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Original Article

# Efficacy of Wells score and Pulmonary Embolism Rule Out Criteria(PERC) to exclude pulmonary embolism in a pulmonary emergency ward

## *Wells ve PERC skorlarının bir göğüs hastalıkları hastanesi acil servisinde pulmoner emboliyi dışlamada etkinliği*

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### Abstract

**Aim:** The Pulmonary Embolism Rule-out Criteria (PERC) rule is a diagnostic algorithm to exclude pulmonary embolism (PE). Even it is not widely used in routine practice, has better negative predictive value in low-risk populations among existed clinical assessment tests. We aimed to examine availability of PERC rules combined with Wells score in a pulmonary emergency ward.

**Material and Methods:** A retrospective hospitalized database study was conducted with 163 patients. All patients who underwent radiological investigation due to suspicious for PE were included. We calculated prevalence of PE in group of PERC negative and PERC positive. All PERC parameters were evaluated solely for risk of PE.

**Results:** PERC positivity was 82.4% in patients diagnosed with PE. There were no significant differences in terms of PERC positivity between PE+ and PE- groups (p=0.336). False positivity rate for moderate to high Wells score was 36.1%. Frequency of PERC negativity among PE negative patients was only %36.1 and %17.6 in PE positive group (p=0.75 and r=-0.025). The sensitivity of the PERC test was 82.3%, specificity 19.6%, PPV 63.1%, NPV 40%, false positivity rate 36.8% and false negativity rate 60%. Among patients with moderate to high wells, 61 patients were diagnosed PE and 14 of them were PERC negative.

**Conclusion:** Our study suggests that PERC scoring system even combined with Wells score does not sufficient enough to prevent unnecessary irradiative imaging studies in a pulmonary emergency ward.

**Keywords:** Wells; PERC; pulmonary embolism

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## Öz

**Amaç:** Pulmoner emboli dışlama kriteri, emboli tanısını dışlamada kullanılan bir tanısal algoritmadır. Rutin pratiğimizde sıklıkla kullanılmasa da düşük klinik riske sahip hastalarda mevcut diğer algoritmalara göre daha iyi bir negative prediktif değere sahiptir. Bir göğüs hastalıkları acil servisinde PERC ve Wells skorunu birlikte değerlendirmeyi amaçladık.

Gereç ve Yöntemler: Hastane kayıt sistemi kullanılarak retsopektif olarak incelenen 163 hasta dahil edildi. Olguların hepsinde pulmoner emboli şüphesi ile görüntüleme yöntemi kullanılmıştı. PERC pozitif ve negatif olan her iki grupta emboli prevelansı hesaplandı. Ayrıc PERC skorunun her bir parametresi pulmoner emboli için risk olması açısından ayrı ayrı ele alındı.

**Bulgular:** Emboli tanısı alan olgularda PERC pozitiflik oranı % 82.4 saptandı. Pulmoner emboli olan ve olmayan gruplar arasında PERC pozitifliği açısından fark saptanmadı (p=0.336). Wells skoru orta-yüksek olan grupta yalancı pozitiflik oranı %36.1'di. Emboli tanısı alan grupta PERC negatiflik oranı %36.1 iken emboli saptanmayan grupta bu oran %17.6'ydı (p=0.75 and r=-0.025). PERC skor sensitivitesi %82.3, spesifitesi %19.6, PPV %63.1, NPV %40, yanlış pozitiflik oranı %36.8 ve yanlış negatiflik oranı %60 saptandı. Wells skoru orta-yüksek olan grupta 61 hastada emboli tanısı koyuldu ve bu hastaların 14'ünde PERC negatifti.

**Sonuç:** Çalışma sonuçlarımızdan yola çıkarak, Wells skoru ile birlikte ele alınsa bile PERC skoru emboli tanı sürecinde gereksiz görüntülemeyi azaltma konusunda yeterli etkinlikte görülmemiştir.


**Anahtar kelimeler:** Wells; PERC; pulmoner embolizm

## Introduction

Pulmonary embolism (PE) can be highly mortal if remains undiagnosed. Referral symptoms are usually non-specific but in cases where hemodynamic instability develops-potential life-threatening condition, the emergency physician does not have enough time to diagnose. In daily practises there are some risk stratification models (Wells score, Geneva score) to estimate clinic probability before diagnostic methods or clinical probability of PE, estimated by the clinician gestalt (unstructured empirical probability) can be preferable.[1] When probability of PE is low and D-dimer level is under 500 µg/mL we tend to exclude PE but higher level of D-dimer can cause further investigation.[2] Computed tomography pulmonary angiogram (CTPA) is first choice in emergency departments (ED) if there is no contraindication. However, by widespread use of CTPA more PE is diagnosed, overall mortality due to PE do not change.[3,4] More over incidence of allergic reactions or nephrotoxicity due to contrast agents are increased.

To avoid unnecessary further diagnostic steps, a scoring system - Pulmonary Embolism Rule-out Criteria (PERC)- was developed to rule out PE by Kline et al. in 2004.[5] PERC contains eight items; age < 50 years, pulse < 100 bpm, arterial oxygen saturation (SpO2) > 94 %, no unilateral leg swelling, no haemoptysis, no recent trauma or surgery, no prior PE or deep venous thrombosis (DVT) and no exogenous oestrogen use. PERC (-) means a patient fulfilling all 8 criteria.[5] Validation studies designed with low clinical probability patients revealed that PERC (-) negative patients' PE risk vary between 0%-1.4%.[6-8] However, its' negative predictive value (NPV) decreased among unselected patient group disregarding degree of clinical probability as shown in Righini's study that 6.7% of PERC (-) patients had PE.[9]

There are many studies investigating reliability of PERC score in ED.[7-11] But to our knowledge there is not any data of pulmonary hospital about using PERC. So, primary outcome is to present our approach to patients suspected to be PE in ED regarding to both PERC and Wells score. Secondary aim is to demonstrate reliability of this score in patients with all clinical probability.

## Material and Methods

### *Study setting and population*

This is a retrospective hospitalized database study. All enrolled patients were assessed in ED and who underwent CTPA and ventilation/perfusion scan (VPS) to exclude or verify PE. When scanning data retrospectively, International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) coding system were used. Patients whose principal or preliminary diagnosis was recorded one of these diagnosis; I.26 (pulmonary embolism), I26.0 (pulmonary embolism with acute cor pulmonale), I.26.9 (pulmonary embolism without cor pulmonale) and I.82 (venous emboli and thrombosis) enrolled to the study. Cut-off value for D-dimer was 500 µg/L.

Study was approved by hospital ethical committee with number; 498-23.06.2015. Written informed consents were obtained from each participants before enrollment.

## Statistical Analyses

Analyses were performed using SPSS version 15.0 (SPSS Inc, Chicago, IL). Continuous variables were expressed as mean ± standard deviation and categorical variables were defined as percentages. Other descriptive statistics were presented as median, minimum and maximum values. The categorical variables were compared with Chi-Square and Fisher's Exact test. Comparisons between two independent groups were performed using Student's t-test for normally distributed continuous variables, and Mann - Whitney U test when the distribution was skewed. Correlations were evaluated with Pearson's or Spearman's correlation tests. A p value less than 0.05 was considered as statistically significant.

## Results

One hundred sixty-three patients suspected for venous thromboembolism were enrolled study. Among 133 PERC positive group 84 patients were diagnosed PE. However, 18 patients had PE in PERC negative group (n=30, 18.4%). Study algorithm and score results of both groups (PERC positive/ negative) was summarized in Figure 1.

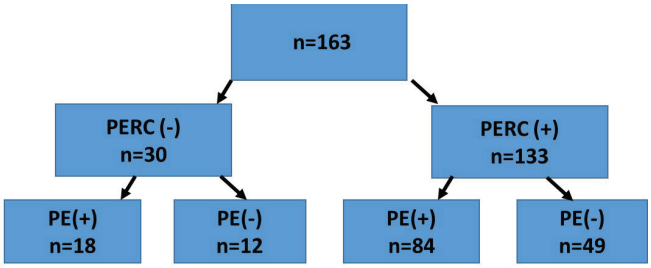


***Figure 1.*** *Flowchart for distribution of PE diagnosis according to PERC score*

Mean age was 57.3±17.9 (±SD) and gender distribution was almost closed to each other. Chronic obstructive pulmonary disease (COPD) and coronary arterial disease (CAD) were most common co-morbidities (27% vs. 15.2%). Among all patients 102 (62.6%) were diagnosed with PE and deep vein thrombosis (DVT) was accompanied in 19 (11.7%) patients. In diagnostic procedures while 132 (81%) patients underwent CTPA, 31 (19%) patients were performed VPC due to renal failure or contrast allergy. Transthoracic echocardiogram (TE) and chest x-ray findings were shown in (Table 1).

A hundred two patients were diagnosed PE and all were symptomatic. In PE group D-dimer level, Wells score were higher than PE negative patients. (p=0.336 vs p=0.003). As expected patients diagnosed with PE had PERC positivity with 82.4% ratio. But even number of PERC positive patients were lower in PE negative group (n=61), there were no significant differences in terms of PERC positivity between PE+ and PE - groups (PE -: 80.3%, PE +: 82.4% and p=0.336). False positivity rate for moderate to high Wells score was 36.1% (Table 2).

**Table 1.** Demographic features of study group

| Variable | |
|---|---|
| Age (years) | 57.3±17.9 |
| Gender | |
| Male | 79 (48.5%) |
| Female | 84 (51.5%) |
| Comorbidity | |
| COPD | 44 (27%) |
| Malignancy | 10 (6.1%) |
| Hypertension | 28 (17.2%) |
| Diabetes mellitus | 10 (6.1%) |
| Cerebrovascular event | 1 (0.6%) |
| Coronary arterial disease | 25 (15.3%) |
| Congestive heart failure | 18 (11%) |
| Alzheimer | 2 (1.2%) |
| Pulmonary embolism | 102 (62.6%) |
| Concomittant DVT | 19 (11.7%) |
| Chest x-ray findings | |
| Normal | 53 (32.5%) |
| Atelectasis | 42 (25.8%) |
| Pleural effusion | 34 (20.9%) |
| Consolidation | 19 (11.7%) |
| Diaphragm elevation | 9 (5.5%) |
| Infarction | 6 (3.7%) |
| Diagnosis with | |
| CT angiography | 132 (81%) |
| Lung scintigraphy | 31 (19%) |
| Transthoracic echocardiogram | |
| Pulmonary artery pressure | 34.2±11.5 |
| Right ventricular dysfunction | 15 (9.2%) |
| Pericardial effusion | 3 (1.8%) |
| Admission d-dimer level | 707 (100-6879) |

**COPD:** Chronic obstructive pulmonary disease, DVT: Deep vein thrombosis, CT: Computed tomography

**Table 2.** Comparison of the reasons for ordering diagnostic tests to patients with and without pulmonary embolism

| | PE+ (n=102) | PE- (n=61) | P value |
|---|---|---|---|
| Symptoms | 102 (100%) | 60 (%98.4) | 0.195 |
| Risk factors | 33 (32.4%) | 22 (36.1%) | 0.754 |
| Chest X-ray findings | 71 (69.6%) | 39 (63.9%) | 0.565 |
| High D-dimer level | 66 (82.5%) | 30 (73.2%) | 0.336 |
| Moderate to high Wells score | 61 (59.8%) | 22 (36.1%) | 0.003 |
| PERC rule positivity | 84 (82.4%) | 49 (80.3%) | 0.909 |

Demographic features between two groups were similar. Number of patients presenting with cough and frequency of concomitant DVT is significantly higher in PE positive group (p=0.03 and p=0.005 respectively) (Table 3).

**Table 3.** Comparison of clinical and laboratory findings of two groups

| Variable | PE+ (n=102) | PE- (n=61) | P value |
|---|---|---|---|
| Age (years) | 57.4±17.5 | 57.2±18.6 | 0.96 |
| Female gender | 48 (47.1%) | 36 (59%) | 0.14 |
| Comorbidity | | | |
| COPD | 29 (28.4%) | 15 (24.6%) | 0.73 |
| Malignancy | 7 (6.9%) | 3 (4.9%) | 0.75 |
| Hypertension | 21 (20.6%) | 7 (11.5%) | 0.2 |
| Diabetes mellitus | 7 (6.9%) | 3 (4.9%) | 0.75 |
| Cerebrovascular event | - | 1 (1.6%) | 0.37 |
| Coronary arterial disease | 16 (15.7%) | 9 (14.8%) | 1 |
| Congestive heart failure | 11 (10.8%) | 7 (11.5%) | 1 |
| Alzheimer | - | 2 (3.3%) | 0.14 |
| Symptoms | | | |
| Chest pain | 55 (53.9%) | 33 (54.1%) | 0.98 |
| Dyspnea | 65 (63.7%) | 38 (62.3%) | 0.99 |
| Fever | 8 (7.8%) | 1 (1.6%) | 0.15 |
| Syncope | 1 (1%) | - | 1 |
| Cough | 26 (25.5%) | 6 (9.8%) | 0.03 |
| Hemoptysis | 13 (12.7%) | 4 (6.6%) | 0.32 |
| Concomittant DVT | 18 (17.6%) | 1 (1.6%) | 0.005 |
| Chest x-ray findings | | | |
| Atelectasis | 25 (24.5%) | 17 (27.9%) | 0.77 |
| Pleural effusion | 24 (23.5%) | 10 (16.4%) | 0.38 |
| Consolidation | 13 (12.7%) | 6 (9.8%) | 0.76 |
| Diaphragm elevation | 6 (5.9%) | 3 (4.9%) | 1 |
| Infarction | 3 (2.9%) | 3 (4.9%) | 0.67 |
| Transthoracic echocardiogram | | | |
| Pulmonary artery pressure | 34.9±10.4 | 32.8±13.6 | 0.4 |
| RV dysfunction | 11 (15.7%) | 4 (12.1%) | 0.77 |
| Pericardial effusion | 2 (2.9%) | 1 (3%) | 1 |
| Admission d-dimer level | 1152.6±1363 | 621.5±313.9 | 0.02 |
| Wells score [median (min-max)] | 3 (0-7.5) | 1.5 (0-7) | 0.009 |

In PE negative group number of patients with low wells score was higher with statistically significance (p=0.003 and r=-0.23). Most of patients in PE positive group had moderate to high wells score significantly when compared to PE negative group (p=0.003 and r=0.23) (Table 2). Frequency of PERC negativity among PE negative patients was only %36.1 and %17.6 in PE positive group (p=0.75 and r=-0.025). As a component of PERC score, while 'pulse rate lower than 100/minute' had a weak negative correlation and 'no previous history of VTE' had weak but significant positive correlation for exclusion of PE (p=0.03, r=-0.168 and p=0.006, r=0.213 respectively) (Table 4).

**Table 4.** Correlation of wells and PERC score in diagnosis and exclusion of pulmonary embolism

| Variable | PE+ (n=102) | PE- (n=61) | p value | r value |
|---|---|---|---|---|
| Low Wells score (score < 2) | 41 (40.2%) | 39 (63.9%) | 0.003 | -0.23 |
| Moderate to high Wells score (score > 2) | 61 (59.8%) | 22 (36.1%) | 0.003 | 0.23 |
| PERC (-) | 18 (17.6%) | 12 (19.7%) | 0.75 | -0.025 |
| PERC criteria | | | | |
| Age < 50 years | 35 (34.3%) | 22 (36.1%) | 0.82 | -0.018 |
| Pulse rate < 100/minute | 83 (81.4%) | 57 (93.4%) | 0.03 | -0.168 |
| O2 sat > 94% | 79 (77.5%) | 53 (86.9%) | 0.14 | -0.116 |
| No leg swelling | 95 (93.1%) | 59 (96.7%) | 0.34 | -0.076 |
| No hemoptysis | 89 (87.3%) | 57 (93.4%) | 0.21 | -0.098 |
| No recent operation | 91 (89.2%) | 55 (90.2%) | 0.85 | -0.015 |
| No previous PE and DVT | 95 (93.1%) | 48 (78.7%) | 0.006 | 0.213 |
| No hormone use | 98 (96.1%) | 61 (100%) | 0.12 | -0.123 |

**COPD:** Chronic obstructive pulmonary disease, DVT: Deep vein thrombosis, RV: Right ventricule

When evaluated according to wells score 80 of them had low and 83 had moderate to high wells score. Even wells score is low number of PE positive patients were similar to PE negatives (PE+ n=41 vs PE- n=39). Nine of PE negative patients were PERC negative. Among patients with moderate to high wells, 61 patients were diagnosed PE and 14 of them were PERC negative (Figure 2).

The sensitivity of moderate to high Wells score was 59.8%, specificity 63.9%, positive predictive value (PPV) 73.5% and NPV 48.7%. The sensitivity of the PERC test was 82.3%, specificity 19.6%, PPV 63.1%, NPV 40%, false positivity rate 36.8% and false negativity rate 60%.

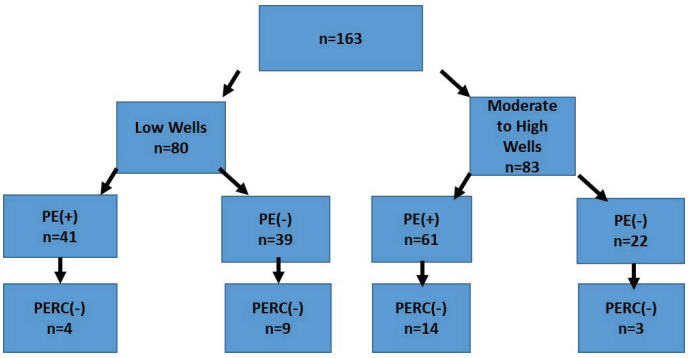


***Figure 2.*** *Flowchart to distribution of patients according to both Wells and PERC sores*

## Discussion

An appropriate approach to PE suspected patients is a common problem in both emergency wards, intensive care units and internal/surgery services. Nowadays clinicians rely on diagnostic procedures combining with probability assessment tests to diagnose or exclude PE.[4]

Study of Dachs and colleagues revealed a 100% sensitivity and 24.6% specifity for PERC rule to exclude PE in an emergency department. So they had concluded that applying PERC rule can reduce 23% of unnecessary CTPA evaluation in an emergency department.[8] A study from Turkey (in an ED) resulted 98% sensitivity and 7% specificity for PERC score. But among 125 patients there were only 5 PERC negative patients. [10] Similar to these two studies in current study while sensitivity of the PERC test was 82.3%, specificity was 19.6%. So it should not be considered as an excellent scoring system to exclude PE in ED.

When figure 2 is examined, adding probability assessment with wells score does not seem to change clinicians' behaviour. Because among 80 low wells patients 13 of them were PERC negative. Even the number of patients diagnosed with PE were nearly half of total wells negative patients (n=41). From another point of view there were 17 PERC negative patients in wells positive group. A previous study with 377 patients with a Wells score (<2), highlighted that the combination of a Wells score (<2) and PERC score (=0) had suboptimal sensitivity for excluding PE in ED (2). So we do not still have a strong scoring system to exclude PE without and imaging method in ED. Similarly, another PERC study combined with the revised Geneva score concluded that even in low risk patients PERC rules are not sufficient enough to exclude PE without a further investigation.[11]

In current study parameters of PERC score were assessed solely. For excluding of PE diagnosis 'pulse rate lower than 100/minute' had a weak negative correlation and 'no previous history of VTE' had weak but significant positive correlation (p=0.03, r=-0.168 and p=0.006, r=0.213 respectively). In contrast to current data, Aydoğdu and colleagues had showed negative correlation with 'no previous DVT or PE history'. In other ED studies with higher number of patients do not have any information about parameters of PERC score individually. [11-13] So these differences should not be expected to have a clinical importance. Even demographic features of these studies are similar, all were designed retrospectively. Also having a patients' medical history in an emergency ward should not be reliable all the time.

Our study revealed; PPV 63.1%, NPV 40%, false positivity rate 36.8% and false negativity rate 60%. To exclude diagnosis of PE with a scoring system NPV and false negativity rate must be lower. Kline JA et al. had already demonstrated that these rule's utility was limited by low specificity and must be used in populations with low pre-test probability and low PE prevalence.[5] Also co-morbidities are an important predisposing factors for thrombosis like coronary artery disease, COPD. Thus, COPD was the most common disease (27%) in current study. So these rates means that PERC scoring is not applicable to exclude in a pulmonary emergency ward.

## Conclusion

Our results revealed that even combined with clinical probability tests, PERC score is not sufficient enough to exclude PE. Additionally, co-morbidities are important confounding factors so even in low risk patients PERC scoring system does not seem to be sufficient enough to prevent unnecessary irradiative imaging studies.

## Declaration of conflict of interest

The authors received no financial support for the research and/or authorship of this article. There is no conflict of interest.

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