Original Article

Poor adherence to the recommended pulmonary embolism diagnostic pathway in the emergency department: A retrospective cohort study

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Abstract:

OBJECTIVES: Pulmonary embolus (PE) is a form of venous thromboembolism associated with increased morbidity and mortality if not diagnosed and treated early. Variations in clinical presentation make the diagnosis challenging. The gold standard for diagnosing PE is a computed tomography pulmonary angiogram (CTPA). Physicians show a low threshold for over-investigating PE. The evaluation of patients with suspected PE should be efficient, including but not limited to the use of risk stratification methods. This study aims to assess the adherence to the recommended diagnostic pathways of ordering CTPAs in patients with suspected PE.

METHODS: This retrospective cohort study included patients above 18 years of age who received a CTPA for a suspected PE in the emergency department (ED) of a hospital between 2015 and 2019. Patient demographic data, chief complaint, variables of the Wells and pulmonary emboli rule-out criteria scores, pregnancy status, investigations, and the patient's final PE diagnosis were extracted from the hospital electronic medical records. Diagnostic pathways that took place were compared to the internationally recommended pathway.

RESULTS: Four hundred and eighty-six patients were included in this study. The mean age was 51.01 (±19.5) years, and 377 (69.3%) patients were female. The recommended PE diagnostic pathway to order CTPA was incorrectly followed in 288 patients (59.3%). Seventy-five (15.4%) patients received an unnecessary CTPA. D-dimer test was ordered unnecessarily in 144 patients (29.6%). The overall prevalence of PE in our population was 9.47% (*n*: 46). Out of the 75 unnecessarily ordered CTPAs, 2 (2.7%) showed PE, while CTPAs ordered using the correct pathway showed 31 (10.9%) PEs.

CONCLUSION: Our study revealed that approximately two-thirds of all CTPA requests did not adhere to the recommended PE clinical decision pathway. There was a significant improper and unnecessary utilization of CTPA imaging and D-dimer testing. Improvements seem imperative to enhance physicians' clinical approach to PE diagnosis.

Keywords:

Clinical decision rules, computed tomography pulmonary angiograms, D-dimer, diagnosis, emergency department, pulmonary emboli rule-out criteria, pulmonary embolism, wells

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Box-ED Section

What is already known on the study topic?

- Pulmonary embolus (PE) is a form of venous thromboembolism
- The clinical presentation of PE is variable and often nonspecific, making the diagnosis challenging
- Computed tomography pulmonary angiography (CTPA) remains the modality of choice in evaluating patients with suspected PE because of its high sensitivity and accuracy.

What is the conflict on the issue? Has it important for readers?

- Physicians tend to have a low threshold for over-investigating PE
- This low threshold usually results in unnecessary testing, contributing to prolonged emergency department (ED) lengths of stay, financial burdens, and patients' exposure to the adverse effects of investigation
- Efficient clinical decision-making strategies, including risk stratification methods, are recommended.

How is this study structured?

- This was a single-center, retrospective cohort study including data from 571 ED patients.

What does this study tell us?

- About two-thirds of CTPAs ordered did not adhere to the proper recommended clinical decision-making pathway, with a substantial amount of unnecessary CTPAs and improper utilization of D-dimer testing
- The adherence to PE clinical decision-making pathway increases the chance of diagnosing PE with CTPAs.

Introduction

Pulmonary embolus (PE) is a form of venous thromboembolism with about 2 million cases reported annually and estimated mortality of 3% from PE alone.[1] The clinical presentation of PE is variable and often nonspecific, making the diagnosis challenging and may cause high morbidity and mortality.[2,3] Therefore, physicians tend to have a low threshold for over-investigating PE.[3,4] This low threshold usually results in unnecessary testing, contributing to prolonged emergency department (ED) lengths of stay, financial burdens, and patients' exposure to the adverse effects of investigation.[5] Computed tomography pulmonary angiography (CTPA) remains the modality of choice in evaluating patients with suspected PE because of its high sensitivity and accuracy.[6] Although CTPA has become the standard investigation modality of PE, it carries risks such as radiation exposure and

contrast-induced nephropathy.[7-9] Therefore, efficient clinical decision-making strategies, including risk stratification methods, are recommended.[3]

The European Society of Cardiology and the American College of Physicians' guidelines on diagnosing PE suggest using validated clinical prediction rules such as the Wells and Pulmonary Emboli Rule Out Criteria (PERC) scores to estimate pretest probability in patients for whom acute PE is being considered.[3,10] However, non-adherence to clinical decision-making pathways and unnecessary testing in the diagnosis of PE is widely reported.[5,11-14] Middle eastern data are still limited. A recent study in the Gulf region found that one-third of CTPA studies did not adhere to recommended pathways.[11]

This study aims to assess the adherence to the recommended diagnostic pathway of ordering CTPA for ED patients with a suspected PE in our setting.[3,10]

Methods

Study design, setting, and population

The study was a retrospective cohort study conducted in the ED of a community-based teaching hospital located in the city of Alain in the United Arab Emirates. The ED operates 24 h a day, 365 days a year, and has a 50-bed capacity, with an average of 115,000 patients annually. Patients coming to the ED would initially be assessed in the triaging area by a licensed emergency medicine physician or general practitioner and allocated to different areas of the ED based on the acuity and clinical condition of the patient. Full-capacity blood testing and specialty consultations are 24-h availability in this tertiary-care hospital. In addition, a CT scanner is located in the ED.

All patients above 18 years of age who presented to the ED with a suspected PE and underwent a CTPA in the ED between January 1st, 2015, and December 31st, 2019, were reviewed. Because our study focused on the adherence of ED physicians, CTPAs ordered by admitting specialty physicians, such as internal medicine and critical care physicians, were excluded. CTPAs ordered by ED physicians were analyzed.

Data collection

The patient data were extracted from the electronic medical record system in the hospital, Citrix Cerner®. Individual patient charts were opened using the medical record number, and the data were coded into an Excel sheet. A random sample of patients was selected to check data accuracy at regular intervals. Data included patient demographics of age, sex, pregnancy status, D-dimer result, CTPA results, and continuous and categorical

data, including the variables of both the Wells and PERC scoring systems [Appendix 1].[15,16]

The Siemens Sysmex CS-5100 System with a cutoff level of 0.5 mg/L was used for D-dimer. A licensed radiology technician performed the CTPA scans using the Siemens Somatom Definition AS 128-slice Scanner, injecting 50 ml of Optiray® (Ioversol) 350 contrast at 4.0 ml/s. The CTPA images were interpreted and reported by a licensed radiologist physician.

The Wells and PERC scores were retrospectively calculated.[15,16] The two-tiered Wells score was used.[17,18] If the patient was classified as "PE Likely" as per the Wells criteria (>4 points), CTPA should have been commenced directly. If the patient was classified as "PE unlikely" as per the Wells criteria (0–4 points), the PERC score should have been implemented. If PERC was calculated to be negative, PE was unlikely, and no further testing should have been required. If PERC was calculated to be positive, a D-dimer test should have been done. If the D-dimer result was negative, PE should have been ruled out. If the D-dimer result was positive, the patient should have undergone a CTPA. If the result of the CTPA was negative, then PE should have been ruled out. If the result of the CTPA was positive, then the PE diagnosis should have been made.

Clinical decision-making pathways that took place were compared to the recommended international clinical decision-making pathway mentioned above.

Outcome measures

This study aimed to find (1) the amount of non-adherence to the recommended clinical decision-making pathway when investigating PE. (2) The amount of necessary and unnecessary CTPAs. Necessary CTPA was defined as the proportion of CTPAs deemed required per the Wells and PERC scores when following the proper pathway. (3) The amount of necessary and unnecessary D-dimer tests. Necessary D-dimer testing was defined as the proportion of D-dimer tests required as per the Wells and PERC scores when following the proper pathway. (4) The PE detection rate in necessary and unnecessary CTPAs.

Data analysis

The data were inserted into an Excel datasheet (Microsoft Excel, 2021, Version 16.57 (Microsoft, Redmond, Washington, USA), [Computer software]). Descriptive and frequency analyses were done using JASP (2022), Version 0.16.2 (University of Amsterdam, Amsterdam, North Holland, Netherlands), (Computer software).

Ethical approval

The local ethics committee approved this study on December 20th, 2020 (#MF2058-2020-760).

Results

Patient demographics

Five hundred and seventy-one patients received a CTPA scan in the ED. Eighty-five patients were excluded as the CTPA was ordered by the admitting specialty team. Four hundred 86 patients were enrolled for analysis. Most of the patients were females (*n*: 377, 69.3%). The mean age (standard deviation) was 51.0 (19.54) years (minimum: 18, maximum: 114). Twenty patients were pregnant (4.1%). Eighty-one (16.67%) patients described being immobile for 3 days or had surgery in the past 4 weeks. Seventy-nine (16.26%) patients had a previous PE or deep vein thrombosis. One hundred and eight (22.22%) patients had malignancies. Only 8 (1.65%) patients were under treatment of hormone therapy. The most common chief complaints were dyspnea (*n*: 259, 52.3%), chest pain (*n*: 142, 29.2%), and palpitations (*n*: 13, 2.7%).

Figure 1 provides the study flow diagram. One hundred and fifty-nine (32.7%) patients were classified as "PE Likely," and 327 (67.3%) patients were classified as "PE Unlikely" based on the Wells scoring system. The PERC was applied to "PE unlikely" patients.

Outcome 1: Amount of nonadherence to the recommended clinical decision-making pathway

Of 486 patients, the recommended PE clinical decision-making pathway was not followed correctly in 288 patients (59.3%). Table 1 provides information about the types of nonadherence.

According to the correct pathway, all PE-likely patients (*n*: 159) should have gotten a direct CTPA. However, 86 (54.1%) of PE likely patients received an unnecessary D-dimer test before the CTPA.

Table 1: Types of nonadherence to recommended pulmonary embolism clinical decision-making pathways

	In all patients, *n* (%)	In group (%)
PE likely group (*n*=159)		
Unnecessary D-dimer test before CTPA	86 (17.7)	54.1
PE unlikely group (*n*=327)		
PERC negative		
Unnecessary direct CTPA	10 (2.1)	3.1
Unnecessary D-dimer and CTPA	58 (11.9)	17.7
Total unnecessary CTPA	68 (13.9)	20.8
PERC positive		
Direct CTPA without D-dimer	127 (26.1)	38.8
Unnecessary CTPA for D-dimer negative patients	7 (14.4)	2.1
Total unnecessary CTPA	75 (15.4)	22.9

PE: Pulmonary embolism, PERC: Pulmonary embolism rule out criteria, CTPA: Computed tomography pulmonary angiography
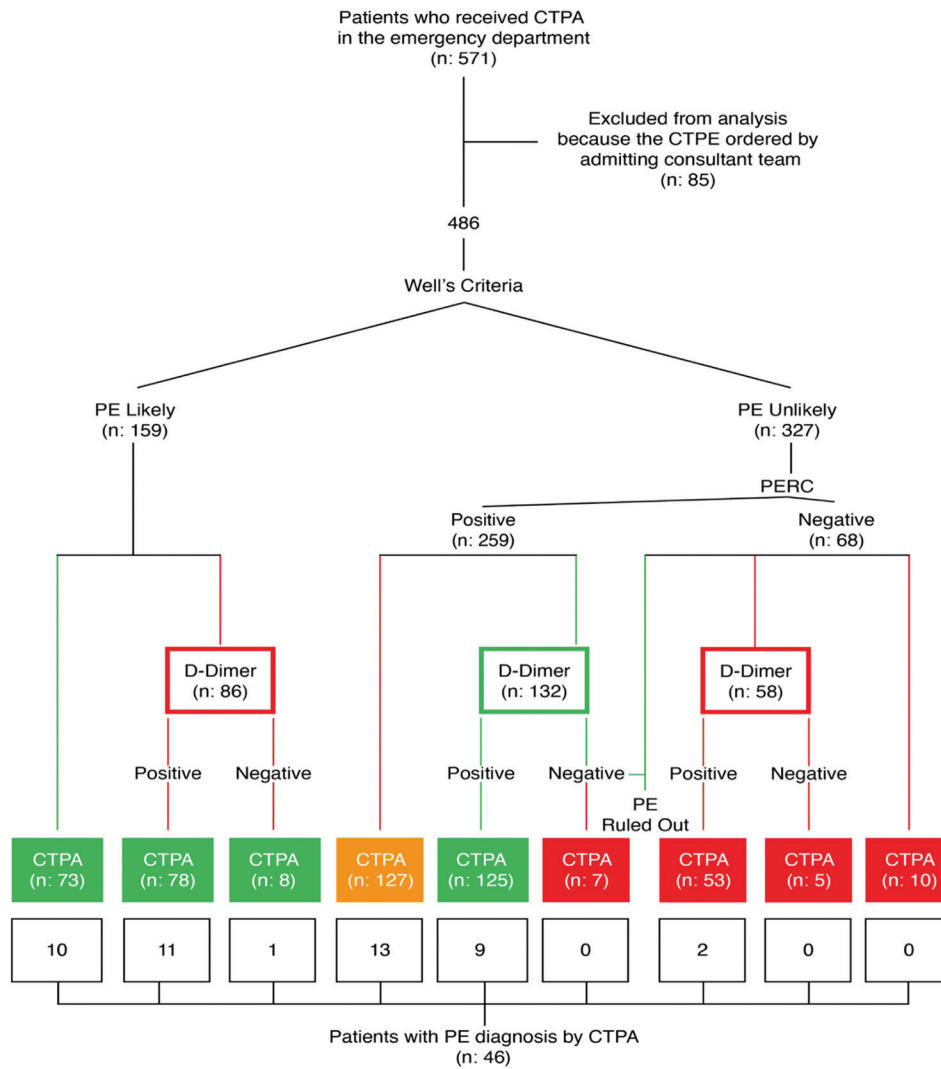
Figure 1: Flow chart depicting the correct (green line) and incorrect (red line) pathways followed through PE evaluation. Red D-dimer boxes represent unnecessary D-dimers. Green D-dimer box represents necessary D-dimers. Green CTPA boxes represent necessary CTPAs. Red CTPA boxes represent unnecessary CTPAs. The orange box represents CTPAs where a necessary or unnecessary decision could not be made on the path because those patients required D-dimer before CTPA. White boxes represent PE diagnosis by CTPA in each path. CTPA: Computerized Tomography Pulmonary Angiography, PE: Pulmonary Embolus, PERC: Pulmonary Embolism Rule Out Criteria

Of the 327 "PE Unlikely" patients, PERC was positive in 259 (79.2%) and negative in 68 (20.8%). PERC-negative patients should have been ruled out of PE according to the recommended clinical decision-making pathway. However, 10 (14.7%) patients in PERC negative group underwent the unnecessary CTPA directly, and 58 (85.3%) received an unnecessary D-dimer before the unnecessary CTPA. All PERC-positive patients (n: 259) should have received a D-dimer test. One hundred and twenty-seven (49.0%) patients of the PERC-positive group had incorrectly undergone a direct CTPA with no preceding D-dimer test. One hundred and thirty-two (51%) patients in PERC positive group underwent the correct pathway and got a D-dimer test before the CTPA. D-dimer test was negative in 7 (5.3%) patients, and they should have been ruled out of PE. However, these patients received an unnecessary CTPA.

Outcome 2: Amount of necessary and unnecessary computed tomography pulmonary angiography
Only 284 (58.4%) CTPAs were considered necessary in our setting. 75 (15.4%) CTPAs were unnecessary according to the recommended PE clinical decision-making pathway. 127 (26.1%) patients who received CTPA were in an undetermined group (neither necessary nor unnecessary) because they were in PERC-positive group and should have received a D-dimer test to determine the need to proceed to CTPA instead of a direct CTPA.

Outcome 3: Amount of necessary and unnecessary D-dimer tests
Two hundred and seventy-six patients (56.7%) received a D-dimer test, which was unnecessary in 144 patients (29.6%). D-dimer was ordered unnecessarily

in 86 patients (54.1%) when Wells score showed a "PE Likely" and in 58 patients (85.3%) when PERC was negative in PE unlikely patients.

Outcome 4: Pulmonary embolus detection rate in necessary and unnecessary computed tomography pulmonary angiography ordered

In our study, the overall prevalence of PE was 9.5% (n: 46). PE was diagnosed in 31 patients (10.9%) who received a CTPA categorized in the necessary group (n: 284). CTPA categorized as unnecessary (n: 75) diagnosed PE with a rate of 2.7% (*n*: 2).

Discussion

In our setting, the PE clinical decision-making pathway was incorrectly followed for most patients. In addition to ordering unnecessary CTPA for patients, there was a considerable amount of incorrect usage of D-dimer testing in the ED. As expected, CTPAs ordered after correctly following the PE clinical decision-making pathway diagnosed more PEs as compared to PEs diagnosed by incorrectly ordered CTPAs.

CTPA is considered the gold standard diagnostic modality for PE.[6] International guidelines suggest using validated clinical prediction rules such as the Wells and PERC scores to estimate pretest probability in patients suspected to have an acute PE.[2,10,19] Wells score alone is used to rule in PE as it has a relatively high specificity.[17] It was also reported that if paired with D-dimer testing, specificity would increase up to 99.7%.[15]

The overuse of the D-dimer to screen for possible PE has been found to add to the cost of healthcare and increase the frequency of testing for PE among very low-risk patients, leading to large numbers of negative CTPA in young patients, increasing the risk of malignancy secondary to radiation exposure.[9,13,16] Therefore, Kline *et al*. derived and tested the PERC rule to justify not ordering a D-dimer. Applying this rule in the low-risk populations yielded sensitivities of 96%100% and specificities of 15%27%.[16] The combination of Wells and PERC to diagnose PE provides additional accuracy and protects against unnecessary investigations.[8]

Our study identifies the overutilization of CTPA in the ED, which is congruent with several other studies globally,[11-13] although no studies provide optimum adherence levels. Our study shows that the majority (59.3%) of CTPA being ordered for patients suspected to have a PE did not adhere to internationally validated guidelines.[2,8,19] The amount of inappropriately ordered CTPA was on the higher end when compared to studies, which report rates from 16.8% to 43%.[11-14,20] Out of the 75 unnecessarily ordered CPAs, only 2 (2.7%) were

positive for PE, subjecting 73 (97.3%) patients out of 75 who underwent the unnecessary CTPA to unnecessary ED waiting times, costs, and an increased risk of CTPA side effects. We could not compare our results to other literature as no literature was found delineating results of unnecessary CTPAs from CTPAs done with nonadherence to the pathway. We believe this finding is significant and should be addressed for institutional improvements.

D-dimer was ordered 29.6% unnecessarily in our study. Al Dandan *et al*. and Osman *et al*. reported unnecessary D-Dimer order at 41.2% and 15%, respectively.[11,13] They also reported the issue of underutilizing the D-dimer test with PERC-positive patients and skipping straight to CT, which was 57% of all PE unlikely cases for both studies. Underutilization of D-dimer testing when required and skipping straight to CTPA happened in 38.8% of all our PE Unlikely cases, which is almost half the amount reported by Al Dandan *et al*. and Osman *et al*.[11,13]

The overall yielding of positive PE in CTPA in our population is 9.5%, similar to the generally accepted threshold of 10% for the positivity rate for CTPA.[21] In our study, when the pathway was not appropriately used and unnecessary CTPAs were ordered, the PE detection rate was four times lower than when the CTPAs were ordered according to PE clinical decision-making pathway. This implies significantly reduced sensitivity when not following the pathway, which was also shown by Roy *et al*. and Yan *et al*. who highlighted that implementing using the tools and following clinical decision-making pathways before ordering CTPAs resulted in a significant reduction in CTPA utilization with a resultant increased positive CTPA rate.[14,19] All our PERC-negative patients did not have a PE on the CTPA that was subsequently performed, confirming the safety of not performing CTPA scans in these patients. This adds further support to the PERC tool developed by Kline *et al*., which states that low-risk patients who satisfy all criteria do not need D-dimer testing or further imaging investigation.[16]

The direct cause for our unnecessary CTPA and D-dimer was improperly following the recommended pathway. Indirectly attributing causes could have been individual factors such as the different methods of approach between physicians, distrust of clinical decision rules, fear of litigation, and insufficient understanding of radiation exposure.[8] Environmental factors such as ED patient load and flow and shift timings and duration could also play a role.[18] An important contributing factor to over-utilizing CTPA could be the availability of CTPA with a rapid turnaround time that is available free of charge for all citizens, which was also noted in a similar study in the Gulf.[11] The underutilization of D-dimer

assay testing when necessary is due to non-adherence to the recommended pathway, which could be attributed to the reluctance to order the test due to the high frequency of false-positive results.[9]

All the studies reviewed regarding investigating the use of risk stratification tools for PE had obtained data pre-COVID. Knowing that COVID-19 infection increases the risk of pulmonary embolism could manipulate the way physicians estimate this risk, which could alter the course of diagnosing patients presenting with mimicking symptoms.[22-24] There are currently no specifically developed or validated risk stratification tools for estimating the risk of PE in COVID-19 patients. This is when ordering a CTPA directly or using the available risk stratification tools heavily depends on clinical gestalt.

A combination of in-house training sessions, adopting computerized physician order entry systems, and utilizing performance feedback reports have been proven to improve adherence to recommended diagnostic pathways, reduce the overutilization of imaging, and enhance physicians' approach to diagnosing PE.[14,19,25,26] Lacking a written diagnostic algorithm to score the clinical probability of PE in suspected patients was also an obstacle adding to the inappropriate workup.[14]

Limitations

This was the first study in the country to assess the utility of risk stratification tools in diagnosing pulmonary emboli in the ED. Being a single-center study may limit the generalization of the results to other settings. Another limitation is the study's retrospective nature, as scores were calculated retrospectively, and there was the risk of over-calculating or under-calculating the Wells score. However, researchers did their best to apply scores with available objective data in the files and randomly cross-checked their accuracy. An important limitation was using a generalized D-dimer cut-off level and not an age-adjusted cut-off level. Finally, this study was conducted on data obtained before the emergence of the COVID-19 pandemic. Therefore, the pandemic might affect and change current practice and usage of PE clinical decision-making pathway in many settings.

Conclusion

Our study revealed that about two-thirds of CTPAs ordered did not adhere to the proper recommended clinical decision-making pathway, with a substantial amount of unnecessary CTPAs and improper utilization of D-dimer testing. The study also highlighted that adherence to PE clinical decision-making pathway increases the chance of diagnosing PE with CTPAs. Further studies are required to elaborate on the influencing factors for the evident nonadherence.

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Appendix 1: Wells and pulmonary embolism rule out criteria

Wells criteria for PE		PE rule-out criteria	
Variables	**Points**	**Variables**	**Points**
Clinical signs and symptoms of DVT	3	Age ≥50 years	1
PE is #1 diagnosis OR equally likely	3	Heart rate ≥100 bmp	1
Heart rate >100 bmp	1.5	Oxyhemoglobin saturation <95%	1
Immobilization at least 3 days OR surgery in the previous 4 weeks	1.5	Unilateral leg swelling	1
Previous, objectively diagnosed PE or DVT	1.5	Hemoptysis	1
Hemoptysis	1	Recent surgery/trauma*	1
Malignancy with treatment within 6 months or palliative	1	Prior PE or DVT	1
		Hormone use[†]	1
PE unlikely	0-4	PERC negative	0
PE likely	>4	PERC positive	>0

*Surgery or trauma ≤4 weeks ago requiring treatment with general anesthesia, [†]Oral contraceptives, hormone replacement, or estrogenic hormone use in male or female patients. PE: Pulmonary embolism, DVT: Deep venous thrombosis, bmp: beat per minute, PERC: Pulmonary embolism rule out criteria