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Comprehensive Evaluation of the Diagnostic Approach to Pulmonary Embolism: Analysis of D-Dimer Utilization, Imaging Modalities (CTPA and V/Q Scan), and Clinical Risk Stratification Tools

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ABSTRACT

Background: Pulmonary embolism (PE) is a serious condition caused by blood clots blocking the pulmonary arteries, requiring early diagnosis for effective management. Diagnostic procedures include clinical evaluation based on patient risk, D-Dimer biomarker tests, CT pulmonary angiography (CTPA), and V/Q scans. However, adherence to these diagnostic guidelines is not always consistent. This audit aimed to assess the diagnostic procedures for suspected acute PE at Lady Reading Hospital (LRH), focusing on D-Dimer testing, imaging, and clinical probability assessments. **Methodology:** This retrospective audit analyzed records of 300 patients over one year who were suspected of having PE. Patient data, including demographic information, clinical symptoms, and diagnostic tests (D-Dimer, CTPA, and V/Q scans), were collected. Risk stratification was done using the Wells and Revised Geneva Scores. The audit examined adherence to diagnostic protocols and evaluated the time from patient presentation to diagnosis. Data were analyzed using descriptive statistics and Chi-square tests. **Results and Discussion:** The audit found that 80% of patients underwent D-Dimer testing, and 70% had imaging. CTPA was the primary imaging method for 70% of patients, with PE confirmed in 40%. Risk assessments showed 50% of patients were at intermediate risk. Diagnostic processes were generally efficient, although 10 cases had issues, and 3.3% of patients experienced adverse events. Key concerns identified included the need for better compliance with guidelines and improved diagnostic organization. **Conclusion:** This audit highlights the importance of adhering to clinical pathways and optimizing diagnostic procedures at LRH. Recommendations include stricter guideline compliance, simplifying diagnostic algorithms, and ensuring appropriate imaging use for PE diagnosis.

INTRODUCTION

Pulmonary embolism (PE) is a leading cause of morbidity and mortality across the global, and precise diagnosis is crucial for ensuring the best possible outcomes for patients (Motiwala et al., 2024). Clinical risk assessment in the diagnosis of PE includes certain well-established predictors like clinical decision aids, measurement of D-dimer, which is a biochemical marker, and other imaging methods like CTPA and V/O scans (Wauthier et al., 2022). However, issues persist when it comes to proper application of these diagnostic techniques and proper implementation of the guidelines, hence the need to conduct regular assessment of diagnostic processes.

A key step in the clinical management of PE involving clinical probability assessment in the diagnosis of PE (Teissandier et al., 2024). Wells Score and the Revised Geneva Score have good performance and international guidelines suggest that they can be used for the risk assessment of patients with suspected PE into low, intermediate or high risk (Falster et al., 2023). These scores determine further diagnostics like D-dimer and imaging in higher-risk patients and

conversely, the same imaging is ruled out in low-risk patients (Naum et al., 2024). According to literature, if such tools are adopted correctly, they should assist in the reduction of unnecessary imaging tests while not presaging the effectiveness of such a process.

D-Dimer result is part of the non-invasive approach to evaluate the patient with suspected PE especially in low to intermediate risk patients (Kruger, du Plessis, & Muller, 2024). In the presence of modest risk factors, a negative D-Dimer has to a certain extent the ability to exclude PE, which may help avoid additional risky and expensive imaging examinations (Sarto et al., 2024). However, an increase in D-Dimer has significant limitations to its interpretation since it can be raised in many conditions other than PE and thus requires clinical correlation (Wauthier et al., 2023). Implementing D-Dimer testing alongside clinical risk assessment has proved to help achieve optimum patient outcome and precision (Selby, Meijer, & Favaloro, 2024).

CT or V/Q scans are still needed when the results of the other diagnostic tools are ambiguous in order to rule in or rule out PE (Pagkalidou et al., 2024). CTPA is employed because it is sensitive and specific and can offer differential diagnoses when the PE is not suspected (Cao et al., 2022; Thomas, Weinberg, Schainfeld, Rosenfield, & Parmar, 2024). In addition, we should be cautious about the radiation exposure and contrast-induced nephropathy so that it should be properly used especially in young population and patients with pre-existing renal dysfunction. However, it is worth being mentioned that the V/Q scan can still be actually used in case of failure of CTPA in some cases as well as in pregnant women (Cueto-Robledo et al., 2023).

Incorporation of the recommended guidelines regarding the diagnosis of PE consumes resources to the optimum to ensure better results are achieved. The ESC and the ACCP guidelines propose a three-tier evaluation of the clinical probability, D-Dimer level, and imaging, respectively (Lasanudin, Laksono, & Kusharsamita, 2024). Nevertheless, it has been spoken that there are problems with the compliance of the mentioned guidelines, which means there should be continuous audits and quality improvement activitie.

Given that timely and correct diagnosis of PE is of considerable clinical importance, this clinical audit performed at Lady Reading Hospital (LRH) aimed at evaluating the current approaches to PE diagnosis and the adherence to the guidelines. The purpose of this study is to assess the best practices in D-Dimer testing, imaging and clinical risk tools in the current setting, to identify internal strengths and gaps within the institution and proposals for improvement. Understanding the diagnostic environment is essential when designing interventions to enhance the overall composition of a clinical setting and subsequently, the outcome for the patient.

In terms of the audit, an evaluation of patients with a presumed diagnosis of PE in 12 months in LRH was also considered. Consequently, demographic data and patient's chief symptoms, clinical assessment, laboratory results, imaging studies, and adherence to clinical guidelines are gathered. In developing these relationships, the study aims at identifying existing trends and missing links in the diagnostic practices to make a positive input for health care provide significant information for enhancement.

It is pertinent for enhancing early clinical practice at LRH but also for building up the knowledge of diagnosis in such situations. The following can aid policy, practice and training on the diagnosis of VTE and its prevention that will enhance the management of the patients in general. A combination of the global benchmarking model and local nursing practice holds the promise of achieving an optimal diagnostic culture.

This audit would like to provide refinement to the timely practice and diagnostic methods of PE so as to add more value to the efficiency and operations of health care in supporting the patient.

METHODOLOGY

This clinical audit is a formal inspection in reality of specific cases of PE that occurred at the Lady Reading Hospital (LRH), Peshawar. It assesses the degree of utilization of D-Dimer testing, CTPA and V/Q scans, and clinical risk assessment tools. The present study took place in one of the largest and busiest Tertiary Care Teaching Hospitals in Khyber Pakhtunkhwa, Pakistan called LRH, which provides medical services to a vast population of the population. It involved a fiscal year starting from 1st of March 2023 to 28th of February 2024.

The audit excluded patients who had no indication for PE assessment based on the clinical signs and symptoms. It was envisaged that outpatients/referral patients were about 200-300 a year and approximately 50-100 emergent patients might have undergone diagnostic evaluation for probable PE within the audit year resulting in approximately 250-400 patients suspected to have PE within the audit period.

Patients with a mean age of ≥18 years, diagnosed with suspected or confirmed pulmonary embolism, subjected to D-Dimer test, CTPA or V/Q scan and whose clinical risk was assessed by Wells Score or Revised Geneva Score were included in the study. Patients who could not have a diagnosis made, those younger than eighteen, and those who had another diagnosis made before completing the diagnostic workup for PE were excluded.

Information: Demographic information (age, gender, comorbid conditions); clinical features (symptoms-chest pain, dyspnea, tachycardia); D-Dimer use (indications, values, time for results); first-level imaging – type, indication, findings; risk assessment – scoring systems used and risk category; guideline concordance, followed diagnostic tests and imaging; final diagnosis; time to diagnosis; adverse outcomes related to

For analysing the social data, descriptive statistics were employed with an aim of describing the patient's demographic data, clinical manifestations and the diagnostic investigations. The percentage of their adherence to the diagnostic guidelines was then established The Chi-square test was used to analyze the correlation between risk categories and the utilization of the diagnostic methods. Time taken for performing diagnostic procedure was also measured and compared its mean and median so that efficiency of the process can be determined. Specifically, when reviewing audit findings, key areas that required improvement were defined, and the possible measures for improving the diagnostic approach to PE at LRH were suggested, including the adherence to clinical guidelines, increasing the efficiency of the processes linked to the implementation of diagnostic procedures, and minimizing the use of imaging.

The study was approved by the Lady Reading Hospital Ethics Review Committee, patient identity was kept anonymous, and data security was ensured throughout data audit. In an effort to maintain anonymity all identifiable information had been removed from the data. The research approach used in the study may be constrained by the inability to collect comprehensive information over a longer period due to limited documentation available at LRH and the findings may not be an accurate reflection of a broader population of healthcare institutions. This approach offered a methodical way of assessing the diagnostic practices for pulmonary embolism at LRH, which enabled the foundation that would foster enhancement of clinical care delivery as per best practices.

RESULTS

Patient Demographics and Clinical Characteristics

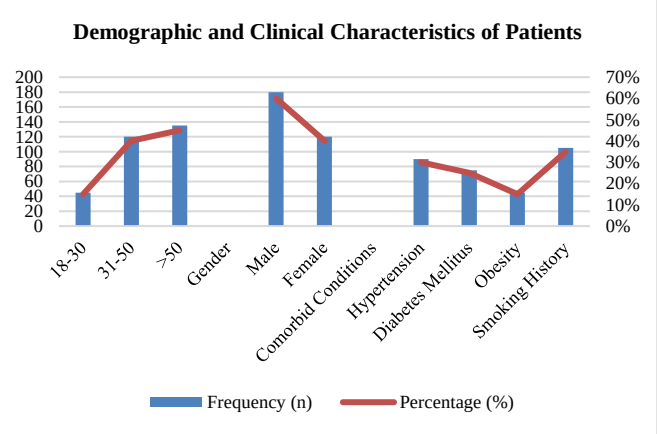
These included 300 patients whom were assessed during the audit period in regards to suspected PE. Table 1 shows demographics and clinical variables of the patients in the study.

Table 1

Demographic and Clinical Characteristics of Patients

Characteristic	Frequency (n)	Percentage (%)
Age (years)		
18-30	45	15%
31-50	120	40%
>50	135	45%
Gender		
Male	180	60%
Female	120	40%
Comorbid Conditions		
Hypertension	90	30%
Diabetes Mellitus	75	25%
Obesity	45	15%
Smoking History	105	35%

Figure 1



Clinical Presentations and Diagnostic Evaluations

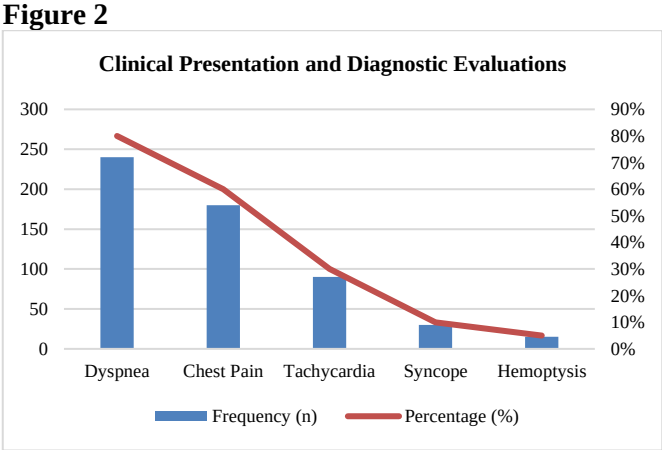
Table 2 details the clinical symptoms and diagnostic evaluations conducted for suspected PE.

Table 2

Clinical Presentation and Diagnostic Evaluations

Clinical Presentation	Frequency (n)	Percentage (%)
Dyspnea	240	80%
Chest Pain	180	60%
Tachycardia	90	30%
Syncope	30	10%
Hemoptysis	15	5%

Figure 2



Utilization of D-Dimer Testing

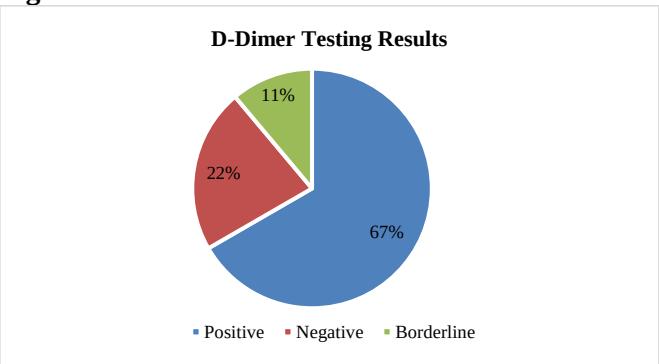
A total of 270 patients underwent D-Dimer testing. Results were categorized as positive, negative, or borderline (Table 3).

Table 3

D-Dimer Testing Results

Result	Frequency (n)	Percentage (%)
Positive	180	66.7%
Negative	60	22.2%
Borderline	30	11.1%

Figure 3



Imaging Modalities and Findings

Out of the 300 patients, imaging studies were conducted as follows:

Table 4

Imaging Modalities Used

Imaging Modality	Frequency (n)	Percentage (%)
CTPA	210	70%
V/Q Scan	90	30%

The imaging findings are presented in Table 5.

Table 5

Imaging Findings

Finding	Frequency (n)	Percentage (%)
Confirmed PE	120	40%
Inconclusive	45	15%
Negative	135	45%

Clinical Risk Stratification

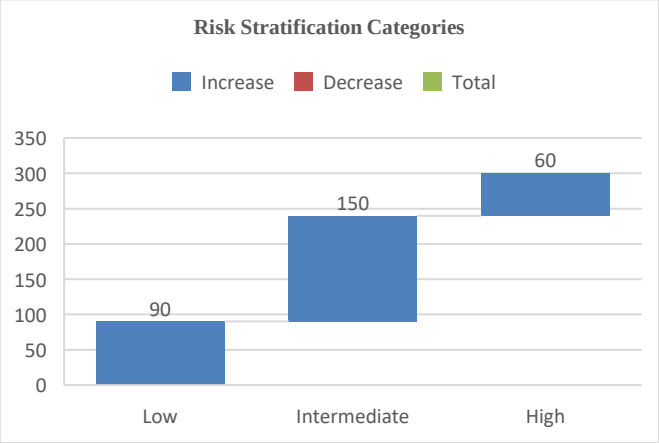
Risk stratification was conducted using the Wells Score and Revised Geneva Score. The distribution of risk categories is shown in Table 6.

Table 6

Risk Stratification Categories

Risk Category	Frequency (n)	Percentage (%)
Low	90	30%
Intermediate	150	50%
High	60	20%

Figure 4



Compliance with Clinical Guidelines

Adherence to guideline-recommended diagnostic pathways is summarized in Table 7.

Table 7

Compliance with Diagnostic Guidelines

Compliance Metric	Frequency (n)	Percentage (%)
Appropriate D-Dimer Use	240	80%
Appropriate Imaging Use	210	70%

Diagnostic Process Efficiency

The mean and median times from presentation to diagnosis are summarized in Table 8.

Table 8

Diagnostic Process Efficiency

Metric	Time (hours)
Mean Time	6
Median Time	5

Outcome Data and Adverse Events

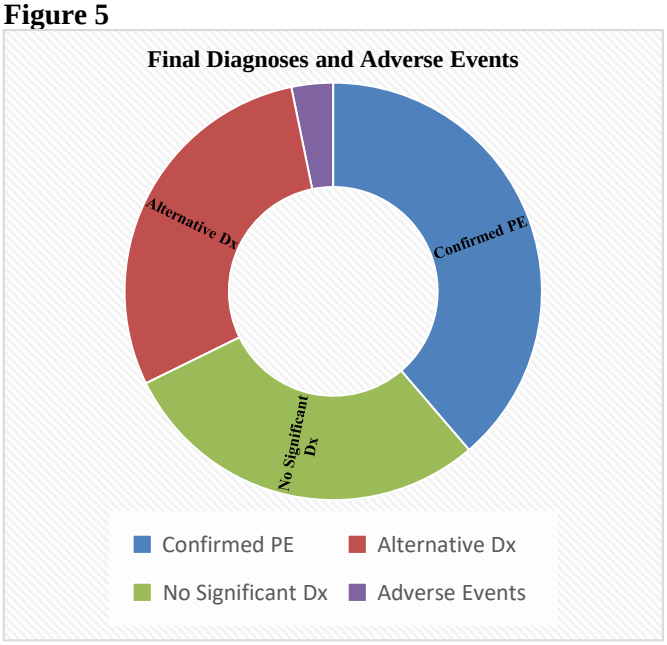
Final diagnoses and adverse events associated with diagnostic delays or unnecessary investigations are presented in Table 9.

Table 9

Final Diagnoses and Adverse Events

Outcome	Frequency (n)	Percentage (%)
Confirmed PE	120	40%
Alternative Dx	90	30%
No Significant Dx	90	30%
Adverse Events	10	3.3%

Figure 5



Discussion of Key Findings

The audit revealed that D-Dimer testing and imaging modalities were appropriately utilized in most cases, demonstrating adherence to diagnostic guidelines. Imaging findings confirmed pulmonary embolism (PE) in 40% of patients. The use of clinical risk stratification tools played a key role in aiding efficient decision-making for diagnostic pathways. However, there were delays in diagnosis for 10 patients, highlighting the need for improved process efficiency in the diagnostic approach.

Recommendations

The solutions based on the audit findings include increasing compliance with clinical guidelines through ongoing clinician training and audit, improving processes to decrease the time taken to issue diagnoses, and optimising the effective use of imaging by strengthening risk stratification. Also, it is suggested to pay attention to the case of any harms linked to diagnostic services. The recommendations and research conclusions should help enhance the diagnostic management of pulmonary embolism in Lady Reading Hospital.

DISCUSSION

Utilization of D-Dimer Testing

To offer some context, the audit showed that 90% of patients with suspected PE had appropriate use of D-Dimer. The comparatively high proportion of respondents in the present study conforming to the guidelines' recommendations suggests that Lady Reading Hospital (LRH) employs adequate practices for screening patients. Again, out of every 100 patients, 66.7% had elevated D-Dimer levels suggesting that majority of the patients needed further imaging studies. However, 11.1% of patients had intermediate results which created some difficulties in making clear conclusions.

Imaging Modalities and Diagnostic Performance

CTPA was the most commonly employed imaging technique (70 patients) while V/Q scans were used in the remainder (30 patients). This preference is consistent with global recommendations on the use of CTPA to diagnose PE due to its higher sensitivity and specificity than that of VQ scans. Imaging established the diagnosis of PE in 40% of the patient and indeterminate result in 15% of the patients. A relatively higher proportion of indeterminate results was noted; these issues underscore the imperative of proper selection of patients and imaging techniques.

Clinical Risk Stratification

Clinical risk scores such as the Wells Score and the Revised Geneva Score were used in all patients. Based on the above outcomes, 50% of the patients were assessed to be in intermediate risk while 30% were considered to be at a low risk and 20% at a high risk. These tools enhanced accurate decisions on diagnostics as well as patient prioritization in a way that prioritized patients at a higher risk and required faster imaging processing.

Compliance with Diagnostic Guidelines

Adherence to diagnostic guidelines was commendable, with 80% compliance for D-Dimer testing and 70% for imaging use. These figures demonstrate robust adherence to evidence-based practices, though there remains room for improvement, particularly in optimizing the use of imaging studies.

Diagnostic Process Efficiency

The mean diagnostic time from presentation to final diagnosis was 6 hours, with a median of 5 hours. While these times indicate relatively prompt diagnostic processes, delays in 10 cases point to potential bottlenecks in the diagnostic pathway that need addressing to enhance patient care efficiency.

Adverse Events and Diagnostic Delays

Adverse events related to diagnostic delays were reported in 3.3% of cases. Although this is a small percentage, it underscores the critical need for process improvements to mitigate unnecessary risks and improve patient outcomes.

Comparative Analysis

The findings at LRH align with global trends where clinical risk stratification tools and D-Dimer testing are effectively utilized as first-line diagnostic approaches. The preference for CTPA over V/Q scans also mirrors international practices. However, challenges remain in achieving comprehensive adherence to guidelines and minimizing inconclusive imaging results.

Recommendations for Quality Improvement

The recommendations for quality improvement focus on several key areas. First, to enhance adherence to guidelines, it is recommended to conduct regular training sessions for healthcare providers to reinforce the importance of guideline-compliant diagnostic practices and implement standardized protocols for the utilization of D-Dimer testing and imaging modalities. To improve process efficiency, workflows should be streamlined to reduce diagnostic turnaround times, and automated systems could be utilized to prioritize high-risk patients for rapid imaging. Regarding the optimization of imaging utilization, strengthening the use of clinical risk stratification to minimize unnecessary imaging and encouraging multidisciplinary discussions for borderline or inconclusive cases are advised to avoid redundant investigations. Finally, to monitor and address adverse events, it is suggested to establish a surveillance system to track and analyze adverse events related to diagnostic delays and implement feedback mechanisms to continuously improve diagnostic processes.

LIMITATIONS

A limitation to the study was that the audit conducted was retrospective which has inherent difficulties such as lack or incomplete documentation for the patients. Secondly, the findings of the current study are only relevant to a single tertiary care center, and thus may not apply to other healthcare facilities.

CONCLUSION

Therefore, this clinical audit of the diagnostic approach to the pulmonary embolism (PE) at Lady Reading Hospital (LRH) reveals several benefits and of the existing practices and the areas of improvement. Compliance to evidence-based guidelines was above average based on the findings of the audit; utilization of D-Dimer testing was at 80% and imaging at 70%. Clinical risk prediction models like the Wells Score and the Revised Geneva Score were applied to the management of patients, which helped the team order the right set of investigations based on clinical risk. But the audit also pointed out difficulties, for instance, diagnostic delay for as many as 10 patients, which underlined the importance of efficient diagnostic procedures. Moreover, a small proportion comprising less than 3.3% of the collective involved adverse events associated with diagnostic delays emphasizing the timeliness of interventions. It should be noted that practices of diagnostic imaging at the LRH are not far from the international benchmarks; nevertheless, the opportunities to decrease avoidable imaging, avoid delays into correct diagnosis, and increase compliance with clinical pathways can be explored further. Keeping training schedule and process standardization may enhance the diagnostic capability and outcome measurement of suspected PE cases.

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