CT Scan Evaluation of Pulmonary Embolism

May Khalid Ameen
Foundation of Technical Education, College of Medical Technology, Baghdad, Iraq.
E- mail: dr_maykhalid@yahoo.com

Abstract

Purpose: To determine the prevalence & anatomic distribution of pulmonary embolism in a group of Iraqi population with clinical suspicion of pulmonary embolism,
& to evaluate the utility of CT pulmonary angiography using our new 64-multidetector CT systems.
Materials and Methods: 57 patients clinically suspected of having PE were examined with contrast-enhanced spiral CT in the cardiac CT center of Ghazy AL-Haryry specialized surgical hospital & Baghdad Teaching Hospital from December 2011 through August 2012. The clinical outcome was used as the confirmatory reference to evaluate the contribution of spiral CT to the final clinical diagnosis.
Results: Spiral CT helped correctly identify 23 patients with PE (sensitivity, 100%).
In 19 (56 %) of the 34 patients without PE, spiral CT provided additional information that suggested or confirmed the alternate clinical diagnosis. In the remaining 15 patients, spiral CT scans were normal.
Conclusion: Spiral CT has good sensitivity and specificity for the diagnosis of PE.
In the majority of patients who do not have PE, it also provides important ancillary information for the final diagnosis.

Keywords: CT, pulmonary embolism

تقييم الانصمام الخثري للشرايين الرئوية بواسطة المفراس

الخلاصة

الهدف: تهدف هذه الدراسة الى معرفة التوزيع التشريحي و مدى شيوع مرض الانصمام الخثري للشرايين الرئوية في شريحة من المرضى العراقيين المشتبه باصابتهم بانصمام الشرايين الرئوية. كما تهدف الى تقييم استخدام اجهزة المفراس الحلزوني الجديدة ذات ال ٦٤ كاشف في تشخيص هذا المرض.

عينة البحث : تضمنت هذه الدراسة ٥٧ مريضا مشتبه باصابتهم بانصمام الشرايين الرئوية تم اجراء فحص المفراس الحلزوني الملون لهم في مستشفى الشهيد غازي الحريري للجراحات التخصصية و مستشفى بغداد التعليمي خلال الفترة من كانون الاول ٢٠١١ الى اب ٢٠١٢. وقد اعتبرت النتائج السريرية النهائية على انها الاثبات النهائي على مدى فعالية المفراس الحلزوني في تشخيص المرض.

النتائج: ساهم فحص المفراس الحلزوني في التشخيص الصحيح للمرض في ٢٣ مريضا مصابا بالانصمام الخثري للشرايين الرئوية مما يعني ان حساسية الفحص في تشخيص المرض كانت ١٠٠%.

في ٣٤ من المرضى أفاد التشخيص النهائي بعدم اصابتهم بمرض مرض الانصمام الخثري للشرايين الرئوية. ساهم فحص المفراس الحلزوني بتوفير علامات اضافية اقترحت أو اثبتت تشخيصا مغايرا في ١٩ مريضا من هؤلاء ال٣٤ مريض (اي ما يعادل ٥٦% من الحالات)زأما في ال ١٥ مريض المتبقين فقد كان فحص المفراس الحلزوني سلبيا (اي طبيعيا).

ألأستنتاج: ان لفحص المفراس الحلزوني حساسية و خصوصية عالية في يشخيص حالات الانصمام الخثري للشرايين الرئوية . أما في حالات خلو المريض من هذا المرض، فان فحص المفراس الحلزوني يساهم في توفيرمعلومات اضافية مهمة في الوصول الى التشخيص النهائى لحالة المريض.

Introduction

Pulmonary embolism (PE) is a life threatening condition with the potential to masquerade as a variety of common disorders, and no single test exists for its definitive diagnosis. Clinically, PE is categorized into acute massive PE, acute medium / small PE, & chronic PE. It is the third most common acute cardiovascular disease, after myocardial infarction& stroke. [1-3].

The signs and symptoms of pulmonary embolism are nonspecific. Clinical algorithms for bedside exclusion of PE are based mainly on negative results of a D-dimer test, which is a highly sensitive, albeit nonspecific, means for ruling out PE [2]. Older imaging tests, such as chest radiography, ventilation–perfusion (V/Q) scintigraphy, and pulmonary angiography, suffer from a lack of specificity or are invasive [3-6]. There for, the diagnosis of pulmonary embolism continues to be a challenge to both clinicians and radiologists & objective diagnostic examinations are mandatory to confirm or rule out the diagnosis of PE.

The use of ventilation perfusion (V/Q), once the first study in the diagnostic algorithm for PE, is in decline [4, 5] owing to the high percentage of indeterminate studies and poor inter-observer correlation [6]. Conventional catheter pulmonary angiography is still regarded by some as the standard technique for diagnosis of PE, but in reality it is infrequently performed [7, 8] as it is an invasive procedure.

In 1980, Godwin et al. [9] were among the first to describe pulmonary embolism on contrast-enhanced CT .

The potential of CT pulmonary angiography (CTPA) has been increasingly realized as a reliable, noninvasive first-line imaging study in both pediatric and adult patients with clinically suspected pulmonary embolism [1].However, CTPA have been shown have limitations regarding accurate diagnosis of small peripheral emboli [10]. The development of multi– detector row CT has led to improved visualization of peripheral pulmonary arteries and detection of small emboli [11-14].

Materials and Methods

Study Population

This prospective study was performed over a period of nine months from December 2011 to August 2012 at the cardiac CT center of Gazy – AL haryry specialized surgical center & at Baghdad teaching hospital.

The study included 57 patients (24 men, 33 women; age range, 21–75 years; mean age, 54 years) with clinical suspicion of PE(based on patients' clinical condition, & elevated D dimer levels) who were referred to the imaging departments of these hospitals for CT pulmonary angiography (CTPA) in whom it was possible to schedule spiral CT scanning within 24 hours of clinical presentation.

The final diagnosis of PE, or otherwise, was based on the clinical outcome based on three months follow up. No other imaging study was used as a reference gold standard for validation of our CT findings.

CTPA Technique

Spiral CT scans were done using Philips 64 MDCT scanner in both centers.

No special modification of the examination technique was done for the purpose of this study. The study population was simply examined by the same protocol used routinely in the center.

An initial native study was performed, followed by contrast-enhanced CT pulmonary angiography.

The scans were obtained in supine position & the patients were instructed

to suspended inspiration during scanning.

A total volume of 80- 90 mL of nonionic contrast material, omnipaque (iohexol) 350 mg I/ml which was injected with a power injector at a flow rate of 5.5 mL/sec. patients who were examined at the cardiac CT center of Ghazy Al Haryry hospital had 45 ml of saline infused after the contrast material to eliminate streak artifact which is usually seen because of high density contrast material in the superior vena cava. This was not done in those examined at Baghdad teaching hospital.

The contrast material was injected through an 18–20-gauge catheter in the antecubital fossa. To eliminate kinking of the subclavian vein at the thoracic inlet, the arm in which contrast material was injected was placed at the patient's side, with the other arm above the patient's head.

Image acquisition was done in a cranio-caudal direction using a bolus tracking technique with the cursor put in the superior vena cava to trigger scanning when the density of contrast material in the superior vena cava reaches 200 HU.

Scanning parameters included : 64 x o.625 mm collimation; 0.5 sec. rotation time; a pitch of 0.8; 120 kVp; 250-300 mA.

Image interpretation

Images were interpreted by the specialist radiologist in charge in each hospitals. Then these images were secondarily analyzed by the author for further details for the purpose of this study.

Images were viewed at mediastinal window (window width, 450 HU; window level, 35 HU), pulmonary vascular window (window width, 250 HU; window level, 35 HU), and lung parenchymal window (window width, 1500 HU; window level, - 500 HU).

The images were analyzed for the presence of pulmonary embolism, as well as any other abnormality in the mediastinum, chest wall, or lung parenchyma. The presence of endoluminal clots or vessel cut off sign was considered diagnostic of embolism on CT.

Results

Twenty three patients had a final diagnosis of pulmonary embolism, & 34 had a final diagnosis of no PE. Thus the prevalence of PE among patient with clinical suspicion of PE was 40%.

CT scans were positive in all the 23 patients with a final diagnosis of PE. (Table 2).Thus the sensitivity of CTPA for detecting PE was 100 %. There was no false negative cases (based on three months follow up).

Of the 34 cases who had a final diagnosis negative for PE, 32 were negative on CTPA (true negative cases) & 2 had inconclusive CT pulmonary angiograms. Thus CT correctly excluded PE in 32 out of 34 patients with a final diagnosis of not PE, yielding a specificity of 94%.

Table 1 Accuracy of spiral CT for the diagnosis of spiral CT

Spiral CT interpretation	Pulmonary embolism at final diagnosis	
	Present	Absent
Positive	23	0
Inconclusive	0	2
Negative	0	32
Total	23	34

Note: Data represent the number of patients

The causes for the two inconclusive spiral CT examinations were streak artifact (*n* = 1), poor contrast material opacification (*n* =1).

Table 2 demonstrates the distribution of emboli according to the largest vessel involved in every patient. Some of the patients who had emboli in the central pulmonary arteries also had emboli in lower order branches. Isolated segmental emboli (without emboli in larger order branches) were seen in 2 (9 %) patients. In addition, segmental emboli were also seen in 1 of the three patients who had emboli in the main pulmonary trunk, & in 2 of those with emboli in the right or left main pulmonary artery & in 4 of those with lobar emboli. Thus the total number of patients who had segmental emboli (isolated segmental + segmental associated with larger order branches) was 9 (39 %) of the 23 patients with CT scans positive for PE.

Isolated subsegmental emboli were found in only two patients in this study. However, they were seen also in 6 patients with emboli in larger order branches. Thus the total number of subsegmental emboli was 8 patients (35 %).

Table 2 Distribution according to the largest pulmonary artery involved in 23 patients with PE

Largest vessel involved	No. of patients	%
Main pulmonary trunk	3	13 %
Right &/or left pulmonary artery	7	30 %
Lobar artery	9	49 %
Segmental artery	2	9 %
Subsegmental artery	2	9 %
Total	23	100%

Of the 34 patients without PE, CT scans were normal in 15 patients. In the other 19 patients without PE, spiral CT scans demonstrated the following findings: air-space consolidation (*n*=8) patients, mediastinal or hilar lymphadenopathy (*n* = 5), pericardial effusion (*n* = 2), lung mass (*n* = 2), mediastinal mass (*n* = 1), multiple pulmonary nodules (*n* = 1). (Table 3)

Table 3 CT findings in 34 patients with no PE

Findings	No. of patients
Normal CT	15
Air space consolidation	8
Mediastinal or hilar lymphadenopathy	5
Pericardial effusion	2
Lung mass	2
Mediastinal mass	1
Multiple pulmonary nodules	1
Total	34

Thus, CT scan provided an alternative diagnosis in 19 (56%) out of 34 patients without PE which comprises (33%) of the whole 57 patients with clinically suspected PE.

Discussion

A potential criticism to this study is that the final diagnosis and categorization of patients into those with, and those without, pulmonary embolism was based on the clinical outcome and not on a gold standard imaging study such as conventional catheter angiography.

This is justified by the following facts:

1. Older imaging tests, such as ventilation–perfusion (V/Q) scintigraphy, suffer from a lack of specificity [4- 6].
2. Although some still regard conventional pulmonary angiography as the gold standard technique for diagnosis of PE,& hence as the standard of reference for verification of findings regarding the presence of PE at competing imaging modalities; however, being an invasive procedure, conventional pulmonary angiography in reality is infrequently performed [7,8]. In addition, the limitations of conventional pulmonary angiography for unequivocal diagnosis of isolated peripheral (segmental or subsegmental) pulmonary emboli was stated in many studies [10, 11]. In the light of such limitations, the status of conventional pulmonary angiography as the standard of reference for diagnosis of PE should be reconsidered.

There for, the most realistic scenario to measure efficacy of CT pulmonary angiography in suspected PE may be assessment of patient outcome. That's why, the clinical outcome was considered by many authors as the ultimate gold standard in judging the clinical utility of an imaging modality in the diagnosis of PE [15, 16].

The prevalence of pulmonary embolism in clinically suspected cases have been estimated to be in the range of 25-35% in different series [16, 17].

The prevalence of PE among patient with clinical suspicion of PE was 40% in this study. This is comparable to the study of Ahmed Z.Kh at 2005 who studied 42 Iraqi patients with suspected PE . The prevalence of PE in his study was 18 (43 %) patients.

The sensitivity & specificity of CTPA 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 our CT findings were not compared with another gold standard imaging modality, there was no way to know confidently that we didn't overlook any of the small peripheral emboli which might be present. Thus, although CTPA in this study correctly diagnosed all of the 23 patients with PE yielding a sensitivity of 100%, some of the small peripheral emboli in patients with central emboli may have been missed. There for, if the calculations of sensitivity, specificity were done per embolus rather than per patient, we would probably have got lower values.

Limitations regarding accurate diagnosis of small peripheral emboli prevented the unanimous acceptance of CTPA as the reference standard for imaging of PE [10].

The overall percentage of isolated subsegmental emboli have been variously reported to be present in 5-36% of individuals with PE [10, 19, 20].

On the Prospective Investigation of Pulmonary Embolism Diagnosis, or PIOPED study [21], only 6% of patients had pulmonary embolism limited to sub-segmental pulmonary arteries.

On the other hand, Osler et al [19] assessed the location of pulmonary emboli on conventional angiography and found that in 30% of patients emboli were limited to sub-segmental level. He concluded that if cross-sectional imaging could depict emboli in only segmental and larger order arteries, then 30% of patients would have gone undiagnosed.

In the current study, isolated subsegmental PE was not found in only two patient (9%). This is much less than the findings of Osler et al [19]. However, the study of Oser et al had an important selection bias: he included only patients with a non – diagnostic ventilation-perfusion (V-P) scan. Since large emboli usually cause a high probability V-P scan ,so the limitation of his study population to only those with a non-diagnostic V-P scans has probably resulted in a bias toward smaller emboli on the expense of larger emboli.

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 (subsegmental or smaller) emboli in this study & hence our calculations were probably biased towards larger central emboli on the expense of more peripheral emboli.

Additionally, although isolated subsegmental emboli (without emboli in larger arteries) were detected in only two (9%) of patients in this study, they were also seen in another 6 patients with emboli in larger order branches. Thus subsegmental emboli were found in 8 (35%) of patient in this study. This was relevant, because helical CT have been shown to have low accuracy for the detection of small peripheral pulmonary emboli [10].

Although occurrence of isolated subsegmental pulmonary thromboembolism is considered a risk for future acute pulmonary thrombo-embolism, a study of patients with isolated subsegmental pulmonary thromboembolism, showed that those who did not receive anticoagulation therapy had no evidence of recurrent pulmonary thromboembolism at 3-month follow-up [22].

Ahmed Z.Kh at 2005 found segmental emboli in 11% of his patients & none of his patients had subsegmental emboli. This is most probably is due to the fact that his study population was examined by a single slice spiral CT system & the contrast injection was done manually. Besides, the slice thickness in that study was 5 mm compared to 0,625 mm slice thickness in this study.

In conclusion, CTPA correctly identified PE in all the 23 patients with a final diagnosis of PE,and excluded PE in 32 out of 34 patients with a final diagnosis of no PE. Besides, CT provided an alternative diagnosis in 33 % of patients with clinically suspected PE (which constitutes 56% of the 34 patients without PE).

References

1. Conrad Wittran. How I Do It: CT Pulmonary Angiography. AJR 2007; 188:1255–1261.

2. Wells PS, Anderson DR, Rodger M, et al. Excluding pulmonary embolism at the bedside without diagnostic imaging: management of patients with suspected pulmonary embolism presenting to the emergency department by using a simple clinical model and d-dimer. Ann Intern Med 2001; 135:98–107.

3. Smita Patel,Ella A. Kazerooni. Helical CT for the evaluation of acute pulmonary embolism. AJR 2005; 185: 135-149.

4. Schibany N, Fleischmann D, Thallinger C, Equipment availability and diagnostic strategies for suspected

pulmonary embolism in Austria. Eur Radiol 2001; 11: 2287–2294.
5. Leveau P. Diagnostic strategy in pulmonary embolism. National French survey.Presse Med 2002; 31:929–932.
6. Blachere H, Latrabe V, Montaudon M, et al. Pulmonary embolism revealed on helical CT angiography: comparison with ventilation-perfusion radionuclide lung scanning. AJR Am J Roentgenol 2000; 174:1041–1047.
7. 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 2001; 16:163–169.
8. Prologo JD, Glauser J. Variable diagnostic approach to suspected pulmonary embolism in the ED of a major academic tertiary care center. Am J Emerg Med 2002; 20:5–9.
9. Godwin JD, Webb WR, Gamsu G, Ovenfors CO. Computed tomography of pulmonary embolism. AJR 1980; 135:691–695
10. Goodman LR, Curtin JJ, Mewissen MW,et al. Detection of pulmonary embolism in patients with unresolved clinical and scintigraphic diagnosis: helical CT versus angiography. AJR 1995; 164:1369–1374.
11. Schoepf U, Holzknecht N, Helmberger TK, et al. Subsegmental pulmonary emboli: improved detection with thin-collimation multi–detector row spiral CT. Radiology 2002; 222:483–490.
12. Sudhakar N. J. Pipavath J. David Godwin. Acute Pulmonary Thromboembolism: A Historical Perspective**.** AJR 2008:191:639-641
13. Stein PD, Fowler SE, Goodman LR, et al.; PIOPED II Investigators. Multidetector computed tomography for acute pulmonary embolism. *N Engl J Med* 2006; 354:2317–2327.
14. Remy-Jardin M, Remy J, Deschildre F, et al. Diagnosis of pulmonary embolism with spiral CT: comparison with pulmonary angiography and scintigraphy. Radiology 1996; 200:699–706.
15. Chaye B, Remy –Jardin M. Non traumatic thoracic emergencies: CT diagnosis of acute pulmonary embolism : the 1st 10 years in : Baert A.L,Gourtsoyiannis N. Emergency Radiology Categorial courses ECR, Germany : Springer-Verlag Berlin Heidelberg 2003:231:231-246.
16. Hartmann I.J.C, Procop M, Spiral CT in the diagnosis of acute pulmonary embolism. MEDICAMUNDI 2002, 46: 2-7.
17. Perrier A, Howarth N, Didiev D. Performance of helical computed tomography in unselected outpatients with suspected pulmonary embolism.
18. Ahmed Z.Kh. Spiral CT findings in clinically suspected acute pulmonary embolism. A dissertation submitted in partial fulfillment for the requirement for the degree of fellowship of the Iraqi board of medical specializations in radio-diagnosis 2005.
19. Osler RF, Zuckerman DA. Anatomical distribution of pulmonary emboli at pulmonary angiography: implications for cross-sectional imaging. Radiology 1996; 199:31-35.
20. Teigen CL, Maus TP. Pulmonary embolism: diagnosis with contrast enhanced electron-beam CT &comparison with pulmonary angiography. Radiology 1995; 194:313-319.
21. Value of the ventilation/perfusion scan in acute pulmonary embolism: results of the prospective investigation of pulmonary embolism diagnosis (PIOPED). The PIOPED Investigators. JAMA 1990; 263:2753–2759.
22. Eyer BA, Goodman LR, Washington L. Clinicians'response to radiologists' reports of isolated

subsegmental pulmonary embolism or inconclusive interpretation of pulmonary embolism using MDCT. *AJR* 2005; 184:623–628.