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ORIGINAL ARTICLE

Diagnostic work-up of patients with suspected pulmonary embolism: a survey of strategies used by emergency physicians

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PURPOSE
In this study, we aimed to document imaging practices and diagnostic strategies used by emergency physicians in patients with suspected high-probability pulmonary embolism (PE).

MATERIALS AND METHODS
A questionnaire investigating the diagnostic strategies used by the emergency physicians in the evaluation of venous thromboembolism was mailed electronically to all emergency department residents and specialists practicing in 62 medical institutions in Turkey. The questionnaire gathered information about the availability and frequency of use of diagnostic imaging modalities in different scenarios in patients with suspected high-probability PE.

RESULTS
Echocardiography, helical computed tomography (CT), and D-dimer test were the most available tools around the clock with a frequency of use of 78%, 73%, and 67%, respectively. One hundred and nineteen of 176 respondents (68%) reported that they request D-dimer "invariably" before performing an imaging examination in patients with suspected high-probability PE (SHPPE). Before ordering advanced imaging, 136 EPs (77%) would always obtain chest radiographs. Fifty-four residents (55%) and 39 specialists (51%) indicated that CTPA would likely be the first examination for patients with SHPPE and with signs of deep venous thrombosis (DVT) ($P = 0.8$). The most frequently selected examination for patients with SHPPE and without signs of DVT was CTPA, reported by 69 of the residents (70%) and 53 of the specialists (69%) ($P = 0.9$).

CONCLUSION
This survey did not show significant variations either in the practices and policies used by emergency physicians, or in the methodological approaches between specialists and residents. Among the imaging modalities, CTPA was the tool most preferred by physicians for patients with suspected acute PE.

Key words: • *venous thromboembolism* • *pulmonary embolism* • *diagnosis* • *diagnostic imaging* • *computed tomographic angiography*

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Venous thromboembolism (VTE) remains a major health problem with an annual incidence of around 1.5 per 1,000, and a mortality rate of 58% and 15% for hemodynamically unstable and stable patients, respectively (1, 2). The most important complication of VTE is pulmonary embolism (PE), for which the mortality rate is approximately 10% (3). Clinical symptoms and signs of deep venous thrombosis (DVT) and PE, together with risk classification, provide important clues for accurate diagnosis; however, clinical diagnosis alone of VTE and PE is not reliable because of its low sensitivity and specificity (2, 4). Consequently, objective diagnostic tests are needed to confirm or exclude the diagnosis of PE, and to allow for prompt management (5).

Advances in imaging equipment and techniques have enhanced diagnostic performance in the setting of acute VTE. Many tests such as computed tomography pulmonary angiography (CTPA) using helical or multi-detector helical CT (MDCT) scanners, pulmonary ventilation-perfusion (V/Q) scintigraphy, and lower extremity Doppler imaging have been used routinely for the immediate evaluation of patients with suspected PE. Nevertheless, none of these tests alone has been found sensitive enough to exclude PE definitively or to justify the decision not to start anticoagulants in these patients. Moreover, even in hemodynamically stable patients, delay in the diagnosis of PE contributes to death and disability (6). These concerns justify a low threshold to test for PE.

It is also suggested that clinicians tend to over-test for PE, as a consequence of the wide availability and increasing acceptance of modern non-invasive diagnostic strategies, and in consideration of medico-legal concerns. As a result, emergency physicians feel the necessity of requiring diagnostic tests such as D-dimer to rule out PE in patients with dyspnea or pleuritic chest pain even in the presence of very low pretest probability. For this reason, diagnosis of thromboembolic disorders including DVT and PE continues to be an important problem for the emergency physician (7).

In this study, we sought to document the attitudes of emergency physicians towards diagnostic strategies for suspected PE in different clinical scenarios.

Materials and methods

Study design and population

All emergency medicine (EM) departments in training and research hospitals, private hospitals, and state hospitals in Turkey where residents and specialists work were identified, and communication was established with these centers. Contact information was gathered for residents and specialists for whom an e-mail address or telephone number was available. Between November 2004 and May 2005, a questionnaire

was e-mailed to 181 EM residents and 157 EM specialists working in 62 institutions. Respondents were asked to complete the survey and return it by e-mail, fax, or regular mail. As a reminder, the survey was electronically mailed to participants several additional times from January to May 2005 in order to increase the response rate.

Survey content

We designed a two-page survey consisting of 12 questions. Most questions were closed-ended and in multiple-choice format. The first question addressed the availability of one laboratory assay (D-dimer) and six imaging modalities: V/Q scan, CTPA, pulmonary arteriography, color Doppler ultrasonography (US), magnetic resonance (MR) angiography, and echocardiography, 24 hours per day and 7 days per week.

In the second and third questions, respondents were asked about their attitudes toward ordering D-dimer before performing imaging examination in patients suspected of high-probability PE (SHPPE). In the second step, they were asked what they would do if D-dimer level was found to be normal in these patients. In the fourth question, respondents were asked about their attitudes on whether treatment would be initiated before the diagnosis was confirmed by imaging examinations in patients with SHPPE.

The fifth and sixth questions gathered information about whether chest radiographs of patients with SHPPE would be obtained before performing advanced imaging, and whether the interpretation of chest radiographs as normal or abnormal would influence the choice of advanced imaging test. Questions 7–9 queried the attitudes of respondents on the first choice of imaging modality in patients with and without signs of DVT and with SHPPE, and whether diagnostic examinations for PE would be required after detecting DVT in the lower extremities by Doppler US. The tenth question asked about their attitudes on the first choice of imaging modality in pregnant patients without signs of DVT and with SHPPE. In the eleventh and twelfth questions, physicians were asked how they were currently evaluating patients if embolism was not detected by helical CT angiography examination with sufficient diagnostic quality.

Data analysis

Survey responses were entered individually into a database. Results for closed-ended questions were expressed as a percentage of total responses, and were analyzed both in aggregate and by individual physician group (i.e., residents and specialists). SPSS for Windows version 11.0 (SPSS Inc., Chicago, USA) was used for statistical analysis. The frequencies and percentages were calculated. Chi square test was chosen for comparison of survey responses between residents and specialists. Associations with $P < 0.05$ were considered statistically significant.

Results

Characteristics of respondents

Of 62 institutions where EM trainees and physicians were working, 45 completed and returned surveys, representing a 73% institutional response rate. A total of 176 (52%) of 338 EPs (157 EM specialists and 181 EM residents) participated from these centers; 77 of them were EM specialists (49% of the total specialists) and 99 of them were EM residents (56% of the total residents). All of the residents were working in the emergency department of the university hospitals; 48 (62.3%) of the specialists were working at university hospitals, 12 (15.6%) at state hospitals, and 17 (22.1%) at private hospitals.

Main results

The imaging and laboratory facilities available around the clock in these centers were as follows: echocardiography in 35 (77.8%), spiral (helical) CT in 33 (73.3%), D-dimer in 30 (66.7%), color Doppler US in 28 (62.2%), V/Q scintigraphy in 12 (26.7%), MR angiography in 11 (24.4%), pulmonary arteriography in 4 (8.9%). Only 7 (4%) had all modalities available, and 37 (21%) had D-dimer + V/Q scintigraphy + spiral (helical) CT.

Seventy-seven residents (77.8%) and 42 specialists (54.5%) reported that they invariably order D-dimer test before proceeding to a radiological examination for high-probability PE ($P = 0.001$). Sixty-seven residents (68.4%), and 44 specialists (67.7%) indicated that they would order an imaging modality if D-dimer level was normal ($P = 0.531$) The numbers of physicians not initiating treatment before confirming the diagnosis by imaging modalities in patients with SHPPE were 11 residents (11.1%), and 9 specialists (11.9%) ($P = 0.274$) (Table 1).

When asked whether chest radiographs would be routinely obtained prior to advanced radiological imaging, 81 of 99 residents (81.8%), and 55 of 77 specialists (71.4%) reported that they would obtain chest radiographs ($P = 0.20$). Sixty-one of the resi-

Table 1. Physician attitudes on D-dimer utilization for the diagnosis of venous thromboembolism, and on initiating treatment before confirmation of the diagnosis

	Residents n = 99 (%)	Specialists n = 77 (%)	*P* value	Total n = 176 (%)
In a patient with SHPPE, would you require D-dimer level before ordering imaging techniques?				
Always	77 (77.8)	42 (54.5)	0.001	119 (67.6)
Frequently	13 (13.1)	17 (22.1)		30 (17.0)
Sometimes	8 (8.1)	6 (7.8)		14 (8.0)
Never	1 (1.0)	12 (15.6)		13 (7.4)
Suppose the D-dimer level is normal in a patient with SHPPE, what would you do next?				
I rule out pulmonary embolism	31 (31.6)	21 (32.3)	0.531	52 (31.9)
I order imaging tests	67 (68.4)	44 (67.7)		111 (68.1)
Would you start treatment for the patient with SHPPE before confirmation by any imaging procedure?				
Yes	43 (43.4)	42 (54.5)	0.274	85 (48.3)
No	11 (11.1)	9 (11.7)		20 (11.4)
Sometimes	45 (45.5)	26 (33.8)		71 (40.3)

SHPPE, suspected high probability pulmonary embolism.

dents (61.6%) and 38 of the specialists (49.4%) indicated that the interpretation of the chest radiographs (as normal or abnormal) would not influence the choice of advanced imaging modality in patients with SHPPE ($P = 0.157$). The numbers of physicians not ordering V/Q scintigraphy for patients with SHPPE and abnormal chest radiographs were 72 residents (72.7%) and 65 specialists (84.4%) ($P = 0.06$) (Table 2).

Fifty-four of 99 residents (54.5%), and 39 of 77 specialists (50.6%) indicated that CTPA ($P = 0.862$) would be their first choice of examination for patients with SHPPE and with the signs of DVT. Table 3 summarizes suggested diagnostic practices with respect to patients with DVT and PE.

Discussion

The use of any protocol to rule out PE depends both on the accuracy of the tests and on the feasibility of the protocol, including consideration of local resources and practice patterns (8). The present study showed that the most-available imaging modalities were echocardiography and spiral (helical) CT, followed by V/Q scintigraphy, MR angiography, and pulmonary arteriography. In general, diagnostic facilities were better in private hospitals, followed by university hospitals, and state hospitals.

D-dimer

In diagnostic algorithms for suspected VTE, D-Dimer testing has been proposed as a first-line diagnostic test following clinical assessment because of its ability to allow for safe exclusion of VTE in several clinical situations (9). Overuse of D-dimer testing in the process of ruling out PE has long been recognized as a significant problem (10). On the beneficial side, D-dimer testing can facilitate wider screening for PE, resulting in a higher rate of diagnosis of this potentially fatal condition. One hundred forty-nine of the 176 respondents in our survey (85%) indicated that D-dimer is the test of choice in cases of SHPPE, whereas 13 (7.4 %) reported that they never require this test. This result shows that the D-dimer test is overused by emergency medicine physicians in the practice of emergency departments.

According to a Level B recommendation in the British Thoracic Society (BTS) guidelines, although a negative D-dimer test reliably excludes PE in patients with low or intermediate clinical probability, and such patients do not require imaging for VTE, the D-dimer assay should not be performed in patients with high clinical probability of PE (11). Our results show that specialists are significantly less likely to order the D-dimer assay than are residents. The main explanation for this observation may be that clinicians with longer experience are more likely to consider diagnostic procedures according to the patients' clinical condition. Dunn et al. (12) found that the sensitivity of D-dimer testing for acute PE was 96.4%, and that the negative predictive value was 99.6%. However, D-dimer is not indicated in patients with suspected high-probability PE, because these patients should undergo further testing irrespective of the D-dimer test result (13,14).

Anticoagulation without imaging

Although diagnosis of PE can be difficult, early detection is important because prompt medical or surgical intervention can be life-saving. PE is a potentially life-threatening condition if not treated, but the introduction of anticoagulants has reduced the associated mortality and morbidity. The PE-related mortality rate in patients treated with anticoagulants varies between 2.5% and 5% (15). With a course of anticoagulant treatment, the recurrence rate of thromboembolic events decreases to approximately 2% to 9% over 3–6 months (16,17).

In our study, the frequency of not starting treatment without confirming the diagnosis of PE with pulmonary imaging is only 11.4% (20 of 176 physicians). As a level C recommendation in BTS guidelines, once VTE has been reliably confirmed, heparin should be given to patients with intermediate or high clinical probability before imaging, and oral anticoagulation should be commenced (11). Thus, a considerable number of patients without proven PE are subjected to the potential complications of anticoagulation. The more recently evaluated diagnostic approaches have focused on identifying patients who probably do not have PE, and therefore do not require anticoagulant therapy. Therefore, prompt and reliable diagnosis by imaging techniques is necessary.

Imaging

Various invasive and non-invasive imaging tools have been used either separately or in combination in order to confirm or exclude the presence of clot in the pulmonary arteries. These are venous compression ultrasonography, ventilation-perfusion lung scanning, CTPA, MR angiography and pulmonary catheter angiography, and echocardiography.

A normal lung scan virtually excludes PE, but an abnormal scan is often due to conditions other than PE. An abnormal chest radiograph increases the likelihood of a non-diagnostic V/Q scan (15). In our survey, 95% of the residents, and 93% of the specialists

Table 2. Physician attitudes on utilization of chest x-ray for the diagnosis of suspected high-probability pulmonary embolism and the effect on advanced diagnostic modalities

	Residents n = 99 (%)	Specialists n = 77 (%)	*P* value	Total n = 176 (%)
Would you request a chest x-ray before advanced radiological imaging procedures for a patient with SHPPE?				
Always	81 (81.8)	55 (71.4)	0.2	136 (77.3)
Frequently	13 (13.1)	15 (19.5)		28 (15.9)
Sometimes	5 (5.1)	7 (9.1)		12 (6.8)
In a patient with SHPPE and chest x-ray positive for emphysema, consolidation, mass etc., indicate which advanced diagnostic imaging technique you would not choose?				
V/Q scintigraphy	72 (72.7)	65 (84.4)	0.060	137 (77.9)
Spiral CT angiography	5 (5.1)	0 (0.0)		5 (2.8)
MR angiography	22 (22.2)	12 (15.6)		34 (19.3)

SHPPE, suspected high-probability pulmonary embolism

indicated that they require chest radiograph before the advanced radiological imaging modalities. The vast majority of respondents (73% of the residents, and 84% of the specialists) reported that they do not order V/Q scan if the chest radiograph is abnormal. Because the likelihood of a non-diagnostic perfusion scan is very high in patients with known cardiopulmonary disease or with an abnormal chest radiograph, the initial diagnostic study should be either helical CT or Doppler US; patients without DVT symptoms should start with a helical CT, and patients with DVT symptoms should start with a lower extremity Doppler (15). Combining lower-limb venous ultrasonography with CT may reduce the overall rate of false-negative results (9).

Table 3. Physician attitudes on the utilization of diagnostic methods in the evaluation of deep venous thrombosis and pulmonary embolism

	Residents n = 99 (%)	Specialists n = 77 (%)	*P* value	Total n = 176 (%)
Suppose signs of DVT are present in a case with SHPPE, which of the following would be your first choice for imaging procedure?				
V/Q scintigraphy	14 (14.1)	14 (18.2)	0.862	28 (15.9)
Spiral CT angiography	54 (54.6)	39 (50.6)		93 (52.9)
MR angiography	0 (0)	1 (1.3)		1 (0.6)
Color Doppler US	21 (21.2)	16 (20.8)		37 (21.0)
Pulmonary arteriography	3 (3.0)	2 (2.6)		5 (2.8)
Echocardiography	7 (7.1)	5 (6.5)		12 (6.8)
If a patient with SHPPE does not have signs of DVT, which imaging procedure would be your first choice?				
V/Q scintigraphy	20 (20.2)	16 (20.8)	0.966	36 (20.5)
Spiral CT angiography	69 (69.8)	53 (68.8)		122 (69.3)
MR angiography	1 (1.0)	1 (1.3)		2 (1.1)
Color Doppler US	1 (1.0)	2 (2.6)		3 (1.7)
Echocardiography	4 (4.0)	3 (3.9)		7 (4.0)
PA chest X-ray	4 (4.0)	2 (2.6)		6 (3.4)
If a pregnant with SHPPE does not have any finding of DVT, which imaging procedure would be your first choice?				
V/Q scintigraphy	8 (8.1)	7 (9.1)	0.967	15 (8.5)
Spiral CT angiography	3 (3.0)	3 (3.9)		6 (3.4)
MR angiography	27 (27.3)	19 (24.7)		46 (26.2)
Echocardiography	61 (61.6)	48 (62.3)		109 (61.9)
If spiral CT angiography with adequate diagnostic quality, shows no embolism in a patient with SHPPE what would be the next step?				
Embolism is ruled out	52 (52.5)	42 (54.5)	0.681	94 (53.4)
Other (additional) procedure is performed to rule out embolism	47 (47.5)	35 (45.5)		82 (46.6)
If spiral CT angiography with adequate diagnostic quality showed no embolism in a patient with SHPPE, which additional procedure would be your choice in your setting?				
V/Q scintigraphy	20 (40.8)	13 (36.1)	0.087	33 (38.8)
MR angiography	0 (0)	3 (8.3)		3 (3.5)
Color Doppler US	4 (8.2)	4 (11.1)		8 (9.4)
Pulmonary arteriography	20 (40.8)	16 (44.5)		36 (42.4)
Echocardiography	5 (10.2)	0 (0)		5 (5.9)

SHPPE, suspected high-probability PE; DVT, deep venous thrombosis.

CTPA has been established as the first-line diagnostic imaging modality for the detection of PE in the central pulmonary arteries, replacing ventilation-perfusion lung scintigraphy and pulmonary angiography (18,19). With the advent of CTPA, the previous advice of the BTS, that conventional pulmonary angiography should be much more widely used, has been discarded (11). This has led to changes in diagnostic strategies. Almost all hospitals in the United Kingdom have been trying to acquire the latest generation of fast multi-slice scanners (20).

In a recent meta-analysis of nine studies using eight single- and one dual-slice helical CT in 520 patients, the overall sensitivity and specificity for CTPA were reported as 86% and 94%, respectively (21). Helical CT also allows a quantitative assessment that correlates well with clinical severity (22). Moreover, when PE is excluded, the true alternative diagnoses relevant to clinical presentation may be recognized (15).

Because of the strong association between DVT and PE, the diagnostic evaluations of these two entities should be considered together (23). Approximately 50% of patients with documented DVT have perfusion defects on V/Q scan, and asymptomatic venous thrombosis is found in approximately 40% of patients with confirmed PE (24). Previous studies showed that 15% of patients with clinical symptoms of PE and a negative helical CT scan have DVT (25). Furthermore, pending results of outcome studies using MDCT, CTPA should be combined with venous ultrasonography to exclude VTE safely (26).

In our study, it was observed that almost all of the participants with DVT detected in the lower extremities by Doppler US also had clinical signs of PE, and, thus, also required a test to exclude PE. The most frequently required tests were CTPA (68%) and V/Q scintigraphy (31%). These data concur with the previous survey among United States clinicians, in which CTPA was reported to be the first-ordered test 71% of the time by all physicians, and 79% of the time by emergency physicians (27). The most frequently preferred first-line studies in patients with signs of DVT and with SHPPE were CTPA (53%) and color Doppler US (21%). The diagnostic work-up can be terminated if either

the CT scan or Doppler US is positive. However, if only one of these tests is performed and is negative, the other test should be performed (28).

In our study, the first-line imaging methods preferred by the respondents for patients without signs of DVT and with SHPPE were CTPA (69%) and V/Q scintigraphy (21%). This result emphasizes that the emergency physicians are aware of the recent transition in diagnostic strategies with the advent of CTPA, and that they have reacted accordingly. More than half of the respondents (53%) reported that they rule out embolism after a negative CTPA of diagnostic quality. This result reflects the fact that the physicians in the emergency department maintain a high level of suspicion even when CTPA is negative for SHPPE; however, a recent study showed that the negative predictive value of multi-slice CTPA plus lower-limb venography was 96% in 191 patients (29). Furthermore, the assessment of the outcome of 3,500 patients, who, because of a negative spiral CTPA, did not receive anticoagulation, showed that the negative predictive value of CT exceeds 99%, which is similar to that reported for pulmonary angiography (30). As a level A recommendation in the BTS guidelines, patients with a good quality negative CTPA do not require further investigation or treatment for PE (11).

Imaging pregnant patients with suspected pulmonary embolism

When asked which imaging modality is employed in pregnant patients with SHPPE and without DVT findings, the majority of respondents (62%) indicated echocardiography, 26% indicated MR angiography, and less than 5% of respondents indicated that they order CTPA in this setting. Echocardiography can provide useful information for clinical decision of initiating thrombolytic treatment in patients with massive or submassive PE by showing the status of right heart chambers. However, only central pulmonary vessels can be evaluated by echocardiography, and PE cannot be excluded if echocardiography is normal. In a recent survey investigating strategies among members of the Society of Thoracic Radiology, Schuster et al. (31) reported that 23 of the 43 respondents (53%) indicated CTPA as an initial study in pregnant patients with suspected PE, whereas V/Q scan was chosen as a first choice by 13 participants (30%). The striking difference in our survey can be explained by the concerns about radiation and intravenous contrast agents that may affect the fetus. However, fetal radiation exposure during CT scan in pregnant patients is well below the 5-rad limit considered to be safe fetal exposure (22). Furthermore, Winer-Muram et al. (32), have reported that CT angiography for PE is associated with a lower average fetal radiation dose (<6 mrad) than ventilation–perfusion imaging (10–37 mrad) during all trimesters. Our study demonstrates that the diagnostic strategy for suspected PE does not differ significantly between trainees and certified emergency physicians.

A possible limitation of the present study is that the questionnaire may not be adequate to reflect the diversity of practices. For example, we did not include the choice of combined CTPA or CT venography. Another limitation is that, as is inherent in all self-reported questionnaires, our survey was subjective in measuring physician perceptions regarding strategies for assessing and initiating treatment in patients with suspected PE. These perceptions may or may not accurately reflect reality, and the real practice may vary from patient to patient, and even in the same department by the same physician depending on the clinical assessment and the availability of diagnostic tests. Finally, because we limited our survey to EM physicians practicing in Turkey, our results may not be applicable to other physician groups or to those who practice in other countries.

In conclusion, this survey demonstrates that the strategies and policies of emergency physicians are in accordance with recently published studies advocating the use of non-invasive imaging modalities for the confirmation or exclusion of suspected high-probability PE. We also learned that medical facilities have sufficient diagnostic tools for the evaluation of VTE, and that CTPA and echocardiography are the most accessible tools around the clock. Neither the practices and policies of emergency physicians, nor the methodological approaches differed significantly between specialists and residents. Spiral or multi-detector-row CT angiography has become a widely available and cost-effective modality, and is widely applied, surpassing other imaging modalities for the diagnosis of PE in Turkey. Pulmonary arteriography is reserved only for patients with indeterminate imaging findings and unresolved clinical suspicion.

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