Internal Medicine and Medical Investigation Journal
E-ISSN: 2474-7750
Homepage: www.imminv.com

ORIGINAL ARTICLE

Corroboration of Spiral Computed Tomography Angiography with D-Dimer Assays in The Accurate Diagnosis of Pulmonary Embolism and Assessment of Its Image Quality

FarheenRazvi[1]*, Taranpreet Singh Kocchar[2], Tejas Kumar Mansukhlal Sejani[3], Gao Jian Bo[4]

[1] *Radiology Department, First Affiliated Hospital of Zhengzhou University, Zhengzhou University, Henan, PRC*
[2] *Internal Medicine Department, First Affiliated Hospital of Zhengzhou University, Zhengzhou University , Henan,PRC*
[3] *Zhengzhou Medical University, Henan, PRC*

*** Corresponding Author:** Farheen Razvi, E-mail: dr.frazvi@gmail.com

ARTICLE INFO

Article history
Received: March 19, 2019
Accepted: June 20, 2019
Published: Nov 11, 2019
Volume: 4
Issue: 3

Conflicts of interest: None
Funding: None

Key words
Pulmonary Embolism (PE),
D-dimer Assay,
Spiral computed tomographic angiography (SCTPA) ,
Single source Computed Tomography (CT)

ABSTRACT

Introduction: Pulmonary embolism is a frequent cause of mortality and morbidity. Aim of this study was to evaluate the utility of spiral computed tomographic angiography in determining the prevalence of pulmonary embolism in a clinically suspicious group and to assess the image quality of a single source computed tomography in diagnosis of pulmonary embolism. We have also investigated the reliability of D-dimer test in ruling out pulmonary embolism.

Materials and Methods: 50 patients clinically suspected of having pulmonary embolism were examined with contrast-enhanced spiral computed tomography in the hospital affiliated to Zhengzhou University from August 2014 to December 2015. Image quality, was assessed by analyzing the attenuation in the pulmonary trunk and its branches in comparison with the background noise. Mean attenuation values and standard deviation were recorded and displayed in Hounsfield Units. The computed tomography values, standard deviation values and signal-noise ratio obtained were then statistically analyzed using SPSS 17.0 software.

D-dimer test results were also obtained for the patients suspected of pulmonary embolism using rapid D-dimer testing and a reference range of 0 – 0.3 µg/l was considered as normal.

Results: Spiral computed tomography was a valuable method for identifying 20 patients with pulmonary embolism (sensitivity, 100%). It could correctly exclude pulmonary embolism in 28 out of 30 non - pulmonary embolism cases yielding a specificity of 94%.In 10 of the 20 patients devoid of pulmonary embolism; Spiral computed tomography provided an alternate clinical diagnosis. In the remaining 10 patients, spiral computed tomographic angiography scans were normal. The statistical analysis of the computed tomography values standard deviation and signal-noise ratio of the pulmonary trunk and pulmonary artery (without right or left predilection) showed a p-value>0.05. D-dimer Test showed elevated levels in 18 patients who were diagnosed with pulmonary embolism on spiral computed tomography scans. 8 patients without pulmonary embolism on spiral computed tomography scans also showed elevated D-dimer levels. The remaining 22 patients had normal D-dimer levels.

Conclusion: Spiral computed tomography has a good sensitivity and specificity for the diagnosis of pulmonary embolism. In the majority of patients who did not have pulmonary embolism, it provided important ancillary information for the final diagnosis. Therefore, combining Spiral computed tomography scan with a D-dimer Test is more effective in the accurate diagnosis of pulmonary embolism.

Published by Mehrabani Publishing LLC.

http://dx.doi.org/10.24200/imminv.xxxxxx

INTRODUCTION

Pulmonary thromboembolism (PTE or PE) and deep vein thrombosis (DVT) known collectively as venous thromboembolism (VTE) encompass one disease entity.PE originates from a DVT that occluded blood vessels of the pulmonary arterial tree and if untreated can cause acute hemodynamic collapse compromising arterial blood flow tə organs and eventual death (1).. (1)

With both environmental (acquired) and genetic factors contributing to the predisposition of the VTE , age , gender, racial and ethnic differences in the epidemiology of DVT/PE exists. Nevertheless as a frequent cause of mortality and morbidity. PE is a major global disease burden. A hospital – based study estimated the global burden of disability-adjusted-life-years (DALYs) from VTE to be 7.6 per 100,000. In the United States about 650,000 cases of PE occur each year , of this approximately 50,000 to 100,000 resulting in death (2

Deaths from PE s mainly due to failure of diagnosis, around 400,000 diagnosis of PE are missed in the United States annually making one of the leading causes of preventable hospital deaths(3).

Conversely, < 20% (sometimes only 5%) of patients investigated for suspected PE actually have the disease .the clinical presentation of PE is nonspecific and manifested with wide variability, to avoid potential misdiagnostic algorithms for PE in suspected individuals incorporates the sequential use of various pre-test probability assessment, analysis of biomarkers of acute thrombosis (D-dimer test) and if necessary, imaging of the chest (4)

A negative D-dimer test, with tailored cut-off values effectively improves the exclusion of PE in non-high pretest probability group and also with positive d-dimer levels are advised for chest imaging. Pulmonary antegrade stick was done in the diagnosis of PE, providing a direct assessment of the vasculature with great sensitivity and specificity.
However, being an invasive test with associated morbidity (6%) and mortality (0.5%) it is not a method of choice among physicians. Various noninvasive imaging modality such as ventilation perfusion (V-P) scanning, magnetic resonance imaging (MRI) and conventional computed tomography (CT) have since been used for diagnosis (5) with the introduction of spiral CT technology, it is now possible to image the chest in a short duration of time and analyze the pulmonary arteries during the peak of contrast enhancement. Many studies have demonstrated the spiral CT has higher sensitivity and specificity for the diagnosis of PE (9-15)

The objectives of the research were studied under three different prerogatives. First, to assess the reliability of spiral CT pulmonary angiography in the diagnosis of PE in a known sample of patients clinically suspected of PE. Second, to assess the image quality of single source CT in diagnosis of PE and third, assessing the reliability of D-dimer test in ruling-out PE.

MATERIALS AND METHODS

The research performed was a prospective study over a period of 16 months, from August 2014 to December 2015 at the CT department of the hospital affiliated to Zhengzhou Medical.

The study group included 50 patients (age range, 25-80 years ; mean age , 50 years) clinically suspected of PE (based on the clinical condition and elevated d-dimer levels). All the 50 patients were referred for CTPA within 24 hours of clinical presentation in order to ascertain the presence of PE .However the final diagnosis was based on clinical examination after a3 month follow-up. The CT scans were assessed for image quality by analyzing the attenuation in the pulmonary trunk and its branches in comparison with the background noise (BN).

SCTPA examinations were performed on a 64 row CT scanner (Discovery CT 750 HD, GE healthcare) as per the routine protocol of the department without any modifications. A plain CT was performed before the contrast enhanced CTPA. All CT data was acquired in a single breath-hold (inspiration) in the cranio-caudal direction from thoracic inlet to the diaphragm, including the lung fields. Following with the parameters set for angiography: tube voltage-120 kVp , tube current- 90 mAs, and gantry rotation time – 0.3 s and pitch factor of 1.2 , detector collimation-128 x 0.6 mm. The field of view (FOV) was limited to 3 cm and slice thickness was 5 mm. Axial images were reconstructed using a medium of soft tissue kernel (B26f) . Contrast enhancement was achieved with 30 ml of contrast material (Iohexol , 350 mgI/ml) followed by a 30 ml saline chaser bolus injected at 4 ml/s . Bolus tracking was used for automated examination start with a delay of 3s when a trigger threshold of 50 Hounsfield units (HU) in the pulmonary trunk was reached

Images were reviewed in mediastinal window (window width, 450 HU;window level, 35 HU) , pulmonary vascular window (window width, 250 HY; window level 35 HU) and the lung parenchymal window (window width;1500 HU; window level 500 HU) .The images were analyzed for the presence of PE, or any other underlying abnormality in the mediastinum, chest wall or lung parenchyma. The presence of endoluminal clots or vessel cut off sign was considered as an embolism on CT . Measurement of the regions of interest (ROI) was performed on RIS/PACS workstation (centricity 4.1, General Electric healthcare Dornstadt, Germany) using the circle tool. Mean attenuation values and standard deviations were recorded and displayed in (HU). The attenuation in the pulmonary trunk (APT) , the pulmonary artery and lobar artery was measured. ROI was drawn as large as possible, to include maximum amount of the contrast filled lumen of the pulmonary arteries. If an embolus was present in the respective segmental pulmonary artery, the contralateral vessel was measured. All measurements were performed by radiologist with experience in chest CT. Signal-to-noise ratio was determined by the following equation -:

• SNR=CTPulmonary Artery /BN

The details for image quality were expressed as "mean ± standard deviations" of the HU values , SNR and SD (image background noise) and then statistically analyzed using SPSS, version 17.4 software. To compare quantitative data between groups, we used the independent t-test sampling for normal distribution data. A p-value < 5% was considered to be of statistical significance

ventricle diameter (RVd), and tricuspid annular plane systolic excursion (TAPSE) showed no significant difference between the two groups with and without LAD involvement in any of these indices. Therefore, none of these parameters have been diagnosed to distinguish LAD involvement from a normal condition (see Table 3).

Table 3. P-value is greater than 0.05 computed tomography of Quality, SD values and SNR values of pulmonary trunk and pulmonary artery

Group	Pulmonary Trunk (Mean ± SD)	Pulmonary Artery (Mean ± SD)	*t-value*	*p*-value
CT quality	378.03±92.75	350.34±83.47	1.569	0.067
SD value	19.36±9.35	21.59±8.33	-1.256	0.212
SNR value	22.35±8.90	17.89±7.01	2.778	0.798

(Abbreviations; CT: computed tomography, SD: standard deviation, SNR: signal-noise ratio)

RESULTS

The CT scans were positive and 20 patients right fully confirming the diagnosis of PE (Table 1). Hence, the prevalence of PE in patients with clinical suspicion of the condition was 40%.Of the 30 cases who had a final diagnosis negative for PE, 28 were negative on SCTPA (true negative cases) and 2 had inconclusive SCTPAs , reasons being artefact or poor contrast opacification. Thus, the sensitivity of CTPA for detecting PE was 100%, it also excluded PE in 28 out of 30 non-PE cases yielding a specificity of 94%. CTPA provided an alternative diagnosis in 10 (33%) out of 30 patients who didn't have PE, comprising 20% of the 50 patients with clinical suspicion. To be absolutely certain if PE was not missed on CT, the results were tallied with the D-dimer test which were employed on all the 30 patients(table 4).A vascular attenuation of 200 HU was issued for the pulmonary trunk, a value that has been previously described as attenuation margin for diagnostic CT angiography(25-27). The CT values, Image Noise (SD) values and SNR values had p-values>/= 0.05 proving to be statistically insignificant meaning there was no significant variation in the image quality.

On applying Pearson's Chi-Square test the value is 0.0001 which indicates P-value to be less than 0.05.The result signifies he validity of the tool in assessing PE. Normal values indicate that the patient has no PE even within the segmental and sub-segmental arteries which is likely to be missed on CT. High value does not confirm PE as it can be elevated in many other systemic diseases as well.

Table 4. Comparing D-dimer levels in patients with and without PE

Group	Patients with PE (on CTt analysis)	Patients without PE (on CTt analysis)
Elevated (0-0.3 µg/ml)	18	8
Normal (0-0.3 µg/ml)	2	22
Column Total	20	30

(Abbreviations; CT: computed tomography, PE: pulmonary embolism)

Table 1. Accuracy of spiral computed tomography for the diagnosis of pulmonary embolism (data represents number of patients)

CT Interpretation	PE at final diagnosis	
	Present	Absent
Positive	20	0
Inconclusive	0	2
Negative	0	28
Total	20	30

(Abbreviations; CT: computed tomography, PE: pulmonary embolism)

Table 2. Distribution according to the largest pulmonary artery involved in 20 patients with PE.

Large Vessel involved	No. of patients	%
Main Pulmonary Trunk	4	20
Right or Left Pulmonary Artery	5	25
Lobar Artery	7	35
Segmental Artery	2	10
Subsegmental Artery	2	10
Total	20	100%

(Abbreviations; PE: pulmonary embolism)

Fig 1. . Embolus in the Right Pulmonary Artery

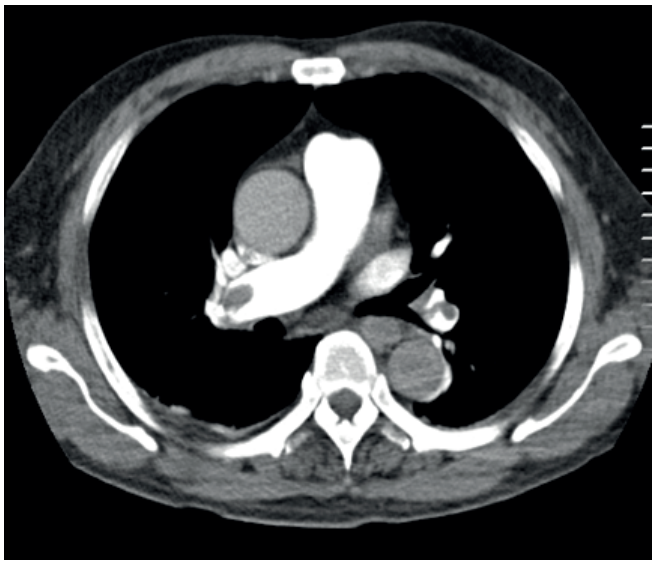


Fig 2. Vessel cut off sign in the Right Pulmonary Artery.

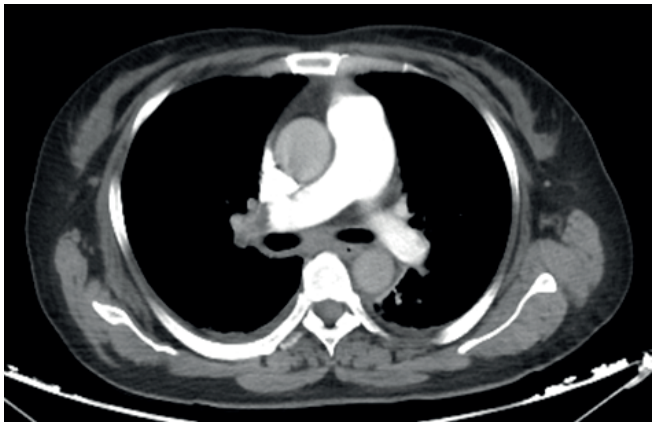
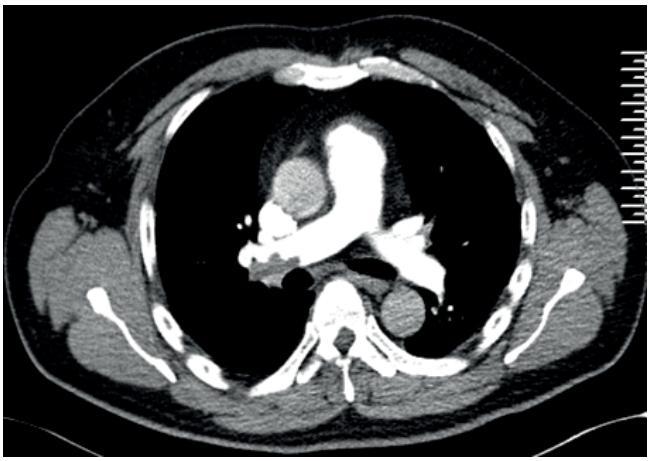


Fig 3.1 Filling defect showing PE in Right Pulmonary Artery



DISCUSSION

A potential criticism to this study is that the final diagnosis and categorization of patients as those with and without PE is based on clinical outcome and not on a gold standard imaging study, such as the conventional catheter angiography. This is justified by the following facts: Older imaging tests, such as ventilation–perfusion (V/Q) scintigraphy suffer from a lack of specificity (4-6). Although some still regard conventional pulmonary angiography as the gold standard technique for diagnosis of PE, being an invasive procedure, in reality is infrequently performed therefore; the most realistic scenario to measure efficacy of CT pulmonary angiography in suspected PE may be assessment of patient outcome. The prevalence of PE in clinically suspected cases have been estimated to be in the range of 35-45% (4-6) the prevalence of PE among patients with clinical suspicion of PE was 40% in this study. The sensitivity & specificity of CT for diagnosing PE in this study was 100% & 94% respectively. The calculations of sensitivity & specificity in this study were done per patient & not per embolus. Since upper CT findings cannot compare with any other imaging modality, we cannot ignore the chances of having overlooked the presence of small peripheral emboli which might be present. If the calculations of sensitivity, specificity were done per embolus rather than per patient, we would probably have got lower values. On the prospective investigation of PE diagnosis, or PIOPED study (21) only 6% of patients had PE limited to sub-segmental pulmonary arteries. Once again, since our CT findings were not validated against another imaging modality in this study, there was no way to be sure that we have correctly identified all the small peripheral (sub-segmental or smaller) emboli in this study and hence our calculations were probably biased towards larger central emboli on the expense of more peripheral emboli. Although isolated sub-segmental emboli (without emboli in larger arteries) were detected in only two (10%) of patients in this study, Occurrence of isolated sub-segmental PE is considered a risk for future acute pulmonary thromboembolism. A study of such patients showed that those who did not receive anticoagulation therapy had no evidence of recurrent PE at a 3 months follow-up.

Imaging Quality: A number of technical, anatomical, and patient related pitfalls may lead to misinterpretation of the CT images: Technical failures occur in 1% to 5% of scans, and usually are due to motion artifacts in dyspneic patients or insufficient vascular enhancement (10).

In patients with severe dyspnea, motion artifacts can produce respiratory mis-registration and inadequate sampling of the pulmonary vessels, resulting in focal areas of decreased attenuation which can mimic a clot.

Streak artifacts originating from dense intravenous contrast within the superior vena cava may obscure the right main and upper lobe pulmonary arteries. These streak artifacts are frequently observed when using a cranio-caudal image acquisition and highly concentrated contrast material. These artifacts can be minimized or eliminated by reducing

Fig 3.2 Filling defect showing PE in Right Pulmonary Artery

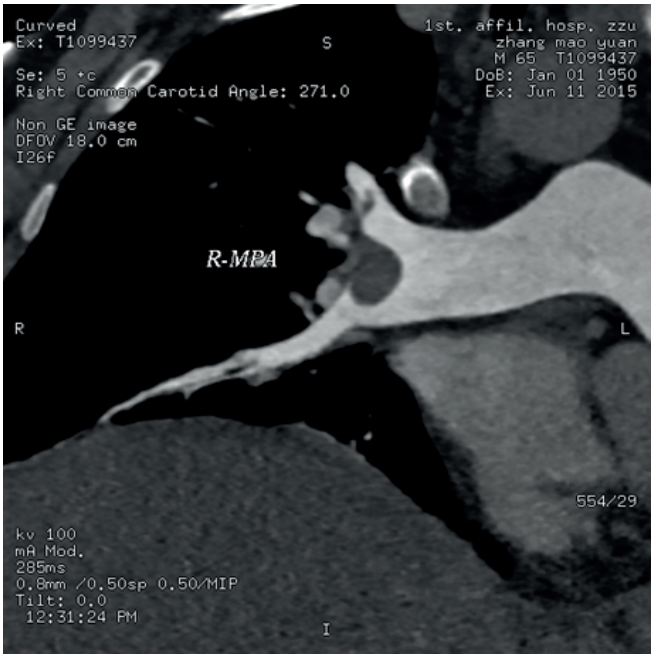


Fig 4.1 PE in the Right Lobar Artery

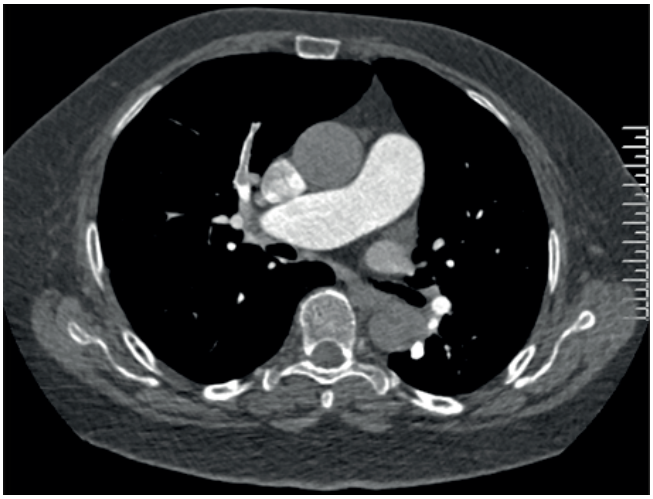
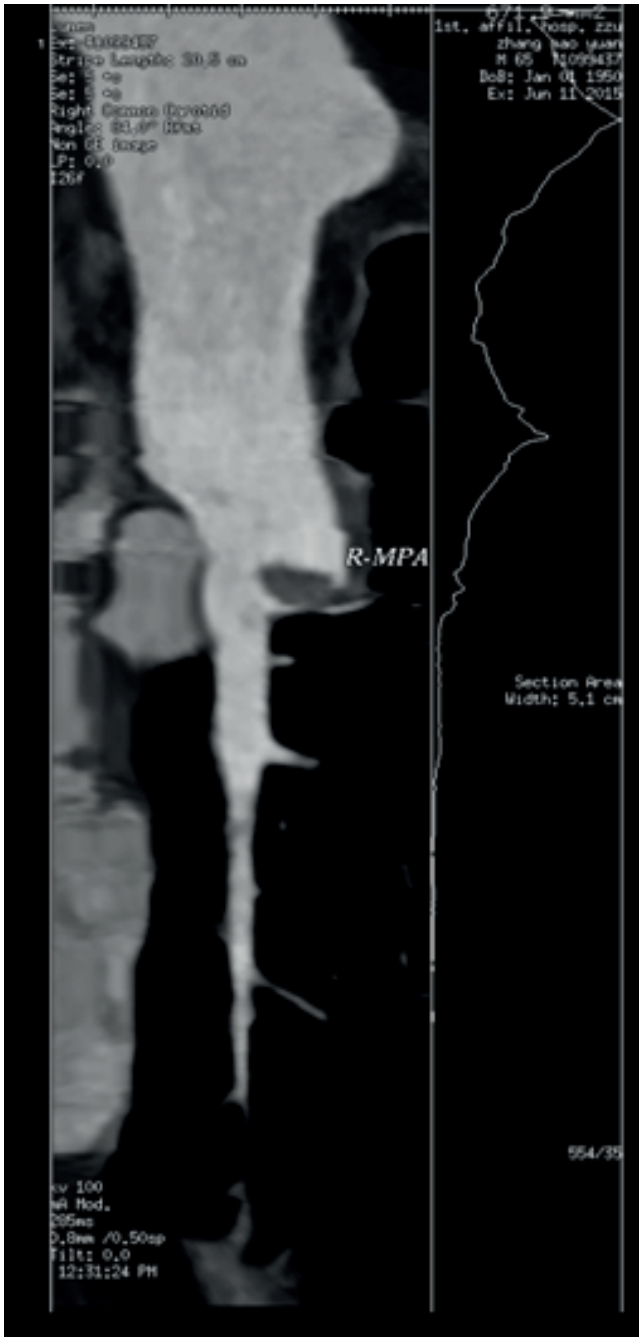


Fig 4.2 PE in the Right Lobar Artery



the iodine concentration or scanning caudo-cranially (16-21).The lymphatic and connective tissue located adjacent to the pulmonary arteries may mimic the appearance of pulmonary emboli. This pitfall can be minimized by careful review of the images and the use of additional imaging rendering tools such as cine-viewing and multi-planar reconstructions.

D-dimer Assay: The main aim of this study was to assess the potential value of a negative assay to exclude the presence of PE and reduce the number of performed SCTPAs. However, elevated d-dimer levels do not always indicate the presence of a clot. Elevated levels may be seen in conditions in which fibrin is formed and then broken down, as in recent surgery, trauma, infection, heart attack, and some cancers or conditions in which fibrin is not cleared normally, as in liver diseases, concentration of D-dimers also increase with age, compromising the specificity of the test in older patients, making it less useful for excluding PE in them. Raising the cut-off value of the test for older patients to points between 600 µg/l and 1000 µg/l increases the test's specificity, but at the cost of safety. We found a low (negative) score to have a very high negative predictive value. Our findings are comparable to other studies in various health care settings. Dunn et al. reported a negative predictive value of 99.6% suggesting that negative results could help to reduce the number of performed CTPAs (41).More recently, Eng et al. and Hirai et al. concluded that

the test alone was suitable for screening patients with a clinical suspicion of PE (52).However, a number of case reports have questioned its exclusivity in ruling out PE(18)]. There is compelling evidence that a negative result can effectively exclude a PE when it is combined with a low pretest clinical probability score. The lasting time of the elevated levels after the occurrence of PE may limit its value in diagnosis. Although the majority of patients have elevated levels as long as 12 days after diagnosis (17).In a few patients with PE, the level returns to normal limits by the seventh day (4).In our study, we have carefully screened patients for suspicion of acute PE. Of our patients, 80% (40 of 50) presented with chest pain, shortness of breath, hemoptysis, or other signs of acute distress (such as unexplained hypoxemia, acute confusion and hypotension) within 7 days. It is not known how long after the initiation of clot formation it becomes elevated in the systemic circulation. Bounameaux and coworkers(3) also reported one patient with a D-dimer level of < 0.5 µg/l who had elevated levels on subsequent measurement. Therefore, they may not be useful in patients presenting immediately after onset of symptoms but this appears to occur in a minority of patients. Previous investigators have reported that the assay may be more useful in diagnosis of outpatients than inpatients(4,22). We conclude that a negative assay by the quick and inexpensive latex agglutination assays is a clinically useful tool in excluding the presence of PE in patients with symptoms present for less than one week, with normal liver function, no active malignancy and no surgery within 3 months. A negative assay should never prevent further investigation, if the clinical suspicion for PE is high.

A practical and evidence based approach is to combine a result with a validated clinical risk score to help select suitable patients for SCTPA. This may result in better use of limited resources, avoid exposure to unnecessary radiation and potential complications from iodinated contrast. It should not be used when the clinical probability of that condition is high. Both increased and normal levels may require follow-up and can lead to further testing. People with positive tests require further study with other diagnostic imaging for excluding PE.

Therefore, the combined spiral CT with d-dimer can be extremely useful in ruling out outpatient patients with PE.

CONCLUSION

The larger segments of pulmonary artery, the pulmonary trunk and the left/right pulmonary artery has p-value > 0.05, which illustrates that the CT values, SD value and SNR of the pulmonary trunk and arteries (right or left) is good enough to diagnose PE.

Correctly identified 20 patients with a final diagnosis of PE, excluded PE in 28 out of 20 patients with a final diagnosis of no PE and provide an alternative diagnosis in 20 out of 30 patients without PE which is 40% of the total 50 patients age were clinically suspected with PE.

The Sensitivity and specificity of the CTPA for diagnosing

Fig 5.1 PE in the Right Segmental Artery

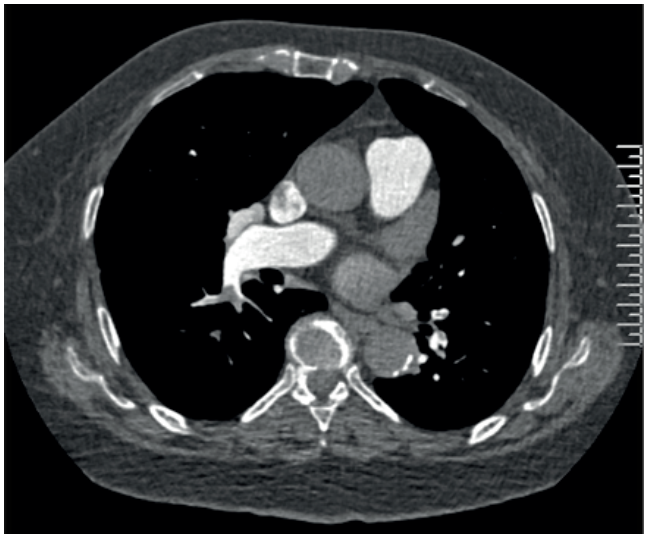
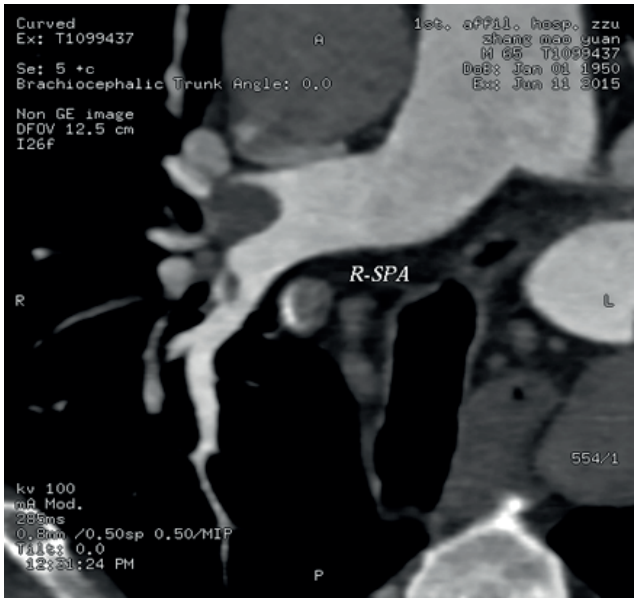


Fig 5.2 PE in the Right segmental Artery



PTE in the study was 100% and 94% respectively.Therefore, a spiral CT has the sensitivity and specificity for diagnosis of PE. In majority of patients, poor do not have PE; it also provides important ancillary information for final diagnosis. The sensitivity and specificity of the d-dimer test is 90% and 73% respectively. Therefore, a sensitive assay cannot accurately rule out PE; however the lack of specificity renders it inefficient as a stand-alone diagnostic test.

In conclusion, spiral CTPA and complimented with d-dimer assay can be used as the chief diagnostic and confirmatory test for PE.

ACNOWLEDGMENTS (Funding source)

The researchers appreciate the CT department of the 1staffiliated hospital of Zhengzhou Medical University for their co-operation and support.

AUTHOR CONTRIBUTIONS

Design of the work, preparation of manuscript was carried out mainly by the 1stauthor FR. TSK and TS assisted in data collection and analysis. All authors have read and approved the paper.

CONFLICT OF INTERESTS

None

ETHICAL STANDARDS

The study protocol has been approved by our institution.

REFERENCES

1. Konstantinides SV, Meyer G, Becattini C, Bueno H, Geersing GJ, Harjola VP, Huisman MV, Humbert M, Jennings CS, Jiménez D, Kucher N, Lang IM, Lankeit M, Lorusso R, Mazzolai L, Meneveau N, Ní Áinle F, Prandoni P, Pruszczyk P, Righini M, Torbicki A, Van Belle E, Zamorano JL; ESC Scientific Document Group . 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS). Eur Heart J. 2019; 31 (1)

2. Wendelboe AM, Raskob GE. Global Burden of Thrombosis: Epidemiologic Aspects. Circ Res. 2016 Apr 29:1340-1347. (2)

3. Zhang LJ, Zhao YE, Wu SY, Yeh BM, Zhou CS, Hu XB, Hu QJ, Lu GM. Pulmonary embolism detection with dual-energy CT: experimental study of dual-source CT in rabbits. Radiology. 2009 Jul;252:61-70 (3)

4. Huisman MV, Barco S, Cannegieter SC, Le Gal G, Konstantinides SV, Reitsma PH, Rodger M, Vonk Noordegraaf A, Klok FA. Pulmonary embolism. Nat Rev Dis Primers. 2018 May 17;4:18028.(4)

5. van Erkel AR, van Rossum AB, Bloem JL, Kievit J, Pattynama PM. Spiral CT angiography for suspected pulmonary embolism: a cost-effectiveness analysis. Radiology. 1996 Oct;201:29-36. (5)

6. Bauer RW, Kerl JM, Weber E, Weisser P, Korkusuz H, Lehnert T, Jacobi V, Vogl TJ (2010) Lung perfusion analysis with dual energy CT in patients with suspected PE-influence of window settings on the diagnosis of underlying pathologies of perfusion defects. Eur J Radiol. doi:10.1016/j. ejrad.2010.09.009 (6)

7. Bjorkdahl P, Nyman U (2010) Using 100- instead of 120-kVp computed tomography to diagnose PE almost halves the radiation dose with preserved diagnostic quality. ActaRadiol (7) 51:260-270

8. Bounameaux H, Perrier A, Righini M. Diagnosis of venous thromboembolism: an update. Vasc Med 2010;15(8):399-406

9. Carrier M, Righini M, Wells PS, et al. Subsegmental PE diagnosed by computed tomography: incidence and clinical implications. A systematic review and meta-analysis of the management outcome studies. J ThrombHaemost 2010;8(9): 1716-1722

10. Kooiman J, Klok FA, Mos IC, et al. Incidence and predictors of contrast-induced nephropathy following CT-angiography for clinically suspected acute PE. J ThrombHaemost 2010;8(10):409-411

11. Mamlouk MD, vanSonnenberg E, Gosalia R, et al. PE at CT angiography: implications for appropriateness, cost, and radiation exposure in 2003 patients. Radiology 2010;256 (11):625-632

12. Stein PD, Chenevert TL, Fowler SE, et al; PIOPED III (Prospective Investigation of PE Diagnosis III) Investigators. Gadolinium-enhanced magnetic resonance angiography for PE: a multicenter prospective study (PIOPED III). Ann Intern Med 2010;152(12):434-443, W142-3

13. Pontana F, Remy-Jardin M, Duhamel A, Faivre JB, Wallaert B, Remy J (2010) Lung perfusion with dual-energy multi-detector row CT: can it help recognize ground glass opacities of vascular origin? AcadRadiol (13)17:587-594

14. Bjorkdahl P, Nyman U (2010) Using 100- instead of 120-kVp computed tomography to diagnose PE almost halves the radiation dose with preserved diagnostic quality. ActaRadiol (14) 51:260-270

15. Stein PD , Matta F , Musani MH , Diaczok B . Silent pulmo- nary embolism in patients with deep venous thrombosis: a systematic review . Am J Med .2010 ; 123 (15): 426-431 .

16. CerianiE ,Combescure C , Le Gal G , et al . Clinical prediction rules for PE: a systematic review and meta-analysis . J ThrombHaemost .2010 ; 8 (16): 957 - 970 .

17. Smith SB ,Geske JB , Maguire JM , Zane NA , Carter RE , M orgenthaler T I. E arly anticoagulation is associated with reduced mortality for acute PE . Chest. 2 010; 137 (17): 1382-1390 .

18. Douma RA , le Gal G , Söhne M , et al . Potential of an age adjusted cut-off value to improve the exclusion of PE in older patients: a retrospective analysis of three large cohorts .BMJ .2010 (18) ; 340 : c1475 .

19. Carrier M , R ighini M , W ells P S, e t al. S ubsegmentalpulmo- nary embolism diagnosed by computed tomography: incidence and clinical implications. A systematic review and meta- analysis of the management outcome studies . J ThrombHaemost .2010 ; 8 (19): 1716-1722

20. Pasha S M, K lok F A, S noep J D, e t al. S afety of excluding acute PE based on an unlikely clinical probability by the Wells rule and normal concentration: a meta- analysis .ThrombRes .2010 ; 125 (20): e123 - e127 .

21. Meyer G, Roy PM, Gilberg S, Perrier A. PE. BMJ 2010 (21);340:c1421

22. Courtney DM, Kline JA, Kabrhel C, Moore CL, Smithline HA, Nordenholz KE. et al. Clinical features from the history and physical examination that predict the presence or absence of PE in symptomatic emergency department patients: results of a prospective, multicenter study.

Ann Emerg Med. 2010;55(22):307-315
23. Agnelli G ,Becattini C . Acute PE .N Engl J Med .2010 ; 363 (2 3): 266 - 274 .
24. LIU XIAO-BO,LIU JIN-GANG,LIU LI-QUN,et al(Department of Cardiothoracic Surgery,Hospital Affiliated to Weifang Medical College,Weifang 261031,China);THE EFFECT OF CT ON THE THERAPY OF PE[J];ActaAcademiaeMedicinae Qingdao Universitatis; (24) 2010-06
25. HUANG Ze-He,ZHONG De-Jun,JIANGSheng,et al Dept.ofRadiology,Qinzhou First People's Hospital,Qinzhou 535000,China;Diagnosis value of multi-slice spiral CT angiography to PE[J];ActaMedicinae Sinica (25);2010-03
26. Engbers MJ, van HylckamaVlieg A, Rosendaal FR. Venous thrombosis in the elderly: incidence, risk factors and risk groups. J ThrombHaemost 2010-8(26):
27. Douma RA, le Gal G, SöhneM, et al. Potential of an age adjusted cut-off value to improve the exclusion of PE in older patients: a retrospective analysis of three large cohorts. BMJ 2010;340:c1475 (27) doi: 10.1136/bmj.c1475
28. Chae EJ, Seo JB, JangYM, et al. Dual-energy CT for assessment of the severity of acute PE: pulmonary perfusion defect score compared with CT angiographic obstruction score and right ventricular/left ventricular diameter ratio. AJR Am J Roentgenol 2010;194(28):604-610
29. GalipienzoJ , García de Tena J , Flores J , Alvarez C , Alonso- Viteri S , Ruiz A . Safety of withholding anticoagulant therapy in patients with suspected PE with a negative multislice computed tomography pulmonary angiogra- phy .Eur J Intern Med .2010 ; 21 (29): 283 -288 .
30. Salaun P Y, C outuraudF , L E Duc-Pennec A , e t al. N on- invasive diagnosis of PE. Chest. 2011; 1 39(30) : 1294 - 1298 .
31. ZHOUZhi-peng,WANGHai-long,DU Zhen-zong,etal.Department of Radiology,Affiliated Hospital of Guilin Medical College,Guangxi541001,P.R.China;Study of chronic pulmonary thromboembolism model in rabbits with 64-slice spiral CT[J];Radiologic Practice; (31) 2011-04
32. Davies HE, Wathen CG, Gleeson FV. Risks of exposure to radiological imaging and how to minimise them.BMJ.2011 (32);342:589-593.
33. den Exter PL, Hooijer J, Dekkers OM, Huisman MV. Risk of recurrent venous thromboembolism and mortality in patients with cancer incidentally diagnosed with PE: a comparison with symptomatic patients. J ClinOncol 2011;29(33): 2405-2409.
34. QuirozR , K ucher N , Z ou K H, e t al. C linical validity of a negative computed tomography scan in patients with sus- pected PE: a systematic review . JAMA. 2012; 293 (34): 2011 .
35. Blachere H, Latrabe V, Montaudon M, et al. PE revealed on helical CT angiography: comparison with ventilation-perfusion radionuclide lung scanning. AJR Am J Roentgenol 2011;(35) 174:1041-1047.
36. Greess H, Wolf H, Baum U et al. Dose reduction in computed tomography by attenuation-based online modulation of tube current: evaluation of six anatomical regions. AEurRadiol 2011; (36)10:391-394.
37. Ghaye B, Szapiro D, I. Mastora et al. Peripheral pulmonary arteries: how far in the lung does multi-detector row spiral CT allow analysis? Radiology 2011; (37)219:629-636
38. Coche EE, Hammer FD, Goffette PP. Demonstration of pulmonary embolism with dynamic gadolinium-enhanced spiral CT. EurRadiol 2011; (38)11:2306-2309.
39. Mastora I, Remy-Jardin M, Suess C et al. Dose reduction in spiral ct angiography of thoracic outlet syndrome by anatomically adapted tube current modulation. EurRadiol 2011; (39)11:590-596.
40. Crawford T, Yoon C, Wolfson K, et al. The effect of imaging modality on patient management in the evaluation of pulmonary thromboembolism. J Thorac Imaging 2011; (40)16:163-169.
41. Koenig SJ, Narasimhan M, Mayo PH. Thoracic ultrasonography for the pulmonary specialist. Chest. 2011;140(41):1332-1341
42. Kory PD, Pellecchia CM, Shiloh A, Mayo PH, Koenig S. Accuracy of ultrasonography performed by critical care physicians for the diagnosis of DVT. Chest. 2011;139(42):538-542
43. MacKenzie JD, Nazario-Larrieu J, Cai T, Ledbetter MS, Duran- Mendicuti MA, Judy PF, Rybicki FJ (2011) Reduced-dose CT: effect on reader evaluation in detection of PE. Am J Roentgenol (43)189:1371-1379
44. ZHANG Yong-kang 1, LIU Yun 2*, CHEN De-jie 1, LIAO Xiao-feng 1, WANG Jiang-ping 1, HUANG Hua-jun 1. Department of General Surgery 1, Department of Obstetrics and Gynecology 2, the Central Hospital of Xiangyang City, Xiangyang 441021, Hubei, CHINA;Diagnostic and therapeutic experiences of 22 cases of acute mesenteric ischemia[J];Hainan Medical Journal; (44) 2012-23
45. Zhang Li,ZengWenbing,WangMingquan,HeZeqing,LiuXinghua,TanQinghua(Diagnostic Center of CT and MR,ChongqingSanxia Central Hospital,Wanzhou,Chongqing 404000,China(45));MSCT pulmonary angiography in the diagnosis of PE applied research(with 22 cases analysis)[J];Chongqing Medicine;2012-24
46. Dunn et al, Wolf JP, Dorfman DM, Fitzpatrick P, Baker JL, Goldhaber SZ. Normal levels in emergency department patients suspected of acute PE.J Am CollCardiol.2012;40(46):1475–1478. doi: 10.1016/S0735-1097(02)02172-1
47. Revel MP, Sanchez O, Couchon S, et al. Diagnostic accuracy of magnetic resonance imaging for acute PE: results of the "IRM-EP" study. J ThrombHaemost 2012 Feb 9. (47) doi:10.1111/j.1538-7836.2012.o4652.
48. Prologo JD, Glauser J. Variable diagnostic approach to suspected PE in the ED of a major academic tertiary care center. Am J Emerg Med 2012 (48); 20:5-9.
49. Schoepf U, Holzknecht N, Helmberger TK, et al. Subsegmental pulmonary emboli: improved detection with thin-collimation multi–detector row spiral CT. Radiology 2012 (49); 222:483-490.
50. Leveau P. Diagnostic strategy in PE. National

French survey.Presse Med 2012 (50); 31:929-932.
51. LIULian-rong,FANYong,ZHAOXin-qian,XING-Zhi-hengDept of radiology,TianjinHaihe hospital 300350,China;The Diagnostic Values of Multi-slice Spiral CT Pulmonary Angiography in PE[J];Journal of Clinical Pulmonary Medicine (51);2012-03
52. Sheh SH, Bellin E, Freeman KD, Haramati LB. PE diagnosis and mortality with pulmonary CT angiography versus ventilation-perfusion scintigraphy: evidence of overdiagnosis with CT?.AJR Am J Roentgenol. 2012 Jun. 198(52):1340-5.
53. Alderson P. O., Martin E. C.PE: diagnosis with multiple imaging modalities. Radiology 2012 (53)
54. in the diagnostic workup of suspected pulmonary thrombo-embolism at high altitude.Medical Journal Armed Forces India68, 142-144. Online publication date: 1-Apr-2012 (54).
55. Chandra S, Sarkar PK, Chandra D, Ginsberg NE, Cohen RI. Finding an alternative diagnosis does not justify increased use of CT-pulmonary angiography. BMC Pulm Med. 2013 (55);13:9.
56. PEI Guang-hua,ZENG Chun Department of Radiology Songzi People′s Hospital,Jingzhou,Hubei 434200,China;Clinical value of 16-slice spiral CT in the diagnosis of PE[J];Journal of Clinical Pulmonary Medicine (56);2013-06
57. Hirai LK, Takahashi JM, Yoon HC. A prospective evaluation of a quantitative assay in the evaluation of acute PE.J VascIntervRadiol.2013;18(57):970-974. doi: 10.1016/-j.jvir.2013.04.020.
58. Marten K, Engelke C, Obenauer S et al. Diagnostic performance of retrospectively ecg-gated multislice CT of acute pulmonary embolism, DiagnostischerStellenwert der retrospektiven EKG-Triggerung in der Mehrschicht-Spiral-CT der akutenLungenembolie. FortschrR”ntgenstr 2013 (58); 175:1490-1495.
59. Chaye B, Remy –Jardin M. Non traumatic thoracic emergencies: CT diagnosis of acute PE : the 1st 10 years in : BaertA.L,Gourtsoyiannis N. Emergency Radiology Categorial courses ECR, Germany : Springer-Verlag Berlin Heidelberg 2013 (59):231:231-246.
60. The PIOPED Investigators Value of the ventilation/perfusion scan in acute PE.J.A.M.A. 2013(60).
61. PE manifested as acute coronary syndrome after arthroscopic anterior cruciate ligament reconstruction.Formosan Journal of Musculoskeletal DisordersOnline publication date: 1-Aug-2013(61).
62. Stein P. D., Hull R. D., Saltzman H. A., PineoG.Strategy for diagnosis of patients with suspected acute PE.Chest 2013 (62)
63. Bounameaux H., de Moerloose P., Perrier A., ReberG.Plasma measurement ofas diagnostic aid in suspected venous thromboembolism: an overview.Thromb. Haemost; 2014-06(63)
64. Ginsberg J. S., Brill-Edwards P. A., Demers C., Donovan D., Panju A. in patients with clinically suspected PE.Chest 2014 (64)
65. Pulmonary Embolism Incidence and Fatality Trends in Chinese Hospitals from 1997 to 2008(65): A Multicenter Registration Study
66. Bagaria V, Modi N, Panghate A, et al. Incidence and risk factors for development of venous thromboembolism in Indian patients undergoing major orthopaedic surgery: results of a prospective study. Postgrad Med J. 2006 (66);82:136-9.