Received:
3 September 2015

Revised:
13 November 2015

Accepted:
24 November 2015

doi: 10.1259/bjr.20150737

Cite this article as:

Bach AG, Meyer HJ, Taute B-M, Surov A. The frequency of incidental pulmonary embolism in different CT examinations. *Br J Radiol* 2016; **89**: 20150737.

SHORT COMMUNICATION

The frequency of incidental pulmonary embolism in different CT examinations

¹ANDREAS G BACH, PhD, MD, ¹HANS J MEYER, ²BETTINA-MARIA TAUTE, MD and ¹ALEXEY SUROV, PhD, MD

¹Department of Radiology, University of Halle, Halle, Germany

²Department of Internal Medicine, University of Halle, Halle, Germany

Address correspondence to: Dr Alexey Surov

E-mail: alex.surov@medizin.uni-halle.de

Objective: Pulmonary embolism (PE) is commonly found in patients with oncologic and non-oncologic disease. The aim of the present study is to assess how frequently suspected, incidental and unreported PE occurs in particular CT examinations. In addition, differences in embolus distribution are to be considered.

Methods: In a retrospective, single-centre study that covered a 5.5-year period, every contrast-enhanced CT examination was reviewed. The study group included 7238 patients with 11,747 CT examinations. A detailed pulmonary artery obstruction index (Mastora score) was used to assess thrombus mass and distribution.

Results: PE frequency was 3.9% in oncologic patients and 6.6% in non-oncologic patients. PE was unsuspected in 54% of all PE events. Incidental PE was mostly often

found in the following CT examinations: evaluation of acute pulmonary disease and follow-up staging. The thrombus mass was higher in non-oncologic patients than in oncologic patients. Furthermore, the thrombus mass was significantly lower in unsuspected PE than in suspected PE. In addition, the thrombus mass was significantly lower in unreported PE than in incidental PE.

Conclusion: The radiologist should pay special attention to pulmonary vessels, even when not asked for PE, in the following CT examinations: evaluation of acute pulmonary disease and follow-up staging.

Advances in knowledge: Particular CT indications are associated with a high frequency of PE. Whether PE is suspected or not and found or not highly depends on thrombus mass.

INTRODUCTION

Pulmonary embolism (PE) is a frequent incidental finding in CT examinations.^{1,2} A significant number of PE is clinically unsuspected (*i.e.* no symptoms or symptoms not recognized). Unsuspected PE are either described by the initial reviewing radiologist (= incidental PE) or overseen (= unreported PE).

Presumably, the frequency of PE is different for particular CT indications, *e.g.* evaluation of chronic pulmonary disease *vs* follow-up staging. Furthermore, the frequency of PE might differ in patients with oncologic diseases *vs* patients with non-oncologic diseases. Finally, the size of PE (*i.e.* thrombus mass) has an effect on symptoms and prognosis in patients with PE.³⁻⁵

Therefore, the aim of the present study was to assess how frequently PE occurs in particular CT indications, and analyse embolus distribution in oncologic patients and in unsuspected PE.

METHODS AND MATERIALS

This study was approved by the institutional ethics committee. In a retrospective, single-centre study, all patients who had received at least one contrast-enhanced CT examination of the chest were reviewed. Patients were identified *via* a retrospective analysis of medical records and using the radiological information system.

Time between study and CT examination was at least 2 years. Owing to this delay, the identification of previously unrecognized PE was considered to be not relevant for patients. Patients and physicians were not informed about PE that was found in the process of this study.

The study period was 5.5 years. Patients with malignant solid and haematogenous diseases were considered as oncologic patients. The study group included 3270 oncologic patients with 6935 CT examinations and 3968 non-oncologic patients with 4812 CT examinations.

When the indication was to search for PE, CT pulmonary angiography was performed. 60 ml of an iodinated intravenous contrast medium (Solutrast® 370 with 370 mg iodine/ml; Bracco Imaging Germany GmbH, Konstanz, Germany) was given at a rate of 2 ml s⁻¹. Typical imaging parameters were 120 kVp, 150–300 mAs and 1-mm slice thickness with a pitch of 0.6–1.2. Automatic bolus timing in the pulmonary trunk was used with effective delays of 12–25 s.

For all other indications, about 60–140 ml of an iodinated intravenous contrast medium was given at a rate of 2 ml s⁻¹. The typical delay was 40–50 s. The imaging parameters were similar to that of CT pulmonary angiography as described previously.

The digital images of all included patients were reviewed by two radiologists with 5 years' (AGB) and 10 years' (AS) experience to

identify unsuspected and unreported cases of PE. All positive findings were confirmed in consensus.

PE was considered as unsuspected when the indication for the CT examination was other than confirming or excluding such diagnosis. PE was considered as unreported, when it was not mentioned in the initial radiological report.

The Mastora score³ was used in the present study to quantify thrombus mass. The obstruction of the mediastinal, lobar and segmental arteries was quantified by a percentage score, and the sum of the percentages gave the global obstruction with a maximum of 300%. The use of the Mastora score also allowed for detailed analysis of thrombus distribution.^{1,3} The two-tailed Mann–Whitney *U* test was used to calculate statistical differences between groups.

Table 1. Frequency of pulmonary embolism (PE) in CT examinations in oncologic and non-oncologic patients

Indication for CT examination	No PE	PE ^a			PE (%)	NNS
		Symptomatic	Incidental reported	Unreported		
Search for PE (oncologic patient)	431	122	0	0	22.1	5
Search for PE (non-oncologic patient)	1396	256	0	0	15.5	6
Vessel disease ^b (oncologic patient)	131	0	6	2	5.8	17
Acute pulmonary disease ^c (non-oncologic patient)	836	0	14	17	3.6	28
Follow-up staging (oncologic patient)	3230	0	31	60	2.7	36
Initial staging or search for tumour (oncologic patient)	1791	0	18	17	1.9	52
Acute pulmonary disease ^c (oncologic patient)	691	0	11	2	1.8	54
Trauma (non-oncologic patient)	276	0	3	2	1.8	56
Vessel disease ^b (non-oncologic patient)	499	0	3	4	1.4	72
Chronic pulmonary disease ^d (non-oncologic patient)	321	0	2	2	1.2	81
Search for tumour (non-oncologic patient)	1009	0	5	4	0.9	113
Other ^e	603	0	0	4	0.7	152
Chronic pulmonary disease ^d (oncologic patient)	237	0	0	0	0.0	N/A
Trauma (oncologic patient)	112	0	0	0	0.0	N/A
All indications (non-oncologic patient)	4496	256	27	33	6.6	15
All indications (oncologic patient)	6666	122	66	81	3.9	26
All indications	11162	378	93	114	5.0	20

NNS, number needed to scan (to find PE).

Indications are sorted in order of descending frequency of detected pulmonary embolism events.

^aMultiple independent PE events in the same patient were considered, but not follow-up of the same PE in the same patient.

^bEvaluation of aneurysm, dissection or thrombosis other than PE.

^cEvaluation of atelectasis, effusion, pneumonia, abscess, perforation and complication of surgical procedures.

^dEvaluation of emphysema, fibrosis and sarcoidosis.

^eEvaluation of pre-operative anatomy and cardiac CT.

RESULTS

The frequency of PE events found in CT examinations with different indications is presented in Table 1. The overall PE frequency was 5.0%. PE frequency was 3.9% in oncologic patients and 6.6% in non-oncologic patients. The most frequent finding of PE was symptomatic PE: 22.1% PE frequency in oncologic patients, and 15.5% PE frequency in non-oncologic patients.

Unsuspected PE (incidental and unreported) was most frequently found in oncologic patients with vessel diseases (5.8%), in non-oncologic patients with acute pulmonary diseases (3.6%) and in oncologic patients during follow-up staging (2.7%). Consider that in the latter group, 60 of 91 PE events were unreported, *i.e.* undiagnosed. The PE frequency in follow-up staging examinations (2.7%) was higher than in initial staging examinations (1.9%). No PE was found in traumatic oncologic patients and in oncologic patients with chronic pulmonary diseases.

The frequency of suspected, incidental and unreported PE events in oncologic and non-oncologic patients is presented in Figure 1.

Figure 1. The frequency of suspected, incidental and unreported pulmonary embolism (PE) events in 3270 oncologic patients with 6935 CT examinations and 3968 non-oncologic patients with 4812 CT examinations. Multiple independent PE events in the same patient were considered, but not follow-up of the same PE in the same patient.

PE was unsuspected (incidental and unreported) in 54% of all PE events in oncologic patients and in 19% of all PE events in non-oncologic patients. The difference is statistically significant ($p < 0.001$). Overall, >50% of unsuspected PE events were unreported. The PE frequency of symptomatic PE in non-oncologic patients (5.3%) is significantly higher ($p < 0.001$) than that in non-oncologic patients (1.7%).

Thrombus mass measured according to the Mastora score is shown in Table 2 (PE in oncologic patients *vs* non-oncologic patients), Table 3 (suspected *vs* unsuspected PE) and Table 4 (reported *vs* unreported PE).

The thrombus mass on each level and on each lobe was significantly lower in oncologic patients compared with non-oncologic patients. In addition, the number of affected vessels was significantly lower in oncologic patients. In a similar way, the thrombus mass was significantly lower in unsuspected PE compared with suspected PE and in unreported PE compared with incidental PE.

DISCUSSION

Our analysis shows that the most frequent unsuspected finding of PE was in evaluations of aneurysm, dissection or thrombosis other than PE. The majority of PE events were incidental (*i.e.* reported). We presume that the attention of the radiologist was aimed at vessels in these examinations.

Surprisingly, the second most frequent unsuspected finding of PE was in the evaluation of atelectasis, effusion, pneumonia, abscess, perforation and complication of surgical procedures. Also, consider that these examinations were performed in non-oncologic patients. This is in contrast to the common paradigm that oncologic patients have a higher frequency of PE.⁶

The third most frequent unsuspected finding of PE was in follow-up staging examinations in oncologic patients. Follow-up staging examinations are commonly performed shortly after therapeutic procedures like radiation, chemotherapy or implantation of port devices. These procedures are considered a risk factor for the development of PE.^{7,8} Furthermore, patients tend to have a more progressed stage of cancer in follow-up examinations than in initial staging examinations. Therefore, this finding underlines the association of cancer progress and increased risk of thrombosis.⁶

In the group of unsuspected PE, >50% was not reported, *i.e.* overseen by the initially reviewing radiologist. Therefore, unreported PE must not be underestimated.

Significantly more PE events were found in CT examinations of non-oncologic patients. Consider that these numbers refer to the frequency of PE events per examination and not per patient. In this study, the average number of CT examinations per patient was 2.1 in oncologic patients and 1.2 in non-oncologic patients. Therefore, the PE frequency per patient is different as described earlier.¹

The thrombus mass was significantly lower in oncologic patients compared with non-oncologic patients. The difference might be due to a speculative number of cases with tumour

Table 2. Thrombus distribution in oncologic and non-oncologic patients with pulmonary embolism

Thrombus characteristics	Oncologic ^a (n = 269)	Non-oncologic ^a (n = 316)	p-value
Thrombus mass			
Global obstruction (Mastora score), (%)	11 (4–36)	18 (6–56)	0.0003
Number of affected vessels (count)	4 (2–10)	6 (3–17)	0.0001
Thrombus distribution by level			
Central obstruction (%)	0 (0–0)	0 (0–8)	0.0071
Lobar obstruction (%)	7 (0–17)	10 (3–30)	0.0009
Segmental obstruction (%)	5 (2–12)	8 (3–22)	0.0001
Thrombus distribution by lobe			
Upper lobe obstruction (%)	2 (0–12)	5 (0–23)	0.0002
Middle lobe obstruction (%)	0 (0–12)	3 (0–25)	0.0004
Lower lobe obstruction (%)	8 (2–19)	12 (4–26)	0.0057

Measurements are sorted in order of ascending *p*-value.

^aMedian (25–75% interquartile range) of metric variables and percent (number) of categorical variables.

embolism. Tumour embolism describes the finding of cellular material from a distant tumour site in the pulmonary arteries. Tumour embolism is radiologically indistinguishable from thromboembolism.⁹

The thrombus mass was significantly lower in unsuspected PE compared with suspected PE. An increased thrombus mass correlated with the presence of acute right ventricular dysfunction/strain and increased pulmonary artery pressure.^{4,10,11} Therefore, a higher thrombus mass is more likely to cause clinical symptoms.

The thrombus mass was significantly lower in unreported PE compared with incidental PE. Presumably, the search error,^{12,13} i.e. the thrombus is never fixed by the eyes of the reviewer, is the most common reason why unsuspected PE stays unreported.

Our study is limited as a single-centre analysis. Standard CT examinations were not optimized for the detection of pulmonary emboli. Poor contrast may have prevented the detection of small emboli, even during the review process, in a number of cases. Therefore, the frequency of unreported PE may have been underestimated.

CONCLUSION

The radiologist should pay special attention to pulmonary vessels, even when not asked for PE, in the following CT examinations: evaluation of acute pulmonary disease and follow-up staging. Significant differences in thrombus mass in oncologic and non-oncologic patients might indicate different mechanisms of PE. Whether PE is suspected or not and found or not highly depends on thrombus mass.

Table 3. Thrombus distribution in suspected and unsuspected (= incidental and unreported) pulmonary embolism events

Thrombus characteristics	Suspected ^a (n = 378)	Unsuspected ^a (n = 207)	p-value
Thrombus mass			
Global obstruction (Mastora score) (%)	25 (6–63)	8 (4–20)	<0.0001
Number of affected vessels (count)	7 (3–18)	3 (2–6)	<0.0001
Thrombus distribution by level			
Central obstruction, (%)	0 (0–8)	0 (0–0)	<0.0001
Lobar obstruction, (%)	13 (3–33)	3 (0–10)	<0.0001
Segmental obstruction, (%)	10 (3–25)	4 (2–8)	<0.0001
Thrombus distribution by lobe			
Upper lobe obstruction, (%)	7 (0–27)	0 (0–3)	<0.0001
Middle lobe obstruction, (%)	7 (0–27)	0 (0–5)	<0.0001
Lower lobe obstruction, (%)	14 (3–30)	8 (4–15)	<0.0001

Measurements are sorted in order of ascending *p* value.

^aMedian (25–75% interquartile range) of metric variables and percent (number) of categorical variables.

Table 4. Thrombus distribution in incidental and unreported pulmonary embolism events

Thrombus characteristics	Incidental ^a (n = 93)	Unreported ^a (n = 114)	p-value
Thrombus mass			
Global obstruction (Mastora score), (%)	17 (6–33)	6 (3–12)	<0.0001
Number of affected vessels (count)	6 (3–10)	2 (1–4)	<0.0001
Thrombus distribution by level			
Central obstruction (%)	0 (0–4)	0 (0–0)	0.0003
Lobar obstruction (%)	10 (3–17)	3 (0–7)	<0.0001
Segmental obstruction (%)	5 (3–12)	3 (2–6)	<0.0001
Thrombus distribution by lobe			
Upper lobe obstruction (%)	2 (0–12)	0 (0–0)	<0.0001
Middle lobe obstruction (%)	2 (0–8)	0 (0–0)	<0.0001
Lower lobe obstruction (%)	10 (5–19)	6 (2–12)	<0.0001

Measurements are sorted in order of ascending *p* value.

^aMedian (25–75% interquartile range) of metric variables and percent (number) of categorical variables.

REFERENCES

- Bach AG, Schmoll HJ, Beckel C, Behrmann C, Spielmann RP, Wienke A, et al. Pulmonary embolism in oncologic patients: frequency and embolus burden of symptomatic and unsuspected events. *Acta Radiol* 2014; **55**: 45–53. doi: [10.1177/0284185113491569](https://doi.org/10.1177/0284185113491569)
- Dentali F, Ageno W, Becattini C, Galli L, Gianni M, Riva N, et al. Prevalence and clinical history of incidental, asymptomatic pulmonary embolism: a meta-analysis. *Thromb Res* 2010; **125**: 518–22. doi: [10.1016/j.thromres.2010.03.016](https://doi.org/10.1016/j.thromres.2010.03.016)
- Mastora I, Remy-Jardin M, Masson P, Galland E, Delannoy V, Bauchart JJ, et al. Severity of acute pulmonary embolism: evaluation of a new spiral CT angiographic score in correlation with echocardiographic data. *Eur Radiol* 2003; **13**: 29–35. doi: [10.1007/s00330-002-1515-y](https://doi.org/10.1007/s00330-002-1515-y)
- Engelke C, Rummeny EJ, Marten K. Acute pulmonary embolism on MDCT of the chest: prediction of cor pulmonale and short-term patient survival from morphologic embolus burden. *AJR Am J Roentgenol* 2006; **186**: 1265–71. doi: [10.2214/AJR.05.0650](https://doi.org/10.2214/AJR.05.0650)
- Vedovati MC, Germini F, Agnelli G, Becattini C. Prognostic role of embolic burden assessed at computed tomography angiography in patients with acute pulmonary embolism: systematic review and meta-analysis. *J Thromb Haemost* 2013; **11**: 2092–102. doi: [10.1111/jth.12429](https://doi.org/10.1111/jth.12429)
- Noble S, Pasi J. Epidemiology and pathophysiology of cancer-associated thrombosis. *Br J Cancer* 2010; **102**(Suppl. 1): S2–9. doi: [10.1038/sj.bjc.6605599](https://doi.org/10.1038/sj.bjc.6605599)
- Khorana AA, Francis CW, Culakova E, Kuderer NM, Lyman GH. Frequency, risk factors, and trends for venous thromboembolism among hospitalized cancer patients. *Cancer* 2007; **110**: 2339–46. doi: [10.1002/cncr.23062](https://doi.org/10.1002/cncr.23062)
- Lee AY, Levine MN. Venous thromboembolism and cancer: risks and outcomes. *Circulation* 2003; **107**(23 Suppl. 1): I17–21. doi: [10.1161/01.CIR.0000078466.72504.AC](https://doi.org/10.1161/01.CIR.0000078466.72504.AC)
- Bach AG, Restrepo CS, Abbas J, Villanueva A, Lorenzo Dus MJ, Schopf R, et al. Imaging of nonthrombotic pulmonary embolism: biological materials, nonbiological materials, and foreign bodies. *Eur J Radiol* 2013; **82**: e120–41.
- Goldhaber SZ, Elliott CG. Acute pulmonary embolism: part I: epidemiology, pathophysiology, and diagnosis. *Circulation* 2003; **108**: 2726–9. doi: [10.1161/01.CIR.0000097829.89204.0C](https://doi.org/10.1161/01.CIR.0000097829.89204.0C)
- Remy-Jardin M, Mastora I, Remy J. Pulmonary embolus imaging with multislice CT. *Radiol Clin North Am* 2003; **41**: 507–19. doi: [10.1016/S0033-8389\(03\)00028-9](https://doi.org/10.1016/S0033-8389(03)00028-9)
- Kundel HL, Nodine CF, Carmody D. Visual scanning, pattern recognition and decision-making in pulmonary nodule detection. *Invest Radiol* 1978; **13**: 175–81. doi: [10.1097/00004424-197805000-00001](https://doi.org/10.1097/00004424-197805000-00001)
- Krupinski EA. Current perspectives in medical image perception. *Atten Percept Psychophys* 2010; **72**: 1205–17. doi: [10.3758/APP.72.5.1205](https://doi.org/10.3758/APP.72.5.1205)