

Original Research Article

Diagnostic Yield, Clinical Probability Score and Utility of Computerized Tomographic Pulmonary Angiography at Moi Teaching and Referral Hospital

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Abstract: Background: Diagnosis of pulmonary embolism (PE) is challenging as the symptoms of PE are non-specific. Computed tomographic pulmonary angiography (CTPA) has emerged in recent years as the imaging modality of choice. However, the wide availability of Computed tomography (CT) has led to concerns about the overutilization of CTPA. Use of D dimers and clinical probability scoring tools like the revised Geneva scores are invaluable in stratifying patients according to the probability of PE. Therefore, the study aimed to calculate the diagnostic yield, clinical probability scores and overutilization of CTPA in patients with suspected PE. **Objective:** To determine the diagnostic yield, clinical probability score, utility and overutilization of CTPA in patients with suspected pulmonary embolism at Moi Teaching and Referral Hospital (MTRH). **Methods:** This was a cross-sectional study conducted at the MTRH between September 2022 and August 2023. A consecutive sampling technique was applied and recruited 102 adult patients. Demographics, revised Geneva scores and D dimers results were recorded. Patients were subsequently categorized into low, intermediate and high probability for PE. **Results:** The diagnostic yield was 29.4%. On the Revised Geneva score, 7 (6.9%) were low risk, 84 (82.4%) moderate risk and 11 (10.8%) high risk. 0%, 25% and 81% in the low, intermediate and high risk groups were diagnosed with PE respectively. 50(49.0%) of participants had positive conventional D dimers while 52(51.0%) were negative. The revised Geneva score had a sensitivity, specificity, positive predictive value and negative predictive value of 83.3%, 44.4%, 38.5% and 86.5% respectively. 7 patients (6.9%) had negative D dimers, low risk on the revised Geneva score and no PE on CTPA. **Conclusion:** The use of D dimers combined with the revised Geneva clinical probability score will stratify patients into risks groups for PE and help to reduce overutilization of CTPA.

Keywords: Pulmonary Embolism, Computed Tomographic Pulmonary Angiography, Revised Geneva Score, D-Dimer, Diagnostic Yield.

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INTRODUCTION

Pulmonary embolism refers to the total or partial occlusion of one or more central or peripheral pulmonary arteries by emboli which typically originate from veins in the lower limbs or pelvis. Pulmonary embolism is a potentially fatal condition if not properly managed. Mortality of untreated pulmonary embolism (PE) is high and complications can occur with extended treatment with anticoagulants. In an Australian study the annual crude incidence rate of pulmonary embolism was found to be 0.31 per 1000 [1]. The one-year mortality rate for PE varies according to studies. In the Prospective

Investigation of Pulmonary Embolism Study (PIOPED) the one-year mortality rate for Pulmonary Embolism was approximately 24% (Worsley DF 1995) while in the Quebec-Venous thromboembolism(Q-VTE) study it was 23% [2]. In contrast the pulmonary embolism registry of Gottingen (PERGO) study reported a one-year mortality rate of 19.7% [3].

Pulmonary embolism presents with several cardiorespiratory symptoms including chest pain, cough, hemoptysis, dyspnea and hypoxia. However, none of the symptoms are specific to this disease and that's why PE

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is referred to as the 'great masquerader' [4]. This therefore necessitates the use of imaging studies to arrive at a conclusive diagnosis. Clinical evaluation and accurate diagnostic testing are required to decrease delays in initiating therapy which will result in reduction of morbidity and mortality due to pulmonary embolism.

Clinical probability scoring tools such Wells score, modified Wells score, revised Geneva classification and Pulmonary embolism rule out scores (PERC) scores are necessary to aid clinical evaluation and optimize the use of diagnostic modalities especially in the emergency departments [5].

Pulmonary angiography has been used historically for diagnosis of Pulmonary embolism, but due to its invasiveness has now been largely replaced by less invasive modalities [6]. Use of multi detector computed tomography technology results in fast acquisition of images and enables 3D reconstruction. The short scan times reduces motion artifacts, making vessels close to the heart easier to visualize. Thinner slices results in improved depiction of segmental and sub segmental arteries. With faster scans less contrast is administered, a factor beneficial in patients with renal or cardiac impairment. Use of Computed tomography potentially minimizes delays in diagnosis and results in improved patient care. Computed Tomographic Pulmonary Angiogram (CTPA) additionally enables direct visualization of blood clot as well as assessment of cardiac and pulmonary function [6]. This will aid in quantifying the degree of pulmonary obstruction and the severity of Pulmonary embolism. Apart from pulmonary embolism, Computed Tomographic Pulmonary Angiogram can pick alternative diagnoses such as pleural effusion, pneumonia, atelectasis, emphysema and pulmonary masses. However, despite being the investigation of choice for diagnosis of Pulmonary embolism, Computed Tomographic Pulmonary Angiogram requires administration of contrast media which is potentially nephrotoxic and deposits a large amount of radiation in tissues which may predispose to malignancies in the long run [5]. To mitigate these effects an alternative modality like ventilation perfusions scans is occasionally considered especially for patients with severe renal impairment, pregnancy and in younger patients.

The widespread availability of Computed tomography has resulted in an increase in the use of Computed tomographic pulmonary angiogram to diagnose pulmonary embolism. Usage has increased especially in the emergency departments in the United States of America [7]. This has led to concern of overutilization of Computed Tomographic Pulmonary Angiogram which has largely been fueled by data from emergency departments in the USA where PE yields are low largely below 10%. These low yields are obtained despite the large increase in the number of investigations in the last decade. In the USA up to 3% of all adult

patients seen in the emergency department have a Computed tomographic pulmonary angiogram recommended [7]. This increased use may result in potential harm including radiation, contrast induced nephropathy, allergies and results in increased health care costs and potentially delays care [8].

CTPA is the gold standard for diagnosis of pulmonary embolism and its requisitions have increased as CT scans have become widely available [9]. It has high sensitivity for diagnosing PE, however the diagnostic yield varies according to different studies with most in the USA below 10%. Overuse of CTPA in diagnosing pulmonary embolism is a common problem especially where CT is widely available. Increasing availability of CTPA is resulting in overutilization in the diagnostic workup of patients presenting with cardiorespiratory symptoms [9]. It is possible to reduce unnecessary CTPA requests by adherence to protocols developed as a result of recommendations from studies and by doing a detailed clinical risk assessment. Excessive use of CTPA also potentially overdiagnoses clinically insignificant cases of PE.

Clinical probability scores help to categorize patients into low, intermediate and high probability for Pulmonary embolism or alternatively into Pulmonary embolism likely and pulmonary embolism unlikely groups [5]. This will guide clinicians on the next appropriate course of action. If well utilized these scores alone or in combination with D dimers can result in a reduction in the number of CTPA requisitions. A pulmonary embolism diagnostic pathway that utilizes clinical probability scoring, D dimers and Computed Tomographic Pulmonary Angiography or ventilation perfusion scans has been adopted worldwide. However, the utilization of this diagnostic pathway has not been explored in our set up. In addition, there are no previous studies in our region which have studied the utilization of clinical probability scores combined with D dimers and Computed Tomographic Pulmonary Angiography in patients with suspected pulmonary embolism [5].

The aim of the current study was to compare the D-dimer test and modified Geneva criteria, which is used for clinical probability assessment, with the results of CTPA in patients who had CTPA requisitions for suspected PE, and consequently, to investigate the applicability of these tests to reduce the excessive use of CTPA.

METHODOLOGY

This was a cross-sectional study undertaken over a period of one year from September 2022 to August 2023. The study was conducted at the Moi Teaching and Referral Hospital Radiology and Imaging department at the CT imaging rooms. The Moi Teaching and Referral Hospital is located along Nandi Road in Eldoret town. Moi Teaching and Referral Hospital is the second largest referral hospital in Kenya after Kenyatta National

Hospital. The computerized tomography unit has two CT machines 32 slice CT scan machine (Siemens Germany) and a 64 slice CT scan (Philips Netherlands).

Study Population and Sampling

The study was undertaken over a 12-month period and included all adult patients with suspected pulmonary embolism referred to the radiology department for Computed tomographic pulmonary angiography and also had D dimers performed.

Adult patients 18 years and above and clinically suspected to have pulmonary embolism, referred to radiology department for CTPA and had D dimer tests performed were included. Patient with confirmed pulmonary embolism who are on treatment and sent for rescanning and patients who declined consent were excluded.

A census study was undertaken due to the low numbers of patients referred for CTPA in the preceding years. These average for 2020 and 2021 was 93 patients. Consecutive sampling technique was applied to this study. Every patient suspected to have pulmonary embolism and referred for CTPA was recruited after obtaining informed consent. A clinical history with emphasis of risk factors was obtained and entered into a questionnaire. Pretest probability scoring using revised Geneva score was done and patients classified as low, intermediate and high probability for PE. A requisition for D dimers was made. All patients subsequently had a CTPA performed.

Study Procedure

Patients who were referred to the radiology department for CTPA were recruited into the study after informed consent was obtained. Clinical history with special emphasis on symptoms such as cough, chest pain, dyspnea or difficulty in breathing and hemoptysis was obtained and entered into the questionnaire. Patients were also asked about the presence /history of eight risk factors for PE. These included history of or current DVT, history of surgery, trauma, immobility of more than 3 days, malignancy, oral contraceptive pills and blood clotting disorders.

Information on patient's demographics age and sex were obtained and entered into the questionnaire. Patient's vital signs SPO2 heart rate was taken and entered into the questionnaire. The revised Geneva score clinical scoring system was applied and patients categorized into low, intermediate and high risk for PE.

Intravenous access was obtained from the referring unit or in the CT rooms within the radiology departments. The CTPA requisition form was checked for completeness and for urea, electrolyte and creatinine results. The patient was positioned on the CT machine in a supine position with their arms above their heads. 60-100mls of contrast media (Iohexol 350mg/ml) at the rate

of 1ml/kg body weight was injected followed by a saline chaser equivalent in volume to 50% of the contrast volume. Image acquisition was triggered when opacification at the main pulmonary artery was at least 250 Hounsfield units (HU). Images were acquired, processed, saved and uploaded to the picture archiving and communication (PACS) system for interpretation by the radiologists in the image reading room.

All images were archived electronically and evaluated by the principal investigator and two consultant radiologists independently. In the case of discrepancy, consensus was reached through discussion with a third radiologist (chief radiologist). The diagnosis of PE was confirmed by the presence of at least one filling defect in the pulmonary tree.

D dimers were requested as part of the routine patient care and results obtained by the principal investigator from the hematology laboratory or from the patients' files.

Data Management and Analysis

The data was collected using questionnaires that had no patient names. Instead, a study code number was used. The questionnaires were kept in a study file and placed under lock and key to ensure that the study information provided was kept confidential. To ensure that the quality of data was maintained, the principal investigator checked the completeness of questionnaire daily before entering the data into a Microsoft access database.

Data was then imported into SPSS version 16. Subsequently coding, cleaning and analysis was done. Descriptive statistics such as mean, standard deviation median and interquartile range were used to summarize continuous data for example age. Frequencies and percentages were used to summarize categorical data such as sex.

Sensitivity, specificity, positive and negative predictive values were calculated for D dimers and revised Geneva scores as compared to CTPA findings. The data is presented in tables, graphs and prose forms.

Ethical Considerations

Ethical approval was sought and obtained from Moi university/MTRH institutional and ethics research committee (IREC) ref no. 0004240 and NACOSTI (National commission for science, technology and innovation) ref no. 579277. Permission was sought from the CEO of MTRH for permission to carry out the study in the facility.

Written informed consent was obtained from all patients enrolled in the study. Participation in the study was voluntary and participants were informed that they could withdraw from the study at any time. Patients'

information was kept confidential by using codes instead of patient's names.

RESULTS

During the study period a total of 102 patients who presented to the radiology department for CTPA and who consented were enrolled. The youngest participant

was 18 years old while the oldest was 97 years old. The mean age was 53.2 (S. D+/- 19.4) years with a median age of 54 years (IQR=28). A total of 62 participants were female comprising 60.8% while male patients were 40 comprising 39.2%. The male to female ratio was 1:1.55. A total of 30 patients had positive PE findings on CTPA giving a diagnostic yield of 29.4%.

Table 1: Revised Geneva score classification

Variable	Frequency	Percentage
Low risk	7	6.9%
Moderate risk	84	82.4%
High risk	11	10.8%

The participants were stratified into three categories of low risk, intermediate risk and high risk with 7,84 and 11 patients respectively. None of the low-

risk patients had PE on CTPA, while 25% (21/84) and 81% (9/11) in the moderate and high-risk groups respectively had PE.

Table 2: Association between Revised Geneva Score Classification and CTPA Findings

Revised Geneva score	PE positive	PE negative	P value
Low risk	0	7	0.004
Intermediate	21	63	
High risk	9	2	
Total	30	72	

When tested against CTPA findings, the revised Geneva score had a sensitivity of 83.3%, specificity of 44.4%, PPV of 38.5% and negative predictive value of 86.5%.

Overall Diagnostic Yield of CTPA in Diagnosing of PE in Patients Suspected of PE at MTRH

In total, 30 patients had PE on CTPA, giving a diagnostic yield of 29.4% (30/102). Of these, 12 (11.7%) had PE with no additional findings while 18 (17.6%) had PE and other additional findings on CTPA. Among the 72 patients without PE, 69 (68.1%) had alternative findings while 3 (2.9%) had normal CTPA findings.

Table 3: Overutilization of CTPA Based on Revised Geneva Score and D-dimer Findings

Variable	Frequency	Percentage
Low Revised Geneva score + D-dimer <500 µg/L	7	6.9%
PE absent on CTPA	7	100%
PE present on CTPA	0	0%

The overuse of CTPA in diagnosis of PE at MTRH is 7/102 that is, 6.9%.

DISCUSSION

The introduction of standardized guidelines and diagnostic protocols which utilizes clinical probability scores, D Dimers and radiological investigations to determine the clinical probability of PE has improved the diagnostic workup of patients with suspected PE. A clinical decision rule result of PE unlikely in combination with normal D dimer result can exclude PE in a sizeable population of patients who present for evaluation (approximately 20-40%) [10]. This reduces the need for additional imaging in these patients and ultimately anticoagulant drugs can be safely withheld.

In our study patients were stratified into two and three tier categories using the revised Geneva score probability score. The revised Geneva score was chosen because it uses only objective criteria as opposed to the

wells score. Out of the 102 patients ,7 were low risk,84 moderate risk and 11 high risks for PE. when the two-tier category was utilized 37 were categorized as PE unlikely (36%) and 65 (64%) PE likely. The PE prevalence among the low, intermediate and high probability groups was 0%,25% and 81.8% respectively. The low PE prevalence among the low probability group and high PE yield in the high probability group may point to adequate stratification of patients for CTPA. Most patients in our study 84/102(83%) fell into the moderate risk category. This agrees with a study done by Abolfotouh in Saudi Arabia where 1254/2010 (62%) were categorized as moderate risk for PE [11].

The PE prevalence among the low, intermediate and high probability groups was 0%,25% and 81.8% respectively. This agrees with results of a study in Saudi Arabia where the PE prevalence was 0%,25.8% and

88.9% respectively [11]. Similarly, a study by Raji H *et al.*, (2018) yielded rates of 18%, 44% and 82% among the low, intermediate and high-risk groups respectively [12].

The revised Geneva scores performance was calculated as a clinical prediction rule. When tested against CTPA findings, the revised Geneva score had a sensitivity of 83.3. %, specificity of 44.4. %, PPV of 38.5. % and negative predictive value of 86.7%. This is in agreement with literature where the revised Geneva score is reported to have a high sensitivity and negative predictive value and a low specificity and positive predictive value. Due to its low specificity and positive predictive value, it is useful to rule out PE and should be combined with D dimers and imaging for diagnostic workup of patients with suspected PE. Our results are in agreement with a study by Gogulakrishnam R *et al.*, (2023) in India which reported the sensitivity, specificity, PPV and NPV of the revised Geneva score as 70%, 52%, 44% and 76% respectively [13].

A total of 50/102 patients (49%) in our study had positive D dimers. The sensitivity, specificity, positive predictive value and negative predictive values of D dimers in our study were 86.7%, 66.7%, 52% and 92.3% respectively. These metrics indicate that although D-dimer is highly sensitive for detecting PE, its low specificity implies that it is less adept at differentiating PE from other conditions that also raise D-dimer levels. The PPV indicates that 52% of patients with elevated D-dimer levels had PE, whereas the NPV shows that 92.3 % of patients with low D-dimer levels were correctly identified as not having PE.

D dimers and have a high sensitivity and low specificity and are utilized to rule out PE. Clinical decision rules like revised Geneva scores also have high sensitivity and low specificity and are best used to stratify patients into PE likely /unlikely groups and not used for diagnosis of PE. Combination of D dimers and the clinical decision rules improves the stratification of patients and guides on who requires a CTPA. The gold standard for diagnosis of PE remains computerized tomographic pulmonary angiography (CTPA).

Overall Diagnostic Yield of CTPA in Diagnosing of PE in Patients Suspected of PE at MTRH

The diagnostic yield of CTPA in our study was 29.4%. This falls within the 15.4 -37.4% range [14]. This range is a recommendation by the Royal College of Radiologists and was arrived at by the British thoracic society standards of care committee pulmonary embolism guidelines development group. Thus far, there is no consensus on the acceptable positive rate of CTPA in diagnosing PE. While the Royal College of Radiologists suggests a minimum yield of 15.4% as the acceptable positive rate of CTPA, certain centres use 10% as the accepted threshold under which overuse of CTPA should be considered [15].

Overutilization of CTPA in Diagnosis of PE at MTRH

Overuse of CTPA in patients suspected of PE has been a concern especially in emergency departments in western countries. In this study the rate of overuse of CTPA was found to be 7%. This could point to underutilization of D dimers and clinical scores or non-adherence to clinical guidelines. In our facility there are guidelines regarding diagnosis of DVT and venous thromboembolism developed by the national ministry of health and adopted by MTRH. However, they are not widely utilized and almost all patients sent to radiology department for imaging have no D dimers or clinical prediction scores for PE done.

This is in agreement to a study done in Michigan USA by Mohammed Osman *et al.*, (2018) involving 395 patients where they established that 41% of the patients were inappropriately referred for CTPA [16]. The diagnostic yield was also low at 5.4% but in concordance with similar USA studies. This could be due to greater accessibility of CTPA in the USA and lack of adherence to guidelines. In contrast yields in European countries are double or triple the American yields [17,18].

A study by Amanda Crichlow, Adam Cuker and Angela M Mills in USA (2012) also arrived at a similar conclusion that 13.8% of CTPA could have been avoided if clinical probability scores and D dimers were utilized.

CONCLUSION

Combination of clinical probability scores and D dimers helps to guide on the course of management and reduces the number of patients who require CTPA for suspected pulmonary embolism. Patients with low probability on Revised Geneva scores most likely don't have PE. In our study no patient out of 11 in this category had PE. The diagnostic yield of CTPA in our study was 29.4% which falls in the 15.4%-37.4% range recommended by the Royal College of Radiologists. 7/102 patients had low probability on revised Geneva score, negative D dimers and no PE. This corresponds to an overutilization rate of 6.9%.

Declaration of Conflict of Interest: The authors declare that they have no conflicts of interest.

AUTHORS' CONTRIBUTIONS

Josphat Kiprotich Sang: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Writing original draft, Writing review and editing.

Loice Sitienei: Conceptualization, Methodology, Supervision, Validation, Writing – review and editing.

Andrew Wandera: Conceptualization, Methodology, Supervision, Validation, Writing – review and editing.

All Authors: Final approval of the version to be published and accountability for all aspects of the work.

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