

A Comparison of ECG and Three Clinical Scoring Methods for the Diagnosis of Pulmonary Thromboembolism

Pulmoner Tromboemboli Tanısında EKG ve Üç Klinik Skorlama Yönteminin Karşılaştırılması

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ABSTRACT

Objective: The clinical diagnosis of pulmonary thromboembolism (PTE) is unreliable because the most frequent symptoms are non-specific. The most important step in making the diagnosis of PTE is to clinically suspect the disease. The aim of the present study was to compare the diagnostic efficiency of an electrocardiogram (ECG) and the Wells, Geneva, and Miniati clinical scoring methods for the diagnosis of PTE.

Material and Method: A prospective study was conducted between January 2006 and January 2007, in which 52 consecutive patients with suspected PTE were enrolled.

Results: Twenty-seven patients were males and 25 were females; the mean age was 52±16.3 years. Thirty-six patients were diagnosed with a PTE. The PTE diagnosis rates among the high probability group were 91.3%, 76.5%, and 100% for the Wells, Geneva, and Miniati clinical scoring methods, respectively. The sensitivity and specificity were 66% and 56%, respectively, when the cut-off value of the ECG score was 3, whereas the sensitivity and specificity were 36% and 100%, respectively, when the cut-off value was 5.

Conclusion: The Wells and Miniati clinical scoring methods were shown to be more predictive of PTE than the Geneva clinical scoring method and an ECG, whereas an ECG was more predictive than the Geneva clinical scoring method.

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Key words: Pulmonary thromboembolism, clinical scoring, ECG score

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ÖZET

Amaç: Pulmoner tromboemboli (PTE) de en sık gözlenen semptomların nonspesifik olması nedeniyle klinik tanı güvenilir değildir. Tanıda en önemli adım klinik olarak hastalıktan şüphelenmektir. Bu çalışmanın amacı PTE tanısında Wells, Geneva, Miniati yöntemine göre elde edilen klinik skorların ve EKG skorlama sisteminin tanısız verimliliğini araştırmaktır.

Gereç ve Yöntem: Prospektif olarak planlandı. Ocak 2006-Ocak 2007 tarihleri arasında, PTE kuşkusu olan ardışık 52 olgu çalışmaya alındı.

Bulgular: Olguların 27'si erkek, 25'i kadın ve yaş ortalamaları 52±16.3 idi. Yapılan tetkikler sonrasında 36 olgu PTE tanısı aldı. Klinik skorlama yöntemlerinde yüksek olasılık grubunda, PTE tanı oranı sırasıyla Wells %91.3, Geneva %76.5, Miniati %100 olarak saptandı. EKG skoru 3 sınır değer alındığında sensitivite %66, spesifisite %56, 5 sınır değer alındığında sensitivite %36, spesifisite %100 olduğu saptandı.

Sonuç: Wells ve Miniati yöntemi Geneva'ya göre daha değerli bulundu. Wells ve Miniati, EKG skorlamasından daha anlamlı, EKG skorlaması ise Geneva'ya göre daha değerli saptandı.

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Anahtar sözcükler: Pulmoner tromboembolizm, klinik skorlama, EKG skoru

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INTRODUCTION

Although the exact incidence of pulmonary thromboembolism (PTE) is not known, it is estimated that there are 600,000 cases annually in the US and 100,000-200,000 of these cases result in death [1]. The mortality rate reaches 30% among undiagnosed cases of PTE; however, the mortality rate decreases to 3% with a timely and accurate diagnosis, and appropriate treatment [2].

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researchers have developed various clinical scoring systems to predict the probability of PTE due to the time loss, cost, and lack of availability of technical equipment at all centers [4-6].

The aim of the present study was to compare the diagnostic efficiency of clinical probabilities obtained from the Wells, Geneva, and Miniati methods among cases with a suspected PTE, as well as to investigate the contribution of a simple electrocardiograph (ECG) scoring system to the diagnosis.

MATERIALS and METHOD

Between January 2006 and January 2007, 52 consecutive patients with a suspected PTE were included in the present study.

The inclusion criteria for the present study were as follows:

1) the presence of at least two of the following symptoms (sudden onset of shortness of breath, sudden onset of chest pain, hemoptysis, tachypnea and/or tachycardia, syncope, history of immobilization, and deep vein thrombosis [DVT]); and

2) patients who were considered to have a PTE by another physician, but had not been started on any therapy.

The clinical scores of the patients included in the present study were calculated via the Wells (Table 1), Geneva (Table 2), and Miniati methods (Table 3). The ECGs of the patients were evaluated and scored (Table 4) by two physicians. Simultaneously, a posteroanterior chest radiograph, blood gas analysis, D-dimer measurement, spiral computed tomography (CT), V/Q scintigraphy, and Doppler US were performed, and the diagnosis of PTE was made. Due to the absence of pulmonary angiography in our center, pulmonary angiography was not performed in any of the patients.

Patients who were diagnosed with a PTE (PTE +) met the following criteria: 1) a thrombosis was determined on spiral CT, treatment was initiated, and clinical improvement was determined after treatment; and 2) V/Q scintigraphy revealed a PTE, who were diagnosed with a PTE via D-dimer measurement, Doppler US, or other examinations, and in whom clinical improvement was determined after treatment.

Patients in whom the diagnosis of a PTE had been excluded (PTE -) met the following criterion: treatment was initiated for other diseases, such as pneumonia or heart failure, diagnosed after examination and who had not developed a PTE within the first 3 months of follow-up.

The clinical scoring of the cases was analyzed via SPSS 11.0 and cases with high, medium, or low proba-

Table 1. Wells clinical scoring method

Criteria	Score
Suspected DVT	3
Low probability for other diagnoses apart from PE	3
Heart rate >100 beats/minute	1.5
Immobilization or surgical operation within last 1 month	1.5
Previous history for DVT / PE	1
Hemoptysis	1
Malignancy	

Scoring; <2 low probability; 2-6 medium probability; >6 high probability

Table 2. Geneva clinical scoring method

Criteria	Score
Age 60-79 years	1
Age >80 years	2
History of previous DVT or PE	2
Surgical operation within the last 1 month	3
Heart rate > 100 beats/minute	1
PaCO ₂ < 35 mmHg	2
PaCO ₂ 35- 39 mmHg	1
PaO ₂ < 49 mmHg	4
PaCO ₂ 49-59 mmHg	3
PaCO ₂ 60-71 mmHg	2
PaCO ₂ 72-82 mmHg	1
Band atelectasis on chest radiograph	1
Elevation of diaphragm on chest radiograph	1

Scoring: <5 low probability; 5-8 medium probability; >8 high probability

Table 3. Miniati clinical scoring method

High probability	1. The presence of at least one of the following symptoms which cannot be explained by any other diagnosis: dyspnea, chest pain, and syncope with sudden onset 2. The presence of at least two of the following signs: ECG finding of right heart load, radiologic oligemia, hilar arterial amputation, or pulmonary consolidation consonant with infarction
Medium probability	The presence of one of the three symptoms, but no accompanying ECG or radiologic findings
Low probability	Absence of any of the three symptoms, or the presence of findings of other diagnoses, such as COPD, pneumonia, lung edema, MI, and pneumothorax, that could explain these symptoms

bilities, as well as the diagnostic value of ECG score, were examined. A receiver operating characteristic (ROC) curve was used to determine the diagnostic values of clinical scores and ECG scores, as well as to compare the findings with each other. ECG scores' sensitivity and specificity were calculated for each cut-off level.

Table 4. ECG scoring

ECG	Score
Tachycardia	2
Incomplete right bundle branch block	2
Complete right bundle branch block	3
T wave inversion in V1	
<1mm	0
1-2mm	1
>2mm	2
T wave inversion in V2	
<1mm	1
1-2mm	2
>2mm	3
T wave inversion in V3	
<1mm	1
1-2mm	2
>2mm	3
T wave inversion in V1- V4	4
S wave in lead 1	0
Q wave in lead 3	1
T wave in lead 3	1
S1Q3T3	2

(total score maximum=21)

RESULTS

Twenty-seven patients were male and 25 patients were female; the mean age was 52±16.3 years. Thirty-six patients were diagnosed with a PTE after the examination. Of the patients diagnosed with a PTE, 23 were male and 13 were female. A PTE was not diagnosed in 16 patients. Of the 16 patients, 11 were diagnosed with pneumonia, 3 were diagnosed with heart failure, 1 was diagnosed with atherosclerotic heart disease, and 1 was diagnosed with vasculitis.

According to the clinical scoring methods, the PTE diagnosis rates among the high probability group were 91.3%, 76.5%, and 100% for the Wells, Geneva, and Miniati clinical scoring methods, respectively. The PTE diagnosis rates among the medium and low probability groups were 72.2%, 70.4%, and 85.3%, and 18.2%, 50.0%, and 21.4% for the Wells, Geneva, and Miniati clinical scoring methods, respectively (Table 5).

ROC analysis of the clinical and ECG scoring methods was done and the area under the curve (AUC) was calculated (Figure 1). The AUC values and 95% confidence intervals of the clinical and ECG scoring methods were analyzed (Table 6). The sensitivity and specificity were 66% and 56%, respectively, when the cut-off value of the ECG score was 3, whereas the sensitivity and specificity were 36% and 100%, respectively, when the cut-off value was 5 (Table 7).

In the present study, ECG scoring was compared with three methods of scoring the clinical probability of a PTE. The Wells and Miniati clinical scoring methods were shown to be more significant than the Geneva clinical scoring method and ECG scoring, whereas ECG scoring was more valuable than the Geneva clinical scoring method.

DISCUSSION

The clinical diagnosis of a PTE is unreliable because the most frequent symptoms are non-specific. However,

Table 5. Rates of the diagnoses made according to Wells, Geneva, and Miniati clinical scoring methods

	PTE diagnosis rates in high probability group	PTE diagnosis rates in medium probability group	PTE diagnosis rates in low probability group
Wells	91.3%	72.2%	18.2%
Geneva	76.5%	70.4%	50.0%
Miniati	100%	85.3%	21.4%

Table 6. AUC values and 95% confidence intervals of the clinical and ECG scoring methods

	AUC	p	95% CI
Wells	0.82	0.000*	0.69-0.95
Geneva	0.59	0.284	0.42-0.76
Miniati	0.81	0.000*	0.68-0.95
ECG	0.70	0.018*	0.57-0.84

*p<0.05

reducing the need for pulmonary angiography, which is an invasive, expensive method associated with morbidity and mortality, and not available in all centers, may be possible with the identification of patients with high, medium, and low levels of clinical probabilities, and with the use of other non-invasive diagnostic methods, such as V/Q scintigraphy together with CTPA. As in any disease, the most important step in making the diagnosis of a PTE is to clinically suspect the disease.

PIOPED was an important prospective study which reported the rates at which an accurate diagnosis can be made with V/Q scintigraphy and clinical scoring in

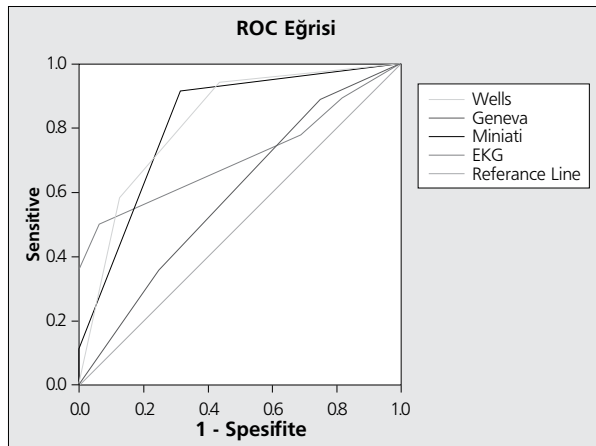


Figure 1. ROC curve of clinical and ECG scorings

Table 7. Sensitivity and specificity considering the cut-off value of ECG score 3 and 5

Cut-off value of ECG scoring	Sensitivity	Specificity
3	66%	56%
5	36%	100%

patients in whom a pulmonary embolus was determined via angiography. In the above-mentioned study, a pulmonary embolus was demonstrated in 96% of cases with high clinical and scintigraphic probabilities, whereas it was 4% in cases with low clinical and scintigraphic probabilities, and 40% in cases with high clinical and low scintigraphic probabilities. In PIOPED, a pulmonary embolus occurred in 68% and 9% of the cases with high and low clinical probabilities, respectively [7].

Another large scale study conducted to identify the clinical probability was the PISAPED [6]. In this study, pulmonary emboli were diagnosed in 91%, 47%, and 9% in of the patients with high, medium, and low probabilities, respectively [6]. In the present study, the PTE diagnosis rates in the high, medium, and low probability groups were 100%, 85.3%, and 21.4%, via the Miniati clinical scoring method.

Wells et al. developed a clinical scoring method in patients who presented with suspected PTE by scoring the risk factors, as well as the clinical and physical examination findings, as high, medium, and low probability. In the above-mentioned study with 1239 participants, a PTE was present in 66.7% of the cases with high probability and in 20.5% and 3.6% of the cases with medium and low probabilities, respectively [4]. In the present study, the rates were 91.3%, 72.2%, and 18.2%, respectively via the Wells clinical scoring method.

Wicki et al. developed the Geneva scoring method by scoring the risk factors, arterial blood gas values, and posteroanterior chest radiograph findings, and the PTE diagnosis rates were reported to be 81%, 38%, and 10% in the high, medium, and low probability groups, respectively [5]. In the present study, the rates were 76.5%, 70.4%, and 50.0% respectively.

Various studies have been conducted on clinical scoring in Turkey (Table 8). In these studies, the Wells clinical

Table 8. Original studies on clinical scoring and the diagnostic percentages in high, medium, and low probability groups in our country

Studies	Diagnosis in high probability group	Diagnosis in medium probability group	Diagnosis in low probability group
Wells			
Wells et al. [4]	66.7%	20.5%	3.6%
Ciftci et al. [8]	100%	90.6%	5%
Berk et al. [9]	100%	84%	1%
Calisir et al. [10]	89.6%	26.4%	7.8%
Gulcu et al. [11]	72.7%	77.3%	26.1%
Geneva			
Wicki et al. [5]	81%	38%	10%
Ciftci et al. [8]	100%	80%	64.3%
Berk et al. [9]	72%	53%	37%
Calisir et al. [10]	83.3%	25.6%	0%
Miniati			
Miniati et al. [6]	91%	47%	9%
Ciftci et al. [8]	94.6%	75%	14.3%

scoring method has generally been determined to be of greater value than other clinical scoring methods [8-11]. In the present study also, the Wells and Miniati clinical scoring methods were shown to be more valuable than the Geneva clinical scoring method, and percentage of PTE diagnoses was higher in the medium and/or low probability groups compared with other studies. This may be due to the prospective design of the present study, the exclusion of cases which were not thought to have a pulmonary embolus, and pulmonary angiography not being performed in any case. Prospective studies are more significant than retrospective studies, thus there is a need for prospective studies regarding clinical scoring on a larger series of patients.

ECG findings are non-specific for the diagnosis of PTE; however, sinus tachycardia, T wave inversion, right bundle branch block, and S1Q3T3 are findings which have been shown to be associated with massive a PTE. Daniel et al. have developed the ECG scoring system based on these four findings in cases in which a PTE was confirmed by pulmonary angiography. In the above-mentioned study, the ECG score had a correlation with the degree of pulmonary hypertension [12]. Iles et al. have reported that cases with an ECG score ≥ 3 had a $> 50\%$ perfusion defect with 70% sensitivity and 59% specificity, whereas those cases with an ECG score ≥ 6 had a $> 50\%$ perfusion defect with 40% sensitivity and 90% specificity [13]. In the study conducted by Kanbay et al., an ECG score of 6.5 indicated a pulmonary embolus with a $> 50\%$ perfusion defect with 41.7% sensitivity and 82% specificity. In the present study, the presence of a PTE had a 66% sensitivity and a 56% specificity when the cut-off value for ECG score was ≥ 3 , whereas the presence of a PTE had a 36% sensitivity and 100% specificity when the cut-off value for the ECG score was ≥ 5 [14]. The results obtained when the cut-off value for the ECG score was ≥ 5 are similar to the results of the other two studies. However, the ECG score and perfusion defect were compared in the present study in which a PTE was diagnosed through ECG scoring. In the other two studies, a cut-off value for the ECG score was given in cases with more massive emboli due a "high probability perfusion defect ($>50\%$)", and this may be the reason why the specificity decreases when the ECG score was 3 in the present study.

In conclusion, determining high, medium, and low probability for a PTE by clinical scoring is important in the diagnostic approach of a PTE. We suggested that a PTE diagnosis in the high and medium probability groups is needed to be placed in the forefront in the Wells and

Miniati clinical scoring methods, which are easily applicable in daily practice. An ECG is an easily available technique for any center, and a PTE should be considered and further analyses should be planned in cases with an ECG score ≥ 5 .

Conflict of Interest

None declared.

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