



# Overuse of Computed Tomography Pulmonary Angiography in the Diagnosis of Pulmonary Thromboembolism “Real-Life Data”

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**Purpose:** Pulmonary thromboembolism (PTE) is a common cause of cardiovascular mortality with an increasing incidence rate. Scoring patients with suspected pulmonary thromboembolism according to their symptoms, findings, and risk factors is useful for empirical diagnosis and management. The combination of D-dimer and clinical scoring allows the diagnosis to be excluded in approximately 30% of patients with suspected PTE without the need for imaging methods. Despite this, clinical scores are not used effectively in the clinic. The aim of this study is to show that computed tomography pulmonary angiography (CTPA) is overused in real life and to emphasize that overuse of CTPA can be prevented with clinical tests.

**Patients and Methods:** We studied 214 patients who underwent CTPA for suspected pulmonary thromboembolism. We evaluated whether clinical probability scoring (Wells scoring, Geneva scoring) was performed prior to CTPA from these patients' records and the health system database, and if so, the scores were evaluated. The rates and results of PERC criteria were also evaluated in patients.

**Results:** Pulmonary thromboembolism was not detected on CTPA in 185 patients (86.4%). PERC criteria were not evaluated in all patients before CTPA. When the PERC criteria were evaluated by the study team, it was found that there was a significant relationship between PTE diagnosis and the criteria. There was also a significant correlation between Geneva score and CTPA results ( $p=0.000<0.05$ ).

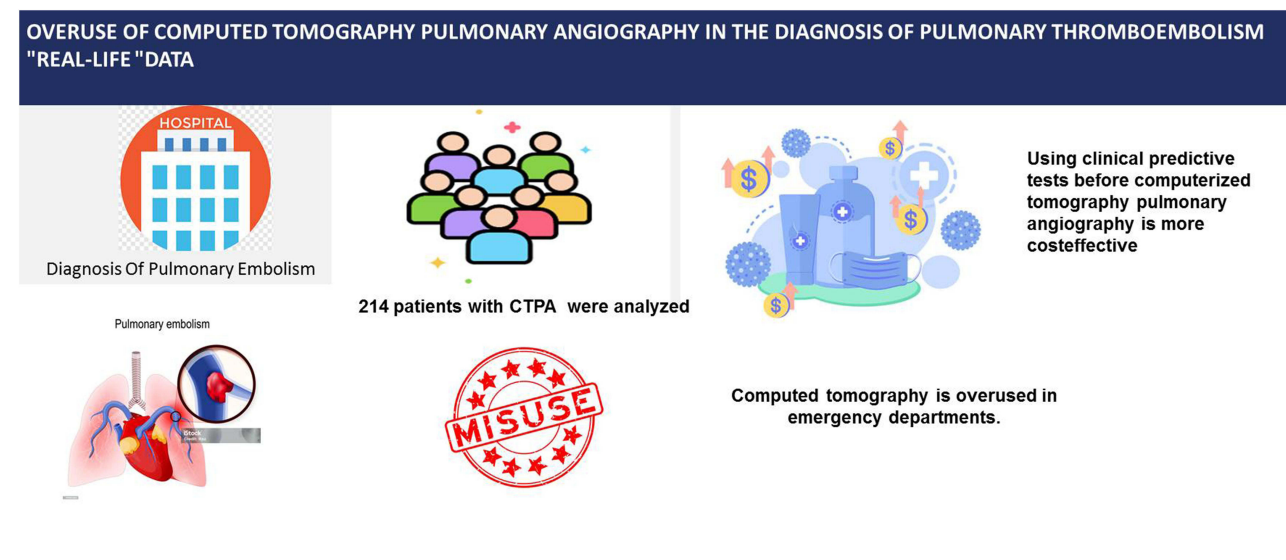
**Conclusion:** Preventing overuse of CTPA by evaluating clinical probability scores, PERC criteria and d-dimer levels is important in many ways. Prevention of overuse of CTPA use will reduce unnecessary workload in clinical functioning and provide financial gain. Although CTPA is a diagnostic method with high diagnostic accuracy in the diagnosis of PTE, it is overused in real life. The overuse of CTPA can be significantly reduced by the combined use of clinical probability scoring (Wells and Geneva), exclusion criteria (PERC) and d-dimer results.

**Plain Language Summary:** Pulmonary thromboembolism (PTE) is a common cause of cardiovascular mortality with an increasing incidence rate. CTPA is the most effective method for the diagnosis of PTE. The diagnostic algorithm includes clinical probability scoring prior to CTPA. However, in clinical practice, it is observed that too much CTPA is applied without clinical probability scoring. Our study has shown the extent to which the unnecessary use of CTPA can be prevented by using clinical scoring systems. We studied 214 patients who underwent CTPA for suspected PTE. Pulmonary thromboembolism was not detected on CTPA in 185 patients (86.4%). When the number of CTPAs performed and the number of patients with clinical probability scoring and PERC criteria were evaluated by the study team. Patients with pulmonary embolism are evaluated, the overuse of CPTA is clearly evident. When the Wells Scores, d-dimer results and Perc criteria were evaluated together, it was found that CTPA was not necessary in many patients. The overuse of CTPA can be significantly reduced by the combined use of clinical probability scoring (Wells and Geneva), exclusion criteria (PERC) and d-dimer results.

Prevention of overuse of CTPA use will reduce unnecessary workload in clinical functioning and provide financial gain.

**Keywords:** clinical risk scoring, overuse of computed tomography pulmonary angiography, pulmonary embolism, predictive tests, costeffectiveness

## Graphical Abstract



## Introduction

Pulmonary thromboembolism (PTE) is a clinical picture of total or partial occlusion of the pulmonary artery and its branches by thrombus material. PTE is now a common cause of cardiovascular mortality with an increasing incidence rate. The annual incidence of venous thromboembolism (VTE), including PTE and deep vein thrombosis (DVT), is more than 10 million worldwide.<sup>1</sup>

In the diagnosis of PTE, disease recognition and clinical suspicion are important. PTE should be suspected especially in patients who present with dyspnea and tachycardia, have normal chest radiography and whose condition cannot be explained by another disease. The clinical picture is nonspecific. However, there may be different clinical presentations ranging from asymptomatic patient to sudden cardiac death.

Clinical classification of patients with suspected PTE by scoring them according to their symptoms, findings, and risk factors is useful for empirical diagnosis and management. The combined use of D-dimer and clinical scoring allows the diagnosis to be excluded in approximately 30% of patients with suspected PTE without the need for imaging methods.<sup>2</sup> Wells scoring and modified Geneva scoring are widely used, validated clinical scoring methods.<sup>3-6</sup> After scoring and clinical evaluation, CTPA is the most commonly used method for diagnosis. Although CTPA, which has a high diagnostic accuracy, is primarily preferred for the diagnosis of PTE, this method has many side effects including cancer and drug toxicity. Therefore, in order to avoid unnecessary CTPA in every patient presenting with dyspnea and chest pain, VTE guidelines in the world and in our country recommend the use of Wells and/or Geneva clinical probability scoring methods. Evaluation of these scores together with pulmonary embolism exclusion criteria (PERC) is a good guide for diagnosis. In patients with PERC criteria and low probability of Wells and/or Geneva, there is a possibility to rule out PTE without further investigation. CTPA is recommended in patients with high Wells and Geneva scores.

The aim of this study was to find out to what extent these scores are used in real life before CTPA is performed and to determine how much CTPA could have been prevented if they had been used.

## Materials and Methods

The study was conducted at Ondokuz Mayıs University Faculty of Medicine and Samsun University Faculty of Medicine Samsun Education and Research Hospital. Chest diseases and radiology departments participated in the study. Patients who were examined with a preliminary diagnosis of pulmonary embolism between January 2023 and January 2024 were included in the study. The study evaluated 214 patients who underwent CTPA following suspected PTE. Patients with

incidental PTE detected in tests performed for another diagnosis (eg aortic dissection, aneurysm, etc.) were not included in the study. We evaluated whether clinical probability scoring (Wells scoring, Geneva scoring) was performed prior to CTPA from patient records and the health system database, and if so, the scores. In addition, the rates and results of PERC criteria were also evaluated. D-dimer levels, echocardiography, risk factors, and clinical findings prior to CTPA were examined. Patients who were not scored and PERC criteria were not checked before the procedure were scored by the study team by accessing the recorded data and patients. The relationship between the results obtained and the CTPA results was investigated. CTPA images were re-evaluated by the radiologist in the study team. The correlation between d-dimer results, ECG findings, echocardiographic findings and CTPA results were investigated.

Data were analyzed in IBM SPSS 20.0 program. Relationships between qualitative variables were tested with Pearson Chi-Square test. The ratios of two and more than two groups were tested with the ratio test.  $p < 0.05$  was considered statistically significant.

## Ethical Approval

The study was reviewed and approved by Samsun University Clinical Research Ethics Committee (reference number: 2023/ 5). Informed patient consent was not required by the ethics committee in view of the retrospective nature of the research and the anonymity of the study data. The guidelines outlined in the Declaration of Helsinki were followed.

## Results

The study included 214 patients. Of the 214 patients included in the study, 82.2% were 50 years of age or older. The percentage of female patients was 49.5% and the percentage of male patients was 50.5%. Pulmonary thromboembolism was not observed in CTPA in 185 (86.4%) patients. PTE was present in 26 (12.1%) patients. CTPA examinations of three patients could not be evaluated due to improper acquisition technique.

Wells scoring was not performed before CTPA in 198 patients (92.5%). Of the scored patients, 5 (2.3%) were considered as low clinical probability, 9 (4.2%) as moderate, and 2 (0.9%) as high clinical probability. In the Wells scoring performed by the study team after CTPA, 133 patients (62.1%) were classified as low probability, 68 patients (31.8%) were classified as intermediate probability, and 13 patients (6.1%) were classified as high probability. Of the 133 patients with low probability, 128 (96.2%) had no PTE on CTPA. PTE was absent in 55 patients with a Wells score of moderate probability and PTE was present in 13 patients. PTE was detected in 11 of the 13 patients with high probability Wells score, while no findings in favor of PTE were detected in two of them (Table 1).

Geneva scoring was not performed in any of the patients before CTPA. After CTPA, 94 patients were scored as low probability, 111 as intermediate, and 9 as high probability by the study team. Pulmonary thromboembolism was not detected in 88 patients (93.6%) among the patients considered as low probability. Of 111 patients with a Geneva score of moderate probability, 96 (86.4%) had no PTE and 14 had PTE. Among the 9 patients whose Geneva scoring was calculated as high probability, PTE was detected in 6 patients (66.6%) and PTE was not observed in 1 patient. There was a significant correlation between Geneva score and CTPA results ( $p = 0.000 < 0.05$ ).

In 117 patients who underwent CTPA, d-dimer levels were not checked before tomography, 10 patients had normal d-dimer levels, and 87 patients had high d-dimer levels. Pulmonary embolism was detected on CTPA in 11 of 13 patients with both high Wells score and d-dimer results. None of the 7 patients with both low clinical probability Wells score and normal d-dimer values had pulmonary embolism (Table 2).

When the echocardiography examinations performed on the patients were evaluated, it was found that 129 patients did not undergo echocardiography before CTPA was performed. Of the 24 patients with echocardiographic findings suggestive of PTE, 12 patients had no filling defect on CTPA and 10 patients had filling defects. CTPA was insufficient for evaluation in two patients. In 51 of 54 patients with normal or non-embolic findings on echocardiography, there was no embolism on CTPA.

In all patients, PERC criteria were not evaluated before CT scanning. When the PERC criteria of the patients were evaluated by the study team after tomography, it was observed that all 26 patients with PERC criterion 0 had no embolism. Of the 187 patients with PERC exclusion criteria greater than 0, 158 (84.4%) had PTE on CTPA. There is a significant relationship between PERC exclusion criteria and CTPA results.

**Table 1** Geneva Score, Wells Score, D-Dimer Result and CTPA Results

	PTE (+) (n)	PTE (-) (n)	TOTAL (n)
<b>WELL'S Score</b>			
Low risk group	5	128	133
Moderate risk group	13	55	68
High risk group	11	2	13
<b>Geneva Skoru</b>			
Low risk group	6	88	94
Moderate risk group	14	96	110
High risk group	6	1	7
<b>D-Dimer</b>			
Normal	0	10	10
High	14	73	87
Not tested	12	102	117

**Table 2** Wells Score, d-Dimer and CTPA Results

Wells Sore				D-dimer			Total	P
				Not Tested	Normal	High*		
Low	CTPA result	Pte (-)	Count %	71 55,5%	7 5,5%	50 39,1%	128 100,0%	0,864
		Pte (+)	Count %	3 60,0%	0 0,0%	2 40,0%	5 100,0%	
Moderate	CTPA result	Pte (-)	Count %	29 52,7%	3 5,5%	23 41,8%	55 100,0%	0,565
		Pte (+)	Count %	6 46,2%	0 0,0%	7 53,8%	13 100,0%	
High	CTPA result	Pte (-)	Count %	2 100,0%		0 0,0%	2 100,0%	0,224
		Pte (+)	Count %	6 54,5%		5 45,5%	11 100,0%	

Hospital admission symptoms of the patients examined in the study were evaluated. The most common presenting complaints were dyspnea and chest pain, respectively.

The physician groups who suspected PTE diagnosis and ordered CTPA were evaluated. Emergency department assistants were the physicians who ordered CTPA most frequently. Of 149 patients who underwent CTPA at the request of the emergency department assistant, no filling defect was observed in 134 patients and PTE was detected in 14 patients. The number of CTPA requests from other physician groups and the distribution of results are shown in Table 3.

## Discussion

The Pulmonary Thromboembolism Diagnostic Algorithm recommends that clinical probability scoring and d-dimer results should be used primarily in the presence of clinical suspicion.<sup>7</sup> After clinical probability scoring, CTPA is performed in cases requiring further investigation. However, it is observed that compliance with the algorithms recommended by the guidelines is low in clinical practice. The overuse of CTPA is a problem both from a financial standpoint and in terms of side effects. In a study, the rate of inappropriate use of CTPA in Europe was found to be 60%.<sup>8</sup>

**Table 3** CTPA Results by Physician Groups Requesting the Test

Physician Groups	PTE (+)	PTE (-)	Inappropriate Technique	Total
Emergency department assistant	14	135	0	149
Emergency assistant consultation with chef	2	3	0	5
Chest medicine assistant	0	5	2	7
Chest medicine assistant consultation with chef	1	4	1	6
Other department's assistant	0	14	0	14
Other department's assistant consultation with chef	0	3	0	3
Emergency department specialist	4	8	0	12
Pulmonologist	4	4	0	8
Cardiology specialist	1	9	0	10

**Abbreviations:** PTE, Pulmonary thromboembolism; VTE, venous thromboembolism; DVT, deep vein thrombosis; CTPA, computed tomography pulmonary angiography; PERC, pulmonary embolism exclusion criteria.

The aim of this multicenter study was to determine the extent to which clinical probability scoring and exclusion criteria are applied in patients with a prediagnosis of PTE and to examine and evaluate how much of the BTPA examination is actually necessary. This study highlighted that when clinical probability scoring and exclusion criteria were applied according to the guidelines, the number of CTPAs, and thus cost and toxicity, decreased.

In the study, Geneva scoring before CTPA was not performed in any patient, while Wells Scoring was not performed in 198 patients (92.5%). When the unscored patients were scored by the study team, 133 patients had a Wells score and 94 patients had a Geneva score with low clinical probability. Pulmonary thromboembolism was not detected in 96.2% of CTPA performed in patients with low Wells score and 93.6% of patients with low Geneva score. These rates indicate that the rate of preventable CTPA is quite high. The study showed a statistically significant correlation between Geneva scoring and CTPA results. In the study by Hanieh et al, PTE was detected on CTPA in 8 of 11 patients with high clinical probability Geneva score, whereas in this study, PTE was similarly observed in 6 of 9 patients with high Geneva score.<sup>9</sup> Consistent with the results of the PIOPED II (Prospective Investigation of Pulmonary Embolism Diagnosis II) study, it is seen that CTPA is overused in patients with low and intermediate probability scores in this study.<sup>10</sup>

In patients with a low clinical probability score, the diagnosis should be supported by evaluation of pulmonary thromboembolism exclusion criteria (PERC). In cases with low clinical probability, the diagnosis can be excluded if the score on the PERC criteria is zero. However, if the clinical probability scoring is low and moderate probability and the PERC criteria score is greater than zero, it is recommended to consider age-adjusted D-dimer results. If the D-dimer value is also high, CTPA is recommended.<sup>11</sup> Preventing overuse of CTPA by evaluating clinical probability scores, PERC criteria and d-dimer levels is important in many ways.

In a study by Stojanovska et al 602 patients were analyzed and it was found that evaluation of PERC criteria significantly reduced the unnecessary use of CTPA.<sup>12</sup> In our study, all 26 patients with PERC criterion 0 had no embolism. Of the 187 patients with PERC exclusion criteria greater than 0, 158 (84.4%) had PTE on CTPA. There is a significant relationship between PERC exclusion criteria and CTPA results.

As understood in other studies and in this study, it is more important to evaluate the clinical evaluations together rather than individually before making a decision for CTPA and to make a decision accordingly. In this study, there was no statistically significant correlation between the D-dimer value and the results of CTPA, while patients with both clinical probability scores and low d-dimer values were found to have PTE. D-dimer results can be affected by many clinical conditions. Apart from PTE, D-dimer can also be high in cases such as infection, cancer, kidney failure, etc. It is thought that the lack of a significant relationship between PTE and d-dimer may be due to this reason.

Preventing overuse of BTPA by evaluating clinical probability scores, PERC criteria and d-dimer levels is important in many ways. Preventing overuse of CTPA will reduce unnecessary workload in clinical functioning and provide financial gains. In a study, it was shown that CTPA application brought an additional cost of 11.3 million dollars per 100,000 patients.<sup>13</sup> In today's world of financial problems, this is a significant amount.

Another problem encountered after overuse of CTPA is contrast nephropathy. This is especially important in elderly, hypertensive and diabetic patients.<sup>14</sup> Studies have reported that contrast nephropathy develops in 12–13% after CTPA.<sup>15,16</sup> In our study, only one patient developed contrast nephropathy, which was less than in other studies.

Limitations of the study include the inability to include every patient in the study due to missing data in the file records while rescoring was performed by the study team.

## Conclusion

In conclusion, although CTPA is a diagnostic method with high diagnostic accuracy in the diagnosis of PTE, it is overused in real life. The overuse of CTPA can be significantly reduced by the combined use of clinical probability scoring (Wells and Geneva), exclusion criteria (PERC) and d-dimer results. Our study clearly demonstrates the inappropriate use of CTPA in clinical practice as it is real life data.

## Ethical Approve

This study was approved by the Scientific Ethics Committee of Samsun University (2023/ 5).

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

## Disclosure

The authors report no conflicts of interest in this work.

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