The Role of Spiral Computed Tomogram in the Diagnosis of Acute Pulmonary Embolism

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ABSTRACT

Acute pulmonary embolism is associated with considerable morbidity and mortality. Early diagnosis and prompt treatment is essential. A number of non-invasive diagnostic tools are available for its detection. However, each one of these tests has its limitations and the invasive pulmonary angiography remains the gold standard. We describe the use of spiral volumetric computerised tomogram in the diagnosis of acute pulmonary embolism in six patients in our centre where ventilation-perfusion scan facility is not available. This safe, simple and non-invasive test has an excellent sensitivity and specificity for the detection of central and segmental pulmonary embolism and may replace the conventional invasive pulmonary angiography for the diagnosis of pulmonary embolism.

Keywords: Pulmonary embolism, Computed tomography (CT), Ventilation-Perfusion Scan

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INTRODUCTION

Acute pulmonary embolism (PE) is a common condition with considerable morbidity and mortality. The diagnosis remains a challenge as the signs and symptoms can often be non-specific. The use of several imaging modalities like ventilation-perfusion (V/Q) scanning, spiral volumetric computed tomographic (CT) scanning, magnetic resonance imaging, CT angiography and digital subtraction angiography suggests that one single technique is not reliably able to confirm or exclude the diagnosis in a patient with clinically suspected PE[1,2]. To date, pulmonary angiography remains the gold standard for establishing the diagnosis of PE.

Currently, V/Q scanning is the most commonly employed first-line investigation in clinically suspected PE. The obvious advantages of V/Q scanning are its low cost, ease of executing the test and its non-invasive nature. It was established in the PIOPED study (Prospective Investigation of Pulmonary Embolism Diagnosis) that a normal or low probability scan has a high negative predictive value and a high probability scan has a high positive predictive value when the results are interpreted along with the clinical assessment of the likelihood of PE. However, in approximately 70% of the patients, the results of V/Q scanning were non-diagnostic[3]. In patients with a non-diagnostic V/Q scan and normal duplex scan of the lower limb veins, pulmonary angiography is the next recommended imaging modality to establish the diagnosis of PE[4]. However, pulmonary angiography is often not requested by clinicians in view of its invasive nature[5].

Recent studies report the usefulness of spiral CT scanning for the detection of central and segmental PE[6]. It is non-invasive, easy to perform, quick and has been reported to have good specificity and sensitivity[7-9]. We report our experience with the use of high-speed spiral CT scan in the diagnosis of acute PE in six patients, five of whom were treated with thrombolytic therapy.

CASE REPORTS

Case 1

This 58-year-old gentleman was admitted with sudden onset of right-sided chest pain and shortness of breath. On examination he was tachypnoeic, pulse rate 100/min, regular and blood pressure 180/100 mmHg. There was no cyanosis. Respiratory examination revealed dullness on percussion and some coarse crepitations in the right lung base. Auscultation of the precordium was normal. Chest X-ray showed a right pleural effusion. Electrocardiogram (ECG) revealed poor progression of 'R' wave in the anterior leads with a deep S wave in lead I and Q wave with T wave inversion in lead III ($S_1Q_3T_3$). Arterial blood gases showed a paO_2 of 57.8 mmHg and $paCO_2$ of 37.1 mmHg. Duplex scan showed deep venous thrombosis in the right lower limb. Spiral CT of the thorax confirmed PE in the proximal right main and left descending pulmonary arteries (Fig. 1). Thrombolytic therapy with intravenous streptokinase was instituted followed by anticoagulation with heparin and subsequently warfarin.

Case 2

This 61-year-old lady had noticed right calf pain and bilateral lower limb swelling (right greater than left) for

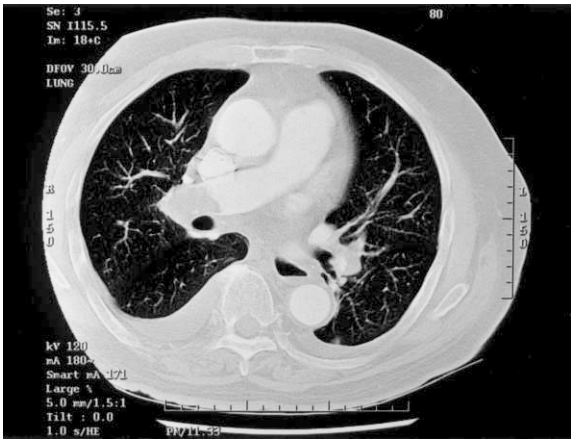

Fig.1 Spiral CT Scan showing filling defect in the proximal right main pulmonary artery. Thrombus also seen in the left basal pulmonary artery. Incidentally bilateral pleural effusion is also noted.

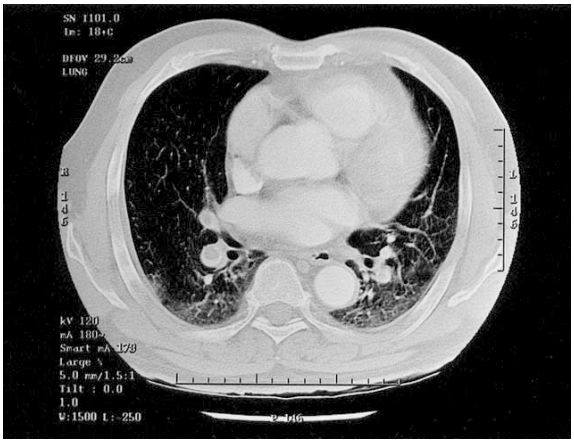

Fig.2 Spiral CT Scan showing filling defects in the segmental branches of the pulmonary arteries in both sides. Note the clear relationship of the bronchioles to the arteries.

one week and complained of sudden onset of shortness of breath associated with poking left-sided chest pain two days prior to admission. She was a known hypertensive on enalapril 5 mg once daily. On examination, pulse rate was 130/min, respiratory rate 30/min and blood pressure 130/90 mmHg. There was no cyanosis. She had bilateral pitting pedal oedema. Jugular venous pressure (JVP) was raised up to the angle of the jaw. On auscultation of the chest, there were bilateral expiratory rhonchi and basal crepitations. There were no cardiac murmurs. Arterial blood gases revealed a paO_2 of 51 mmHg and a $paCO_2$ of 49 mmHg. Chest X-ray showed cardiomegaly with bilateral pleural effusions. ECG was normal except for sinus tachycardia and a left axis deviation. Two-dimensional Echocardiogram (2D Echocardiogram) was normal. Spiral CT of the thorax confirmed the diagnosis of PE in the segmental branches of the pulmonary arteries bilaterally (Fig. 2). She was treated with recombinant tissue plasminogen activator (rTPA) followed by anticoagulation with heparin and subsequently warfarin.

Case 3

This 57-year-old gentleman, known to have obstructive sleep apnea, complained of sudden onset shortness of breath one day prior to and while on board a four-hour flight. Examination revealed a respiratory rate of 30/min, pulse 100/min, regular and blood pressure of 116/80 mmHg. There was no cyanosis. He had pitting oedema up to the knees bilaterally. JVP was raised up to angle of the jaw. Both calves were soft and supple. Auscultation of the respiratory and cardiovascular systems were normal. Arterial blood gases revealed a paO_2 of 68 mmHg and a $paCO_2$ of 34 mmHg. Chest X-ray showed cardiomegaly with upper lobe venous blood diversion. ECG revealed sinus tachycardia with deep S wave in lead I and Q wave with T wave inversion in lead III ($S_1Q_3T_3$ pattern). 2D Echocardiogram revealed a dilated right heart with abnormal septal motion compatible with the diagnosis of cor-pulmonale. Spiral CT of the thorax confirmed PE in the right and left main pulmonary arteries as well as the descending segmental arteries bilaterally. Thrombolytic therapy with rTPA was given followed by anticoagulation with heparin and subsequently warfarin.

Case 4

This 22-year-old gentleman, on treatment for pulmonary tuberculosis for the past three months, was admitted with complaints of chest pain and shortness of breath of four days duration and haemoptysis a day before admission. Examination revealed that he was tachypnoeic. Pulse rate was 110/min, regular and BP 120/80 mmHg. There was no cyanosis. ECG showed sinus tachycardia with right heart strain. Arterial blood gases showed a paO_2 of 64 mmHg and a $paCO_2$ of 34 mmHg. Duplex scan of the lower limb veins confirmed deep venous thrombosis in both legs. 2D Echocardiogram showed dilated right heart chambers with grossly elevated pulmonary artery systolic pressure at 90 mmHg. Spiral CT of the thorax confirmed multiple emboli in both the left and right branches of the pulmonary artery. Patient was given thrombolytic therapy with rTPA and subsequently anticoagulated in the usual manner. An inferior vena cava filter was placed transvenously. He recovered well but has residual severe pulmonary hypertension.

Case 5

This 28-year-old gentleman, on anti-tuberculous therapy for the past 12 months, presented with acute onset of shortness of breath and pleuritic chest pain of four days duration associated with hemoptysis. On examination, his respiratory rate was 30/min, pulse rate 100/min, regular and blood pressure 120/80 mmHg.

There was no cyanosis. There was no clinical evidence of deep vein thrombosis. Auscultation of the respiratory and cardiovascular systems were normal. Arterial blood gases revealed a paO_2 of 57.8 mmHg and a $paCO_2$ of 25.6 mmHg. Chest X-ray showed cardiomegaly with upper lobe venous blood diversion. ECG revealed sinus tachycardia with right heart strain pattern. 2D Echocardiogram showed severe pulmonary hypertension with moderate tricuspid regurgitation and right heart dilation. Spiral CT of the thorax confirmed multiple small filling defects within the left upper and lower segmental pulmonary artery branches consistent with pulmonary emboli. He was treated with rTPA followed by anticoagulation with heparin and subsequently warfarin.

Case 6

This 72-year-old gentleman presented with sudden onset chest pain and giddiness associated with sweating and loss of consciousness for 15 minutes. There was associated left lower limb swelling for the past few days. On examination, pulse rate was 90/min regular, respiratory rate 18/min, and blood pressure 130/90 mmHg. There was no cyanosis. Auscultation of the respiratory and cardiovascular systems were normal. The left calf was noted to be tense and swollen. Arterial blood gases showed a paO_2 of 75.6 mmHg and a $paCO_2$ of 37.2 mmHg. ECG revealed atrial fibrillation and right bundle branch block (RBBB) pattern at presentation, which resolved after 24 hours into normal sinus rhythm with no RBBB pattern. Duplex ultrasound demonstrated thrombus in the left femoral and popliteal veins. 2D Echocardiogram revealed a dilated right heart with mild pulmonary hypertension. Spiral CT of the thorax confirmed the diagnosis of PE in the right and left main pulmonary arteries and also in basal segmental arteries. Thrombolysis with intravenous rTPA was planned but could not be administered due to lack of consent. Instead, patient was anticoagulated with heparin and subsequently warfarin.

DISCUSSION

Pulmonary embolism (PE) remains a common cause of mortality and its diagnosis is missed in up to 71% of instances. Prompt diagnosis and appropriate therapy has been shown to reduce the mortality from 30% to less than 10%[10]. However, the currently available non-invasive diagnostic methods lack adequate sensitivity and specificity in establishing the diagnosis of PE.

The most commonly applied first line investigation in the assessment of clinically suspected PE is the V/Q scan. However, the results of the PIOPED study showed that although the high probability scan had a high specificity of 97%, the sensitivity was low as it failed to identify 149 out of 251 patients (59%) with angiographically proven PE. Moreover, in the event of a past history of PE, the specificity of the high probability scan was reduced as well. Including the intermediate probability scans certainly increased the sensitivity from 41% to 82%, but did so at the cost of specificity, which dropped from 97% to 52%. The conclusions drawn from this large multicentre trial was that a high probability scan with a high clinical suspicion of pulmonary embolism has a high positive predictive value and a low probability or normal scan along with a strong clinical assessment of absence of PE makes the diagnosis of PE unlikely[3].

However, only a minority of patients with PE have a high probability scan. Worsley et al comprehensively analysed the PIOPED study data and reported that only 34% cases corresponded to either a high or a low/normal probability scan[11]. In the vast majority of patients with an intermediate scan, it is not possible to establish a diagnosis without further investigations. Duplex ultrasound of the legs have been shown to detect deep venous thrombosis in 50% of patients with angiographically proven PE[12]. The finding of deep venous thrombosis in a patient suspected of PE obviates an extensive search for PE as the presence of deep venous thrombosis justifies anticoagulation of the patient. However, an intermediate probability V/Q scan and a negative duplex ultrasound of the legs is seen in as many as 30% of patients clinically suspected to have a PE, 20 - 30% of whom are seen to have a PE at pulmonary angiography[13]. Hence, treating these patients with unresolved V/Q scan and a negative duplex ultrasound of the legs on clinical probability alone is not reliable or good clinical practice. This would result in some patients without PE being treated whereas some with a PE not. PIOPED study suggested the use of pulmonary angiography in these unresolved cases. The morbidity and mortality associated with pulmonary angiography was quite low in the PIOPED study. However, in many centres, pulmonary angiography is not carried out due to its invasive nature. Sotsman et al observed that only 12% in a series of 434 patients with an unresolved diagnosis of PE underwent pulmonary angiography[5]. Moreover, the facilities to perform an emergency pulmonary angiography may not be available in many centres.

Spiral computed tomography is a non-invasive method of diagnosing PE and recently there has been an increased interest in this diagnostic tool. All the patients in our series had an urgent spiral CT (General Electric Hispeed Cti Spiral Scanner) scan performed based on the clinical suspicion of PE as V/Q scanning facility is not available in our centre. One hundred mls of non-ionic contrast medium was injected at a rate of

2.5 mls per second and 5 mm thickness scans were performed with the patient holding their breath (one breath hold scanning). In the event of inability to hold breath, slow and shallow breathing scanning was done. In all the six cases reported, the scan clearly depicted the emboli enabling us to confirm the diagnosis and institute prompt therapy.

The ability of spiral CT to provide a diagnosis of PE has been well emphasised by van Rossum et al: they reported a sensitivity of 95% and the specificity was 97%, the positive and negative predictive values being 97% and 97% respectively. They suggested that spiral CT could be used as an alternative to V/Q scanning and possibly even to pulmonary angiography[9]. In a recent prospective study including 142 patients with suspected PE, Mayo et al reported a sensitivity and specificity of spiral CT for diagnosing PE as 87% and 95% respectively[14]. The spiral CT findings enabled a correct diagnosis in 80% of the cases in whom the V/Q scan was interpreted as intermediate probability. In their study, the sensitivity of spiral CT was noted to be greater than that of V/Q scanning for the diagnosis of PE. However, in a recent review, it has been suggested that the current place for spiral CT in the diagnosis algorithm for clinically suspected PE should be in the situation where the perfusion or V/Q scan shows intermediate probability of PE, or where there is discordance between clinical and lung scan probabilities with a negative leg ultrasound[15]. Ferretti et al in a prospective study reported that spiral CT could replace pulmonary angiography to demonstrate PE in patients with intermediate probability V/Q scan and a negative duplex ultrasound of the legs[16]. Over a three-month follow-up period, 5.4% of their patients with a negative spiral CT had a recurrent PE which is comparable to the recurrence rate of 0.6% - 4.2% reported in follow-up studies of patients with suspected PE and a negative pulmonary angiography[17,18].

Spiral CT is quick and well suited for the acutely ill patient. One of the major advantages is its ability to depict unsuspected intrathoracic disease that may account for the presenting symptoms. Ferreti et al[16] found unequivocal abnormalities of lung parenchyma on spiral CT which explained the clinical findings and non-diagnostic V/Q scan in 11% of patients whereas van Rossum et al found pleural and parenchymal lesions on spiral CT in 57% patients with non-diagnostic V/Q scans[9]. In chronic pulmonary embolism, spiral CT not only visualises the thromboemboli but also depicts wall thickness, pulmonary infarction, evidence of pulmonary hypertension and right heart enlargement. Moreover, in today's high cost of medical care, studies have shown that spiral CT is likely to improve cost-effectiveness in the diagnostic workup of PE[19].

One of the major limitations of the spiral CT scan is its inability to depict subsegmental arteries. It is useful only for detection of PE in central and segmental pulmonary arteries. Currently, visualisation is limited to the fourth-generation arteries[7-9]. The ability to detect segmental arteries is determined largely by the scan thickness. Remy-Jardin et al demonstrated that with 3 and 2 mm sections, 85% and 95% of segmental arteries could be demonstrated respectively[7] whereas Ferreti et al could visualise only 78% of the segmental arteries using 5 mm cuts[12]. Goodman et al prospectively studied 20 patients with unresolved diagnosis following V/Q scanning with spiral CT and pulmonary angiography and noted that the sensitivity and specificity of spiral CT when compared to pulmonary angiography in detecting PE was 63% and 89% respectively. However, the sensitivity and specificity improved to 86% and 92% respectively when the results for only the central (segmental and larger) vessels were compared[8].

There are certain limitations in our study. The number of patients studied is small and this is a single centre retrospective analysis. Moreover, it is a group of case studies rather than a whole series and hence does not include the outcome of all the spiral CT scans done at our centre for the investigation of patients with clinically suspected PE.

In conclusion, though the precise role of the various non-invasive imaging techniques in the diagnosis of acute pulmonary embolism remains to be clarified, the results of spiral CT as a diagnostic tool in the detection of PE is promising. It has high sensitivity and specificity, gives quick results and can help provide alternative diagnoses. Current helical CT technology however limits visualisation up to fourth generation pulmonary arteries. We suggest that V/Q scanning when available should still be used as the first line investigation in the diagnosis of clinically suspected PE. The role of spiral CT should currently be limited to patients with an intermediate probability V/Q scan and a negative lower limb duplex ultrasound. A large multicentre randomised trial is necessary to assess the efficacy and cost-effectiveness of spiral computed tomogram compared to V/Q scanning as the first line investigation in the diagnosis of clinically suspected PE.

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