronary syndrome (ACS) and acute pulmonary embolism (APE) in patients presented primarily with abnormal negative T waves on their admission Electrocardiogram.
Methods: This research was a retrospective study in which 297 patients (97 patients with APE and 200 with ACS) were included. The patients were admitted to the emergency ward of a tertiary heart center between 2015 and 2017. In addition to the evaluation of distribution of negative T waves, the depth of the inverted precordial T waves was measured.
Results: The mean age of patients was 62.0 ± 11.4 in ACS group and 60.7 ± 17.6 in APE group (P value = 0.563). Total negative T in V3 and V4 in ACS and APE groups was 9.1 mm and 4.2 mm respectively (P value <0.001). Total magnitude of negative T in anterior leads divided by total magnitude of negative T in inferior leads for ACS and APE groups were 15.1 ± 12.0 and 5.4 ± 3.6 respectively (P value = 0.001).
ROC curves showed that total magnitude of negative T in V4 divided by negative T in V1 can be valuable. A cutoff point of 1.75 with sensitivity of 73.5% and specificity of 84.9% (95% CI 0.79–0.91 $P < 0.001$) could differentiate APE patients from ACS patients.
Conclusion: This study suggests that total magnitude of negative T in left precordial leads divided by right precordial leads can be valuable in differentiating APE from ACS.

Introduction

Acute pulmonary embolism (APE) is a potentially life threatening condition with a mortality rate reported 2–8% in patients with appropriate diagnosis and treatment, reaching up to 30% in untreated cases [1, 2].

Although clinical suspicion is the first step in the diagnosis of APE, various presentations and broad-spectrum causes of dyspnea as the main symptom of the disease can be attributed to large numbers of delayed diagnosis and misdiagnosed cases [3]. Generally, electrocardiogram (ECG) is the first available modality used in patients with chest pain and dyspnea in emergency rooms. Despite its restricted value in diagnosis of APE, it can help to determine high risk patients and predict adverse outcomes [4]. On the other hand, ECG is still a major diagnostic tool in patients with suspected acute coronary syndrome (ACS). Cardiac troponin is commonly ordered in this setting, and has been shown to be elevated in both severe APE and ACS. Hence, its value in differentiating ACS and APE is limited. Similarities in ECG changes, possible cardiac troponin elevation in both ACS and APE, and common symptomatology in presentation of both conditions such as chest pain, dyspnea and syncope may lead to mismanagements and increased mortality in this specific group of patients [5–7].

That being said, it seems that immediate and correct differentiation of ACS and APE in emergency rooms is necessary. Recently, it has been suggested that ECG can be utilized in differentiating APE from ACS with left anterior descending coronary artery (LAD) disease. The sensitivity and specificity of this method was estimated as 88% and 99% respectively [8, 9].

The aim of this study is to determine differences between ACS and APE in patients presented primarily with abnormal negative T waves in their ECG at emergency room. Identification of diagnostic criteria on

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ECG with higher sensitivity in comparison to previous studies will be our ultimate goal.

Methods

This research was a retrospective study in which 297 patients (97 patients with APE and 200 with ACS) were included. The patients were admitted to the emergency ward of heart hospital between 2015 and 2017. Demographic and clinical characteristics of the patients in both groups were obtained from medical records.

Each patient was considered hypertensive if there was observed blood pressure of 140/90 or more or was already on antihypertensive drug treatment. Hypercholesterolemia was defined as total cholesterol of ≥240 mg/dl or history of receiving lipid-lowering agents. Cardiac troponin-I was measured in first hour after admission by using immune-enzymo-metric assay kits. (AccuBind kits, Monobind Inc.USA) The values ≥1.4 ng/ml (the 99th percentile) were considered as positive [10].

These criteria used for patient selection:

1. Absence of the conditions which may prevent precise assessment of ST-T changes on ECG for example complete left bundle branch block (LBBB), hypertrophic cardiomyopathy and left ventricular hypertrophy, ventricular pacing, or receiving digoxin and other drugs which may cause ST-T changes, electrolyte abnormalities and metabolic disease, severe anemia.
2. No past history of ischemic heart disease or severe pulmonary disease, no documented previous ECG abnormality.
3. Legible and accessible ECG on admission with T wave inversion ≥1.0 mm in two or more precordial leads (V_{1-4}).

A Q-wave myocardial infarction on admission ECG was considered as the exclusion criterion [11].

This study was approved by the Ethics Committee of our University. The informed consent was obtained from all subjects.

Patients with pulmonary embolism had symptoms such as sudden onset of dyspnea, tachypnea, chest pain/discomfort, palpitations, syncope, hypotension or shock. The diagnosis of APE was established by pulmonary computed tomography angiography (CTA) in all the patients [1].

In the ACS group, patients who had new onset symptoms including presence of symptoms at rest, new onset of symptoms or recent increasing angina were evaluated. All the patients underwent cardiac catheterization during hospitalization and all the coronary angiograms were evaluated by two cardiologists who were blind to all other clinical data. The diagnosis of ACS was confirmed by the presence of T wave inversion in precordial leads with or without T wave changes in other leads along with angiographic findings of stenosis ≥70% needing angiographic intervention (according to patient's interventional cardiologist) in one or more of the main coronary arteries [12]. Patients with ST segment elevation on presentation were excluded.

A 12-lead electrocardiogram was recorded from each patient at a paper speed of 25 mm/s and an amplification of 10 mm/mV on admission. All ECGs were interpreted by two cardiologists who were blind to all other clinical data.

In addition to the evaluation of distribution of negative T waves, peak of negative T was measured which was related to the precordial leads.

Other ECG findings, previously demonstrated to be related to/associated with APE, were evaluated: P pulmonale (positive P waves with amplitudes ≥2.5 mm in limb leads or >1.5 mm negative P in lead V1), right axis deviation (QRS electrical axis between +90° and +180°), left axis deviation (QRS electrical axis between −30° and −90°), S1S2S3 pattern (presence of S waves with amplitudes ≥1.5 mm in leads I, II, and III) and S1Q3T3 pattern (presence of S waves in lead I and Q waves in lead III, each having amplitudes >1.5 mm, in association with negative T in lead III).

Distribution and magnitude of negative T waves in two groups of patients were evaluated in precordial, inferior and lateral leads. Pre-specified analysis was done to calculated the total magnitude of negative T in V1-V2 and V3-V4 and the magnitude of negative T in V4 divided by V1 ratio to find the distribution of the deepest negative T in ACS and APE [13].

Statistical analysis

Continuous data are expressed as mean values ± standard deviation, and categorical data are expressed as numbers and percentages. A *P* value <0.05 was considered significant. Kolmogorov-Smirnov and Chi-square and Fisher tests were used to compare categorical variables.

Results

The mean age of patients was 62.0 ± 11.4 in ACS group and 60.7 ± 17.6 in APE group (*P* value = 0.563). In ACS group 34 patients (17.0%) and in APE group 16 patients (16.4%) had elevated serum cTnI. (*P* = 0.913) In APE group CTA showed sub-segmental PE in 9.2% of patients. Table 1 shows characteristics of patients. In ACS group, the deepest T (mean T inversion) was found in aVL (1.6 mm) as limb lead and in V4 (4.6 mm) as precordial lead; while, in APE group, the deepest T waves were seen in lead III (1.5 mm) and V3 (2.7 mm). Total magnitude of negative T in V1 and V2 was 4.3 mm and 4.2 mm in ACS and APE respectively (*P* value = 0.787). Total negative T in V3 and V4 in ACS and APE groups was 9.1 mm and 4.2 mm respectively (*P* value < 0.001). The possible diagnostic power of negative T according to ACS and APE groups in different leads are shown in Table 2. Compared to ACS patients, patients with APE had deeper negative T in inferior leads than anterior leads. Total magnitude of negative T in anterior leads divided by total magnitude of negative T in inferior leads for ACS and APE groups were 15.1 ± 12.0 and 5.4 ± 3.6 respectively (*P* value = 0.001). In all of patients in ACS group, a lesion with a stenosis >70% was documented. Fig. 1 shows the distribution of frequency of negative T wave in different leads in patients of both groups. Although in APE patients deepest negative T was seen in V1 more frequently, none of them had deepest negative T in V5-V6 (Fig. 2). Receiver Operating Characteristic (ROC) curves showed that total magnitude of negative T in left precordial leads divided by right precordial leads can be valuable in differentiating APE

Table 1
Characteristics of patients admitted with acute coronary syndrome (ACS) and pulmonary thromboembolism (PTE).

		ACS N = 200	PTE N = 97	*P* value
Gender	Male, n (%)	96 (48%)	49 (50.5%)	0.724
	Female, n (%)	104 (52%)	48 (49.5%)	
Age, years		62.0 ± 11.4	60.7 ± 17.6	0.563
Diabetes mellitus, n (%)		44 (22%)	14 (14.4%)	0.169
Smoking, n (%)		52 (26%)	16 (16.5%)	0.103
HTN, n (%)		116 (58.0%)	38 (39.2)	0.008
Hyperlipidemia, n (%)		92 (46%)	30 (30.9%)	0.030
Heart rate		75.9 ± 15.0	99.5 ± 19.2	<0.001
Triglycerides		154.5 ± 14.2*	145.2 ± 73.1	0.600
Cholesterol		187.9 ± 41.4	167.0 ± 43.3	0.006
Hemoglobin		13.3 ± 1.9	13.2 ± 2.6	0.656
cTnI		1.3 ± 0.25	0.3 ± 0.06	<0.001
HDL		42.8 ± 15.4	33.0 ± 10.1	<0.001
LDL		109.1 ± 35.7	107.1 ± 35.3	0.783
Systolic BP, mmHg		139.3 ± 23.2	119.1 ± 17.2	<0.001
P pulmunale		0 (0.0%)	7 (7.2%)	0.006
Left axis deviation		2 (1.0%)	3 (3.1%)	0.298
S1S2S3		8 (4.0%)	26 (26.8)	<0.001
S1T3Q3		4 (2.0%)	51 (52.6)	<0.001

HDL: high density lipoprotein, LDL: low density lipoprotein, *mean ± standard error.