J Hong Kong Col Radiol. 2010;13:68-72

ORIGINAL ARTICLE **CME**

Audit of Computed Tomographic Angiograms for Pulmonary Embolism in a Regional Hospital in Hong Kong

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ABSTRACT

Objective: *To audit requests for computed tomographic pulmonary angiograms, usage of pre-test pulmonary embolism probability scores, and D-dimer measurements in patients with suspected pulmonary embolism in a regional hospital in Hong Kong.*

Methods: *A retrospective study was performed for all computed tomographic pulmonary angiograms requested for clinically suspicious pulmonary embolism during the period of 1 January 2008 to 31 December 2008. Clinical notes were reviewed and patients were being included or excluded according to predefined inclusion and exclusion criteria.*

Results: *Of the 109 cases of computed tomographic pulmonary angiogram requests (after excluding 12), there were 25 who had pulmonary embolism. The percentage of computed tomographic pulmonary angiograms positive for pulmonary embolism was 23%. Not any documented standardised pre-test pulmonary embolism probability score was noted. D-dimer tests were performed in 27 cases, however, most of these requested tests were not performed according to 2003 British Thoracic Society guidelines.*

Conclusion: *There was a nearly 5-fold increase in requests for computed tomographic pulmonary angiograms for suspected pulmonary embolism over a 4-year period (2004 vs 2008). In our audit, the percentage reported positive was 23%, which was lower than most diagnostic study series in which the reported prevalence ranged from 28 to 33%. Reasons for this are multifactorial and may include a lower overall prevalence of pulmonary embolism in Chinese patients and speculations about ineffective patient selection by referring physicians. The latter possibility was supported by the observation that there was no documented use of any standardised pre-test pulmonary embolism probability score in our 109 cases. The audit also suggested misuse of D-dimer tests, which can be improved if the referring physicians were more aware of the sensitivity and the limitations of such tests.*

Key Words: *Angiography; Diagnostic imaging; Predictive value of tests; Pulmonary embolism; Sensitivity and specificity; Tomography, X-ray computed*

中文摘要

香港一間地區醫院肺動脈栓塞患者的電腦斷層血管造影審核

萬民偉、陸嬈、鄭志成

目的：對香港一間地區醫院作以下三方面的審核：進行電腦斷層（CT）肺動脈血管造影的轉介病例，檢查前肺動脈栓塞預測值的使用，以及對懷疑肺動脈栓塞患者的D－二聚體的測量。

方法：用事先制定的排除及納入準則，回顧2008年1月1日至12月31日期間因懷疑患上肺動脈栓塞而進行CT肺動脈血管造影病人的病歷紀錄。

結果：研究期間，除了12宗病例無被納入研究範圍外，共有109宗要求進行CT肺動脈血管造影的轉

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Submitted: 16 Apr 2010; Accepted: 19 Jul 2010.

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介病例，其中肺動脈栓塞的確診病例有25個。CT肺動脈血管造影呈陽性結果的佔23%。病歷紀錄中並沒有記載任何肺動脈栓塞預測值的標準。有27個病例進行了D－二聚體測試，可是其中大部份未有根據英國胸科協會2003年的指引進行此檢測。

結論：因懷疑患上肺動脈栓塞而要進行CT肺動脈血管造影的病例數目，2008年比2004年四年間幾乎增加了5倍。本研究所得的陽性率為23%，比其他大部份診斷研究系列（陽性率為28%至33%）都要低。造成這結果有很多原因，其中包括患有肺動脈栓塞華籍病人的總發病率偏低；而且在缺乏肺動脈栓塞預測值標準的情況下，醫生可能未有一套有效的病人篩選準則所致。本研究亦發現D－二聚體測試有可能被不當使用，如果負責轉介的醫生能掌握此測試的敏感度及了解其限制，相信可以改善情況。

INTRODUCTION

Prompt diagnosis of pulmonary embolism (PE) remains a challenge for clinicians. Overall mortality of PE has been reported to be as high as 30% in untreated cases,[1] while it is reduced to 2.5% with treatment.[2] With the improvement in resolution and speed of computed tomography (CT) as well as easy accessibility to such services, there is an increasing trend towards utilising CT pulmonary angiogram (CTPA) to diagnose or exclude PE. There are several clinical guidelines available for the diagnosis of PE. The 2003 British Thoracic Society (BTS) guidelines suggest 3 diagnostic steps in making a diagnosis of PE: pre-test probability testing (e.g. revised Geneva score), D-dimer measurement, and imaging (CTPA or ventilation/perfusion [V/Q] scan).[3]

We therefore set out to audit the use of CTPA in a regional hospital in Hong Kong, as well as the frequency of pre-test probability testing, and D-dimer measurements for suspected cases of PE.

METHODS

Inclusion criteria were the age of 18 years or above, and clinical suspicion of PE (prior to CTPA). Exclusion criteria were incidental finding of PE on CT examination (e.g. during staging of malignancy, searching for infection), poor image quality of CTPA, patients with known PE, CTPA showing equivocal results, and incomplete clinical data.

Source of Patients

In- and out-patients having CTPAs in the Department of Radiology, Pamela Youde Nethersole Eastern Hospital, for suspected PE during the period of 1 January 2008 to 31 December 2008 constituted the study patient population, most of whom were Chinese.

Diagnostic Evaluation

CTPA examinations were performed using a 16-slice multi-detector helical CT scanner (Aquilion 16; Toshiba, Otawara, Japan) with collimation of 1 mm and pitch of 15/16. A standard dose of 70 ml Iopamiro 370 contrast (Bracco, Milan, Italy) was injected. Automatic triggering of the helical scan was performed with the Sure-start function of the Toshiba CT machine, with the region of interest being the main pulmonary trunk. The triggering threshold was 150 HU.

The CT diagnostic evaluation criteria for PE were similar to those in Prospective Investigation Of Pulmonary Embolism Diagnosis (PIOPED) II.[4]

Diagnostic criteria for acute PE by CTPA were as follows: failure of contrast material to fill the entire lumen because of a central filling defect (the artery may be enlarged, compared to similar arteries); a partial filling defect surrounded by contrast material on a cross-sectional image; contrast material between the central filling defect and the artery wall on an in-plane, longitudinal image; and a peripheral intraluminal filling defect that forms an acute angle with the artery wall. CTPA was used as the diagnostic standard in this study. Diagnosis of PE was made by consensus of 2 radiologists with 6 years' and 25 years' working experience.

Study Design

All CTPA examinations requested for clinically suspicious PE during the period of 1 January to 31 December 2008 were identified with the help of Radiology Information System. Clinical notes were reviewed and patients were either included in or excluded from the audit according to the inclusion and exclusion criteria.

Analysis included the collection of demographic data, documentations of any pre-test probability score, D-dimer measurement, and CTPA results (positive, negative, inconclusive). The clinical diagnosis and any complications of the CTPA were also recorded.

Image reports were reviewed by authors. For those with uncertain findings, the images were reviewed and correlated with results of other imaging modalities (Doppler ultrasonography [USG] of lower limbs, V/Q lung scans) and patient's clinical course. The final diagnosis mainly based on images was also decided.

RESULTS

A total of 121 CTPAs were performed during the study period. Only 1 patient was an Indian, while the rest were Chinese. They included 62 females and 59 males; 68 (56%) CTPAs were performed during the office hours.

According to the exclusion criteria, 12 cases were excluded from the analysis—8 were follow-up CTPAs for known prior PE, 2 were follow-up CTPAs for incidentally discovered PEs, 1 because of incomplete clinical data, and 1 due to equivocal CTPA findings.

Among the remaining 109 patients having CTPA, 25 (23%) had PE. There was no difference in the percentage of PE-positive CTPAs between those performed during and after office hours. There was no formal documentation of any usage of pre-test probability testing in any case. There were 27 cases in whom the D-dimer test was performed, and elevated levels were encountered in 18 cases.

There were incidental but significant findings in 10 of 109 patients. They included 3 with pneumonia, 3 with aortic dissection, 1 each with a lung abscess and interstitial lung disease, and 2 with lung malignancies. One patient in our series experienced contrast extravasation. No other complications associated with CTPA were recorded.

DISCUSSION

There has been a steep increase in requests for CTPA in recent years. The authors compared the data in 2004 and in 2008 (Table 1), during which the same CT machine was used. There were 109 requests for PE in 2008, while there were only 22 in 2004, indicating a nearly 5-fold increase over 4 years. The shift of clinician's preference towards CTPA as the primary investigation tool for PE was probably multifactorial and may have been due to increased availability of CT, and other forms of imaging (e.g. V/Q scans) being more indirect. However the percentage of positive PE cases did not increase in parallel, being 55% in 2004 vs 23% in 2008 (Table 1).

Table 1. Comparison of computed tomography pulmonary angiogram (CTPA) in 2008 and 2004.

	2008	2004
No. of CTPA requests	109	22
No. of pulmonary embolism–positive CTPAs	25	12
% positive for pulmonary embolism	23%	55%

The percentage of PE-positive CTPAs in our audit was 23%, which was lower than in most diagnostic series that reported the frequency of PE in the range of 28 to 33%.[5] The authors hypothesise that the lower percentage was partially accounted for by the lower overall prevalence of PE in Chinese population (only 1 of our 109 patients was non-Chinese).[6] Another possible explanation was the relaxation of selection criteria for performing CTPAs. The PE pre-test probability scoring system was shown to be effective in patient selection for CTPA,[7] but was not used in any of the patients we audited. Clinical probability was assessed solely by in-charge physicians, which may be subjective and experience-dependant.

Having reviewed the 2004 data, we found that 23% (5 cases) of CTPAs were performed after positive findings in Doppler USG of lower limbs (4 cases) or V/Q scan (1 case), which was in contrast to 4% (4 of the cases) in 2008. These findings suggest that a higher percentage of positive CTPA in 2004 was due to more patients belonging to higher-risk groups suggested by results of other preceding investigations, e.g. equivocal V/Q scan or positive Doppler USG studies of the lower limbs.

According to the diagnostic flowchart by 2003 BTS guidelines,[3] first, patients should be triaged into high-, intermediate-, or low-probability groups according to their pre-test probability score. Blood D-dimer assay should only be considered following assessment of clinical probability. There are 3 common systems of D-dimer assays which have been studied in large clinical studies of PE, namely, red cell agglutination, enzyme-linked immunosorbent assay (ELISA), and Medical Devices Agency (MDA) D-dimer tests. They are different in terms of sensitivity (87-98%),[8] but all have poor specificity. The red cell agglutination test, which is the most commonly used in Hong Kong, has

Table 2. Revised Geneva pre-test probability score for pulmonary embolism (PE).

Risk factors	Points
Age ≥65 years	1
Previous deep vein thrombosis or PE	3
Surgery (under general anaesthesia) or fracture (of the lower limbs) within 1 month	2
Malignant condition (solid or haematological malignant condition), currently active or considered cured <1 year	2
Unilateral lower limb pain	3
Haemoptysis	2
Heart rate (beats/min)	3
75-94	
≥95	5
Pain on lower-limb deep venous palpation and unilateral oedema	4
Clinical probability (total)	
Low	0-3
Intermediate	4-10
High	≥11

a good negative predictive value of 97% in those with low clinical probability.[9] However the overall negative predictive value (85%) of the test cannot exclude PE in the intermediate- and high-probability groups.[9] ELISA and MDA D-dimer assays are more advantageous than the red cell agglutination test in this respect.[10,11]

Our hospital used a qualitative red cell agglutination test, called Minutex (Trinity Biotech, Co Wicklow, Ireland). According to the guidelines, red cell agglutination D-dimer test should only be performed for patients in the low-clinical-probability group, in whom a negative result excludes the possibility of PE and renders CTPA examination unnecessary. In this audit of 109 patients, 18/27 had elevated D-dimer levels. We reviewed all 27 cases and triaged them into different probability groups using the revised Geneva pre-test probability score (Table 2),[12] and the findings are summarised in Table 3. According to the diagnostic flowchart by 2003 BTS guidelines, 21 of our patients could be categorised as intermediate (n=17) or high (n=4) risk and should have had a CTPA without a D-dimer assay, while the remaining 6 patients belonging to the low-probability group had the D-dimer assay correctly. This suggested that 21 D-dimer tests were actually not necessary. Of the 6 patients in the low-probability group, 2 had normal D-dimer levels which virtually excluded the possibility of PE, rendering the CTPA unnecessary (both CTPAs were negative). For the remaining 4 patients with elevated D-dimer level, half had PE-positive CTPAs. So our audit concluded that misuse of D-dimer assay was very common in our hospital. The reason may be that referring physicians were not well informed of the sensitivity and limitations of the D-dimer test used in our hospital. If the D-dimer assays with higher sensitivity (e.g. ELIZA, MDA assay) have been used (as in some other hospitals in Hong Kong), normal D-dimer results could have excluded 9 cases of suspected PE (2 with low risk and 7 with intermediate risk) without undergoing CTPA.

Limitations

We excluded cases with poor CTPA image quality from the analysis. However this may result in selection bias, as patients with PE are likely to have tachypnoea leading to motion artefacts.

We did not use the traditional gold standard (i.e. pulmonary angiogram) for the diagnosis of PE. For pragmatic reasons, we treated CTPA results as the final diagnosis. In our audit, most of CTPA findings were definite, according to diagnostic criteria proposed in PIOPED, so reliance on CTPA for the diagnosis of PE was probably acceptable. Notably, we only excluded 1 case due to equivocal CTPA findings. This was a 72-year-old man in whom a segmental thrombus could not be definitively identified, and subsequent lower-limb Doppler did not reveal any deep vein thrombosis. However, the patient was treated as having PE although he did not belong to the high-risk group and regrettably he had no follow-up CTPA.

CONCLUSION

There was a nearly 5-fold increase of the requests in CTPA for suspected PE over the 4 years from 2004 to 2008. The percentage of PE-positive CTPAs was

Table 3. Correlation blood D-dimer levels (27 cases in 2008) with the revised Geneva pre-test probability score.

Blood D-dimer level	Revised Geneva pre-test probability score		
	0-3	4-10	≥11
Normal	2 (all CTPA –ve)	7 (all CTPA –ve)	0 (all CTPA –ve)
Elevated	4 (+ve CTPA in 2 cases)	10 (+ve CTPA in 3 cases)	4 (+ve CTPA in 3 cases)

Abbreviation: CTPA = computed tomographic pulmonary angiogram.

23%, which was lower than in most series in which the reported prevalence ranges from 28 to 33%. The explanation for this finding may be multifactorial and includes a lower overall prevalence of PE in Chinese subjects and a relaxation of patient selection criteria by referring physicians. There was no documented use of any standardised pre-test PE probability score. Our audit also suggested misuse of D-dimer tests, which could be corrected if the referring physicians were more aware of the sensitivity and limitations of the D-dimer testing.

REFERENCES

1. Dalen JE, Alpert JS. Natural history of pulmonary embolism. Prog Cardiovasc Dis. 1975;17:259-70.
2. Carson JL, Kelley MA, Duff A, et al. The clinical course of pulmonary embolism. N Engl J Med. 1992;326:1240-5.
3. British Thoracic Society Standards of Care Committee Pulmonary Embolism Guideline Development Group. British Thoracic Society guidelines for the management of suspected acute pulmonary embolism. Thorax. 2003;58:470-83.
4. Stein PD, Fowler SE, Goodman LR, et al. Multidetector computed tomography for acute pulmonary embolism. N Engl J Med. 2006;354:2317-27.
5. Au VW, Veitch E, Gustafson S. Radiological investigation of pulmonary embolism: an audit in a teaching hospital. J Hong Kong Coll Radiol. 2005;8:141-5.
6. Joynt GM, Li TS, Griffith JF, et al. The incidence of deep venous thrombosis in Chinese medical Intensive Care Unit patients. Hong Kong Med J. 2009;15:24-30.
7. Iles S, Hodges AM, Darley JR, et al. Clinical experience and pre-test probability scores in the diagnosis of pulmonary embolism. QJM. 2003;96:211-5.
8. Kline JA, Johns KL, Colucciello SA, Israel EG. New diagnostic tests for pulmonary embolism. Ann Emerg Med. 2000;35:168-80.
9. Ginsberg JS, Wells PS, Kearon C, et al. Sensitivity and specificity of a rapid whole-blood assay for D-dimer in the diagnosis of pulmonary embolism. Ann Intern Med. 1998;129:1006-11.
10. Freyburger G, Trillaud H, Labrouche S, et al. D-dimer strategy in thrombosis exclusion — a gold standard study in 100 patients suspected of deep venous thrombosis or pulmonary embolism: 8 DD methods compared. Thromb Haemost. 1998;79:32-7.
11. Bates SM, Grand'Maison A, Johnston M, Naguit I, Kovacs MJ, Ginsberg JS. A latex D-dimer reliably excludes venous thromboembolism. Arch Intern Med. 2001;161:447-53.
12. Le Gal G, Righini M, Roy PM, et al. Prediction of pulmonary embolism in the emergency department: the revised Geneva score. Ann Intern Med. 2006;144:165-71.