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A retrospective evaluation of CT pulmonary angiographic clot burden score and ECG score and relation to early and late mortality of pulmonary embolism

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A B S T R A C T

Pulmonary Thromboemboli (PTE) is considered a prevalent, potentially fatal disease with mortality of 2-60% even in the presence of anticoagulation. Use of standard 12-lead electrocardiography has gained a special position during recent years for specification of early and late mortality risk in PTE. The aim of the recent study is to examine whether there is a relationship between the ECG Score system and the pulmonary artery clot load scoring system when diagnosing PTE. In a cross-sectional and descriptive-analytical study, that performed in Pulmonary ward Department of Internal Medicine of Tabriz University of Medical Sciences on patients with PTE visiting and being hospitalized, we retrospectively examined the relationship between clot volume score in computed tomography angiography (CTA) and ECG findings in PTE and their relationships to early and late mortality in these patients. In this study, by examining the clinical files of 200 patients with PTE, 118 patients were male and 82 were female. The mean age of male patients was 62.95±14.79 and in female patients was 57.12±15.03 year. In CTA, 111 patients suffered from massive pulmonary thromboemboli and 89 suffered from submassive pulmonary thromboemboli. Sinus tachycardia was the most common finding in the patients' ECG. The value of positive findings in ECG was significantly higher in massive pulmonary thromboemboli. The mean ECG score was 10.48±4.13 in the massive pulmonary thromboemboli patients and 2.97±2.73 in the submassive pulmonary thromboemboli patients. The mean ECG score was significantly higher in the massive pulmonary thromboemboli patients than submassive pulmonary thromboemboli. 23 (11.5%) of the patients had died at the hospital. 9 (5.08%) of the patients had died after discharge.

Introduction

Pulmonary Thromboemboli (PTE) is considered a prevalent, potentially fatal disease with mortality of 2-60% even in the presence of anticoagulation. During the past one decade, with the introduction of CT pulmonary angiography, these patients' diagnostic algorithm was transformed, and the diagnostic precision increased dramatically along with the CT pulmonary angiography technology progress. Although CT pulmonary angiography is mainly used as a non-invasive diagnostic test to show clots inside vessels, another advantage it provides is to reject or confirm alternative diagnoses. This is why CT pulmonary angiography is considered as the first-line diagnostic tool for PTE today (1-3).

Primary studies during the past 10 years have stated CT pulmonary angiography sensitivity as 83-100%. Studies in recent years, however, have reduced the sensitivity to 90%. Not only is CT pulmonary angiography used in recent years as a selective diagnostic test, but it has also gained a special position among specialists as a tool for specification of the treatment type and prognosis. Proposed prognostic factors in CT pulmonary angiography include the ratio of the right ventricle diameter to that of the left ventricle in a cross section, ventricular septal turn toward the left ventricular cavity, the ratio of the pulmonary root diameter to that of the aorta, azygos vein and IVC diameter, and contrast medium reflux into IVC (1, 3-4).

Two of the new methods for using CT pulmonary angiography to specify early and late mortality are three-dimensional reconstruction of right ventricular volumes and specification of clot load in pulmonary vessels. For specification of clot load values, similar scoring systems, based on the following items, are used (4-6).

1. Obstruction location: Existence of thrombosis in the segmental artery is scored one point and as many points as the number of the lobe segments in lobar proximal arteries.
2. Obstruction degree: If there is a partial obstruction and distal area perfusion, the location score is multiplied by one, and if there is a full obstruction, the location score is multiplied by two.

For example, a clot in the upper lobe of the right lung will score 6 points if the obstruction is full, and a partial obstruction in the middle lobe artery of the right lung will score 2 points.

During the past years, clinical criteria and echocardiography were used for specification of in-hospital early mortality risk and use of fibrinolysis factors. Occurrence of shock and hypotension, right ventricle functioning disorder in echocardiography, and biological markers demonstrating ventricle functioning disorder like heart troponin are considered as criteria for PTE with high or medium risk (2, 6).

Use of standard 12-lead electrocardiography has gained a special position during recent years for specification of early and late mortality risk in PTE. In fact, it had been known since many years ago that electrocardiographic changes are observed although temporarily in almost all patients with PTE in the acute phase. In some but not all recent studies, mention has been made of the relationship between electro-cardiographic findings and PTE intensity. Effects of specific ECG findings on PTE's hospital mortality have not been studied

fully so far. The justifying mechanism has justified all ECG abnormalities in the area of functional or structural disorders as resulting from high pressure-overload over the right ventricle (7-8).

In these patients, ECG is routinely provided before CT pulmonary angiography is performed. Based on different reports, the standard ECG score system in PTE has been provided, as displayed in the table below (7-9).

The purpose of the recent study is to examine whether there is a relationship between ECG score and pulmonary artery clot load scoring when diagnosing PTE. The relationships between these two scorings and early mortality and, if possible, mortality 3 months after treatment with telephone calls will also be included in the study.

The aim of this study is to examine the relationship between the pulmonary artery clot load scoring system in CT pulmonary angiography and the ECG score system in PTE and their relation to in-hospital and late mortality.

Materials and methods

In a cross-sectional and descriptive-analytical study, that performed in Pulmonary ward of Internal Medicine Department of Tabriz University of Medical Sciences on patients with PTE visiting and being hospitalized, we retrospectively examined the relationship between clot volume score in computed tomography angiography (CTA) and ECG findings in PTE and their relationships to early and late mortality in these patients.

We extracted the files of all the patients hospitalized in the lung department of Imam Reza Hospital since founded diagnosing PTE proven by CT pulmonary angiography, which included 1707 patients. By examining these patients' files and because they were so incomplete and we could not verify late mortality in the patients, we finally selected 200 patients' files with rather more complete information and included them in the study. And by examining these patients' files, we extracted and examined the information needed.

The patients' CT pulmonary angiographies were specified and scored based on clot-burden-score by two radiologists as detailed below:

1. Obstruction location: Existence of thrombosis in the segmental artery was scored one point and as many points as the number of the lobe segments in lobar proximal arteries.

2. Obstruction degree: If there was a partial obstruction and distal area perfusion, the location score was multiplied by one, and if there was a full obstruction, the location score was multiplied by two.

In the second step, the patients' primary ECGs will be scored by two lung specialists as detailed below:

All the patients hospitalized with PTE in the lung department of Imam Reza Hospital since founded whose diagnoses had been confirmed by CT pulmonary angiography constituted all the cases examined in this study, which included 1707 patients. After examining these patients' files and because they were so incomplete and we could not verify late mortality in the patients, we finally selected 200 patients' files with rather more complete information and included them in the study. And by

examining these patients' files, we extracted and examined the information needed.

Statistical Analysis

The collected data were analyzed by SPSS-17 statistical software. The collected data were expressed as percentage and mean ± SD. Continuous (quantitative) variables were compared by Independent samples and Paired t test. Categorical (qualitative) variables were compared by contingency tables and Chi-square test or Fisher's exact test. P-value ≤0.05 was considered statistically significant.

Ethical considerations

It is not intended in order not to interfere with treatment and diagnosis, and all the patients' information will also be kept confidential.

Result and Discussion

In this study, the following results were obtained by examining the clinical files of 200 patients with PTE hospitalized in Imam Reza Hospital:

118 of the patients were male and 82 were female. The mean age of male patients was 62.95±14.79 ad in the female patients was 57.12±15.03 year (P=0.007).

In the CT pulmonary angiographies performed on the patients, 111 of the patients suffered from massive pulmonary thromboemboli and the other 89 suffered from submassive pulmonary thromboemboli.

The findings of the ECGs performed on the patients have been displayed in Table 1. The mean ECG score of the patients with PTE was 7.14±5.16. The findings of the ECGs performed on the patients based on the CT pulmonary angiography results have been displayed in Table 2.

The mean ECG score was 10.48±4.13 in massive pulmonary thromboemboli and 2.97±2.73 in submassive pulmonary thromboemboli.

The mean ECG score was significantly higher in the patients with massive pulmonary thromboemboli than submassive pulmonary thromboemboli (P<0.001).

23 (11.5%) of the patients had died at the hospital. 9 (5.08%) of the patients had died after discharge.

The findings of the patients' ECGs based on the CT pulmonary angiography results have been displayed in Table 1. The findings of the patients' ECGs based on hospital and post-discharge mortality have been displayed in Tables 2 and 3. The patients' ECG score value ranges based on the CT pulmonary angiography results, early mortality, and late mortality has been displayed in Chart 1 to 3.

In this study, by examining the ECG and CT pulmonary angiographic findings of the patients visiting with PTE, we specified their relations to the patients' hospital (early) and out-of-hospital (late) mortality values, and the results demonstrate that these patients' early mortality value is 13.5%, and the late mortality value in these patients is about 5%.

PTE is often the complication of deep abdominal vessels and lower limb thrombosis. CT pulmonary angiography is the golden standard used for PTE diagnosis due to abundance and availability (10). In comparative studies with lung scintigraphy, CT pulmonary angiography has had better

sensitivity (11). CT pulmonary angiography also has the advantage of revealing pathologies of other structures in the thorax (12-13).

The death rate resulting from untreated PTE is stated as about 30%; therefore, it is of great importance to confirm the diagnosis aided by a non-invasive imaging method with high sensitivity (14-17). PTE's clinical symptoms and experimental findings are non-specific, based on which PTE's occurrence or PTE's intensity cannot be stated (14-17).

In our study, the overall mortality rate of the patients under study was 16% in total. It has been suggested that ECG findings may be able to predict PTE's occurrence and its clinical consequence. Nevertheless, an ECG in a patient with PTE may be accompanied by a wide variety of manifestations (18-21), and ECG, therefore, offers no sensitive or specific criteria or manifestations for identification of PTE.

In our study, the incidence of positive findings predicting embolism was significantly higher in the patients with massive pulmonary thromboemboli than in those with submassive pulmonary thromboemboli.

In earlier studies, some findings prevalent in ECG such as BB have been suggested as findings predicting PTE's occurrence and, in some cases, PTE's intensity and specifying treatment prognosis (22). In our study, too, there was a significant relationship in massive pulmonary thromboemboli between the embolism intensity and the ECG findings.

Similarly, it was suggested in Kanbay's study that ECG is valuable in demonstrating PTE's intensity based on anatomy (21). The results of Golpe's study also demonstrated that ECG is related to PTE's intensity (23). Ferrari and colleagues observed that T-invert is the most prevalent abnormality related to PTE's intensity in pre-cordial lead, such that the invertibility of T-invert was accompanied by changes in PTE (18).
In our study, the T-invert value was significantly higher in the patients with massive pulmonary thromboemboli, such that there was not a significant difference between the patients with massive pulmonary thromboemboli and those with submassive pulmonary thromboemboli in T-invert less than 1mm, but intense T-invert was significantly higher in massive pulmonary thromboemboli.

Geibel and colleagues observed that existence of at least one of the ECG changes is an independent predictor of clinical outcomes (24). Nevertheless, in the present study, there was not a prominent statistical difference from the point of view of the number of the ECG changes and the embolism intensity, and none of these findings was able to predict the occurrence of intense embolism.

In another study performed by Sinha in New York in 2008 to assess the role of 12-lead ECG in improvement of PTE prediction, ECGs were provided from patients suspected of pre- CT pulmonary angiographic embolism, and ECG changes were compared to the control group with negative CT pulmonary angiography, demonstrating that changes in ECG are significantly related to PTE (20).

In our study, the frequency of ECG's positive findings in the items under study was significantly higher in the patients with massive pulmonary thromboemboli, and since no investigation was made in our study between the patients with embolism and

those without embolism, no comments can be made about the diagnostic value of the above items in confirmation of PTE diagnosis, and the above items more often become positive in the patients with massive pulmonary thromboemboli.

By examining ECG changes in PTE, Kostrubiec stated that 7.1% of the patients passed away during hospitalization, and the patients suffered complications in 14.3% of the cases. Patients with complications had prominently higher mean ECG scores than the group without complications. Right ventricular contraction disorder was found in echocardiography in 23.2% of the cases, which had higher ECG scores than the group without the problem.

Table.1 ECG finding of patients based on CT Pulmonary angiography

	CT Pulmonary angiography		P
	Massive	Submassive	
Tachycardia	111	55	<0.001
Incomplete right bundle branch block	38	10	<0.001
Complete right bundle branch block	41	3	<0.001
T wave inversion in V1 1-2 mm	38	9	<0.001
T wave inversion in V1 >2 mm	44	7	<0.001
T wave inversion in V2 <1 mm	24	20	0.885
T wave inversion in V2 1-2 mm	40	2	<0.001
T wave inversion in V2 >2 mm	18	4	0.008
T wave inversion in V3 <1 mm	21	14	0.555
T wave inversion in V3 1-2 mm	44	4	<0.001
T wave inversion in V3 >2 mm	21	3	<0.001
T wave inversion in V1-4 >2 mm	27	0	<0.001
T wave in lead III	37	13	0.002
Q wave in lead III	38	3	<0.001
S1Q3T3	49	10	<0.001
S wave in lead I	51	11	<0.001

Chart. 1 Distribution of ECG score of patients based on CT Pulmonary angiography

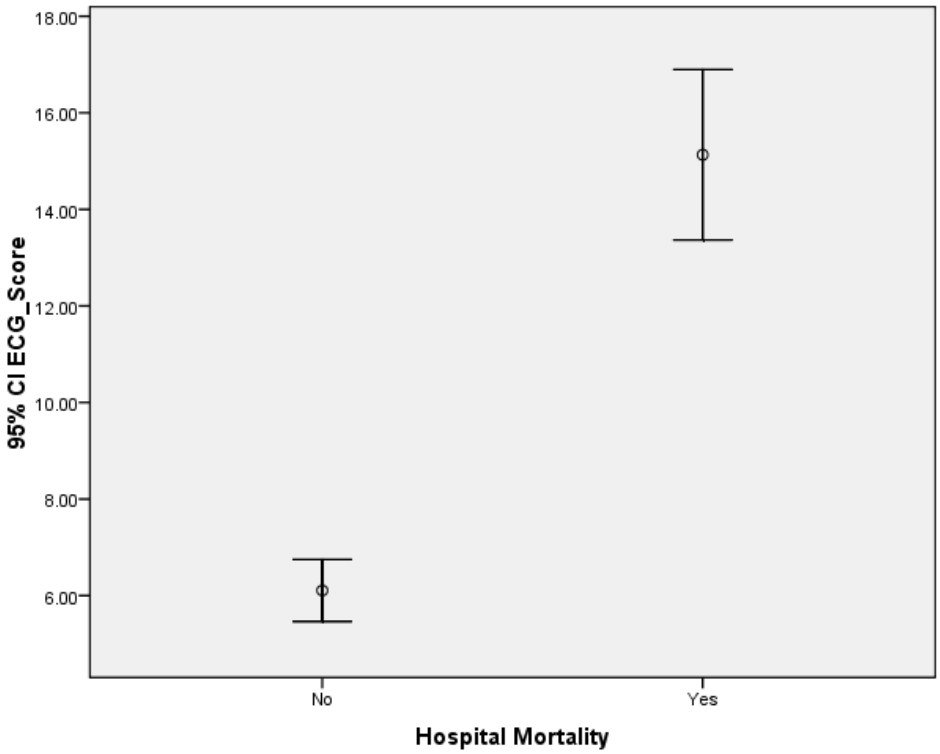


Chart.2 Distribution of ECG score of patients based on Hospital Mortality

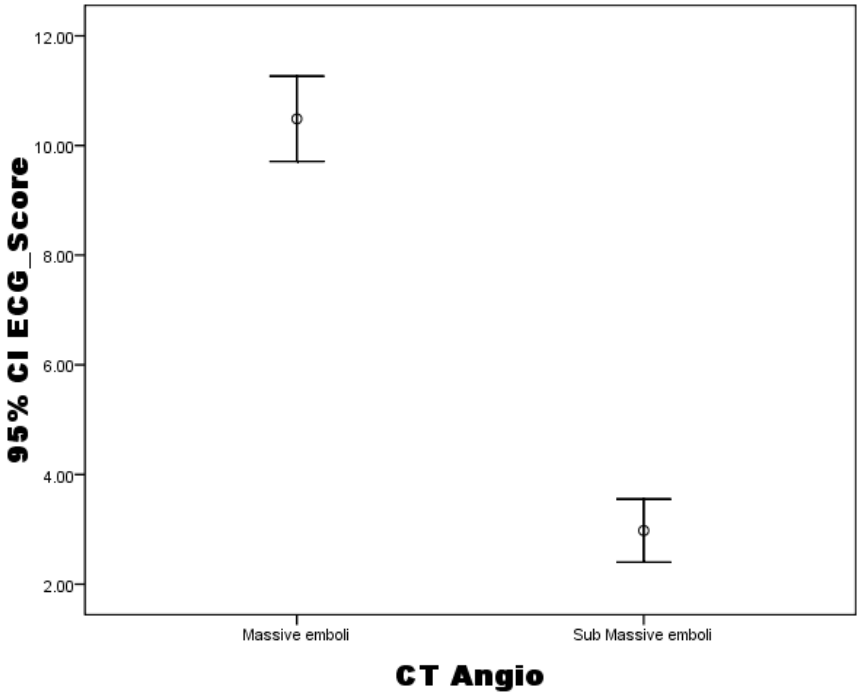


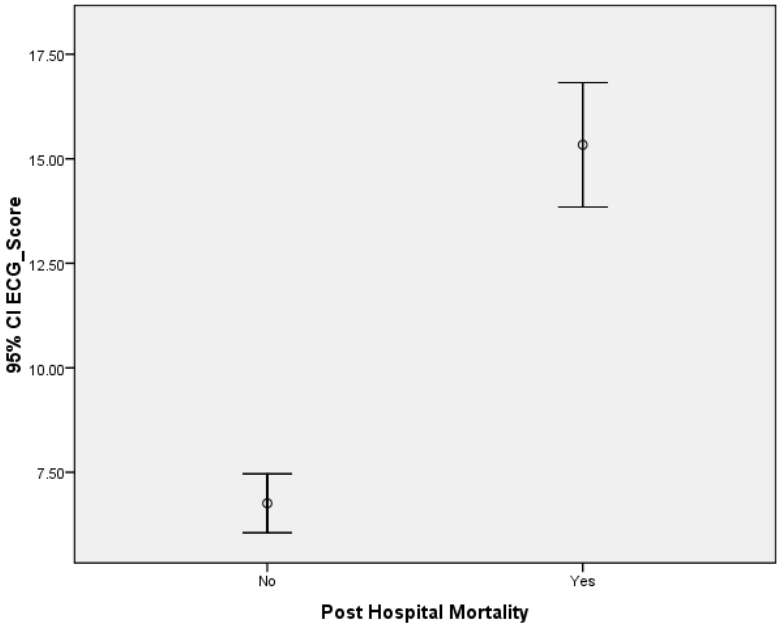
Table.2 ECG finding of patients based on Hospital Mortality

	Hospital Mortality		P
	Alive	Dead	
Tachycardia	143	23	0.016
Incomplete right bundle branch block	43	5	0.787
Complete right bundle branch block	29	15	<0.001
T wave inversion in V1 1-2 mm	41	6	0.756
T wave inversion in V1 >2 mm	32	19	<0.001
T wave inversion in V2 <1 mm	40	4	0.571
T wave inversion in V2 1-2 mm	23	19	<0.001
T wave inversion in V2 >2 mm	22	0	0.083
T wave inversion in V3 <1 mm	26	9	0.008
T wave inversion in V3 1-2 mm	39	9	0.071
T wave inversion in V3 >2 mm	15	9	<0.001
T wave inversion in V1-4 >2 mm	14	13	<0.001
T wave in lead III	36	14	<0.001
Q wave in lead III	26	15	<0.001
S1Q3T3	49	10	0.118
S wave in lead I	52	10	0.169

Table.3 ECG finding of patients based on Post Hospital Mortality

	Post Hospital Mortality		P
	Alive	Dead	
Tachycardia	157	9	0.362
Incomplete right bundle branch block	46	2	0.629
Complete right bundle branch block	35	9	<0.001
T wave inversion in V1 1-2 mm	43	4	0.219
T wave inversion in V1 >2 mm	44	7	0.001
T wave inversion in V2 <1 mm	38	6	0.004
T wave inversion in V2 1-2 mm	40	2	0.914
T wave inversion in V2 >2 mm	21	1	0.658
T wave inversion in V3 <1 mm	31	4	0.052
T wave inversion in V3 1-2 mm	43	5	0.038
T wave inversion in V3 >2 mm	20	4	0.014
T wave inversion in V1-4 >2 mm	25	2	0.349
Q wave in lead III	36	5	0.019
S1Q3T3	52	7	0.003
S wave in lead I	59	3	0.567
T wave in lead III	45	5	0.045

Chart.3 Distribution of ECG score of patients based on Post Hospital Mortality



ECG score's sensitivity, specificity, and positive and negative predictive values were 92%, 65%, 44%, and 97%, respectively, in predicting the occurrence of right ventricular contraction disorder and 75%, 46%, 19%, and 92% for pulmonary hypertension (25).
In our study, the hospital mortality value was 13.5%, and the ECG score value and also the passed-away patients, whether early or late, were more in the patients with massive pulmonary thromboemboli.

In a study, Kukla assessed the value of ECG changes in myocardial damage prediction and prognosis in patients with PTE, including 225 patients with a mean age of 66.00±15.2 years. In this study, 26 in-hospital deaths were observed with a death rate of 11.5% and complications in 58 cases (25.7%). There were increased levels of troponin in 46% of the cases. Logistic regression analysis demonstrated that in-hospital death was related to coronary chest pain, SBP<100, PR>100, the S1Q3T3 sign, QR-in-V1, ST segment decrease in leads V4-V6, ST segment increase in lead III, ST segment increase in lead V1, and different troponin values. The following ECG changes were prominently prevalent in patients with increased troponin as compared to those with normal troponin levels: the S1Q3T3 sign, T-invert in leads V2-V4, ST segment decrease in leads V4-V6, ST segment increase in lead III, ST segment increase in leads V1 and V2, and QR-in-V1. The study suggests that ECG parameters are useful in myocardial damage prediction and prognosis assessment in patients with PTE (19).

In another study, Ryu assessed standard 12-lead ECG patterns in PTE and risk assessment based on these patterns. For this purpose, 125 patients with a mean age of 63±14 years were assessed. ECG score was recorded in all patients. Among ECG's different findings, sinus tachycardia and T-invert in leads V1-4 had been observed as more prevalent. The mean ECG score and right ventricular systolic pressure were 7.36±6.32 and 49±21 millimeters mercury, respectively. ECG score was prominently positively related to right ventricular systolic pressure. The patients were divided into two groups: ECG score over 12 and ECG score below 12. Right ventricular hypokinesis was observed more in cases with high ECG score. Multi-variable analysis demonstrated that high ECG score independently specifies right ventricular systolic pressure and occurrence of right ventricular hypokinesis (26).

Conclusion

In this study, by examining the clinical files of 200 patients with PTE hospitalized in Imam Reza Hospital, 118 of the patients were men and 82 were women. In the CT pulmonary angiographies performed on the patients, 111 of the patients suffered from massive pulmonary thromboemboli and the other 89 suffered from submassive pulmonary thromboemboli. Sinus tachycardia was the most prevalent finding in the patients' ECGs. The value of positive findings in the patients' ECGs was significantly higher in the massive pulmonary thromboemboli cases.

The mean ECG score in the patients with massive pulmonary thromboemboli was 10.48±4.13, and the mean ECG score in the patients with submassive pulmonary thromboemboli was 2.97±2.73. The mean ECG score was significantly higher in the patients with massive pulmonary thromboemboli. 23 (11.5%) of the patients had died at the hospital. 9 (5.08%) of the patients had died after discharge.

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