Utilization of Electron Beam CT Scan in Diagnosis of Pulmonary Embolism

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Abstract

Pulmonary embolism is a difficult entity to diagnose clinically and pulmonary angiogram has been the gold standard for the diagnosis. Our objective was to evaluate the usefulness of electron beam (Ultrafast) CT scan in aiding the diagnosis of such an entity, thus avoiding an invasive procedure. Between April 1995 and March 1996 we prospectively studied 20 patients with clinical suspicion of pulmonary embolism by conventional perfusion scan of the lung, by invasive pulmonary angiography and by contrast enhanced electron beam CT scan. Simple statistic correlation between the 3 methods was obtained in regard to sensitivity and specificity utilizing the pulmonary angiogram as the gold standard. The sensitivity and specificity of contrast enhanced electron beam CT scanning was 95 per cent and 100 per cent respectively. The correlation of positive and negative result of all three imaging modalities was 60 per cent.

Contrast enhanced electron beam (Ultrafast) CT scan is a good alternative diagnostic modality for pulmonary embolism.

Pulmonary embolism (PE) is generally thought to be a rare disorder in Asia including Thailand. Very little information is available in regard to its epidemiology and its natural history probably due to the difficulty in making the diagnosis on clinical grounds. Previous study using hospital based patients in Thailand suggested a significant increase in the yearly admission of acute cor-pulmonale[1]. Obviously pulmonary embolus is one of the causes of acute cor-pulmonale. However, premortem diagnosis of pulmonary emboli at least in our experience offered only 42 per cent accuracy[2]. Pulmonary angiography has been regarded as the gold standard method for the diagnosis but the proce-

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dure is invasive in nature, thus has limited its own numbers[3-5]. Several other imaging modalities ranging from simple chest X-ray, ventilation/perfusion scan, both transthoracic and transesophageal echocardiogram[6]. Conventional CT, MRI[7] and lately electron beam CT[2] are currently in use. Imaging of a moving organ such as the heart and pulmonary artery by conventional CT has been limited by its poor quality due to long acquisition time. Electron beam technology in conjunction with CT scanning make the acquisition time much shorter (within 100 milliseconds compared to 3 seconds by conventional CT) and provide an excellent image quality. We took on the study to compare the usefulness of this technology in diagnosing pulmonary embolism to the standard method.

METHOD

Patient Selection

All patients who were admitted to Ramathibodi Hospital, Mahidol University and clinical suspicion of pulmonary emboli was made, were invited to participate in the study. The study was conducted from April 1995 to March 1996. There was no age limit. These patients were asked to undergo all 3 investigations i.e. by conventional perfusion scan of the lung, pulmonary angiography and CT scanning with new electron beam technology. In addition, the standard work-up was also obtained namely chest X-ray (CXR), electrocardiogram (ECG) and arterial blood gas (ABG). We excluded those patients with hemodynamic instability (judged by the level of blood pressure of <80 mmHg and/or sign of hypoperfusion) and those who had significant renal insufficiency (judged by serum creatinine >3mg/dl). Informed consent was obtained prior to study. The protocol was approved by the university IRB*.

Pulmonary Angiography

Pulmonary angiography was done selectively and serially into right and left pulmonary artery *via* 5 or 6F pigtail catheter. 50 ml of nonionic contrast medium was delivered at each pulmonary artery with power injector at the rate of 25 ml/sec. Image acquisition of each side of the lung was done in digital format using the Toshiba digital cardiac catheterization system, which utilized CCD camera technology. Biplane (AP and lateral) acquisition was done simultaneously at the rate of 30 frames per second for 15 seconds under 512x512 format (262144 pixels). Image interpretation was done by 1 experienced radiologist and 2 experienced cardiologists on separate occasions. Disagreement was settled by consensus of the three. Evidence of pulmonary emboli (a positive result) was noted when there was at least one of the following signs:

1. Intraluminal filling defect.
2. Vessel cut off
3. Railroad sign for which contrast medium was seen mainly around the vessel wall due to thrombus sitting in the middle of the arterial lumen.

Conventional Lung Perfusion Scan

Due to the resource limitation and its established role as a screening mode of pulmonary emboli, only perfusion scan was carried out in most patients. 8 mCi of 99^{m} Tc macroaggregate albumin (MAA) with 150,000 particles was administered intravenously in rapid fashion. While patients were in supine position, planar image acquisition was done *via* an Elscint dual-head Helix gamma camera. The views of acquisition were anterior, posterior, lateral, right and left posterior oblique. Those images were interpreted by an experienced nuclear radiologist in conjunction with the most recent chest X-ray. Positive result of pulmonary emboli was called when there was more than subsegmental defect.

Electron Beam CT Scanning

Computerized tomography scanning was done using C-150 Scanner (Imatron, San Francisco, CA) in conjunction with contrast agent to obtain 30 continuous slices of 6 mm section. 80 ml of Sodium ioxitalamate (telebrix, Bois, France) was injected at the rate of 2 ml per second into the antecubital vein *via* 18G angiocath or needle. Once the circulation time of the individual patient was determined (usually with the use of magnesium sulfate method) the clock was started. The scanning was started 5 seconds beyond the measured circulation time from the level of the middle of aortic arch to the lung base. Image acquisition was ECG gated and required 100 milliseconds for completion of each image. During the image acquisition patients were asked to hold their breath as long as possible and then slowly exhale. In cases of unwillingness to hold their breath, they were asked to breathe slowly. The total examination time took less than 20 minutes in all cases.

* IRB = Internal review board.

Image interpretation was carried out by 2 experienced radiologists. Several zones were divided according to tomographical anatomy and looked thoroughly into small branches of the pulmonary artery. No segment was read as inadequate or indetermined. Positive signs of pulmonary emboli were among the following:

1. Filling defect in the course of the vessel.
2. Vessel cutoff.

Statistical Analysis

Using pulmonary angiography as the gold standard for the diagnosis of pulmonary emboli, the usefulness of contrast enhanced electron beam CT scanning will be expressed as sensitivity and specificity. The positive and negative coherence of the 3 different imaging modalities will be noted in terms of percentage of the whole patient group. Comparison of these parameters of electron CT & perfusion lung scan was done using student-*t* test. P-value less than 0.05 is considered significant.

RESULT

From April 1995 to March 1996, 32 patients were noted to have clinical suspicion of pulmonary embolism. The demographic and clinical pictures of these patients are illustrated in Table 1. The mean age was 42 years and ranged from 22 to 70 years. Dyspnea was the most common symptom although some of them had chest pain as the major complaint. The average duration of symptoms was 5 days. Twelve out of the initial 32 patients were excluded, 7 of whom had hemodynamic instability not suitable for getting both tests. No consent was obtained for both tests in 5 patients, 2 of whom underwent pulmonary angiogram alone and 3 underwent electron beam CT alone.

There were 13 cases of positive evidence of pulmonary emboli by pulmonary angiography. Image example is seen in Fig. 1. Contrast enhanced electron beam CT was able to demonstrate the evidence of thrombus in all of these subjects, thus giving 100 per cent sensitivity (Fig. 2 and Table 2

Table 1. Patient population profiles.

Suspicious of PE	32 patients
Age (years)	22-77 (M 42Y)
Symptom duration (days)	1-14 (M 5 d)
Dyspnea	100%
Hemodynamic instability	7
No consent	5
Entering study	20

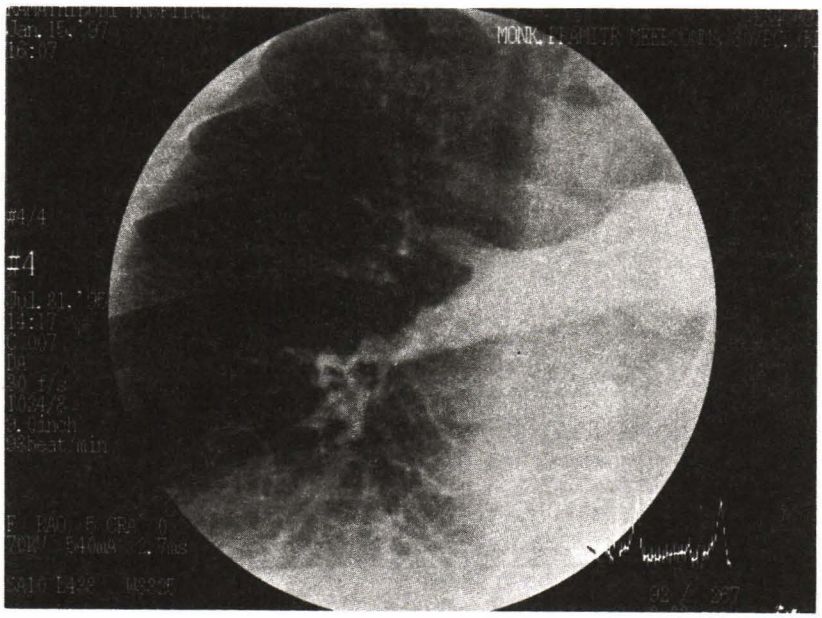

Fig. 1. Pulmonary angiogram showing filling defect in the right pulmonary artery.

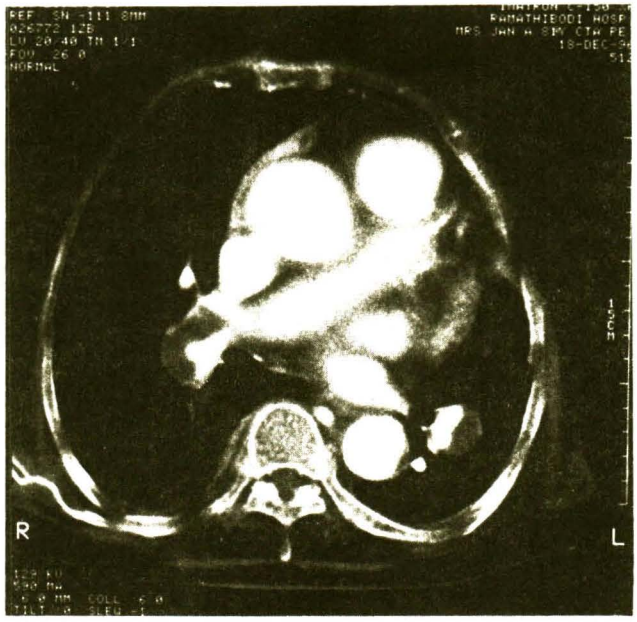

Fig. 2. Electron beam CT of pulmonary artery with thrombus in the right pulmonary trunk.

Table 2. Results of perfusion lung scan, electron beam CT and pulmonary angiogram in the studied population.

Patient	Perfusion scan	Electron beam CT	Pulm Angio
1	High	Positive	Positive
2	High	Positive	Positive
3	High	Positive	Positive
4	High	Positive	Positive
5	High	Positive	Positive
6	High	Positive	Positive
7	High	Positive	Positive
8	High	Positive	Positive
9	High	Positive	Positive
10	High	Positive	Positive
11	Low	Negative	Negative
12	Low	Negative	Negative
13	High	Negative	Negative
14	High	Negative	Negative
15	High	Negative	Negative
16	High	Negative	Negative
17	Intermediate	Positive	Positive
18	Intermediate	Positive	Positive
19	Intermediate	Negative	Negative
20	Low	Negative	Positive

Table 3. Sensitivity & specificity of perfusion scan and electron beam CT with pulmonary angiogram as the gold standard.

		Pulmonary Angiography	
		Positive	Negative
Electron beam CT	Positive	12	1
	Negative	0	7
	Total	12	8
Sensitivity	100%	Specificity	95%

		Pulmonary Angiography	
		Positive	Negative
Perfusion scan alone	Positive	10	4
	Negative	3	3
	Total	13	7
Sensitivity	76%	Specificity	42%

&3). However, contrast enhanced electron beam CT scan was read as positive in one out of 7 cases which had no evidence of such emboli by angiography, thus giving specificity of 95 per cent. In comparison, the conventional lung perfusion without ventilation scan but with conjunction of recent chest X-ray offered a sensitivity of 76 per cent and a specificity of 42 per cent (p value <0.05). The coherence of the 3 tests (positive and negative in all) was 60 per cent.

DISCUSSION

Pulmonary embolism though considered a rare disease in Asia, can be fatal. The incidence may be underestimated due to the nonspecific clinical manifestation and to inaccuracy of the current diagnostic modality. In PIOPED study the sensitivity of Ventilation and Perfusion scan was only 41 per cent, though the specificity was noted to be up to 97 per cent[9]. Our result in regard to the use of perfusion scan only is biased due to the nonspecific nature of perfusion defect which can occur simultaneously with the decrease in ventilation. However, when the clinical picture was incorporated into the equation, the high likelihood of disease clinically with high probability by lung scan predicted the presence of pulmonary emboli in 96 per cent of cases[10]. In the same manner, when the clinical suspicion was low and the lung scan was negative there was only 4 per cent chance that those patients would have pulmonary emboli.

Pulmonary angiography has been the standard test to diagnose pulmonary embolism[5]. Though a relatively safe procedure, it requires expertise of the operator in puncturing the big vein and handling the catheter in the right heart. A big load of contrast medium needs to be delivered in a short duration and can be a threat to some patients with hemodynamic instability. The procedure has to be carried out in a special laboratory with several groups of personnel involved and is not totally without risk. In PIOPED study, major complications (death, respiratory distress requiring CPR or intubation, renal failure requiring dialysis and hematoma that required blood transfusion) occurred in 14 patients out of 1,111 patients (1.3%) with suspected acute pulmonary emboli[9]. Mills et al reported three deaths in patients with RVEDP greater than 20 mmHg[11]. In our series, we did not encounter any serious complication, partly because non-ionic low osmolarity contrast medium was used. Other noninvasive imaging of the pulmonary artery is needed for rapid diagnosis so prompt therapy either with anticoagulation and/or thrombolytic therapy can be initiated. Conventional CT scan has not offered any better accuracy than the conventional ventilation and perfusion scan due to poor image quality even with the use of contrast enhancement. The poor image quality was mainly due to movement of the imaging organ (heart and pulmonary artery). Electron beam CT scanning is superior to the conventional CT scan in a unique

way i.e. it can capture the image in 100 milliseconds in contrast to 3 seconds by regular CT[8]. With this rapid image acquisition it can be gated to the ECG thus avoiding the blur of image caused by movement. With the help of contrast media the small distal structure of the pulmonary artery can be visualized and thus provides a better resolution even to see a small piece of thrombus. Electron Beam CT scan with contrast enhancement can be done with slow infusion of contrast medium thus posing very little risk hemodynamically to the patient. Our experience with this technology has been very encouraging with very good sensitivity and good specificity.

At the time of this writing we relied mainly on electron beam contrast CT scan as the mode of diagnosis should possibility of pulmonary emboli be a problem.

Limitation of the study

The number of patients enrolled is still small but it includes all comers with the possibility of pulmonary emboli. Pulmonary angiogram, though not done as a conventional cut film mode, was done in cine mode with digital processing and thus provided as good if not better images[12], electron beam CT scan is not universally available and may not become a standard in many hospitals.

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การวินิจฉัยเส้นเลือดพุลโมนารีย์อุดตันด้วยเอกซเรย์คอมพิวเตอร์ชนิดอิเล็กตรอนบีม†

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ภาวะเส้นเลือดพุลโมนารีย์อุดตันเป็นภาวะที่วินิจฉัยได้ยาก การวินิจฉัยที่เป็นมาตรฐานคือการฉีดสารทึบรังสีและถ่ายภาพ ซึ่งต้องอาศัยการสวนหัวใจ จุดประสงค์ของการวิจัยนี้คือการใช้เอกซเรย์คอมพิวเตอร์อย่างไวมากเพื่อการวินิจฉัยภาวะนี้ ได้ทำการศึกษาผู้ป่วย 20 รายที่สงสัยว่าจะมีภาวะเส้นเลือดพุลโมนารีย์อุดตัน ระหว่างเดือนเมษายน 2538 ถึงมีนาคม 2539 ด้วยการเปรียบเทียบผลของการทำ perfusion lung scan, การสวนหัวใจเพื่อฉีดสารทึบรังสีและถ่ายภาพ และ การใช้เอกซเรย์คอมพิวเตอร์อย่างไว เมื่อใช้การสวนหัวใจเพื่อฉีดสีและถ่ายภาพเป็นมาตรฐาน เอกซเรย์คอมพิวเตอร์อย่างไวมากสามารถให้ความไวในการวินิจฉัย 95% และมีความจำเพาะ 100% เอกซเรย์คอมพิวเตอร์อย่างไวมากสามารถใช้เป็นเครื่องวินิจฉัยภาวะเส้นเลือดพุลโมนารีย์อุดตันได้เป็นอย่างดี

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