



## Original paper

# Unsuspected pulmonary embolism identified using multidetector computed tomography in hospital outpatients

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## ARTICLE INFORMATION

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**AIM:** To evaluate the incidence of unsuspected pulmonary embolism (PE) in an unselected population of outpatients undergoing contrast-enhanced multidetector computed tomography (MDCT) for indications other than the investigation of PE.

**MATERIALS AND METHODS:** Outpatients undergoing CT of the chest over a 6-month period were retrospectively identified and images reviewed. Inpatients and patients undergoing unenhanced CT of the chest were excluded. Data, including referring specialty, patient age and sex, reasons for examination, level of embolism, image quality, and section thickness were recorded. Radiology reports were reviewed with respect to whether or not the embolism was noted at the time of initial reporting.

**RESULTS:** Following exclusions 440 patients were reviewed (195 women and 245 men). PE was identified in 10 of the 440 patients, an incidence of 2.23%. One pulmonary embolus was in the main pulmonary artery, three were in lobar arteries, three in segmental arteries, and three in subsegmental arteries. Patients over the age of 60 years were more likely to have an embolism (9/300, 2.9%) compared with those under 60 years (1/140, 0.7%). Seven of the 10 positive examinations were carried out in patients who were known or later shown to have malignancy. Seven of the 10 emboli were reported at the time of initial reporting.

**CONCLUSION:** The outpatient population has a significant incidence of unsuspected PE. PE should be actively sought when reporting examinations performed for alternative indications, particularly where cancer is a known or suspected diagnosis.

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## Introduction

Pulmonary embolism (PE) is a common condition with a documented annual incidence of 500,000 cases in the United States,<sup>1</sup> and is responsible for considerable morbidity and mortality. The advent of thin-section multi-detector CT (MDCT) has led to the diagnosis of unsuspected PEs being made in contrast-enhanced CT examinations of the thorax where there was no clinical suspicion of PEs.

Therefore, it is important that radiologists are aware of the capability of the technique in diagnosing unexpected PEs and actively seek to exclude the diagnosis on all contrast-enhanced CT chest examinations, whatever the indication.

Previous studies have highlighted an incidence of unsuspected PE of up to 5.7% in high-risk populations, such as cancer patients and inpatients.<sup>2–5</sup> Silent PEs are also well described in patients with deep vein thrombosis.<sup>6–8</sup> The aim of the present study was to investigate the incidence of unsuspected PEs in outpatients undergoing routine contrast-enhanced MDCT of the chest. A further aim was to evaluate the aetiological factors relating to PE in outpatients and to compare the enhancement and diagnostic utility of the four- and 16-section systems.

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## Materials and methods

Outpatients undergoing CT of the chest for indications other than suspected PEs over a 6-month period were retrospectively identified and analysed within 1 week of the examination being performed. Data including the referring specialty, age of the patient, indication for the examination, most proximal level of the embolism, quality of the images, and section thickness were documented. The radiology reports were reviewed with respect to whether or not the embolism had been noted at the time of initial reporting. Patients were examined using either a 16-section or a four-section system (Toshiba Aquillion Series, Toshiba Medical Systems, Tokyo, Japan). Patients who had been referred for outpatient investigation by a range of medical and surgical specialties were included. Inpatients and unenhanced examinations were excluded, as were patients with a past history of venous thromboembolism. Institutional approval was obtained for the study.

### Imaging protocols

The parameters used for the examination depended on the indication for the study. Most studies were performed using a standard protocol with 100 ml of iodinated contrast medium injected at a rate of 3–4 ml/s with imaging performed in a single breath-hold 20 s after the start of contrast medium injection. One millimetre thick images were reconstructed using the 16-section system and 2–3 mm section thickness for the four-section system. The imaging protocols employed are outlined in Table 1.

### Image evaluation

All images were routinely reported at the time the study was performed. Images were re-examined for this study using a three-dimensional workstation within a week of the examination being performed by one of two radiology registrars under supervision of a consultant cardiothoracic radiologist who reviewed all the positive and equivocal scans. The radiologists were blinded to the initial report. CT images were assessed for the presence of PE and the location of the most proximal thrombus in the central, lobar, segmental, or subsegmental pulmonary arteries was recorded. The radiologist reviewing the images also noted whether the contrast opacification of the pulmonary arteries was good (good enhancement of segmental and subsegmental pulmonary arteries), moderate (good enhancement of segmental but not subsegmental

pulmonary arteries), or poor (poor enhancement of the entire pulmonary arterial tree). Patients who had poor contrast enhancement were excluded from the study.

## Results

Among the 449 patients evaluated, 440 (97.8%) were considered to have good ( $n = 395$ ) or moderate ( $n = 45$ ) pulmonary artery opacification. Nine images showed poor contrast enhancement and these were excluded from further study. Of the 440 patients remaining, 195 (44.3%) were female and 245 (55.7%) male. The age range of patients was 19–94 years, median age 67 years.

PE was discovered using CT in 10 of the 440 patients, an overall incidence of 2.23%. The proximal extent of the thrombus is shown in Fig. 1. One pulmonary embolus was in the main pulmonary artery, three were in lobar arteries, three in segmental arteries, and three in subsegmental arteries. Seven of the 10 PEs were identified at the initial time of reporting. The emboli that were not identified were all subsegmental and the clinical teams were informed within a week of the scan being performed.

The age distribution for all patients is shown in Table 2. Patients over the age of 60 years were more likely to have an unsuspected pulmonary embolus (9/300, 3%) compared with those aged under 60 (1/140, 0.7%) but this was not a statistically significant finding (Fisher's exact test,  $p = 0.1853$ ).

The majority of patients who underwent outpatient CT of the thorax were referred by chest physicians (227/440) or by general surgeons (154/440). Of the 10 patients who had PEs, five were referred by the chest physicians, four by general surgeons, and one by orthopaedics. The indication for the majority (77.7%) of the examinations was the investigation of known or suspected cancer (342/440). Seven of the 10 positive examinations were carried out in patients who had known malignancy or were later proved to have malignancy. There was a similar proportion of positive examinations in patients with malignancy (6/342, 1.7%) and in those being investigated for other conditions (1/98, 1%,  $p = 1.0$ ), although numbers of positive cases were small.

The four-section machine was far more likely to show poor or moderate enhancement of the pulmonary arteries compared with the 16-section machine. Of the 367 patients examined using the 16-section machine, only 10 (2.7%) showed moderate enhancement of the pulmonary arteries and three (0.8%) showed poor enhancement, while 354 (96.5%) showed good enhancement. Of the 82 patients examined using the four-section machine, 35 (42.7%)

**Table 1**  
Imaging parameters<sup>a</sup>

Protocol	kV	Contrast and concentration (mg/ml)	Contrast volume (ml)	Table feed (mm/rotation)	Pitch	No of patients
Chest (16-section)	120	Niopam 300	90	23	23	358
Aorta (16-section)	120	Iomeron 400	100	23	23	6
Chest (4-section)	120	Niopam 300	90	11	5.5	76
Aorta (4-section)	120	Iomeron 400	100	11	5.5	0

<sup>a</sup> Tube current (mA) is controlled by software.

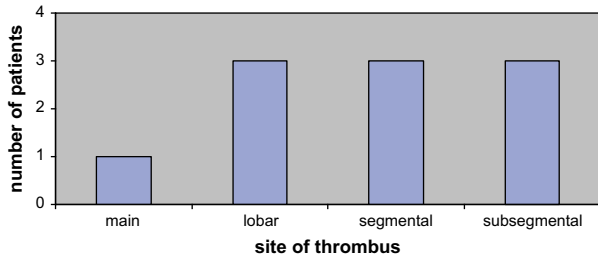


Figure 1 Proximal extent of thrombus.

showed moderate enhancement, six (7.3%) showed poor enhancement of the pulmonary arteries, and 41 (50%) showed good enhancement. Contrast enhancement is illustrated in Fig. 2. These numbers include the scans that showed poor enhancement of the pulmonary arteries, which were excluded from the remainder of the analysis above.

Three hundred and sixty-four of the patients included in the study were examined using the 16-section machine and 76 patients using the four-section machine. Two of the examinations that were positive for PE were performed on the four-section machine. One of these showed a PE in a lobar artery and one in a segmental artery. There was no difference in the proportion of examinations positive for PEs using the four-section (2/76, 2.6%) or the 16-section (8/364, 2.2%) machine provided the contrast enhancement of the pulmonary arteries was adequate ( $p = 0.69$ ); however, all the unsuspected subsegmental PEs were detected using the 16-section machine.

## Discussion

Of the outpatient population undergoing CT thorax in the present study, 2.2% had unsuspected PEs. The incidence of PEs is higher than in previously published studies that used thicker collimation, but lower than in the inpatient population for the same institution. The findings of the present study raise the likelihood that PE may be a more frequent event in the hospital outpatient population than was previously recognized.

Our institution does not manage the bulk of the oncology work for our region (with the exception of upper gastrointestinal, hepatobiliary, and some chest oncology). Allowing for this, there was still a very high proportion of patients being investigated for malignancy (77.7%).

The number of positive examinations in this study was too small to permit detailed analysis of this group. A larger study with greater numbers of positives would be necessary to draw more significant conclusions regarding the

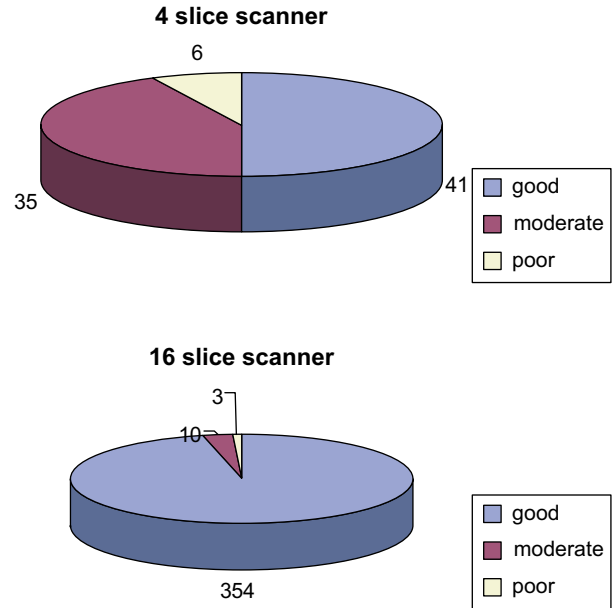


Figure 2 Enhancement of the pulmonary arteries using the four and 16-section machines.

characteristics of the patients with unsuspected PEs. It has been shown that the older population is more likely to develop thromboembolic disease<sup>2,9–11</sup> and although more PEs were found in the over 60 years age group, this only represents a suggestion of an age effect and is not supported by statistical analysis. The lack of a statistically significant effect of age may be related to the relatively small number of patients and small number of positive results. There was no relationship between PE and referral speciality.

The clinical significance of these unsuspected PE remains unclear. One of the patients had a lobar embolus (Fig. 3), and there was no reason to suppose that unsuspected large



Figure 3 A 74-year-old man with an unsuspected right main pulmonary artery embolus.

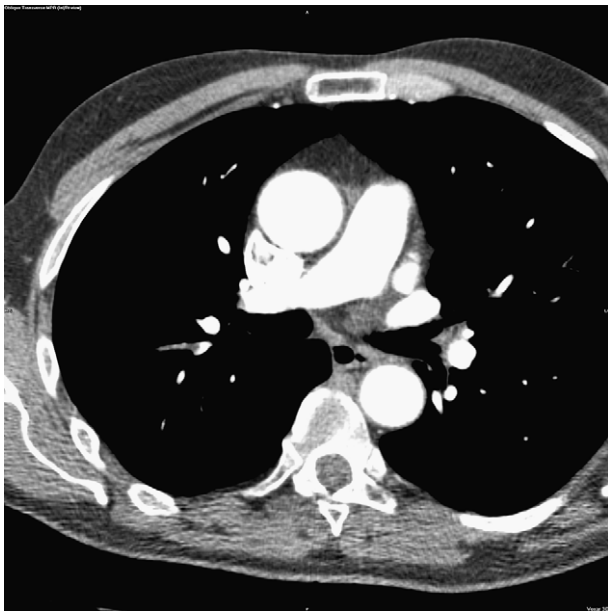
Table 2 Age distribution of patients

Age (years)	n	No. positive	Percent positive
<50	58	0	0
50–59	80	1	1.3
60–69	113	6	5.3
70–79	135	2	1.5
>80	54	1	1.9

central or lobar emboli are of any less importance than those that present with clinical symptoms. The majority of the unsuspected PEs in the present study were small, occurring at the segmental or subsegmental level (Figs. 4 and 5) and the clinical significance of these smaller PEs is less certain. In one study of patients without previous cardiovascular disease, the arm of patients randomized to receive no anticoagulation following silent PE did not show any adverse outcome compared with those who were treated.<sup>8</sup> One of the physiological functions of the lung is to act as a filter for embolic particles to prevent their passage into the systemic circulation.<sup>12</sup> However, there is a belief that small PEs occurring without symptoms may be a precursor of larger events with more serious clinical consequences.<sup>13</sup> These small events may also play a role in later development of thromboembolic pulmonary hypertension. At our institution all unsuspected emboli are currently managed with anticoagulation in the same manner as any embolus that is diagnosed following investigation to look specifically for PE. It remains to be seen whether in the future clinical practice may change in the management of these smaller unsuspected emboli.

A recent study at our institution showed an inpatient rate of unsuspected PE of 5.7%.<sup>2</sup> This rate almost certainly underestimated the true prevalence of PE in the inpatient population as patients being investigated for PE were not included. The present study has found the rate of unsuspected PE in the hospital outpatient population to be 2.2%. Patients with known or suspected thromboembolic disease were also excluded from this study, so this may also be an underestimation.

It can probably be assumed that the outpatient hospital population has more risk factors for PE than the general population and indeed 77.7% of the present study



**Figure 4** A 66-year-old man with a subsegmental pulmonary embolus. This was not seen at the initial time of reporting. The clinical team were informed of the finding 1-week later.



**Figure 5** Segmental embolus in a patient known to have lung cancer.

population were under investigation for known or suspected malignancy, which is a widely accepted risk factor. Although not unwell enough to warrant admission to hospital, outpatients have co-morbidities and are likely to be less mobile than the general population.

The first studies to describe the frequency of “incidental” PE detected on CT tended to show lower rates of PE than more recent studies. Winston et al.<sup>13</sup> found an incidence of unsuspected PE of 0.4% in 1996 in an outpatient population of 1320 patients. Gosselin et al.<sup>14</sup> examined a population of 625 outpatients in 1998 and found an incidental rate of PE of 0.6%. Both these studies were performed using single-detector systems with relatively large collimation (5–10 mm). More recently in 2005, Storto et al.<sup>3</sup> reported an incidence of 0.9% unsuspected PEs in 107 outpatient examinations using a four-section system. The present study found a higher incidence at 2.2% in an unselected outpatient group of 440 and similarly, a study performed recently at our institution by Ritchie et al.<sup>2</sup> reported an incidence of 5.7% of unsuspected PEs in inpatients. Both these recent studies used mostly 16-section MDCT, and a high proportion of the unexpected emboli were at the segmental or subsegmental level. The higher rate of detection of PE in recent studies is likely to reflect the improvements in resolution of small pulmonary arteries using 16-section MDCT<sup>15,16</sup> and the ability to identify small peripheral emboli that were not previously seen using single-section systems.<sup>17–21</sup>

In the present study, the majority of PEs were positively identified at the time of the initial report, but three of the 10 positives were initially missed, which is a similar finding to the previous study.<sup>2</sup> It is possible that suboptimal window settings could have contributed to failure to identify these emboli. In a study of 581 patients, Storto et al.<sup>3</sup> concluded that the use of wide window settings improved the detection of PEs. It is also possible that the size of the emboli resulted in their being overlooked (all were subsegmental).

In conclusion, an unsuspected PE was found in 2.2% of the unselected outpatient population undergoing MDCT examinations of the thorax. This is a higher proportion than has previously been described presumably owing to the use of a 16-section machine. Statistical analysis was hampered by small numbers of positive results. There was no statistically significant relationship between age and PE. There was also no pattern regarding the anatomical distribution of the emboli, although again the numbers of positive examinations were small. These findings suggest that the incidence of PE in the outpatient population is higher than previously suspected and unless specifically sought, a significant proportion will be overlooked on the initial report.

This study reaffirms the need for radiologists to be vigilant in the reporting of contrast-enhanced CT chest and to pay close attention to the pulmonary arteries, even if the examination has not been optimally timed for their examination. This study also poses questions regarding the management of patients with small asymptomatic peripheral PEs.

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