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KLİNİK ÇALIŞMA
RESEARCH ARTICLE

Wells Score and Pulmonary Embolism Rule Out Criteria in Preventing Over Investigation of Pulmonary Embolism in Emergency Departments

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SUMMARY

Wells Score and Pulmonary Embolism Rule Out Criteria in Preventing Over Investigation of Pulmonary Embolism in Emergency Departments

Introduction: Unnecessary diagnostic tests are usually ordered to most of the patients with dyspnea or pleuritic chest pain, because of the worse outcomes of missed diagnosis of pulmonary embolism (PE). To identify rates and causes of over investigation for PE and to search whether it was possible to reduce this over investigation by using Wells score and Pulmonary Embolism Rule Out Criteria (PERC).

Materials and Methods: A retrospective observational cohort study performed in an emergency department of a tertiary care university hospital. All patients who were ordered diagnostic with the suspicion of PE were included in the study. They were grouped into two as PE (+) and PE (-) and compared.

Results: Among 108 patients, 53 (49%) were diagnosed as PE (+) and overdiagnosis was present in 55 (51%) patients i.e., PE (-). The sensitivity of high Wells score was 43%, specificity 78%, positive predictive value 66% and negative predictive value 59%. PERC criteria found to be negative (when all of the eight criteria were fulfilled) in only five patients. The sensitivity of the test was 98%, specificity 7%, positive predictive value 50%, negative pre-

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dictive value 80%. When individual parameters of PERC were evaluated solely for the exclusion of PE; "no leg swelling" and "no previous deep venous thrombosis or PE history" were found significantly negatively correlated with PE diagnosis ($p=0.001$, $r=-0.325$ and $p=0.013$, $r=-0.214$ respectively).

Conclusion: Over investigation of PE in emergency departments still remains as an important problem. In order to prevent this, the clinical prediction rules must be developed further and their use in combination should be searched in future studies.

Key words: Over investigation, pulmonary embolism, pulmonary embolism rule out criteria, PERC rule, Wells score

ÖZET

Acil Servislerde Pulmoner Tromboemboli Ön Tanısı ile Gereksiz Tetkik Yapılması Wells Skoru ve Pulmoner Emboli Ekartasyon Kriterleri ile Önlenebilir mi?

Giriş: Pulmoner emboli (PE) tanısını atlamanın doğurabileceđi olumsuz sonuçlar nedeniyle acil servise nefes darlığı veya plöretik göđüs ağrısıyla başvuran pek çok hastaya PE yanlış ön tanısı ile gereksiz tanısai testler uygulanmaktadır. Bu çalışmanın amacı, PE ön tanısı ile yapılan aşırı tetkik oranını ve nedenlerini belirlemek; Wells ve Pulmoner Emboli Ekartasyon Kriterleri (PERC) kullanılarak bu oranın azaltılıp azaltılamayacağını araştırmaktır.

Hastalar ve Metod: Üçüncü basamak bir üniversite hastanesinin acil servisinde gerçekleştirilen bu retrospektif gözlemsel kohort çalışmada PE şüphesiyle tetkik planlanan tüm hastalar çalışmaya dahil edildiler. Tetkik sonuçlarına göre PE (+) ve PE (-) olarak iki gruba ayrılarak demografik ve laboratuvar özellikleri, tetkik sonuçları, Wells ve PERC skorları açısından karşılaştırıldılar.

Bulgular: Çalışmaya dahil edilen toplam 108 hastanın 53 (%49)'üne PE (+) tanısı koyuldu ve gereksiz tetkikin 55 (%51) hastada yapıldığı belirlendi; PE (-). Yüksek Wells skorunun (>6) sensitivitesi %43, spesifitesi %78, pozitif prediktif değeri %66, negatif prediktif değeri %59 olarak bulundu. PERC değerlendirmesinin sadece beş hastada negatif olduğu (toplam sekiz kriterin de karşılandığı) bulundu. Testin sensitivitesi %98, spesifitesi %7, pozitif prediktif değeri %50, negatif prediktif değeri %80 olarak değerlendirildi. PERC kriterlerini oluşturan alt başlıklar ayrı ayrı PE'yi ekarte etme güçleri açısından değerlendirildiğinde "bacakta şişme, çap farkı olmaması" ve "daha önce geçirilmiş derin ven trombozu veya PE öyküsü olmaması" kriterleri ile PE tanısı arasında istatistiksel anlamlı negatif korelasyon belirlendi (sırasıyla; $p=0.001$, $r=-0.325$ and $p=0.013$, $r=-0.214$).

Sonuç: Acil servislerde PE ön tanısıyla aşırı tetkik yapılması günümüzde halen önemli bir sorundur. Bunu önlemek için günlük pratikte kullanılan Wells skoru, PERC skoru gibi klinik tahmin skorları yetersiz kalabilmektedir. Bu skorlar geliştirilmeli veya kombine edilecek kullanılmaları yönünde daha ileri çalışmalar planlanmalıdır.

Anahtar kelimeler: Aşırı tetkik, pulmoner emboli, pulmoner emboli ekartasyon kriterleri, PERC, Wells skoru

INTRODUCTION

Pulmonary embolism (PE) is a common, frequently undiagnosed and potentially fatal cardiovascular emergency (1). In the United States annually over 110 million patients seek emergency department care and approximately 10 million of these patients have complaints of dyspnea, chest pain or both (2). An estimated 600.000 cases of PE are diagnosed in United States each year (3). But there are also many undiagnosed, missed PE cases because of the non-specific nature of PE symptoms such as dyspnea, chest pain, syncope and fever. Especially in cases with fever PE can be frequently misdiagnosed as pneumonia (4). Other possible causes for misdiagnosis of PE are chronic obstructive pulmonary disease (COPD) exacerbation, congestive heart failure, acute coronary syndrome, aortic dissection, cerebrovascular event and pleuritis (5). Autopsy studies have revealed that PE follows acute coronary syndrome as the second most common cause of unexpected death in outpatients (6,7).

PE diagnosis is frequently made by being suspicious about the disease. Depending on the clinical and laboratory properties and the medical histories of the patients, most of the PE cases are diagnosed in the emergency departments either by a pulmonologist or an emergency physician (8). Because of the worse outcomes of missed diagnosis of PE such as death or chronic thromboembolic pulmonary hypertension, emergency department physicians and also pulmonologists usually order unnecessary diagnostic tests such as D-dimer and computed tomography (CT) angiography in most of the patients with dyspnea or pleuritic chest pain. Besides, several reports have indicated that physicians order a diagnostic test for PE because of the fear of medical malpractice (9,10). In addition to these factors, the wide availability and acceptance of D-dimer and CT angiography may contribute to the high frequency of ordering unnecessary tests for PE in emergency departments (11). D-dimer test, although still being commonly used, has high false positivity rate (12). The consequences

of performing PE diagnostic tests by just depending on high D-dimer levels include: increased cost, increased use of emergency department and hospital resources, increased risk of radio contrast agent associated acute renal failure and increased risk of future malignancies depending on the exposure to CT associated radiation (13). Hence, in emergency departments both the over investigation and misdiagnosis of PE should be prevented. For this purpose some scores have been developed such as Wells score and Pulmonary Embolism Rule Out Criteria (PERC) by combining some clinical properties and possible risk factors (14,15). Wells score is being commonly used in our emergency department, but we have not yet implemented the PERC to our daily practice. In this retrospective study, we aimed to identify rates and causes of over investigation for PE in our emergency department. As a secondary outcome we also aimed to determine whether it was possible to reduce this over investigation rate with the use of Wells score and PERC in daily practice.

MATERIALS and METHODS

This study was designed as a retrospective observational cohort study. It was performed in an emergency department of a tertiary care university hospital i.e. Gazi University Medical Faculty Hospital in Ankara in Turkey, between the years 2009 and 2010. It is a reference hospital in the region that patients are accepted from many other hospitals both from the Ankara district and from many other cities near Ankara. The local ethics committee of our institution had approved the study.

Patient Selection and Evaluation

Inclusion criteria: All patients who were ordered diagnostic tests by an emergency or pulmonary physician in the emergency department with the suspicion of PE were included in the study if they were > 18 years old.

Exclusion criteria: Patients with missing medical records were excluded from the study.

According to our emergency department's daily working routine, all patients were first evaluated by paramedics before being admitted to the emergency department. After being admitted, the patient was evaluated by a resident of emergency department and by an emergency department specialist. If they clinically suspect from PE, further tests were planned for

the diagnosis of PE directly by the emergency department physicians. If they had any doubt about the diagnosis they asked for consultation from the pulmonologist. For the clinical evaluation Wells clinical prediction score was used in emergency department by both emergency and pulmonary physicians (14). The ones having moderate or high clinical risk of Wells score were further evaluated with CT angiography. Parameters used for the decision to perform tests for the diagnosis of PE were noted to medical records.

The test that was preferred at first glance for the diagnosis of pulmonary embolism was a 64-slice multislice CT angiography (General Electric™, Light speed VCT, 64 slice) in our university hospital. If CT angiography could not be performed because of morbid obesity or increased renal function tests then venous Doppler ultrasonography (USG) of lower extremities, ventilation-perfusion scintigraphies were used for diagnosis.

Data Collection

Following data were recorded; demographic properties (age, sex, weight), underlying diseases, physical examination, vital findings and symptoms at admission, venous thrombosis risk factors (malignancy, thrombophilia, previous deep venous thrombosis (DVT) or PTE, immobilization, surgical operation or trauma within the last four weeks, pregnancy etc.), D-dimer levels, arterial blood gas analysis values, posteroanterior chest X-ray, electrocardiography, echocardiography (if performed in the emergency department), laboratory tests such as hemostasis tests, complete blood cell count and liver and kidney function tests. Wells scoring, PERC were calculated retrospectively once again (14,15). If possible, causes of ordering diagnostic tests were extracted and recorded from the medical records of the patients. The results of the diagnostic tests were obtained. According to these results patients were grouped into two as PE (+) and PE (-) patient groups and they were compared. Rate of over investigation and factors leading to this over investigation were investigated. The possible effects of clinical prediction scores (Wells and PERC) were assessed for the prevention of over investigation.

Definitions

Venous thromboembolism was diagnosed if patients have (16-18);

1. Pulmonary thrombus identified in multislice CT pulmonary angiography or,

2. Clinical suspicion of PTE and high probability V/Q lung scan or,
3. Moderate probability V/Q lung scan and DVT diagnosed in lower extremity venous Doppler USG or,
4. DVT diagnosis with bilateral lower extremity Doppler USG.

Wells Clinical Prediction Score; was defined in detail in Table 1 (14).

Pulmonary Embolism Rule Out Criteria (PERC); A negative PERC criteria [PERC (-)] requires the clinician to answer no to all of the following eight questions (15):

1. Is the patient older than 49 years of age?
2. Is the pulse rate above 99 beats/minute?
3. Is the pulse oximetry reading < 95% while the patient breathes room air?
4. Is there a present history of hemoptysis?
5. Is the patient taking exogenous estrogen?
6. Does the patient have a prior diagnosis of venous thromboembolism (VTE)?
7. Has the patient had recent surgery or trauma? (Requiring endotracheal intubation or hospitalization in the previous four weeks.)
8. Does the patient have unilateral leg swelling? (Visual observation of asymmetry of the calves).

Table 1. Wells clinical prediction score (14)

Characteristics	Score
Previous pulmonary embolism or deep vein thrombosis	1.5
Heart rate > 100 beats/minute	1.5
Recent surgery or immobilization	1.5
Clinical signs of deep vein thrombosis	3
Alternative diagnosis less likely than pulmonary embolism	3
Hemoptysis	1
Cancer	1
Interpretation:	
Low probability: 0-1 points	
Intermediate probability: 2-6 points	
High probability: 7 or more	

In this study the answers of these questions were extracted from the medical records of the patients and PERC score calculated retrospectively.

Statistics

SPSS for Windows 15.0 software was used for the statistical analysis of the results (SPSS for Windows; Chicago, IL, USA). Results are presented as mean \pm SD and percentiles or median (range) values. The independent samples t-test, the chi-square and Mann-Whitney U tests were used for comparison of the categorical and continuous variables. Correlation was investigated with Pearson correlation tests for parametric values. A difference was considered statistically significant when $p < 0.05$.

RESULTS

Patient Characteristics

A total of 125 patients who were suspected and investigated for PE were evaluated for the study. Sixteen patients were excluded due to missing medical records and one patient due to being pregnant for three months. Thus, study was performed with 108 patients. Demographic characteristics and comorbidities of the whole group were summarized in Table 2.

Diagnostic Tests

Diagnostic tests were ordered to the entire study group with the suspicion of PE. Thoracic multislice CT angiography was performed in 104 (96%) patients, lower extremity Doppler USG was performed in 4

Table 2. Demographic, social properties and comorbidities of the study group

Characteristics	n= 108 Mean \pm SD
Age (years)	64 \pm 16
Sex (female), n (%)	52 (48%)
Married, n (%)	95 (88%)
Comorbidity, n (%)	90 (83%)
Obstructive lung disease (COPD, asthma)	27 (25%)
Diabetes mellitus	24 (22%)
Coronary arterial disease	24 (22%)
Malignancy	37 (34%)
Cerebrovascular event	12 (11%)
Hypertension	45 (42%)
Congestive heart failure	11 (10%)
Alzheimer	10 (9%)

(4%) patients. All of the patients who had Doppler USG were diagnosed as deep venous thrombosis. Among the whole study group, 53 (49%) were diagnosed as pulmonary embolism [PE (+)], and in 55 (51%) PE was ruled out [PE (-)]. Among the 55 patients without PE, diagnostic tests were ordered by emergency medicine resident in 19 (35%), by pulmonary medicine resident in 30 (55%), by both pulmonary and emergency medicine residents in 6 (11%). Among the 53 patients with PE, diagnostic tests were ordered by emergency medicine resident in 22 (42%), by pulmonary diseases resident in 27 (51%), by both pulmonary medicine and emergency medicine resident in 2 (4%) and by other physicians in 2 (4%) patients. The reasons for ordering diagnostic tests were summarized in Table 3. High D-dimer levels, high Wells score (> 6) and the presence of hypoxia and hypocapnia in arterial blood gas analysis were identified as the significant parameters ($p < 0.05$). False positivity rates for these parameters were 67% for high D-dimer, 64% for hypoxia and hypocapnia and 22% for high Wells score.

The demographic characteristics, comorbidities, admission symptoms, chest X-rays and electrocardiographies of patients with and without PE were compared in Table 4. Except the cerebrovascular event that was identified more frequent in PE (+) patients, no significant difference was identified in any of these parameters between the two groups (Table 4).

Clinical Prediction Rules and D-dimer

The clinical prediction rules (Wells score and PERC) and D-dimer levels of the two groups were compared in Table 5. In PE (+) patients D-dimer levels and Wells scores were found significantly higher ($p < 0.005$). High Wells score (score > 6) was found sig-

nificantly correlated with the PE diagnosis ($p = 0.014$, $r = 0.230$). The sensitivity of high Wells score was 43%, specificity 78%, positive predictive value 66% and negative predictive value 59%. PERC found to be negative (when all of the eight criteria were fulfilled) in only five patients. Among those 5 patients, 1 was diagnosed as PE (+), the remaining four were PE (-) ($p = 0.193$). The sensitivity of the test was 98%, specificity 7%, positive predictive value 50%, negative predictive value 80%, false positivity rate 93% and false negativity rate 2%. When individual parameters of PERC were evaluated solely for the exclusion of PE; "no leg swelling" and "no previous DVT or PE history" were found significantly negatively correlated with the diagnosis of PE ($p = 0.001$, $r = -0.325$ and $p = 0.013$, $r = -0.214$ respectively) (Table 5).

DISCUSSION

In the last few years, the importance of PE has been understood well, especially by the emergency physicians. With the fear of medical malpractice unnecessary diagnostic tests are being ordered for PE (9,10). Besides, the wide availability and acceptance of D-dimer tests and CT angiography might also contributed to increased rate of ordering excessive diagnostic tests for patients admitted to emergency departments (11,19). For our study population, excessive CT angiography was ordered for 53 (51%) patients. This was lower in the study of Jimenez Castro et al. as 29%; but much higher, varying between 80-93%, in many studies searching about the utility of PERC in low risk patient populations (20-23).

These excessive diagnostic tests not only increase the cost and length of stay in crowded emergency departments, but also have probable worse effects on patients such as radio contrast related renal failure or increased risk of malignancy due to radiation exposure (24). Hence, we searched the reasons of ordering excessive diagnostic tests from the medical records and compared the characteristics of the patients with and without PE. The high D-dimer level, high Wells score and hypoxia and hypocapnia in arterial blood gas analysis were found as significant parameters for ordering excessive CT angiography. Low Wells score excluded PE cases successfully, however in four patients with low Wells score, acute PE was identified in CT angiography. On the other hand, ECG and chest X-ray findings were remained less important in decision making. Among

Table 3. Comparison of the reasons for ordering diagnostic tests to patients with and without pulmonary embolism

Characteristics	PE (+) n= 53 (%)	PE (-) n= 55 (%)	p
High D-dimer level	45 (85)	37 (67)	0.027
Arterial blood gas analysis (hypoxia and hypocapnia)	43 (81)	35 (64)	0.034
Symptoms	45 (85)	39 (71)	0.064
ECG findings	3 (6)	9 (16)	0.070
Chest X-ray findings	18 (34)	14 (26)	0.243
High Wells score	23 (43)	12 (22)	0.014

Table 4. Comparison of the demographic characteristics, symptoms, chest X-rays and electrocardiographic findings of patients with and without pulmonary embolism

Characteristics	PE (+)	PE (-)	p
	n= 53 Mean ± SD	n= 55 Mean ± SD	
Age (years)	65 ± 17	63 ± 16	0.538
Sex (female), n (%)	29 (55%)	23 (42%)	0.125
Comorbidity, n (%)	42 (79)	48 (87)	0.195
Obstructive lung disease (COPD, asthma)	10 (19)	17 (31)	0.190
Diabetes mellitus	11 (21)	13 (24)	0.449
Coronary arterial disease	9 (17)	15 (27)	0.146
Malignancy	19 (36)	18 (33)	0.445
Cerebrovascular event	9 (17)	3 (6)	0.05
Hypertension	19 (36)	26 (47)	0.157
Congestive heart failure	4 (8)	7 (13)	0.285
Alzheimer	5 (9)	5 (9)	0.605
Pregnancy	1 (2)	1 (2)	0.743
Symptoms, n (%)			
Chest pain	22 (42)	26 (47)	0.341
Dyspnea	37 (70)	46 (84)	0.070
Fever	9 (17)	9 (16)	0.568
Syncope	10 (19)	10 (18)	0.561
Cough	17 (32)	14 (26)	0.292
Sputum	15 (28)	10 (18)	0.154
Chest radiography, n (%)			
Diaphragm elevation	18 (34)	14 (26)	0.243
Linear atelectasis	9 (17)	5 (9)	0.185
Pleural effusion	10 (19)	12 (22)	0.425
Hilar enlargement	19 (36)	12 (22)	0.090
Hyperlucency	0 (0)	3 (6)	0.125
Infiltration	12 (23)	16 (30)	0.274
Sinus obstruction	16 (30)	15 (28)	0.475
Infarct	1 (2)	1 (2)	0.748
Electrocardiography, n (%)			
Sinusal tachycardia	13 (25)	22 (40)	0.065
Bradycardia	1 (2)	1 (2)	0.743
S1Q3T3	14 (26)	9 (16)	0.149
Ischemia	23 (43)	11 (20)	0.008
Right bundle branch block	1 (2)	2 (4)	0.514
Left bundle branch block	1 (2)	3 (6)	0.323
Atrial fibrillation	5 (9)	4 (7)	0.476

the ECG findings only the ischemia was identified higher in PE (+) patients and this may be explained by severe hypoxemia leading to the development of ischemic findings. No any demographic parameters was identified for differentiating PE (+) and (-) patients. Except the cerebrovascular event that was identified higher in PE (+) patients, other underlying comorbidities also had no effect on over investigation of PE.

In order to prevent this excessive diagnostic testing, many clinical prediction rules have been developed. The Wells score is the most widely used prediction

rule for PE, derived first in year 1998 and then validated in a group of 247 patients where the rates of PE for low, intermediate and high clinical probability were 2%, 18.8% and 50% respectively (14). The association of a low clinical probability of PE and a low D-dimer concentration has been shown to safely rule out PE (25). In 2004, Kline JA, et al. derived the PERC, an eight factor decision rule to support the decision not to order a diagnostic test for PE in patients for whom the clinician already had a low clinical suspicion for PE (15). From the year 2004, many studies have been performed to validate the utility of PERC (21-23,26-29). They all commented

Table 5. Comparison of the clinical prediction rules and laboratory parameters for the diagnosis and exclusion of pulmonary embolism

Characteristics	PE (+)	PE (-)	p	r
	n= 53	n= 55		
	Mean ± SD	Mean ± SD		
D-dimer	4545 ± 3033	2699 ± 2695	0.002	
Wells score	5.9 ± 2.7	4.5 ± 2.2	0.005	
Low Wells score (score < 2)	4 (8)	9 (16)	0.133	-0.135
Moderate Wells score (score 2-6)	26 (49)	34 (62)	0.127	-0.128
High Wells score (score > 6)	23 (43)	12 (22)	0.014	0.230
PERC score	5.2 ± 1.03	5.6 ± 1.13	0.077	
PERC (-) (8 criteria fulfilled)	1 (2)	4 (7)	0.193	-0.128
PERC criteria				
Age < 50 years	12 (23)	12 (22)	0.551	0.010
Pulse rate < 100/minute	28 (53)	27 (49)	0.422	0.037
O ₂ sat > 94%	14 (26)	16 (29)	0.462	-0.030
No leg swelling	37 (70)	52 (95)	0.001	-0.325
No hemoptysis	48 (91)	50 (91)	0.605	-0.006
No recent operation	43 (81)	45 (82)	0.561	-0.009
No previous PE and DVT	44 (85)	54 (98)	0.013	-0.244
No hormone use	52 (98)	55 (100)	0.491	-0.098

PE: Pulmonary embolism, DVT: Deep venous thrombosis.

that the PERC rule is best suited to a patient population with a prevalence of < 10% PE. In this low prevalence population they assessed the sensitivity of the rule as 100%, specificity varying between 16%-33%, negative predictive value as 100% (21-23, 26-29). In addition to the necessity of low prevalence population, PERC should only be applied to low risk patients, so an application of another clinical decision rule such as Wells criteria is necessary to evaluate the clinical risk. Only Wolf, et al. evaluated this rule not only in low risk population but for all risk levels of PE and stated that PERC was highly sensitive (100%) with an excellent negative predictive value (100%) for a population of all risk groups (22). They identified the obvious disadvantage of PERC as it would have missed 3 cases of PE (22). In comparison, using the Wells clinical probability score in combination with D-dimer missed only two cases of PE (26,30). As Singh B, et al., explained in their review that the existing literature suggest consistently high sensitivity and low but acceptable specificity of the PERC to rule out PE in patients with low pretest probability (31). When the pretest probability is low PERC are highly sensitive in predicting PE and D-dimer testing is thus unnecessary. In their review the two of the included studies [Hugli, et al. (32) and Righini, et al. (33)] reported a higher frequency of missed PE and have raised a concern about the reli-

ability of PERC. But their higher failure rate was thought to be likely resulting from the higher PE prevalence observed in their European settings (32,33). Hugli, et al. reported that PERC rule alone or even when combined with the revised Geneva score cannot safely identify very low risk patients in whom PE can be ruled out without additional testing, at least in populations with a relatively high prevalence of PE (32). It should always be remembered that the PERC rule was developed for use in low probability settings. Similar to Hugli et al. we also identified high PE prevalence in our study as 49%.

We retrospectively analyzed our results for PERC and found it to be negative (when all of the 8 criteria were fulfilled) in only 5 (5%) patients. We thought that this low number of patients with PERC (-) can be explained with our small study population and high prevalence of PE. Among those 5 patients, 1 was diagnosed as PE (+), the remaining four were PE (-) (p= 0.193). We identified the sensitivity of the test as 98%, specificity 7%, positive predictive value %50, negative predictive value %80, false positivity rate %93 and false negativity rate %2. When individual parameters of PERC rule were evaluated solely for the exclusion of PE; "no leg swelling" and "no previous DVT or PE history" were found significantly negatively correlated with the diagnosis of PE (p=

0.001, $r = -0.325$ and $p = 0.013$, $r = -0.214$ respectively). This result was in consistence with the study of Wolf et al. that identified the unilateral leg swelling, recent surgery and history of VTE as the predictors of PE diagnosis in bivariate analysis (22). Hence, we thought that instead of providing all of the 8 criteria, some classification can be made also for the PERC, by scoring the criteria according to their power of excluding PE.

We also evaluated Wells score in this study and found a significant correlation between high Wells score (score > 6) and the PE diagnosis ($p = 0.014$, $r = 0.230$). The sensitivity of high Wells score was identified as 43%, specificity 78%, positive predictive value 66% and negative predictive value 59%. Since this is a retrospective study with low patient number we couldn't evaluated the role of combined PERC rule and Wells score or combined PERC rule and D-dimer testing in preventing excessive diagnostic testing for PE. So our results about individually assessed PERC rule and Wells score could not be attributed to general, could just be accepted as a good representative of the current status in an emergency department of a tertiary care university hospital.

But there are some studies in the literature that evaluated the PERC rule together with Wells score or revised Geneva score. In a study performed by Penalozoa A, et al., 959 patients were studied and overall PE prevalence was identified as 29.8%; 74 (7.7%) patients were PERC (-) and among them 4 (5.4%) patients had final diagnosis of PE (34). In this study, the combination of (-) PERC rule with low pretest probability assessed by revised Geneva Score (RGS) or gestalt clinical assessment was also evaluated. When (-) PERC rule was combined with RGS, PE prevalence was found as 6.2% and when combined with low clinical gestalt probability, PE prevalence was identified as 0%. They concluded that (-) PERC rule combined with low clinical gestalt probability seems to identify a group of patients for whom PE could easily be ruled out without additional test, but this result should be confirmed by a larger study to ensure its safety (34).

Similar to our study, Crichlow A, et al. studied the overuse of computed tomography pulmonary angiography in the evaluation of patients with suspected pulmonary embolism in the emergency department (35). They studied 152 suspected PE subjects, 11.8%

diagnosed with PE, which was much lower than our PE prevalence. Among those 152 suspected PE patients, 14 (9.2%) met PERC, none of whom were diagnosed with PE. A low risk Wells score (≤ 4) was assigned to 110 (72%) subjects, of whom only 38 (35%) underwent clinical D-dimer testing (elevated in 33/38). Of the 72 subjects with low risk Wells scores who did not have D-dimers performed in the emergency department, archived research samples were negative in 16 (22%). All 21 subjects with low risk Wells scores and negative D-dimers were PE negative. CT-pulmonary angiography time (median 160 minutes) accounted for more than half of total emergency department length of study (median= 295 minutes) in this study. They concluded that, in total 9.2% and 13.8% of CT-pulmonary angiography procedures could have been avoided by use of PERC rule and Wells/D-dimer respectively (35).

As a conclusion, with our results and with the information that we obtained from the literature we can say that over investigation of PE in emergency departments still remains as an important problem. In order to prevent this, neither the clinical prediction rules (Wells score and PERC rule) nor the D-dimer test are sufficient individually. So, they must be developed further or their use and efficacy in combined form should be searched in future extensive studies.

CONFLICT of INTEREST

None declared.

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