

Single-Detector Helical Computed Tomography as the Primary Diagnostic Test in Suspected Pulmonary Embolism: A Multicenter Clinical Management Study of 510 Patients

Marco J.L. van Strijen, MD; Wouter de Monyé, MD; Jan Schiereck, MD; Gerard J. Kieft, MD; Martin H. Prins, MD; Menno V. Huisman, MD; and Peter M.T. Pattynama, MD, for the Advances in New Technologies Evaluating the Localisation of Pulmonary Embolism (ANTELOPE) Study Group*

Background: Helical computed tomography (CT) is a readily available tool for diagnosing pulmonary embolism (PE); however, its role in the management of patients with clinically suspected PE has not been fully established.

Objective: To determine the effectiveness and safety of using helical CT of the pulmonary arteries as the primary diagnostic test in patients with suspected PE.

Design: Multicenter, prospective clinical outcome study.

Setting: Two academic hospitals and one large teaching hospital in the Netherlands.

Patients: 510 consecutive inpatients and outpatients with clinically suspected PE followed for 3 months.

Interventions: Patients underwent helical CT of the pulmonary arteries within 24 hours after presenting with signs and symptoms of PE. If CT results were normal or inconclusive, compression ultrasonography was performed on the same day as CT and repeated on days 4 and 7 if findings on the first compression ultrasonography were normal. When CT or compression ultrasonography results were positive for thromboembolism, anticoagulation was started. Anticoagulation was not started when results of CT were negative for PE or indicated an alternative diagnosis that explained the clinical signs and symptoms, or when results on serial compression ultrasonography were normal.

Measurements: Patients received instructions to report any

symptoms or signs of PE or deep venous thrombosis (DVT) during the 3-month follow-up period. The authors performed compression ultrasonography or phlebography for suspected DVT and pulmonary angiography for suspected PE.

Results: Computed tomography identified PE in 124 of 510 patients (24.3%) and an alternative diagnosis in 130 patients (25.5%); CT scans were normal in 248 patients (48.6%). The CT scan could not be interpreted in 8 patients (1.6%) and was not obtained in 2. Compression ultrasonography revealed DVT in 2 patients at the first examination; findings on repeated compression ultrasonography at days 4 and 7 were normal. Mortality in the patients with normal helical CT scans was 4.1% (10 of 246 patients). No patients in this group died of fatal PE, 1 patient developed nonfatal PE, and venous thromboembolism occurred in 0.4% of these patients (95% CI, 0% to 2.2%). In the patients with alternative diagnoses, 1 patient had DVT on objective testing during follow-up. Mortality in this group was 21.5% (28 of 130 patients); in 1 of these patients, PE could not be confidently ruled out as a contributing cause of death. Venous thromboembolism occurred in 1.5% of these patients (CI, 0.2% to 5.6%).

Conclusions: In patients with suspected PE, helical CT can be used safely as the primary diagnostic test to rule out PE. Serial compression ultrasonography has limited additional value.

Ann Intern Med. 2003;138:307-314.

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For author affiliations, see end of text.

*For a list of the Advances in New Technologies Evaluating the Localisation of Pulmonary Embolism (ANTELOPE) Study Group, see the Appendix.

The clinical diagnosis of pulmonary embolism is difficult because the symptoms are nonspecific. Therefore, objective diagnostic imaging is needed in all patients. Helical computed tomography (CT) of the pulmonary arteries is rapidly gaining acceptance as a diagnostic test for suspected pulmonary embolism. Helical CT is a relatively noninvasive procedure that can be used to diagnose pulmonary embolism by directly imaging the intravascular clot. Since the initial report on helical CT in suspected pulmonary embolism almost a decade ago (1), numerous validation studies have evaluated the accuracy of helical CT; overall sensitivities range from 64% to 100% and specificities range from 89% to 100% (2–4). It has become evident that helical CT cannot identify all patients with pulmonary embolism because it may miss clots confined to the subsegmental pulmonary artery branches. An advantage of he-

lical CT is that it can provide an alternative diagnosis to explain the patient's signs and symptoms. This is relevant because pulmonary embolism is not confirmed in two thirds of the patients in whom it was clinically suspected. From theoretical cost-effectiveness analyses, an optimal diagnostic strategy would combine helical CT with compression ultrasonography to detect venous thromboembolism (5). However, these analyses have not been validated by prospective clinical management studies in consecutive patients with suspected pulmonary embolism (5, 6).

We performed a prospective outcome study in consecutive patients with suspected pulmonary embolism to evaluate a simple, relatively noninvasive diagnostic algorithm consisting of single-detector helical CT followed by serial venous compression ultrasonography of the veins in the lower limbs.

Context

One strategy for diagnosing pulmonary embolism is helical computed tomography (CT) of the pulmonary arteries followed by compression ultrasonography of the leg veins if the CT scan shows no embolism and no clear alternative diagnosis.

Contribution

This prospective study of 510 patients with clinically suspected pulmonary embolism found that one third of the CT scans that were negative for emboli identified alternative diagnoses. Only 2 of the 248 patients with negative CT scans and no alternative diagnoses had positive results on venous compression ultrasonography. 376 patients had no evidence of emboli on CT scans and did not receive anticoagulant therapy; 2 had documented thromboembolism during 3 months of follow-up.

Implications

Helical CT alone misses few clinically important pulmonary embolisms.

—The Editors

ter, Utrecht; and Leyenburg Hospital, The Hague) participated in this clinical management study, which was part of the Advances in New Technologies Evaluating the Localisation of Pulmonary Embolism (ANTELOPE) multi-center initiative. The Ethics Committees of the participating centers approved the study protocol.

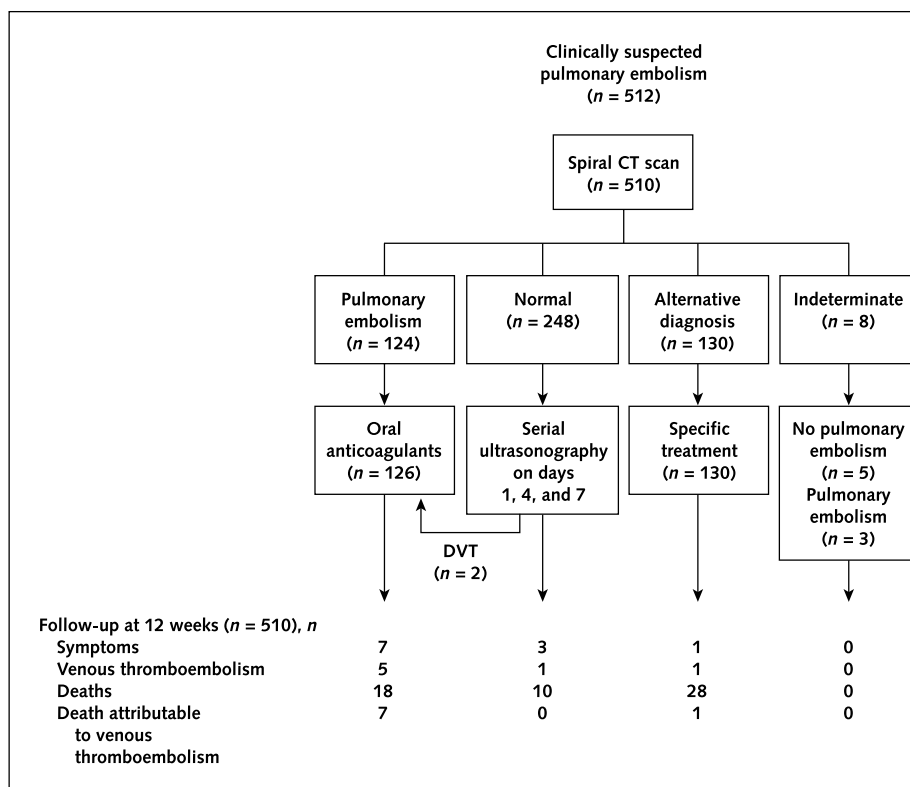
The **Figure** shows the diagnostic strategy of the study. All included patients underwent helical CT of the pulmonary arteries within 24 hours after they presented with signs and symptoms of pulmonary embolism. Anticoagulant therapy was started when the CT scan showed pulmonary embolism. When results of CT were negative for pulmonary embolism but identified a clear alternative diagnosis that explained the patient's clinical signs and symptoms, pulmonary embolism was considered absent and anticoagulant treatment was not started. A normal or inconclusive CT scan that did not show an alternative diagnosis was followed by compression ultrasonography on day 1. If findings on this first compression ultrasonography examination were normal, the study was repeated on days 4 and 7. The finding of deep venous thrombosis (DVT) on serial compression ultrasonography established a classifying diagnosis of pulmonary embolism, and anticoagulant treatment was started. In patients with normal results on serial compression ultrasonography, pulmonary embolism was considered absent and anticoagulant treatment was not

METHODS

Study Design

Three institutions in the Netherlands (Leiden University Medical Center, Leiden; Utrecht Medical Cen-

Figure. Outcomes at initial presentation and at 12 weeks in 512 patients with clinically suspected pulmonary embolism.



CT = computed tomography; DVT = deep venous thrombosis.

started. No anticoagulant treatment was given during the diagnostic work-up. To assess the safety of the diagnostic strategy, patients were followed for 3 months.

Patients

All consecutive inpatients and outpatients who presented with clinically suspected pulmonary embolism in one of the three participating centers between April 1999 and May 2000 were eligible for study enrollment (Table 1). All patients were seen by the physician on call either at the emergency or outpatient department (approximately half were seen by pulmonary physicians and half by internists). Pulmonary embolism was suspected in patients with sudden onset of unexplained dyspnea; sudden deterioration of chronic obstructive lung disease; pleuritic chest pain exaggerated by breathing; and, occasionally, hemoptysis. The preceding signs and symptoms were sometimes seen in combination with known risk factors for venous thromboembolism. We excluded patients from the study if they had undergone objective diagnostic testing for pulmonary embolism or DVT during the week preceding screening for inclusion in the study or if they had received anticoagulant therapy or heparin for more than 24 hours before being evaluated for inclusion in the study. Additional exclusion criteria were age younger than 18 years, pregnancy, or failure to obtain written informed consent.

Three-Month Follow-up

During follow-up, all patients received routine clinical care from their physicians. We instructed patients to report to the physician or to the local study coordinator immediately if they experienced signs or symptoms that suggested pulmonary embolism (dyspnea or pain on respiration) or DVT (swelling or pain in the legs). When in doubt, the study coordinator was always available for consultation. If venous thromboembolism was suspected, we used compression ultrasonography or phlebography in patients with suspected DVT and used pulmonary angiography in patients with suspected pulmonary embolism. These diagnostic tests have negative predictive values for excluding DVT and pulmonary embolism of greater than 98% (7–10). After 6 weeks and at the end of the 3-month follow-up period, the study coordinator saw all patients to assess the incidence of venous thromboembolism by completing standardized checklists. All relevant data were recorded on six separate forms that were part of the case record form; the forms provided information on contacts, diagnosis, admission, hemorrhage, mortality, and follow-up.

Adjudication

Recurring symptoms, deaths during the study, and deaths during follow-up were recorded and adjudicated by an independent adjudication committee, which was unaware of the diagnostic test outcomes and patient status. On the basis of the diagnostic and laboratory tests that were performed, the committee decided whether recurring symptoms were caused by venous thromboembolism or whether death could be attributed to venous thromboem-

Table 1. Patients Screened for the Advances in New Technologies Evaluating the Localisation of Pulmonary Embolism (ANTELOPE) Study (Part II)

Patients	Value, n
Screened	704
Excluded*	99
Age <18 y	5
Pregnancy	2
Immediate thrombolytic therapy indicated	5
Objective diagnostic work-up already started	31
Treatment already started	56
Eligible	611
Informed consent obtained	512

* Two exclusion criteria in 6 patients.

bolism, hemorrhage, or an unrelated cause. Hemorrhage was defined as major when bleeding required transfusion or the source of bleeding was located retroperitoneally or intracranially.

Imaging Studies

We used only single-detector helical CT scanners in this study. A 5-mm-per-second table feed was used to scan a 16-cm volume in the caudocranial direction from the top of the diaphragm to a level slightly above the aortic arch; a 5-mm collimation and a pitch of 1 (120 kV, 210 mA) was used. Imaging was delayed for 15 to 20 seconds after the start of the intravenous injection of contrast medium. The dose rate and total iodine dose were standardized. High creatinine serum values were not a contraindication for administering contrast medium. We took special measures, such as hydration and dialysis, to ensure patient safety. Imaging was done during a 32-second single breath hold. In patients who could not suspend respiration (very dyspneic patients), scanning was done during shallow, gentle respiration. Images were reconstructed at 2-mm intervals.

We performed gray-scale compression ultrasonography by using a 7.5- to 10-MHz, phased-array linear probe at the level of the common femoral and popliteal veins (11). Deep venous thrombosis was diagnosed when the vein could not be compressed or a clear thrombus mass could be seen in the vein. No attempts were made to image the venous trajectory between these two levels or the calf veins; a two-point compression ultrasonography examination (venous compression examined at the groin and knee level) is similar in accuracy to more extensive examination of venous compressibility along the entire length of the common femoral vein until the trifurcation of the deep calf veins (12).

CT Image Analysis

Experienced CT radiologists read the scans on a monitor that allowed cine mode viewing (scrolling) at a standard mediastinal window (window width, 350 HU; window level, 50 HU) and lung window (window width, 1500 HU; window level, 500 HU) setting. Previous study results show no difference in the reliability of experienced CT

Table 2. Clinical and Demographic Characteristics of Enrolled and Eligible Patients with Suspected Pulmonary Embolism*

Variable	Enrolled Patients	Patients without Informed Consent	Eligible Patients
Patients, <i>n</i>	512	99	611
Mean age ± SD, <i>y</i>	55.6 ± 18.1	59.6 ± 18.2	56.2 ± 18.2
Men/women, <i>n/n</i>	202/310	46/53	248/363
Inpatients, <i>n</i>	236	60	296
Outpatients, <i>n</i>	276	39	315
History of VTE, <i>n</i> (%)	67 (14)	12 (12)	79 (13)
Family history of VTE, <i>n</i> (%)	70 (14)	5 (5)†	75 (12)
Risk period for VTE, <i>n</i> (%)‡	226 (44)	63 (64)	289 (47)
Active malignancy, <i>n</i> (%)	100 (20)	21 (21)	121 (20)
Estrogen use, <i>n</i> (%)	67 (13)	NA	NA
Chronic obstructive pulmonary disease, <i>n</i> (%)	74 (14)	NA	NA
Congestive heart failure, <i>n</i> (%)	48 (9)	NA	NA

* NA = not available; VTE = venous thromboembolism.

† Incomplete information on family history of VTE in these patients.

‡ Immobilization, surgery, or trauma within 3 months of presentation.

radiologists (13). Overlapping images (now reconstructed every 3 mm) were also printed on hard-copy film at the two standard settings. Dual readings were not routinely performed because of the study design (a clinical management study). We used previously described criteria (1) to detect pulmonary embolism by CT. The quality of the CT scans was recorded in the case record form (filling of the pulmonary vessels, contrast enhancement, motion artifacts, and general readability). A CT scan was considered to be inconclusive if opacification of vessels was insufficient or major imaging artifacts were present. Alternative diagnoses were based on established criteria of radiologic practice.

Statistical Analysis

Data were centrally collected and analyzed by independent biostatisticians and epidemiologists from the Department of Clinical Epidemiology, Academic Medical Center Amsterdam. Possible outcomes were 1) presence of pulmonary embolism or DVT, 2) absence of pulmonary embolism or DVT but identification of an alternative diagnosis, 3) normal, or 4) indeterminate. In the patients who did not have pulmonary embolism or DVT, we recorded the incidence of venous thromboembolism during 3 months of follow-up. Exact 95% CIs were calculated from the binomial distribution by using Confidence Interval Analysis in SPSS statistical software (SPSS, Inc., Chicago, Illinois). The a priori acceptable upper limit of the 95% CI for the 3-month thromboembolic risk was 4%, which was based on similar outcome studies of pulmonary

embolism (14, 15). We also recorded the incidence of bleeding events in patients receiving anticoagulant treatment.

Role of the Funding Source

The funding source had no role in the design, conduct, analyses, and reporting of the study or in the decision to submit the manuscript for publication.

RESULTS

During the recruitment period, 704 patients presented with suspected pulmonary embolism; 611 were eligible (Table 1). Of these eligible patients, 99 declined (or were unable) to give written informed consent. Thus, the study sample consisted of 512 patients (202 men and 310 women), and the median age was 55.1 years (range, 18 to 96 years) (Table 2). Age, sex, and recorded risk factors for venous thromboembolism were similar in the group of eligible patients and those who were enrolled.

Results of the Diagnostic Algorithm

Helical CT was scheduled in all 512 patients who met the inclusion criteria; however, the test could not be performed in 2 patients because contrast agents were contraindicated in one patient and another patient could not maintain a supine position. Thus, helical CT scans were obtained in 510 patients (99%) (Figure).

Computed tomography showed pulmonary embolism in 124 of 510 patients (24.3%). After adjustment for activated partial thromboplastin times, all 510 patients were given intravenous unfractionated heparin for at least 5 days; oral anticoagulant therapy was also started and continued for 3 to 6 months. In 130 patients (25.5%), helical CT showed no pulmonary embolism but an alternative diagnosis that sufficiently explained the presenting symptoms (for example, aortic dissection, pneumothorax, or pneumonia) could be made. None of these 130 patients received anticoagulant therapy. We categorized the alternative diagnoses into six groups (Table 3).

Table 3. The Six Main Categories of Alternative Diagnoses

Category	Patients, %
Pneumonia	51
Malignancy	17
Progression of pleural fluid (underestimated on conventional chest radiography)	8
Cardiac failure	8
Chronic obstructive pulmonary disease	5
Other (e.g., pneumothorax, aortic dissection)	11

Results of CT were normal in 248 patients (48.6%). These patients had compression ultrasonography on day 1; thrombosis was identified in 2 patients on the first compression ultrasonography. In 1 patient, there was evidence of DVT. In another patient, compression ultrasonography was extended because the patient had a central venous line placed; thrombosis was identified in the subclavian vein at the tip of the line. Of the remaining 246 patients, compression ultrasonography was performed on day 4 in 191 patients (78%) and on day 7 in 190 (77%) patients. All findings on compression ultrasonography were normal. In all patients who did not complete ultrasonography tests according to the protocol, no anticoagulant treatment was given and the patients were followed for 3 months. In most cases, ultrasonography was not done because patients with normal findings on previous helical CT or ultrasonography did not return to the hospital.

In 8 patients (1.6%), results of CT were indeterminate or could not be interpreted. In 2 of these patients, the diagnosis was uncertain; in the remaining 6, the quality of the CT scan was insufficient. In 3 of these patients, pulmonary embolism could not be excluded; also, an alternative diagnosis could not be suggested and additional pulmonary angiography did not show pulmonary embolism. These 3 patients received oral anticoagulant therapy. The remaining 5 patients did not receive anticoagulant therapy. In 2 of these 5 patients, serial compression ultrasonography was performed and results were normal. The other 3 patients received treatment for the alternative diagnoses of pneumonia and chronic obstructive pulmonary disease.

Three-Month Follow-up

No patient was lost to follow-up. Of the 246 patients who did not receive anticoagulant therapy and who had normal CT and compression ultrasonography scans, 3 returned during the 3-month follow-up with clinical symptoms that may have been caused by venous thromboembolism. Repeated helical CT demonstrated a nonfatal pulmonary embolism in 1 patient; thus, the false-negative rate was 0.4% (CI, 0.0% to 2.2 %) and the sensitivity was 99.6%.

Of the 130 patients who were given alternative diagnoses on the basis of CT, none received anticoagulant therapy. One patient presented with possible symptoms of venous thromboembolism during follow-up, and compression ultrasonography demonstrated DVT.

Of the 129 patients who received anticoagulant therapy (124 with pulmonary embolism, 2 with DVT, and 3 without a definitive diagnosis), 7 presented with symptoms. In 5 of the 7, a thromboembolic event (DVT in 3 [diagnosed by compression ultrasonography] and pulmonary embolism in 2 [diagnosed by helical CT and pulmonary angiography]) was documented.

In the 5 patients with inconclusive results on CT who did not receive anticoagulant therapy, none returned with

Table 4. Cause of Death Compared with Possible Outcomes Based on the Diagnostic Algorithm

Cause of Death	Diagnostic Algorithm Outcomes			Total
	Pulmonary Embolism	Normal Computed Tomography Scans	Alternative Diagnosis	
	←————— <i>n</i> —————→			
Pulmonary embolism	5			5
Cardiovascular event	3	2	3	8
Malignancy	7	5	18	30
Sudden death			1*	1
Other	3	3	6	12
Total	18	10	28	56

* Pulmonary embolism could not be ruled out with confidence in this patient.

symptoms of pulmonary embolism or with hemorrhages; none of the patients died.

Table 4 presents the causes of death in patients in the three groups of possible outcomes. Death was not attributable to pulmonary embolism in any of the patients with normal results on CT. In one patient who had an alternative diagnosis, the adjudication committee could not confidently rule out pulmonary embolism as a contributing cause of death. This 74-year-old patient had an extensive mediastinal tumor mass (small-cell lung carcinoma) and died suddenly 22 days after inclusion in the study. In the group with an alternative diagnosis on helical CT, death was usually attributed to progression of malignancy. In the patients with confirmed pulmonary embolism who received anticoagulant therapy, 7 (5.6%) died as a direct consequence of their initial pulmonary embolism. Hemorrhage occurred in 20 patients (16%) and was major in 5 (6%); 2 patients had fatal bleeding episodes.

The overall results of our management strategy are as follows: 3 of 376 patients with negative results on CT for pulmonary embolism (that is, the results of CT were normal or an alternative diagnosis was made) had venous thromboembolism. Thus, the total venous thromboembolism rate was 0.8% (CI, 0.2% to 2.3%). Of note, if compression ultrasonography had not been performed, and, therefore, the 2 patients who initially had a normal helical CT scan and were found to have DVT on ultrasonography had presented with DVT at follow-up, the rate of venous thromboembolism would have been 1.3% (5 of 376 patients; CI, 0.4% to 3.1%). The rate of venous thromboembolism in the group with an alternative diagnosis was 1.5% (2 of 130 patients; CI, 0.2% to 5.6%).

DISCUSSION

With complete follow-up, our study demonstrates that helical CT is safe as the main diagnostic test in patients with suspected pulmonary embolism. In patients with normal findings on CT and compression ultrasonography and in those for whom an alternative diagnosis could be iden-

tified to explain the signs and symptoms, we could safely rule out pulmonary embolism and not administer anticoagulant therapy. Three of 376 patients (0.8%) who did not receive anticoagulant therapy had venous thromboembolism during the 3-month follow-up. This figure is similar to those of other tests for venous thromboembolism; venous thromboembolism occurred in up to 0.6% of patients after normal perfusion lung scans (16, 17) and 1.9% of patients after normal pulmonary angiograms (18). Moreover, our rate compares favorably with that of other studies evaluating normal helical CT. Four studies evaluated patients with suspected pulmonary embolism and normal results on helical CT (19–22). The venous thromboembolism rate varied from 0% to 1.4%. Of note, one of these studies was retrospective and had no follow-up in 12% of the patients (21); in another study, 8.4% of patients had no follow-up (22). Two other studies evaluated the safety of normal results on helical CT in patients who had previous ventilation–perfusion lung scintigraphy that did not show a high probability of pulmonary embolism (23, 24). In the first study of 112 patients with normal results on helical CT and on compression ultrasonography (23), 5.4% (6 of 112 patients; CI, 1.3% to 9.7%) developed pulmonary embolism or DVT during the 3-month follow-up. In the second study, 3 of 71 patients (4.2%) with normal results on helical CT developed venous thromboembolism (24). We believe that the strength of our study lies in its size, its strict adherence to the diagnostic outcome for treatment, its complete and prospective follow-up of consecutive patients, and its independent adjudication of all outcomes.

A few issues deserve comment. First, of the 611 eligible patients, 99 were not included because they declined or could not provide written informed consent. The patient characteristics of this group, however, were similar to those of the study group (Table 2), thereby obviating selection bias. Second, following the protocol of serial compression ultrasonography was difficult despite continued efforts for strict protocol adherence. All eligible patients had the first compression ultrasonography, but only 190 of 248 patients (77%) completed three compression ultrasonography sessions. The main reason that compression ultrasonography was not performed relates to the low patient adherence for returning to the hospital when previous results of helical CT and ultrasonography had been normal.

We believe that this potential bias does not invalidate our results. If anything, this bias would have resulted in some patients with DVT being erroneously assigned to the “normal” group, thereby not receiving anticoagulant therapy and having a higher incidence of venous thromboembolism. The low patient adherence and low diagnostic yield (DVT was demonstrated in 2 of 248 patients [0.8%] on serial compression ultrasonography and was not demonstrated during repeated examinations) led us to believe that it is neither practical nor effective to recommend serial compression ultrasonography in clinical practice. Of note,

even when only a normal result on helical CT would have been adequate to justify not giving anticoagulant therapy (and ultrasonography would not have been performed), the rate of venous thromboembolism would have been 1.3% (5 of 376 patients) in the 3-month follow-up. This figure is similar to the rate of venous thromboembolism reported in studies that used other tests for ruling out a diagnosis of pulmonary embolism (16–18). It should be noted that the incidence of DVT after normal single-detector helical CT for suspected pulmonary embolism was higher in studies that used CT venography. In one study (25), the incidence was 3.6% (16 of 450 patients), and in another study (26), the incidence was 5.5% (31 of 565 patients). Therefore, we believe that it may be prudent to reinforce the finding of a normal helical CT scan with compression ultrasonography on the day of referral to rule out DVT; however, this should be done only if CT does not point to an alternative diagnosis.

A potential advantage of helical CT in the work-up of suspected pulmonary embolism is that it may lead to an alternative diagnosis that explains the patient’s signs and symptoms. In our study, helical CT identified an alternative diagnosis in 130 of 512 patients (25.4%). In previous series, alternative diagnoses were identified in 30.9% (27) and 46.1% (28) of patients (Table 3). The mortality rate was relatively high in the group of patients with identified alternative diagnoses on CT. Most deaths were attributable to progression of malignancy; pulmonary embolism could not be ruled out as a possible cause of death in only one patient.

Additional refinement of the diagnostic strategy may be possible by including the pretest probability for pulmonary embolism in combination with D-dimer testing. A study shows that pulmonary embolism can be safely excluded in patients with a low clinical suspicion of pulmonary embolism and a normal D-dimer level (29). Whether these tests, when added to our diagnostic algorithm, could reduce the number of patients in whom CT has to be performed and whether it is safe not to administer anticoagulant therapy in patients with a high clinical suspicion of pulmonary embolism and normal results on helical CT should be studied prospectively.

We emphasize that our study, as well as the previous CT management studies cited earlier, used single-detector helical CT scanners. Very recently, a newer generation of helical CT scanners that use multidetector technology has become available. These scanners have several advantages for imaging the pulmonary arteries: shorter imaging time, thinner imaging sections, and more extensive coverage of the thorax. Initial experimental studies suggest higher sensitivity for small subsegmental pulmonary embolism, especially when 1-mm-thick imaging sections are used (29–31). Whether this indeed translates into a higher sensitivity and specificity for (subsegmental) pulmonary embolism remains to be determined.

In conclusion, our study shows that single-detector

helical CT can be used safely as the primary diagnostic test to evaluate suspected pulmonary embolism. The added value of serial compression ultrasonography was limited in our patients. If compression ultrasonography is required, it probably could be limited to a single examination in patients with normal helical CT scans at the day of presentation.

APPENDIX: THE ADVANCES IN NEW TECHNOLOGIES EVALUATING THE LOCALISATION OF PULMONARY EMBOLISM (ANTELOPE) STUDY GROUP

Academic Medical Center, Amsterdam, the Netherlands: B.J. Sanson, MD; H.R. Büller, MD; H.J. Baarslag, MD; J.A. Reekers.

Leiden University Medical Center, Leiden, the Netherlands: W. de Monyé, MD; P.M.T. Pattynama, MD; M.V. Huisman, MD; A.E. Meinders, MD.

Leyenburg Hospital, The Hague, the Netherlands: M.J.L. van Strijen, MD; G.J. Kieft, MD; F.E.E. Treurniet, MD; S.J. Smith, MD.

Slotervaart Hospital, Amsterdam, the Netherlands: M.R. Mac Gillavry, MD; D.P.M. Brandjes, MD; F. Turkstra.

Free University Medical Centre, Amsterdam, the Netherlands: P.J. Hagen, MD; P.E. Postmus, MD; F.G. van den Berg, MD; R.P. Golding, MD; R.A. Manoliu, MD.

University Hospital Utrecht, Utrecht, the Netherlands: I.J.C. Hartmann, MD; J.D. Banga, MD; T.H. Lo, MD; P.F.G.M. van Waes, MD.

From Leyenburg Ziekenhuis, The Hague; Leiden University Medical Center, Leiden; Utrecht Medical Center, Utrecht; and Erasmus Medical Center Rotterdam, Rotterdam, the Netherlands.

Acknowledgments: The results of this study are part of the results of the ANTELOPE Study Group (Advances in New Technologies Evaluating the Localisation of Pulmonary Embolism), a Dutch prospective multicenter trial on pulmonary embolism. The authors thank Annette van den Berg-Huijsmans, Gerda Labadie, and Ria Koolma for their help with the statistical analysis of the results and management of the data.

Grant Support: By grant D94-090 from the Dutch National Health Insurance Council (Ziekenfondsraad).

Requests for Single Reprints: Menno V. Huisman, MD, Department of General Internal Medicine, Room B3Q-84, Leiden University Medical Center, PO Box 9600, 2300 RC Leiden, the Netherlands; e-mail, m.v.huisman@lumc.nl.

Current author addresses and author contributions are available at www.annals.org.

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Current Author Addresses: Drs. van Strijen and Kieft: Department of Radiology, Leyenburg Ziekenhuis, Leyweg 275, 2545 CH The Hague, the Netherlands.

Dr. Monyé: Department of Radiology, Leiden University Medical Center, PO Box 9600, 2300 RC Leiden, the Netherlands.

Dr. Schiereck: Department of Radiology, Utrecht Medical Center, Utrecht, PO Box 85500, 3508 GA Utrecht, the Netherlands.

Dr. Prins: Department of Epidemiology, Academic Hospital Maastricht, PO Box 616, 6200 MD Maastricht, the Netherlands.

Dr. Huisman: Department of General Internal Medicine, Room B3Q-84, Leiden University Medical Center, PO Box 9600, 2300 RC Leiden, the Netherlands.

Dr. Pattynama: Department of Radiology, Erasmus Medical Center Rotterdam, PO Box 2040, 3000 CA Rotterdam, the Netherlands.

Author Contributions: Conception and design: M.J.L. van Strijen, G.J. Kieft, M.H. Prins, M.V. Huisman, P.M.T. Pattynama.

Analysis and interpretation of the data: M.J.L. van Strijen, M.H. Prins, M.V. Huisman.

Drafting of the article: M.J.L. van Strijen, M.V. Huisman, P.M.T. Pattynama.

Critical revision of the article for important intellectual content: M.J.L. van Strijen, W. de Monyé, G.J. Kieft, M.H. Prins, M.V. Huisman, P.M.T. Pattynama.

Final approval of the article: M.J.L. van Strijen, W. de Monyé, J. Schiereck, G.J. Kieft, M.H. Prins, M.V. Huisman, P.M.T. Pattynama.

Provision of study materials or patients: M.J.L. van Strijen, W. de Monyé, J. Schiereck, M.H. Prins, M.V. Huisman.

Statistical expertise: M.H. Prins.

Obtaining of funding: G.J. Kieft, M.H. Prins, P.M.T. Pattynama.

Administrative, technical, or logistic support: P.M.T. Pattynama.

Collection and assembly of data: M.J.L. van Strijen, W. de Monyé, J. Schiereck.