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Balancing Clinical Judgment and Imaging: Evaluation of Pulmonary Embolism Using Modified Wells Score, Age-Adjusted D-Dimer, and CT Pulmonary Angiography

Research Article

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Abstract

Objective: To evaluate the diagnostic performance of the Modified Wells Score and age-adjusted D-dimer values in predicting pulmonary embolism and to correlate these findings with computed tomography pulmonary angiography (CTPA).

Materials and Methods: This prospective analytical study included 77 patients clinically suspected of pulmonary embolism who were referred for computed tomography pulmonary angiography. Modified Wells Score categorization, standard and age-adjusted D-dimer values were recorded and correlated with CTPA findings.

Results: Pulmonary embolism was detected on CTPA in both Wells-likely and Wells-unlikely groups. Age-adjusted D-dimer demonstrated improved negative predictive value in the pulmonary embolism unlikely group, reducing unnecessary CTPA examinations.

Conclusion: An integrated diagnostic approach combining Modified Wells Score, age-adjusted D-dimer, and CTPA improves diagnostic accuracy and optimizes utilization of imaging in suspected pulmonary embolism.

Keywords: Pulmonary embolism; Modified Wells score; Age-adjusted D-dimer; CT pulmonary angiography [4,5].

Introduction

Pulmonary embolism (PE) is the third most common acute cardiovascular condition after myocardial infarction and stroke and represents a major cause of morbidity and mortality worldwide. Early diagnosis and prompt initiation of treatment are essential because untreated PE carries a high mortality rate, whereas appropriate anticoagulation therapy significantly reduces morbidity and mortality. The clinical presentation of PE is often nonspecific, including symptoms such as dyspnea, chest pain, tachycardia, and syncope. Because these features overlap with several cardiopulmonary disorders, diagnosis based solely on clinical findings can be challenging. Therefore, clinical prediction rules have been developed to estimate the probability of PE and guide further diagnostic testing. The Modified Wells Score is one of the most commonly used clinical prediction tools for stratifying patients into low or high probability categories. Patients classified as low probability can undergo D-dimer testing to exclude PE without imaging. However, the specificity of conventional D-dimer testing

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decreases with increasing age because several clinical conditions can elevate D-dimer levels. To overcome this limitation, age-adjusted D-dimer thresholds have been proposed. This strategy increases the D-dimer cut-off value according to patient age, thereby improving specificity and reducing unnecessary imaging studies in elderly patients. Computed tomography pulmonary angiography (CTPA) has emerged as the reference standard imaging modality for diagnosing pulmonary embolism due to its high sensitivity and specificity and its ability to identify alternative thoracic pathologies. The present study aimed to evaluate the diagnostic performance of the Modified Wells Score and age-adjusted D-dimer values in predicting pulmonary embolism and to correlate these findings with CT pulmonary angiography, thereby assessing the effectiveness of a combined diagnostic approach. [1-5].

Review of literature

Although several studies have evaluated the role of the Modified Wells score and D-dimer testing in the diagnosis of pulmonary embolism, important limitations remain. Previous research has demonstrated that combining clinical prediction rules with D-dimer testing can improve diagnostic sensitivity and help exclude pulmonary embolism; however, the specificity of conventional D-dimer testing is low, particularly in elderly patients, leading to a high rate of false-positive results and unnecessary imaging investigations. Recent studies have suggested that age-adjusted D-dimer thresholds may improve diagnostic efficiency by increasing specificity without compromising safety. Nevertheless, there is limited data evaluating the combined diagnostic performance of Modified Wells score and age-adjusted D-dimer values with correlation to CT pulmonary angiography, particularly in tertiary care hospital settings. Therefore, the present study aims to assess the diagnostic utility of these parameters and their correlation with CT pulmonary angiography in patients with suspected pulmonary embolism.

Materials And Methods

Ethics Statement: The study was approved by the Institutional Ethics Committee, and informed consent was obtained from all participants.

Study Design: Prospective analytical study.

Study Setting: The study was conducted in the Department of Radiodiagnosis at S.S. Institute of Medical Sciences and Research Centre over a period of two years.

Study Population: A total of 77 patients clinically suspected of pulmonary embolism who were referred for CT pulmonary angiography were included.

Inclusion Criteria

Patients referred for CT pulmonary angiography from outpatient or inpatient departments.

Patients with clinical suspicion of pulmonary embolism.

Exclusion Criteria

Follow-up cases of pulmonary embolism

Patients with contrast allergy

Patients with renal failure

Patients on anticoagulation therapy

Patients unwilling to provide consent

Clinical Assessment

The Modified Wells Score was calculated for each patient and categorized as:

PE unlikely: ≤4

PE likely: >4

Laboratory Assessment

D-dimer levels were measured using immunofluorescence technology.

Standard cut-off: 500 ng/mL

Age-adjusted cut-off: Age × 10 ng/mL for patients >50 years

CT Pulmonary Angiography Protocol: CT pulmonary angiography was performed using a multidetector CT scanner according to the standard institutional protocol with intravenous administration of iodinated contrast. 80–100 ml of non-ionic iodinated contrast was injected at 4–5 ml/s using a power injector, followed by a saline flush. Images were reconstructed in axial, coronal, and sagittal planes to evaluate the pulmonary arterial tree. CTPA images were independently reviewed by two experienced radiologists blinded to the clinical probability scores and D-dimer results.

Statistical Analysis

Statistical analysis was performed using appropriate statistical software. Quantitative data were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Diagnostic performance parameters including sensitivity, specificity, PPV, NPV, and ROC analysis were calculated. A p-value <0.05 was considered statistically significant.

Results

Out of 77 patients evaluated, Pulmonary embolism was detected

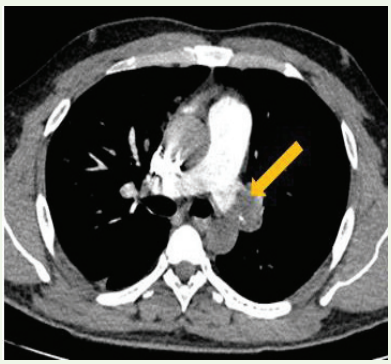

Figure 1: CT pulmonary angiography (CTPA) axial images demonstrate a well-defined intraluminal thrombus with calcific foci causing near-complete luminal occlusion of the left main pulmonary artery, in keeping with pulmonary embolism. The total modified Wells score is 4.5 (>4), indicating that pulmonary embolism is likely.

Citation: Indushree TV, Shyam S, Akshay H Janakare, Parthasarathy KR. Balancing Clinical Judgment and Imaging: Evaluation of Pulmonary Embolism Using Modified Wells Score, Age-Adjusted D-Dimer, and CT Pulmonary Angiography. Indian J Appl Radiol. 2026;12(1): 226.

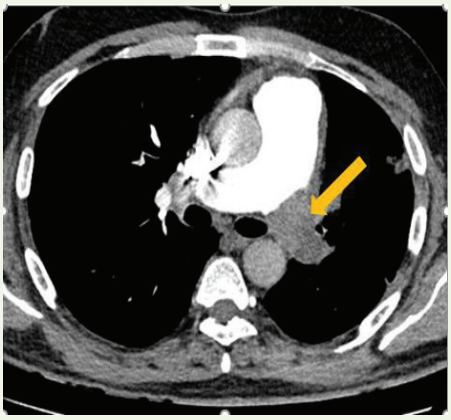

Figure 2: CT pulmonary angiography (CTPA) axial images demonstrate an intraluminal thrombus causing complete luminal occlusion of the left main pulmonary artery, consistent with pulmonary embolism. Despite a total modified Wells score of 1.5 (≤4; PE unlikely) and a negative age-adjusted D-dimer value of 350, imaging findings confirm pulmonary embolism.

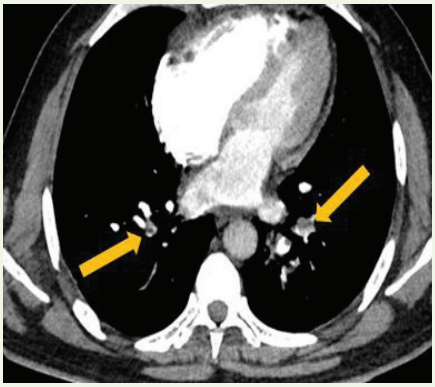

Figure 3: CT pulmonary angiography (CTPA) axial images demonstrate intraluminal thrombi within the interlobar and segmental branches of both lungs, consistent with bilateral pulmonary embolism. The total modified Wells score is 3 (≤4; PE unlikely); however, the age-adjusted D-dimer level is elevated at 1250 (positive), supporting the diagnosis in correlation with imaging findings.

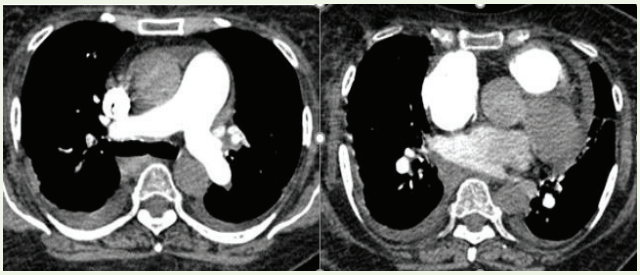

Figure 4: CT pulmonary angiography (CTPA) demonstrates normal opacification of the main, lobar, segmental, and subsegmental pulmonary arteries with no evidence of intraluminal filling defect or thrombus. The total modified Wells score is 3 (≤4; PE unlikely); however, despite a markedly elevated age-adjusted D-dimer level of 3300 (positive), there is no imaging evidence of pulmonary embolism on CTPA.

Table 1: Modified well's score for pulmonary embolism.

MODIFIED WELLS SCORE	Maximum score	Patient score
1. Clinical signs of DVT	3.0	
2. Alternate diagnosis less likely than pulmonary embolism.	3.0	
3. Previous pulmonary embolism or DVT	1.5	
4. Heart rate > 100	1.5	
5. Surgery within 4 weeks or immobilization for more than 3 days	1.5	
6. Haemoptysis	1.0	
7. Active cancer	1.0	
TOTAL SCORE		

CATEGORIES:
PE unlikely: ≤4
PE likely: >4
Correlated with CT pulmonary angiography.

on CTPA in both the Modified Wells score "likely" and "unlikely" categories. A subset of patients categorized as pulmonary embolism unlikely demonstrated positive findings on CTPA, highlighting the limitations of clinical scoring alone. D-dimer values were interpreted using age-adjusted thresholds before correlation with CTPA findings. Age-adjusted D-dimer values demonstrated higher negative predictive value in the pulmonary embolism unlikely group when compared to standard cutoff values, reducing unnecessary CTPA examinations. False-positive and false-negative results were observed, emphasizing the importance of an integrated diagnostic approach [4,5].

Demographic Characteristics

The study included 77 patients, with a mean age of 49.05 ± 18.68 years. The majority of patients were between 31 and 70 years of age. Males constituted 58.4% of the study population.

Clinical Characteristics

Clinical signs of deep vein thrombosis were present in 11.7% of patients. Recent surgery or prolonged immobilization was observed in 40.3%, while tachycardia (>100 bpm) was noted in 42.9% of patients.

Wells Score Distribution:

Based on the Modified Wells Score:

- PE likely: 47 patients (61%)
- PE unlikely: 30 patients (39%)

D-Dimer Levels

Elevated D-dimer levels (>500 ng/mL) were observed in 76.6% of patients.

CTPA Findings

CT pulmonary angiography confirmed pulmonary embolism in 33 patients (42.9%), while 44 patients (57.1%) showed no evidence of embolism.

The most common site of embolism was the main pulmonary artery (20.8%), followed by segmental arteries (15.6%) and subsegmental arteries (15.6%).

Diagnostic Performance

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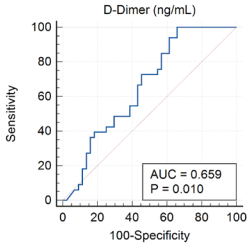
Table 2: Diagnostic Performance of Clinical and Laboratory Parameters for Pulmonary Embolism

Parameter	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)	Diagnostic Accuracy (%)
Modified Wells score	78.5 (95% CI 62–89)	52.3 (95% CI 38–66)	53.3 (95% CI 41–69)	76.7 (95% CI 59–88)	63.6 (95% CI 53–74)
Age-adjusted D-dimer in Wells-unlikely group	85.7 (95% CI 42–99)	60.9 (95% CI 41–78)	40.0 (95% CI 19–64)	93.3 (95% CI 70–99)	66.7 (95% CI 49–80)
Combined rule (Modified Wells score + age-adjusted D-dimer)	97.0 (95% CI 85–99)	31.8 (95% CI 20–47)	51.6 (95% CI 39–64)	93.3 (95% CI 70–99)	59.7 (95% CI 49–70)

Table 3: Correlation of D-dimer, Modified Wells Score, and Combined Rule with CTPA Findings

Variable	Total Patients (n)	CTPA Positive (n)	P value
D-dimer elevated (Wells-unlikely group)	15	6	0.041
D-dimer normal (Wells-unlikely group)	15	1	
Modified Wells score PE likely (>4)	47	26	0.009
Modified Wells score PE unlikely (≤4)	30	7	
Combined rule: Likely/ unlikely with positive D-dimer	62	32	0.006(strongest association)
Combined rule: Ruled out	15	1	

Table 4: Diagnostic accuracy of D Dimer to predict Pulmonary embolism



Area under the ROC curve (AUC)

Area under the ROC curve (AUC)	0.659
Standard Error [a]	0.0619
95% Confidence interval [b]	0.542 to 0.763
z statistic	2.572
Significance level P (Area=0.5)	0.0101

[a]DeLong et al., 1988
[b]Binomial exact

Youden index

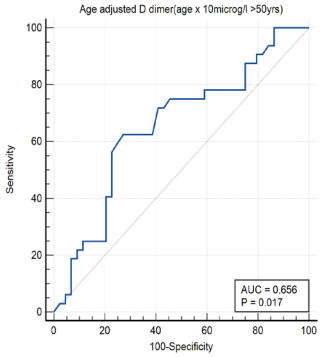
Youden index J	0.3409
Associated criterion	>300
Sensitivity	100.00
Specificity	34.09

ROC curve analysis demonstrated:

Parameter	AUC
D-dimer	0.659
Age-adjusted D-dimer	0.656
Wells score	0.647

The ROC analysis showed an area under the curve (AUC) of 0.659, indicating modest diagnostic performance of D-dimer in predicting PE. The result was statistically significant (p = 0.0101).

Table 5: Age Adjusted D-Dimer levels to predict Pulmonary embolism



Area under the ROC curve (AUC)

Area under the ROC curve (AUC)	0.656
Standard Error [a]	0.0650
95% Confidence interval [b]	0.538 to 0.761
z statistic	2.394
Significance level P (Area=0.5)	0.0167

[a] DeLong et al., 1988
[b] Binomial exact

Standard D-dimer testing demonstrated high sensitivity but low specificity, whereas age-adjusted D-dimer improved specificity.

Alternative Diagnoses:

CTPA also identified alternative diagnoses including:

- Pleural effusion
- Pulmonary edema
- Pneumonia
- Emphysema
- Malignancy

Discussion

The diagnosis of pulmonary embolism remains challenging due to its nonspecific clinical presentation and potentially fatal outcome. Clinical prediction rules combined with laboratory testing and imaging have therefore become essential components of diagnostic algorithms.

The Modified Wells Score demonstrated moderate diagnostic accuracy in this study, consistent with previous studies. While it is useful for risk stratification, clinical scoring alone cannot reliably exclude pulmonary embolism. D-dimer testing has high sensitivity

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but limited specificity. Age-adjusted D-dimer thresholds have been proposed to improve specificity, particularly in elderly patients. Our findings support the use of age-adjusted thresholds to reduce unnecessary imaging. CT pulmonary angiography remains the definitive imaging modality for diagnosing PE, providing direct visualization of intraluminal filling defects and allowing identification of alternative thoracic pathologies. The results of this study support the use of a combined diagnostic strategy incorporating clinical scoring, laboratory testing, and imaging [4,5] [7,8] [9,12].

Conclusion

A combined diagnostic approach using Modified Wells Score, age-adjusted D-dimer testing, and CT pulmonary angiography improves diagnostic accuracy in patients with suspected pulmonary embolism. Age-adjusted D-dimer thresholds help reduce unnecessary imaging, particularly in elderly patients, while maintaining diagnostic safety. [4,5].

Limitations

1. Single-center study
2. Small sample size
3. Lack of long-term follow-up

Further multicenter studies are required to validate these findings.

Conflict of Interest Statement: The authors declare no conflict of interest.

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