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ORIGINAL ARTICLE

Safety of ruling out acute pulmonary embolism by normal computed tomography pulmonary angiography in patients with an indication for computed tomography: systematic review and meta-analysis

I. C. M. MOS,*[1] F. A. KLOK,*[1] L. J. M. KROFT,† A. DE ROOS,† O. M. DEKKERS‡ and M. V. HUISMAN*
Section of Vascular Medicine, Department of General Internal Medicine – Endocrinology; †Department of Radiology; and ‡Department of Clinical Epidemiology and Department of Endocrinology and Metabolic Diseases, LUMC, Leiden, the Netherlands

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Summary. *Introduction*: Several outcome studies have ruled out acute pulmonary embolism (PE) by normal computed tomography pulmonary angiography (CTPA). We performed a meta-analysis in order to determine the safety of this strategy in a specific group of patients with a strict indication for CTPA, that is, 'likely' or 'high' clinical probability for PE, an elevated D-dimer concentration, or both. *Methods*: Studies that ruled out PE by normal CTPA, with or without subsequent normal bilateral compression ultrasonography (CUS), in patients with a strict indication for CTPA, were searched for in Medline, EMBASE, Web of Science and the Cochrane dataset. The primary endpoint was the occurrence of (fatal) venous thromboembolism (VTE) in a 3-month follow-up period. *Results*: Three studies were identified that excluded PE by CTPA alone (2020 patients), and three studies that performed additional CUS of the legs after normal CTPA (1069 patients). The pooled incidence of VTE at 3 months was 1.2% [95% confidence interval (CI) 0.8–1.8] based on a normal CTPA result as a sole test, and 1.1% (95% CI 0.6–2.0) based on normal CTPA and negative CUS findings, resulting in negative predictive values of 98.8% (95% CI 98.2–99.2) and 98.9% (95% CI 98.0–99.4), respectively. This compares favorably with the VTE failure rate after normal pulmonary angiography (1.7%, 95% CI 1.0–2.7). The risk of fatal PE did not differ between the diagnostic strategies (0.6% vs. 0.5%). *Conclusion*: A normal CTPA result alone can safely exclude PE in all patients in whom CTPA is required to rule out this disease. There is no need for additional ultrasonography to rule out VTE in these patients.

Correspondence: Menno V. Huisman, LUMC (C4-68), Albinusdreef 2, Postbus 9600, 2300 RC Leiden, the Netherlands.
Tel.: +3171 5262085; fax: +3171 5248140.
E-mail: M.V.Huisman@LUMC.nl

[1]These authors contributed equally to this work.

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Introduction

Computed tomography pulmonary angiography (CTPA) is currently the preferred thoracic imaging test for patients suspected of having pulmonary embolism (PE) [1]. This is the result of the high negative predictive value (NPV) of CTPA, which has been shown to range from 98.7% to 99.9% [2,3]. In addition, it has been demonstrated that there is no necessity to perform additional imaging, for example compression ultrasonography (CUS), after normal multidetector-row CTPA before excluding venous thromboembolic disease and withholding anticoagulant therapy [2,3]. However, in these studies, patients with 'low' and 'intermediate' as well as patients with 'high' clinical pretest probability of having PE were selected for CTPA. In several recent studies, it has been shown that acute PE can be ruled out without the need for radiological imaging tests in a specific patient population with 'low' or 'unlikely' clinical probability of having PE in combination with a normal high-sensitivity D-dimer test result [4–6]. As the NPV of a test is dependent on the incidence of the disease in the tested population, the NPV of CTPA in patients in whom PE cannot be ruled out by a clinical decision rule (CDR) and a D-dimer test, that is, with 'likely' or 'high' pretest probability for PE or an abnormal D-dimer test result (incidence of PE 37–47% [7]), is likely to be less favorable than the NPV of CTPA in the overall population suspected of having PE (incidence of PE 20–26% [7]). Furthermore, several studies have shown that, despite a negative CTPA result, deep vein thrombosis (DVT) can be identified by compression ultrasonography in patients with suspected PE [4,8,9].

Our objective was to perform a systematic review and meta-analysis to determine the safety of excluding acute PE on the basis of a normal CTPA result alone for all patients with clinically suspected acute PE and a strict indication for CTPA to rule out PE, that is, with a 'likely' or 'high' clinical probability or an elevated D-dimer concentration. In addition, we studied the additional value of CUS after a normal CTPA result in this specific patient cohort.

Materials and methods

Data sources

A literature search was performed to identify all published prospective outcome studies that excluded PE on the basis of a normal CTPA result. MEDLINE, EMBASE, Web of Science and the Cochrane dataset were searched, using predefined search terms. Search criteria included 'pulmonary embolism' or 'venous thromboembolism' or 'venous thrombosis' and 'computed tomography' or 'spiral CT'; a complete overview of the search criteria is given in the Appendix. Articles published from January 1990 until September 2008 were eligible for this analysis. Articles were not limited to the English language. All references of the included studies were reviewed for potentially relevant articles.

Study outcome

The outcome of this meta-analysis was the NPV of CTPA and the safety of withholding anticoagulant therapy on the basis of a normal CTPA result in patients with a strict indication for CTPA, that is, a CDR indicating 'likely' or 'high' probability, an elevated D-dimer concentration, or both. Endpoints were objectively confirmed adverse thrombotic events subsequent to a normal CTPA result, including all occurrences of venous thromboembolism (VTE), that is, both DVT and PE, and mortality attributable to PE.

Study selection and inclusion criteria

Mandatory for inclusion was a diagnostic strategy based on a CDR and a D-dimer test without additional imaging tests prior to CT scanning. In addition to studies that used CTPA as the only imaging test, we also included studies that had used CUS of the legs following a normal CTPA result to study the additional value of CUS for ruling out VTE. Further criteria for selection were: a prospective design, consecutive selection, predefined endpoints, clear descriptions of inclusion and exclusion criteria, and a clinical follow-up of more than 1 month. Two reviewers (I.M. and F.K.) independently reviewed all identified studies. In cases of disagreement, a third reviewer (M.H.) was consulted.

Data abstraction

Data regarding study design, patient characteristics, diagnostic algorithm [CDR, D-dimer assay, and computed tomography (CT) modality], follow-up period, completeness of follow-up and endpoints were abstracted by two independent researchers. Guidelines proposed by the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group were followed for extraction and presentation of the data [10]. Individual study quality was assessed by the following items: patient enrollment, outcome assessment, duration of follow-up, loss-to-follow-up, and funding source.

Statistical analysis

We identified the reported number of objectively confirmed VTEs and in addition all deaths attributed to PE for each study. Patients who received anticoagulants for reasons other than VTE and patients who were lost to follow-up were excluded from the analysis. A meta-analysis was performed by pooling the proportions in a fixed effects model as well as in a random effects model. Because the criteria for the performance of CTPA in the included studies were comparable, the disease incidence was expected to be similar between the studies. For this reason, pooling of the NPV was reasonable. The proportions were weighted according to the inverse of the squared standard error. The proportions and confidence intervals (CIs) shown in the text represent a fixed effects model calculated proportion. Studies with CTPA alone and with additional CUS following a normal CTPA result were pooled separately. For assessment of heterogeneity, I^2 was calculated for all comparisons [11]. We defined the upper limit of the 95% CI of the fatal and non-fatal 3-month thromboembolic rate after a normal invasive pulmonary angiography as the cut-off point for the safe exclusion of PE by CTPA, and thereby compared CTPA with the reference standard. For assessment of the effect of the additive use of CUS following a normal CTPA result on mortality, the weighted relative risk of fatal PE was calculated. Finally, the sensitivity of both diagnostic strategies was calculated. For statistical analysis, SPSS version 16.0 and COMPREHENSIVE META-ANALYSIS (version 2.0; Biostat, Englewood, NJ, USA) were used.

Results

Study selection

The literature search revealed 1075 studies; 1052 studies were excluded after review of title and abstract, and 23 studies were identified for more detailed evaluation. After full review, an additional 18 studies were excluded owing to a diagnostic algorithm that did not meet our predefined criteria, that is, no CDR, D-dimer test or CTPA performed, or performance of supplementary imaging before the CTPA. Three studies using CTPA without further imaging [5,12,13] and three studies that incorporated CUS after the CTPA [4,8,9] were left for inclusion in this meta-analysis (Fig. 1). No new articles were identified by reviewing the references of these included studies.

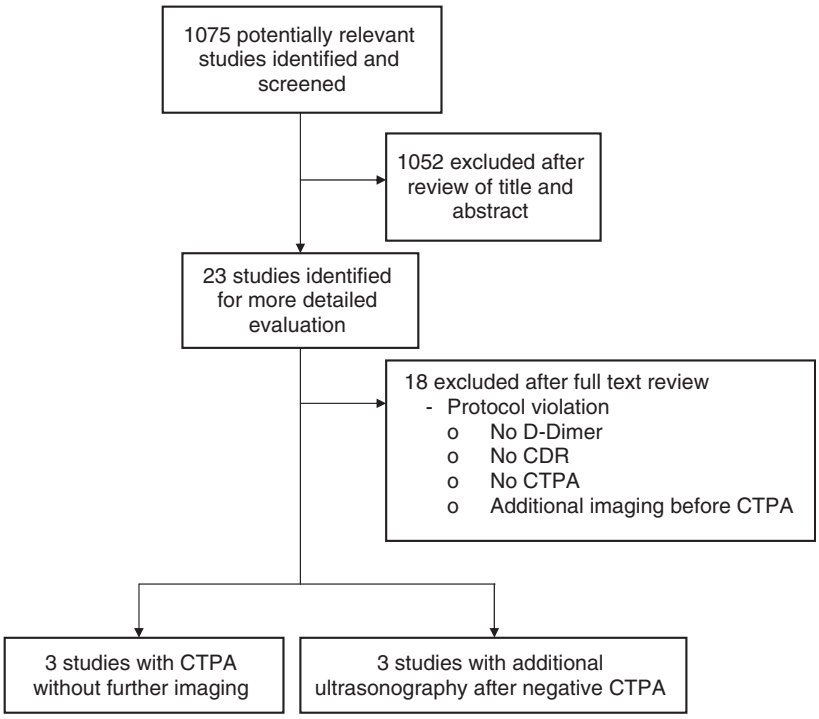

Fig. 1. Flow diagram of study selection. CDR, clinical decision rule; CTPA, computed tomography pulmonary angiography.

Quality and characteristics of included studies

All six included studies were of a prospective design with consecutive patient enrollment. The duration of follow-up was 3 months in all studies, and loss to follow-up varied between 0.0% and 1.3% (Table 1). The demographic characteristics of patients in the studies were comparable (Table 2). The mean age varied from 50.2 to 60 years, the proportion of males ranged between 35% and 46%, and the majority of patients were outpatients (Table 2). Different CDRs were used, that is, the Geneva score [14], the revised Geneva score [15,16], the Wells rule [17], or the Hyers criteria [18], in a two-level or three-level scheme (Table 2). Also, different quantitative D-dimer tests were used: VIDAS D-dimer assay (BioMérieux, Marcy-l'Etoile, France), STA Liatest (Diagnostica Stago, Asnières, France), SimpliRED (Agen Biomedical Limited, Acaccia Ridge, Australia), Tinaquant assay (Roche Diagnostica, Mannheim, Germany), and an immunoturbimetric latex agglutination assay (IL-Test; Instrumentation Laboratory, Lexington, MA, USA). Furthermore, the use of single-detector or multi-detector row CT modalities varied between the studies (Table 2). In two studies, patients were randomized between two diagnostic strategies, that is, CTPA or ventilation/perfusion scintigraphy and CTPA, or CUS preceding CTPA [4,12]. Only the patients randomized to CTPA were included in this analysis. Overall, the fraction of patients who had an indication for CTPA was 70% (range: 35%–93%). The overall proportion of inconclusive CT scan results was reported to be 1.8% (range: 0.9%–4.6%). The overall incidence of PE by positive CTPA in these cohorts was 28% (range: 18%–36%).

Meta-analysis

Three studies were identified that excluded PE in symptomatic patients with an indication for CT-scanning based on a normal CTPA result without additional imaging tests. Of all 2020 patients with an initial normal CTPA result, 25 (1.2%, 95% CI 0.80–1.8) were diagnosed with VTE in a 3-month follow-up period (Tables 3 and 4; Fig. 2). Of these, 12 (12/2020; 0.60%, 95% CI 0.40–1.1) were classified as fatal PE. Markedly, in only two of these 12 patients, an autopsy was performed, and PE was objectively identified as the cause of death. The NPV for symptomatic VTE in 3 months following a normal CTPA result in patients with an indication for CTPA was 98.8% (95% CI 98.2–99.2).

In the three studies that included CUS of the legs subsequent to a normal CTPA result, 1069 symptomatic patients with an indication for CTPA and eventually a normal CTPA result were identified. Twenty-one cases of DVT (21/1069; 2.4%, 95% CI 1.6–3.7) were identified by CUS performed shortly after the CTPA (Tables 3 and 4). During 3 months of follow-up, nine additional patients (9/1048; 1.1%, 95% CI 0.60–2.0) with an initially normal CTPA result and a normal CUS result were diagnosed with symptomatic VTE. Four of these 1048 patients in whom VTE was excluded, and who were not treated with anticoagulants, died (4/1048; 0.50%, 95% CI 0.20–1.1), possibly as a consequence of PE. The NPV for symptomatic VTE in 3 months after a normal CTPA result followed by CUS was 98.9% (95% CI 98.0–99.4). Therefore, the NPV of CTPA alone was equal to the NPV of CTPA followed by CUS (98.8% vs. 98.9%).

Table 1 Study quality assessment

Study	Study design	Patient enrollment	Outcome assessment	Duration of follow-up (months)	Lost to follow-up (*n*, %)	Funding source
van Belle *et al.* [5]	Multicenter	Prospective, consecutive	Radiologist and adjudication committee blinded	3	4 (0.1)	Unrestricted grants from the participating hospitals
Righini *et al.* [12]	Multicenter RCT	Prospective, consecutive	Independent and adjudication committee blinded	3	1 (0.1)	Grant from the Swiss National Research Foundation, from the Projects Hospitaliers de Recherche Clinique and from Pneumonlogie Développement
Ghanima *et al.* [13]	Single center	Prospective, consecutive	Independent adjudication committee	3	0 (0)	Grant from the Eastern Norway Regional Health Authory
Anderson *et al.* [9]	Multicenter	Prospective, consecutive	Laboratory, radiologist and adjudication committee blinded	3	11 (1.3)	Grant from Heart and Stroke Foundation of Nova Scotia
Anderson *et al.* [4]	Multicenter RCT	Prospective, consecutive	Radiologists and adjudication committee blinded	3	7 (1)	Grant from the Canadian Institutes of Health Research
Perrier *et al.* [8]	Multicenter	Prospective, consecutive	Independent adjudication committee	3	4 (1.2)	Grant from the Hirsch Fund of the University of Geneva

RCT, randomized controlled trial.

Table 2 Patient characteristics of included studies

Study	Total study population (*n*)	Age, years (± SD)	Male (*n*, %)	History of VTE (*n*, %)	Cancer (*n*, %)	Recent surgery, immobilization or trauma (*n*, %)	Outpatients (*n*, %)	CDR (two-level or three-level scheme)*	Design	Single-slice CT/MSCT	D-dimer test
van Belle *et al.* [5]	3306	53.0 (18)	1409 (43)	480 (15)	476 (14)	610 (19)	2701 (82)	Wells (two-level)	Multicenter	Single-slice/ MSCT	VIDAS/Tinaquant
Righini *et al.* [12]	901†	59.5 (19)	410 (46)	121 (14)	72 (8.0)	59 (6.5)‡	901 (100)	RGS (three-level)	Multicenter	MSCT	VIDAS
Ghanima *et al.* [13]	432	58	201 (47)	43 (10)	31 (7.2)	38 (8.8)	432 (100)	Hyers criteria (three-level)	Single-center	MSCT	STA-Lia
Anderson *et al.* [9]	858	50.2 (18)	300 (35)	77 (9.0)	58 (6.8)	160 (19)	858 (100)	Wells (three-level)	Multicenter	Single-slice	SimpliRED/IL test§
Anderson *et al.* [4]	694†	53.3 (19)	259 (37)	64 (9.2)	67 (9.7)	161 (23)‡	619 (90)	Wells (two-level)	Multicenter	Single-slice/ MSCT	Local practice
Perrier *et al.* [8]	756	60 (19)	302 (40)	142 (19)	75 (9.9)	146 (19)	756 (100)	GS (three-level)	Multicenter	MSCT	VIDAS

CDR, clinical decision rule; CT, computed tomography; GS, Geneva score; MSCT, multislice CT scan; RGS, revised Geneva score; SD, standard deviation; VTE, venous thromboembolism. *Two-level scheme, likely/less likely; three-level scheme, low, intermediate and high clinical probability. †Only patients included in the CT group after randomization. ‡Number of patients with recent immobilization not mentioned. §Immunoturbimetric latex agglutination assay.

Table 3 Outcome of negative computed tomography (CT) scans of the included studies

Study	Total study population (*n*)	CTPA performed (*n*, %)	Inconclusive CTPA result (*n*, %)	CTPA positive for PE (*n*, %)	CTPA negative for PE (*n*, %)	Resulting study population* (*n*)	VTE in follow-up (by immediate CUS according to protocol/ symptomatic)	Fatal PE (certain/ possible) (*n*/*n*)
CTPA alone								
van Belle *et al.* [5]	3306	2249 (68)	20 (0.9)	647 (30)	1505 (67)	1435	–/18	2/5
Righini *et al.* [12]	838†	558 (67)	15 (2.7)	179 (32)	364 (65)	364‡	–/5	0/3
Ghanima *et al.* [13]	432†	329 (76)	15 (4.6)	93 (28)	221 (67)	221	–/2	0/2
CTPA followed by CUS								
Anderson *et al.* 2005 [9]	858	300 (35)§	8¶ (1.7)	59 (20)	241 (80)	241**	11/0	0/0
Anderson *et al.* 2007 [4]	694	646 (93)	10 (1.5)	115 (18)	531 (82)	531	7/4	0/2
Perrier *et al.* [8]	756†	524 (69)	13 (2.5)	187 (36)	324 (62)	297	3/5	0/2

CTPA, CT pulmonary angiography; CUS, compression ultrasonography; PE, pulmonary embolism; VTE, venous thromboembolism (i.e. deep vein thrombosis and pulmonary embolism). *Total number of patients with normal CTPA result, with complete follow-up, and without anticoagulant therapy. †This number does not include study patients in cases of protocol violation, lost to follow-up, or use of oral anticoagulants for other reasons than VTE. ‡In the follow-up of the complete study population without PE, one patient was lost to follow-up and 30 patients used anticoagulant therapy for other reasons than PE; the fraction of the latter patients in the normal CTPA cohort was not reported. §Only CT scans performed in case of either 'high' clinical probability or elevated D-dimer in combination with 'low' or 'intermediate' clinical probability. ¶Number of inconclusive CTPA results for all CT scans performed in this study ($n = 467$). **Of the total study population, in 26 patients PE was ruled out by other means than by CTPA (CT indicated but not performed, or inconclusive CTPA result followed by additional imaging; the fraction of the latter patients in the normal CTPA cohort was not reported).

The pooled proportions of fatal PE in follow-up were comparable (0.6% and 0.5%, Table 4), indicating a relative risk of 1.2. The use of a random effects model did not materially influence the study results (Table 4). The pooled sensitivity for detecting PE by CTPA alone was 97.3% (95% CI 96.1−98.2), and the sensitivity for detecting PE by CTPA combined with CUS was 97.4% (95% CI 95.1−98.6).

Discussion

The main finding of this study is that the NVP of CTPA for ruling out PE in a patient population with an indication for CT scanning to exclude acute PE is 98.8% (95% CI 98.2−99.2). Furthermore, the 3-month mortality risk of PE after a normal CTPA result in this particular patient population is very small (0.60%, 95% CI 0.40−1.1). Invasive pulmonary angiography is the reference standard for the diagnosis of PE [1]. The upper limit of the 95% CI of the 3-month VTE rate after normal pulmonary angiography is 2.7% [19]. If this fraction is used as the upper post-test probability limit above which it is no longer safe to rule out PE by a diagnostic test, our data show that a normal CTPA result alone is a valid criterion for the safe exclusion of acute PE, even in this specific population. Furthermore, the 3-month PE-associated mortality rate after a normal invasive pulmonary angiography result is 0.3% (95% CI 0.02−0.7), which is comparable to the pooled mortality rate observed in our study (0.60%, 95% CI 0.40−1.1) [19].

Our analysis of the three studies that included CUS after a normal CTPA result allowed us to test the additional value of CUS for ruling out VTE. In these three studies, the proportion of patients with CUS-proved DVT in spite of a normal CTPA result was low (2.4%). Furthermore, the NPV for symptomatic VTE in 3 months of follow-up of CTPA alone was comparable to the NPV of CTPA followed by CUS (98.8% and 98.9%). In accordance with this finding, the VTE-related mortality risk was not different between the diagnostic strategies.

Some additional observations require comment. We intended to study the performance of CTPA in all patients in whom this imaging modality is required to rule out PE. For this reason, our study patients had an overall moderate probability of having PE (28%). It could be reasoned that the NPV of the CTPA is lower in more selected patients with a high clinical probability than in the population that we studied here. It is of note that in the recent guidelines of the European Society of Cardiology on the diagnosis of acute PE, the safe exclusion of PE in a high clinical probability population by a normal CTPA result alone is being debated because of the possibility of false-negative CTPA results [1]. Nonetheless, no current evidence exists that additional imaging, for example CUS or ventilation/perfusion scintigraphy, would prevent VTE in a 3-month follow-up period in this small, selected group of patients. In our analysis, it was not possible to study this issue in more detail, as none of the included studies had reported the incidence of symptomatic VTE after a normal CTPA result alone in a selection of high-probability patients only. In addition, the

Table 4 Random effects model and fixed effects model proportions of study endpoints

Model	VTE in FU after normal CTPA without CUS	Fatal PE in FU after normal CTPA without CUS	Positive echo directly subsequent to normal CTPA followed by CUS	VTE in FU after normal CTPA and negative CUS	Fatal PE in FU after normal CTPA and negative CUS
Fixed	1.2	0.6	2.4	1.1	0.5
95% CI	0.8–1.8	0.4–1.1	1.6–3.7	0.6–2.0	0.2–1.1
Random	1.2	0.6	2.0	1.0	0.5
95% CI	0.8–1.8	0.4–1.1	0.7–5.2	0.4–2.3	0.2–1.1
I^2	0.000	0.000	78.98	29.35	0.000

CI, confidence interval; CTPA, computed tomography pulmonary angiography; CUS, compression ultrasonography; FU, follow-up; PE, pulmonary embolism; VTE, venous thromboembolism.

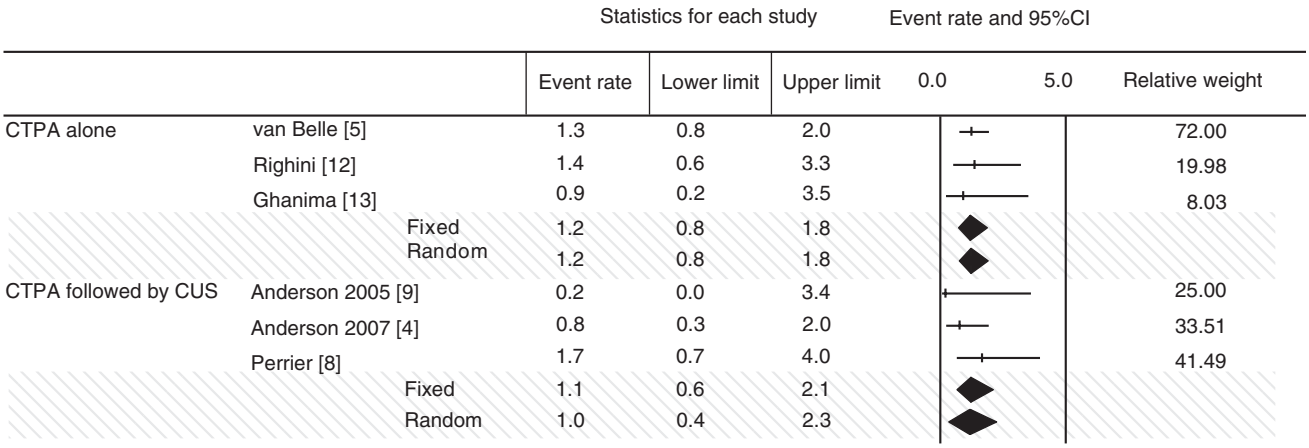

Fig. 2. Pooled proportions (fixed effects model and random effects model) of confirmed venous thromboembolism after a normal computed tomography pulmonary angiography (CTPA) result and after a normal CTPA result followed by a negative result for compression ultrasonography (CUS) of the legs.

distinction of patients with a high clinical probability for PE is clinically unpractical, because this would imply a different diagnostic strategy for the same (normal) CTPA result, as it would be unpractical and unnecessary to distinguish patients with a 'low' from patients with a 'less likely' clinical probability for the interpretation of a normal D-dimer test result. Furthermore, the best threshold, that is, CDR cut-off or D-dimer concentration cut-off, for defining a 'high'-risk population in whom a negative CTPA result does not safely rule out PE is unknown.

We consider our results to be representative, because: (i) our findings are based on a pooled analysis of a large cohort of over 3000 patients; (ii) the analyzed studies were of high quality with a prospective design, including consecutive patients and using standardized diagnostic tests; (iii) follow-up time was consistent in all studies (3 months) and all endpoints were well defined and confirmed by objective tests using predefined criteria; and (iv) the demographic characteristics of the patients were comparable between all included studies.

This meta-analysis has some limitations. It is inherent in the design of a meta-analysis that pooling observational or non-randomized data could lead to biases. Specifically for our analysis, different CDRs, D-dimer assays and CT scanners were used between the included studies. The distinct use of the CDRs, with either two-level (PE 'likely' or 'unlikely') or three-level ('low', 'intermediate' or 'high' probability of PE) schemes, resulted in differences in the fraction of patients who were eligible for CTPA without the need for D-dimer testing. Nevertheless, quantitative, highly sensitive D-dimer tests were used in all six included studies, and all patients with an abnormal D-dimer test result underwent CTPA. Thus, the different use of CDRs did not affect the overall proportion of patients that was finally selected for CTPA. Also, we could not correct for differences between the performances of single-detector-row and multi-detector-row CT scanners. In addition, all included studies reported a low number of inconclusive CTPA results (1.8%). We excluded these cases from our analysis. Finally, by study design, we could not objectively assess whether the reported VTE-related mortality was actually caused by an acute PE. Definite cause of death was only determined by autopsy in 11% of the fatal cases. As a consequence, our mortality rates are likely to be overestimated.

In summary, the NPV and safety of excluding acute PE in patients with an indication for CTPA, that is, 'likely' or 'high'

clinical probability, an elevated D-dimer concentration or both, by a normal CTPA result without further imaging tests are comparable to the NPV and safety of normal invasive pulmonary angiography. Furthermore, a strategy including CUS of the legs following a normal CTPA result did not improve diagnostic performance. The clinical implication of our findings is that anticoagulant therapy can safely be withheld in all patients with suspected PE after using CDRs and D-dimer testing, and a normal CTPA result. In our view, there is no need for additional CUS of the legs to rule out VTE in these patients.

Disclosure of Conflict of Interests

The authors state that they have no conflict of interest.

Appendix. Complete search strategy

PubMed

(''pulmonary embolism''[Mesh] OR ''pulmonary embolism'' OR ''Pulmonary Embolisms'' OR ''Pulmonary Thromboembolisms'' OR ''Pulmonary Thromboembolism'') AND (computed tomography OR ''computed tomographic'' OR ''computer tomography'' OR ''computer tomographic'' OR ''Computed Tomographies'' OR ''Computerized Tomographies'' OR ''Computerized Tomography'' OR ''Computerized Tomographic'' OR ''Computerised Tomographies'' OR ''Computerised Tomography'' OR ''Computerised Tomographic'' OR ''CAT Scan'' OR ''CAT Scans'' OR (CT[tw] AND (imaging[tw] OR screening[tw] OR diagnosis[tw] OR diagnostic[tw] OR angiography[tw]))) AND (Longitudinal Studies OR Follow-Up Studies OR Prospective Studies OR prospective OR follow-up OR followup OR RCT OR Randomized Controlled Trials OR Randomized Controlled Trial OR Randomised Controlled Trials OR Randomised Controlled Trial OR randomised OR randomized).

Web of Science

ts = (''pulmonary embolism*'' OR ''Pulmonary Thromboembolism*'') AND ts = (''computed tomograph*'' OR ''computer tomograph*'' OR ''Computerized Tomograph*'' OR ''Computerised Tomograph*'' OR ''CAT Scan*'' OR (CT AND (imaging OR screening OR diagnos* OR angiograph*))) AND ts = (longitudinal* OR ''follow-up'' OR ''follow up'' OR prospectiv* OR followup* OR RCT OR RCTS OR randomised OR randomized).

Cochrane

''pulmonary embolism''[Mesh]
''pulmonary embolism'' OR ''Pulmonary Embolisms'' OR ''Pulmonary Thromboembolisms'' OR ''Pulmonary Thromboembolism''
AND
computed tomography
''computed tomographic'' OR ''computer tomography'' OR ''computer tomographic'' OR ''Computed Tomographies'' OR ''Computerized Tomographies'' OR ''Computerized Tomography'' OR ''Computerized Tomographic'' OR ''Computerised Tomographies'' OR ''Computerised Tomography'' OR ''Computerised Tomographic'' OR ''CAT Scan'' OR ''CAT Scans''
(CT AND (imaging OR screening OR diagnos* OR angiograph*))

EMBASE

(exp Lung Embolism/ OR lung embolism$.mp OR pulmonary embolism$.mp OR pulmonary thromboembolism$.mp) AND (exp computer assisted tomography/ OR computer tomograph*.mp. OR computed tomograph*.mp OR computerized tomograph*.mp OR computerised tomograph*.mp OR CAT scan$.mp OR (CT.mp AND (imaging OR screening OR diagnos* OR angiograph*).mp)) AND (exp Longitudinal Study/ OR longitudinal stud$.mp OR follow-up stud*.mp OR exp Follow Up/ OR prospective stud*.mp OR exp Prospective Study/ OR Randomized Controlled Trial/ OR randomized.mp OR randomised.mp).

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