Positive Pulmonary Computed Tomography Angiography in Patients with Suspected Acute Pulmonary Embolism: Clinical Prediction Rules, Thromboembolic Risk Factors, and Implications for Appropriate Use

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Background: *Acute pulmonary embolism (PE) is associated with a variety of non-specific clinical manifestations. Using diagnostic algorithms that are based on internationally recognized guidelines, pulmonary computed tomography angiography (CTA) serves as the gold standard diagnostic imaging tool in PE. However, inappropriate use of pulmonary CTA may lead to unnecessary radiation exposure, contrast exposure, and cost. Based on our review of the literature, there is no existing data regarding prevalence and appropriate use of pulmonary CTA in suspected acute PE in Thailand.*

Objective: *To assess the prevalence of positive pulmonary CTA and evaluate appropriateness of use of pulmonary CTA, according to clinical prediction rules and recent guidelines.*

Material and Method: *Three hundred consecutive patients admitted to the general medical ward at a large university-based tertiary referral center who were sent for pulmonary CTA due to suspected acute PE were included. Prevalence of positive pulmonary CTA for PE and other abnormalities were analyzed. Baseline clinical characteristics (including thromboembolic risk factors) and basic investigations (including chest X-ray, ECG, pulse oximetry, and D-dimer) were compared between patients with and without acute PE.*

Results: *Acute PE was diagnosed by pulmonary CTA in 110 (36.7%) patients. According to Wells score and revised Geneva score, patients were categorized into low, moderate, and high probability, as follows: 63, 178, and 59 patients, respectively, and 44, 246, and 10 patients, respectively. Patients with high probability according to Wells score and revised Geneva score had higher rate of positive pulmonary CTA results, as compared to low and moderate probability (59.3%, 7.9%, and 39.3%, respectively, and 60%, 19.5%, and 38.2%, respectively). Predictors of positive CTA were sign of deep vein thrombosis (DVT) (OR: 2.6, 95% CI: 1.497-4.514; p<0.001), S1Q3T3 (OR: 4.211, 95% CI: 2.242-7.908; p<0.001), and enlarged right pulmonary artery (OR: 2.439, 95% CI: 1.475-4.035; p<0.001). Using multivariate analysis, all three parameters remained independent factors. In the Wells score low probability group, 31 of 63 patients were not tested for D-dimer prior to pulmonary CTA, with only one patient in that group being diagnosed with acute PE.*

Conclusion: *This was the first study to investigate prevalence of positive pulmonary CTA for acute PE in a large university-based tertiary referral hospital in Thailand. Prevalence of positive test for PE by pulmonary CTA in patients with suspected acute PE was approximately 33%. Sign of DVT, S1Q3T3 pattern, and enlarged right pulmonary artery were significant clinical predictors of positive pulmonary CTA. Positive pulmonary CTA result was much less likely in patients with low probability, especially in the absence of thromboembolic risk factors and positive D-dimer. This study emphasized the importance and value of accurate and effective triage in reducing both patient care costs and patient radiation exposure.*

Keywords: *Pulmonary embolism, Pulmonary computed tomography angiography, Thromboembolic risk factors, Appropriate use*

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Acute pulmonary embolism (PE) is an emergent and life-threatening condition. The mortality rate is as high as 30% in untreated patients[1,2]. Its nonspecific symptoms and signs make diagnosis difficult and may contribute to delayed diagnosis or misdiagnose.

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According to Prospective Investigation of Pulmonary Embolism Diagnosis II (PIOPED II)[3], several clinical prediction rules (e.g., Wells score, revised Geneva score, and modified Geneva score) are preferred in the stepwise diagnosis of acute PE. Accuracy of these clinical prediction rules was validated by pulmonary computed tomography

angiography (CTA), the gold standard for diagnosis of PE[4,5]. Sensitivity and specificity of pulmonary CTA were reported to be 83 to 100% and 89 to 97%, respectively[3,6-10]. Having acknowledged the strengths of pulmonary CTA in PE diagnosis, it should be noted that the procedure is expensive and not risk-free. Unnecessary pulmonary CTA may lead to unnecessary contrast exposure (e.g., contrast-induced nephropathy), unnecessary radiation exposure, and avoidable cost[6,8]. Clinical probability assessment prior to pulmonary CTA not only increases diagnostic yield, but also decreases the potential for adverse outcomes and unnecessary treatment costs.

One study from Thailand reported prevalence of acute PE of 0.28% in patients admitted in the hospital for more than three days[11]. Prevalence in Thai patients was different from rates reported in the United States and Europe, which were 0.4% and 18.3%, respectively[12]. This disparity may be explained by race-related differences in thromboembolic likelihood and accessibility to pulmonary CTA.

From the literature review, prevalence of positive pulmonary CTA for PE was low, varying from 9.84 to 16%[13,14]. This low rate of positive test result may be explained by inadequate clinical probability assessment, potentially leading to inappropriate use of pulmonary CTA. There are no reports in the literature regarding positive pulmonary CTA in PE in inpatients with suspected acute PE in Thailand. Prevalence in Thailand may be different from rates reported in previous studies due to differences in predisposing genetic factors and physician tendency or preference in requesting pulmonary CTA.

The aim of this study was to evaluate the prevalence of positive pulmonary CTA for acute PE in patients admitted to the medical ward of Siriraj Hospital. The secondary outcomes that we investigated were clinical predictors and appropriateness of the physician's order and/or indications for pulmonary CTA.

Material and Method

Patients were included who were admitted to the medical ward of Siriraj Hospital for pulmonary CTA with indications of suspected acute PE. Exclusion criteria included patients who could not complete the physical examination, patients with suboptimal image quality, and patients with repeated pulmonary CTA.

Thromboembolic risk factors

Baseline characteristics (e.g., age, gender, and underlying diseases) were recorded. Risk factors for PE were identified, including fractured hip or leg, hip or knee replacement, major general surgery, major trauma, spinal cord injury, central venous catheterization, chronic cardiac or pulmonary disease, hormone therapy, malignancy, oral contraceptive pill use, cerebrovascular disease, postpartum, previous venous thromboembolism, thrombophilia, bed rest more than three days, immobility condition, age more than 65 years, obesity, antepartum, and varicose vein.

Clinical symptoms and signs compatible with PE and deep vein thrombosis (DVT) were assessed. Sign of DVT was defined using the Wells' criteria of a calf diameter more than 3 cm compared to another calf. Basic investigations, such as electrocardiogram (ECG), chest X-ray, pulse oxymetry, arterial blood gas, and D-dimer were also analyzed.

Pretest probability for PE

Two clinical prediction scoring systems (Wells score and revised Geneva score) were used to assess pretest probability for each patient. Patients were categorized as low, moderate, and high probability for PE.

Definition of positive pulmonary CTA

Pulmonary CTA results were obtained from the radiology report. The definition used for PE in this study was direct visualization of a low attenuation filling defect that partly or completely occludes a contrast-filled pulmonary artery on pulmonary CTA[15].

Statistical analysis

All statistical analysis was performed using SPSS Statistics version 15.0 (SPSS, Inc., Chicago, IL, USA). Continuous data were expressed as mean and standard deviation, with dichotomous data being presented as numbers and percentages. Univariate analysis was performed to evaluate individual risk factors for determining probability of positive pulmonary CTA for PE. The factors with p-value <0.10 were further analyzed using multivariate analysis (enter method). A 95% confident interval was used to estimate the precision of the odds ratio. A p-value <0.05 was considered statistically significant.

Results

Three hundred consecutive patients were included. Mean age was 60 years and 63.3% of subjects were female. The most common symptom was dyspnea (87.3%). The most common signs were tachypnea (69.3%), followed by tachycardia (60.3%). Signs of

deep vein thrombosis were found in 22.7% of patients (Table 1). All patients with DVT underwent duplex ultrasound and the results revealed positive DVT in 65 patients.

Among ECG findings, sinus tachycardia was most commonly found (52%), followed by abnormal S1Q3T3 pattern (18.3%). The enlargement of right pulmonary artery by chest X-ray (defined by diameter >16 mm in male and >14 mm in female) was found in 38.7% of patients. One hundred fifty-two patients had D-dimer >500 ng/ml (Table 1).

Thromboembolic risk factors

Almost all patients (93.66%) had at least one thromboembolic factor. Among 19 patients with no identifiable risk factors, six were diagnosed as acute PE by pulmonary CTA. Risk factors for PE for each individual were categorized into strong (odds ratio: >10), moderate (odds ratio: 2-9), and weak (odds ratio: <2) thromboembolic factors (Table 2)[16]. Common risk factors were age >65 years (45.3%), malignancy (42%), chronic cardiac or respiratory disease (17.7%), and thrombophilia (15.5%). Regarding malignancy, lung cancer, non-Hodgkin lymphoma, and breast cancer were found in 9.4%, 5.4%, and 5.1% of patients, respectively. Among thrombophilias, systemic lupus erythematosus (SLE), antiphospholipid syndrome, and myeloproliferative neoplasm were diagnosed in 5%, 3.7%, and 2% of patients, respectively.

Table 1. Clinical manifestations and basic investigation in 300 patients suspected of having acute pulmonary embolism (PE)

Clinical manifestations	
Dyspnea	262
Chest pain	29
Palpitation	5
Cough	35
Hemoptysis	13
Syncope	7
Signs of DVT	68
Tachycardia (>100/minute)	181
Tachypnea (>20/minute)	208
Fever (temperature >38.5°C)	56
Hypotension (SBP <90 mmHg)	40
Cyanosis	5
Cardiac arrest	4
ECG	
Sinus tachycardia rate >100/minute	156
Sinus bradycardia rate <50/minute	3
Atrial fibrillation rate >100/minute	8
Right axis deviation	35
Right bundle branch block	20
Right ventricular hypertrophy	13
S1Q3T3 pattern	55
CXR	
PA enlargement (right PA: male >16 mm, female >14 mm)	116
ABG/pulse oxymetry	
Hypoxemia (PaO_2 <60 mmHg, O_2 saturation <90%)	256
D-dimer	
D-dimer >500	152

DVT = deep vein thrombosis; SBP = systolic blood pressure; ECG = electrocardiogram; CXR = chest X-ray; PA = pulmonary artery; ABG = arterial blood gas
All results presented as frequency

Table 2. Thromboembolic risk factors in 300 patients suspected of having acute PE

	n	%
Strong thromboembolic factors		
Fracture (hip/leg)	6	2.00
Hip/knee replacement	4	1.30
Major general surgery	8	2.70
Spinal cord injury	2	0.70
Moderate thromboembolic factors		
Central venous lines	1	0.30
Chemotherapy	24	8.00
Chronic heart or respiratory failure	53	17.70
Hormone therapy	2	0.70
Malignancy	126	42.00
Lung	28	
Breast	15	
Cervix	6	
Ovary	5	
Colorectal	3	
Stomach/esophagus	7	
Hepatocellular carcinoma	9	
Cholangiocarcinoma	3	
Prostate	7	
Non-Hodgkin lymphoma	16	
Leukemia	7	
Multiple myeloma	4	
Sarcoma	2	
Others (e.g., thymoma, unknown primary)	14	
Oral contraceptive pill	2	0.70
Paralytic stroke	16	5.30
Previous VTE	26	8.70
Thrombophilia	45	15.00
SLE	15	
Antiphospholipid syndrome	11	
Protein C/Protein S deficiency	2	
Myeloproliferative disorder	6	
Other (e.g., nephrotic syndrome)	11	
Weak thromboembolic factors		
Bed rest >3 days	38	12.70
Immobility due to sitting (e.g., prolonged car or air travel)	9	3.00
Age >65 years	136	45.30
Obesity	6	2.00
Varicose veins	6	2.00

VTE = venous thromboembolism; SLE = systemic lupus erythematosus

Results of pulmonary CTA

Pulmonary CTA was positive for PE in 110 patients (36.7%). Other results from pulmonary CTA testing are presented in Table 3.

Clinical manifestations that might be predictive signs of positive pulmonary CTA for acute PE were DVT (OR: 2.6, 95% CI: 1.497-4.514; $p = 0.001$), S1Q3T3 ECG pattern (OR: 4.211, 95% CI: 2.242-7.908; $p<0.001$), and enlargement of right pulmonary artery by chest X-ray (OR: 2.439, 95% CI: 1.475-4.035; $p<0.001$) (Table 4). Using multivariate analysis, all three parameters remained independent factors (OR: 2.138, 95% CI: 1.121-4.079; $p = 0.021$ for DVT, OR: 3.487, 95% CI: 1.782-6.823; $p<0.0001$ for S1Q3T3, and OR: 2.353, 95% CI: 1.346-4.116; $p = 0.003$ for radiographic right pulmonary artery enlargement).

Clinical prediction rules

Using Wells scoring criteria, patients were categorized into low, moderate, and high probability groups at 63, 178, and 59 patients, respectively. By revised Geneva score, patients were grouped into low, moderate, and high probability classifications at 44, 246, and 10 patients, respectively. Patients with high probability classification according to Wells score or revised Geneva score had a higher rate of positive pulmonary CTA results for acute PE, as compared to patients in the low and moderate probability groups (Table 5).

Table 3. Results of pulmonary CTA in 300 patients suspected of having PE

Pulmonary CTA findings	n	%
Pulmonary embolism	110	36.7
Pulmonary infection	55	18.3
Lung cancer	25	8.3
Pulmonary metastasis	30	10.0
Interstitial lung disease	11	3.7
Atelectasis	37	12.3
Pleural effusion	94	31.3
Pneumothorax	4	1.3
COPD/asthma	16	5.3
Bronchiectasis	13	4.3
CTEPH	12	4.0
Pulmonary hypertension	72	24.0
Heart failure	39	13.0
Pericardial effusion	24	8.0
SVC syndrome	6	2.0
Miscellaneous	6	2.0

CTA = computed tomography angiography; COPD = chronic obstructive pulmonary disease; CTEPH, chronic thromboembolic pulmonary hypertension; SVC = superior vena cava

D-dimer assays

Regarding Wells score, D-dimer was tested in 32 of 63 patients (51.79%) in the low probability group. D-dimer was positive in 28 patients and negative in four patients in this population. Using D-dimer in combination with low probability status, none of the patients with negative D-dimer was found to have acute PE. In patients with moderate probability, D-dimer testing was performed in 94 patients (38.2%), from which two of six patients with negative D-dimer had positive pulmonary CTA for acute PE.

Treatment and outcomes

Almost all patients (107 of 110 patients) with positive pulmonary CTA had specific treatment, including anticoagulant in 104 patients, fibrinolysis in two patients, and thromboembolectomy in six patients. Three patients (2.7%) had no specific treatment due to contraindications. Eighty-three of 86 patients (78.2%) were discharged with improved status. Twenty-four patients (21.8%) died.

Discussion

Our study revealed positive pulmonary CTA in 110 patients (36.7%) who underwent CTA for suspected acute PE. Significant clinical predictors for positive CTA were sign of DVT, S1Q3T3 pattern, and enlarged right pulmonary artery.

Patients categorized as being low probability by the two prediction rule systems had lower incidence of positive pulmonary CTA, particularly by Wells scoring. Positive pulmonary CTA for acute PE in patients with low clinical prediction rule in addition to negative D-dimer was very rare in our study. Negative D-dimer strengthens the unlikelihood of acute PE. Therefore, it can be reasonably concluded that use of clinical prediction rules is an effective clinical strategy for determining appropriate use of pulmonary CTA.

Acute PE is a life-threatening disease; however, this bad prognosis can be attenuated if this condition is correctly diagnosed and managed in a timely fashion[17,18]. Pulmonary CTA is the investigation of choice in diagnosis of acute PE, given its high sensitivity and specificity[6,19,20]. However, unnecessary use of this test leads to radiation exposure, contrast

Table 4. Comparisons among clinical manifestations between patients with and without positive CTA for acute PE

	PE		No PE		OR	95% CI	*p*-value
	n	%	n	%			
Clinical manifestations							
Dyspnea	91	34.7	171	65.3	0.532	0.268-1.056	0.068
Chest pain (pleuritic/substernal)	14	48.3	15	51.7	1.701	0.788-3.674	0.172
Palpitation	2	40.0	3	60.0	1.154	0.190-7.017	1.000
Cough	13	37.1	22	62.9	1.023	0.493-2.123	0.950
Hemoptysis	7	53.8	6	46.2	2.084	0.682-6.367	0.241
Syncope	3	42.9	4	57.1	1.304	0.286-5.936	0.710
Signs of DVT (leg swelling)	37	54.4	31	45.6	2.600	1.497-4.514	0.001
Tachycardia (>100/minute)	71	39.2	110	60.8	1.324	0.815-2.151	0.256
Tachypnea (>20/minute)	78	37.5	130	62.5	1.125	0.674-1.879	0.652
Fever (temperature >38.5°C)	15	26.8	41	73.2	0.574	0.301-1.094	0.089
Hypotension (SBP <90 mmHg)	17	42.5	23	57.5	1.327	0.675-2.610	0.411
Cyanosis	0	0	5	100.0	0	0	0.162
Cardiac arrest	3	75.0	1	25.0	5.299	0.544-51.578	0.141
ECG							
Sinus tachycardia rate >100	60	38.5	96	61.5	1.058	0.635-1.762	0.830
Sinus bradycardia rate <50	2	66.7	1	33.3	3.423	0.306-38.241	0.558
Atrial fibrillation rate >100	1	12.5	7	87.5	0.229	0.028-1.889	0.265
Right axis deviation	16	45.7	19	54.3	1.420	0.693-2.913	0.337
Right bundle branch block	11	55.0	9	45.0	2.083	0.831-5.225	0.111
Right ventricular hypertrophy	7	53.8	6	46.2	1.940	0.633-5.950	0.255
S1Q3T3 pattern	36	65.5	19	34.5	4.211	2.242-7.908	<0.001
CXR							
RPA enlargement (male >16 mm, female >14 mm)	56	48.3	60	51.7	2.439	1.475-4.035	<0.001
ABG/pulse oxymetry							
Hypoxemia (PaO_2 <60 mmHg or O_2 saturation <90%)	93	36.3	163	63.7	0.897	0.438-1.836	0.765
D-Dimer							
D-dimer >500 ng/ml	65	42.8	87	57.2	3.736	0.791-17.632	0.125

p-value <0.05 indicates statistical significance

Table 5. Clinical prediction according to the Wells score and the revised Geneva score in 300 patients suspected of having acute PE

	Total	No PE		PE	
		n	%	n	%
Wells score					
Low probability	63	58	92.10	5	7.9
Moderate probability	178	108	60.70	70	39.3
High probability	59	24	40.70	35	59.3
Total	300	190	63.30	110	36.7
Revised Geneva score					
Low probability	44	36	80.49	8	19.5
Moderate probability	246	150	61.79	96	38.2
High probability	10	4	40.00	6	60.0
Total	300	190	63.30	110	36.7

media exposure, and added cost. The trend of increased pulmonary CTA reported outside Thailand is similar in Thailand and at Siriraj Hospital. Our patients on the medical ward had a higher chance of having symptoms that needed to be differentiated from acute PE, such as unexplained dyspnea, hypotension, hypoxia, and other predisposing diseases due to complex medical illness. The number of annual pulmonary CTA at Siriraj Hospital has increased exponentially, with a cost of approximately 300 USD per examination.

Our study had a different primary objective than the other two papers that studied acute PE in Thailand[2,11]. Those studies focused on incidence, clinical characteristics, and outcomes in patients with acute PE. We focused mainly on the appropriateness of pulmonary CTA in patients on medical wards with suspected acute PE and the predictors of positive results.

Among the 300 patients with suspected acute PE that we evaluated, 110 (36.7%) had a positive pulmonary CTA for acute PE. This rate emphasizes the need for risk factor evaluation and D-dimer results. PIOPED II investigators advised that objective clinical assessment is essential prior to imaging[3]. Positive pulmonary CTA for acute PE in our study was approximately 33%, which is relatively high compared

to the previous three papers. The first study included 575 patients from various clinical settings, as follows, 267 inpatients, 258 patients from emergency department, and 50 outpatients. Positive CTA for acute PE was 9.57%, with results differing by clinical setting (12% inpatients, 8.5% patients from emergency department, and 2% outpatients)[21]. The second study, which was conducted in 2003, studied patients in the general medical ward and emergency department[13]. They found positive CTA in 9.84% of patients, with 6.36% of patients from the emergency department testing positive[13]. That study concluded that pulmonary CTA had been overused in the diagnosis of acute PE. The third study, which included 227 pediatric patients, found positive CTA for acute PE in 16%[14]. The difference in percentage of positive CTA between our findings and findings from previous studies may be explained by differences in the patient population and/or how decisions for pulmonary CTA requests are made. Our study population was composed of adult patients admitted to the general medical ward in a university-based tertiary referral hospital; patients that often have multiple comorbidities, as well as thromboembolic risk factors. This patient population may be at higher risk for acute PE. At our university hospital, decision-making regarding pulmonary CTA request in patients with suspected acute PE is based strictly on clinical prediction rule and thromboembolic risk factors under the supervision of a specialist. Attending physicians, including internal medicine residents, sub-specialty fellowships, and attending staff, were likely to perform a thorough clinical assessment prior to requesting pulmonary CTA.

With regard to thromboembolic risk factors, the most common were age >65 years (45.3%), malignancy (42%), chronic cardiac or respiratory disease (17.7%), and thrombophilias (15.5%). Our data indicated that it is unlikely (5.46% chance) to have a positive pulmonary CTA result in patients with no thromboembolic risk factors. Therefore, thromboembolic risk factor assessment is an effective clinical method for determining the appropriateness of requesting pulmonary CTA in patients suspected of having acute PE. Risk factors were mainly categorized at the low or moderate levels.

Dyspnea, tachypnea, and tachycardia were common, but nonspecific manifestations. Signs of deep vein thrombosis had high association with positive pulmonary CTA (OR: 2.6, 95% CI: 1.497-4.514; $p = 0.001$). For ECG results, sinus tachycardia was the most common ECG finding. The second most common ECG finding, S1Q3T3 pattern, had significant association with positive pulmonary CTA (OR: 4.211, 95% CI: 2.242-7.908; $p<0.001$). Our study had lower prevalence of S1Q3T3, as compared to previous study[2]. Generally, S1Q3T3 is observed in any condition that results in rapidly increased right ventricular volume and is not specific to acute PE. The sensitivity, specificity, PPV, and PPV of S1Q3T3 were 65.46%, 69.796%, 32.727%, and 90%, respectively. Therefore, S1Q3T3 may be beneficial in helping physicians recognize acute PE. Right pulmonary artery enlargement from chest X-ray was found in about half of patients with positive CTA, with significant association (OR: 2.439, 95% CI: 1.475-4.035; $p<0.001$).

Our study had some limitations. Right pulmonary artery measurement on chest X-ray was measured at the level of the bronchus intermedius in the postero-anterior upright position. Chest X-ray, however, was performed in positions other than upright postero-anterior view, including supine antero-posterior view in some patients, which has the potential for false-positive finding of pulmonary artery enlargement. While the pulmonary CTA was read by several radiologists, all were staffs in university hospital.

The combination of D-dimer test and thromboembolic risk factor assessment provided an even higher sensitivity and negative predictive value, with further triaging when CT angiography for PE is indicated. The effective combination of clinical assessment and D-dimer test has been reported in several studies[3,4,13,22-24]. Our study revealed that D-dimer test is underused, as it was requested in only 50.79% and 52.81% of patients in the low and moderate probability classifications, respectively. Moreover, in the low probability group among 31 patients in whom D-dimer was not tested, only one patient had positive pulmonary CTA for PE. Our study also showed that among patients with negative D-dimer, none of the patients in the low probability group had acute PE. Accordingly, we recommend that D-dimer be systematically tested in patients with low to intermediate probability prior to pulmonary CTA, given that it is widely available, non-invasive and relatively inexpensive. Standard international guidelines recommend that D-dimer levels be tested in patients with low or intermediate risk for PE[3,4,12,22,23]. The results of D-dimer testing might enhance the physician's ability to more accurately request pulmonary CTA in patients with suspected acute PE.

Conclusion

Prevalence of positive pulmonary CTA in patients suspected of having acute PE on the medical ward at our large university-based tertiary referral center was higher than rates reported in previous studies. This study was the first to address positive pulmonary CTA results in a large university hospital setting in Thailand. In the absence of thromboembolic risk factors and positive D-dimer, there is a low probability of testing positive for pulmonary CTA. Our results emphasize the need for and relevance of clinical prediction rules and thromboembolic risk factors, combined with D-dimer results. This selectivity and triage step has the potential of lowering costs and reducing radiation exposure to patients.

What is already known on this topic?

Most prior studies, including two papers from Thailand, focused on addressing incidence, clinical characteristics, and outcomes in patients with acute PE[2,11]. Few studies have focused on the appropriateness of pulmonary CTA examination in acute PE, with no studies on this subject having been conducted in Thailand.

What this study adds?

This was the first study in Thailand to address prevalence of positive pulmonary CTA in patients admitted on the medical ward that were suspected of having acute PE and the first to investigate predictors of positive pulmonary CTA results. We also evaluated the appropriateness of pulmonary CTA examination in a large university hospital.

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Potential conflicts of interest

None.

References

1. Carson JL, Kelley MA, Duff A, Weg JG, Fulkerson WJ, Palevsky HI, et al. The clinical course of pulmonary embolism. N Engl J Med 1992; 326: 1240-5.
2. Sompradeekul S, Ittimakin S. Clinical characteristics and outcome of Thai patients with acute pulmonary embolism. J Med Assoc Thai 2007; 90 (Suppl 2): 59-67.
3. Stein PD, Woodard PK, Weg JG, Wakefield TW, Tapson VF, Sostman HD, et al. Diagnostic pathways in acute pulmonary embolism: recommendations of the PIOPED II investigators. Am J Med 2006; 119: 1048-55.
4. Ceriani E, Combescure C, Le Gal G, Nendaz M, Perneger T, Bounameaux H, et al. Clinical prediction rules for pulmonary embolism: a systematic review and meta-analysis. J Thromb Haemost 2010; 8: 957-70.
5. Tsimogianni AM, Rovina N, Porfyridis I, Nikoloutsou I, Roussos C, Zakynthinos SG, et al. Clinical prediction of pulmonary embolism in respiratory emergencies. Thromb Res 2011; 127: 411-7.
6. Stein PD, Fowler SE, Goodman LR, Gottschalk A, Hales CA, Hull RD, et al. Multidetector computed tomography for acute pulmonary embolism. N Engl J Med 2006; 354: 2317-27.
7. Patel S, Kazerooni EA, Cascade PN. Pulmonary embolism: optimization of small pulmonary artery visualization at multi-detector row CT. Radiology 2003; 227: 455-60.
8. Coche E, Verschuren F, Keyeux A, Goffette P, Goncette L, Hainaut P, et al. Diagnosis of acute pulmonary embolism in outpatients: comparison of thin-collimation multi-detector row spiral CT and planar ventilation-perfusion scintigraphy. Radiology 2003; 229: 757-65.
9. Qanadli SD, Hajjam ME, Mesurolle B, Barre O, Bruckert F, Joseph T, et al. Pulmonary embolism detection: prospective evaluation of dual-section helical CT versus selective pulmonary arteriography in 157 patients. Radiology 2000; 217: 447-55.
10. Winer-Muram HT, Rydberg J, Johnson MS, Tarver RD, Williams MD, Shah H, et al. Suspected acute pulmonary embolism: evaluation with multi-detector row CT versus digital subtraction pulmonary arteriography. Radiology 2004; 233: 806-15.
11. Aniwan S, Rojnuckarin P. High incidence of symptomatic venous thromboembolism in Thai hospitalized medical patients without thromboprophylaxis. Blood Coagul Fibrinolysis 2010; 21: 334-8.
12. Torbicki A, Perrier A, Konstantinides S, Agnelli G, Galie N, Pruszczyk P, et al. Guidelines on the diagnosis and management of acute pulmonary embolism: the Task Force for the Diagnosis and Management of Acute Pulmonary Embolism of the European Society of Cardiology (ESC). Eur

Heart J 2008; 29: 2276-315.
13. Mamlouk MD, vanSonnenberg E, Gosalia R, Drachman D, Gridley D, Zamora JG, et al. Pulmonary embolism at CT angiography: implications for appropriateness, cost, and radiation exposure in 2003 patients. Radiology 2010; 256: 625-32.
14. Lee EY, Tse SK, Zurakowski D, Johnson VM, Lee NJ, Tracy DA, et al. Children suspected of having pulmonary embolism: multidetector CT pulmonary angiography--thromboembolic risk factors and implications for appropriate use. Radiology 2012; 262: 242-51.
15. Kuriakose J, Patel S. Acute pulmonary embolism. Radiol Clin North Am 2010; 48: 31-50.
16. Anderson FA Jr, Spencer FA. Risk factors for venous thromboembolism. Circulation 2003; 107: I9-16.
17. Lee CH, Hankey GJ, Ho WK, Eikelboom JW. Venous thromboembolism: diagnosis and management of pulmonary embolism. Med J Aust 2005; 182: 569-74.
18. Henzler T, Barraza JM Jr, Nance JW Jr, Costello P, Krissak R, Fink C, et al. CT imaging of acute pulmonary embolism. J Cardiovasc Comput Tomogr 2011; 5: 3-11.
19. Perrier A, Roy PM, Sanchez O, Le Gal G, Meyer G, Gourdier AL, et al. Multidetector-row computed tomography in suspected pulmonary embolism. N Engl J Med 2005; 352: 1760-8.
20. van Belle A, Buller HR, Huisman MV, Huisman PM, Kaasjager K, Kamphuisen PW, et al. Effectiveness of managing suspected pulmonary embolism using an algorithm combining clinical probability, D-dimer testing, and computed tomography. JAMA 2006; 295: 172-9.
21. Costantino MM, Randall G, Gosselin M, Brandt M, Spinning K, Vegas CD. CT angiography in the evaluation of acute pulmonary embolus. AJR Am J Roentgenol 2008; 191: 471-4.
22. Tapson VF. Acute pulmonary embolism. N Engl J Med 2008; 358: 1037-52.
23. Sanchez O, Planquette B, Meyer G. Update on acute pulmonary embolism. Eur Respir Rev 2009; 18: 137-47.
24. Gupta RT, Kakarla RK, Kirshenbaum KJ, Tapson VF. D-dimers and efficacy of clinical risk estimation algorithms: sensitivity in evaluation of acute pulmonary embolism. AJR Am J Roentgenol 2009; 193: 425-30.

ผลบวกของการตรวจเอกซเรย์คอมพิวเตอร์พบลิ่มเลือดในหลอดเลือดแดงพัลโมนารี: การพยากรณ์ทางคลินิก ปัจจัยเสี่ยง และความเหมาะสมในการตรวจ

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ภูมิหลัง: *โรคลิ่มเลือดในหลอดเลือดแดงพัลโมนารีมีอาการและอาการแสดงที่ไม่จำเพาะทำให้ต้องอาศัยการตรวจสืบค้นเพิ่มเติม การตรวจสืบค้นที่ได้รับการยอมรับ คือ การตรวจเอกซเรย์คอมพิวเตอร์ อย่างไรก็ตามการตรวจวิธีนี้มีข้อจำกัดในแง่ปริมาณรังสี สารทึบรังสี และค่าใช้จ่ายที่ไม่จำเป็น ปัจจุบันยังไม่มีข้อมูลเกี่ยวกับผลบวกของการตรวจรวมถึงความเหมาะสมในการส่งตรวจในประเทศไทย*

วัตถุประสงค์: *เพื่อหาความชุกของผลบวกของการตรวจเอกซเรย์คอมพิวเตอร์พบลิ่มเลือดในหลอดเลือดพัลโมนารี การพยากรณ์ทางคลินิก ปัจจัยเสี่ยง และความเหมาะสมในการตรวจ*

วัสดุและวิธีการ: *ผู้นิพนธ์ทำการรวบรวมผู้ป่วยจำนวน 300 ราย ที่รับไว้อยู่ในหอผู้ป่วยอายุรศาสตร์ โรงพยาบาลศิริราช ที่ได้รับการส่งตรวจเอกซเรย์หลอดเลือดแดงปอดเนื่องจากสงสัยโรคลิ่มเลือดในหลอดเลือดแดงปอด จากนั้นทำการวิเคราะห์หาความชุกของผลบวกจากการตรวจ รวมถึงเปรียบเทียบปัจจัยในการพยากรณ์ผลบวกจากการตรวจ ทั้งอาการ อาการแสดงทางคลินิก และการตรวจสืบค้นพื้นฐาน*

ผลการศึกษา: *ผลบวกของการตรวจเอกซเรย์คอมพิวเตอร์สำหรับโรคลิ่มเลือดในหลอดเลือดแดงปอดเท่ากับร้อยละ 36.7 เมื่อคำนวณโดยใช้ Well's score และ revised Geneva's score พบว่า ผู้ป่วยอยู่ในกลุ่มความน่าจะเป็นโรคน้อยจำนวน 63 และ 44 ราย ปานกลางจำนวน 178 และ 246 ราย และมากจำนวน 59 และ 10 ราย ตามลำดับ ผู้ป่วยที่จัดอยู่ในกลุ่มความน่าจะเป็นมากมีโอกาสพบผลบวกจากการตรวจสูงกว่ากลุ่มความน่าจะเป็นปานกลางและน้อย ปัจจัยที่สัมพันธ์กับผลบวกจากการตรวจ ได้แก่ การพบลิ่มเลือดที่หลอดเลือดดำขา การพบ S1Q3T3 จากการตรวจคลื่นไฟฟ้าหัวใจ และการพบหลอดเลือดแดงพัลโมนารีข้างขวาโต*

สรุป: *การศึกษานี้เป็นการศึกษาแรกที่ทำการศึกษาถึงผลบวกของการตรวจเอกซเรย์คอมพิวเตอร์สำหรับโรคลิ่มเลือดในหลอดเลือดแดงปอดที่ทำในโรงพยาบาลศิริราช ซึ่งเป็นโรงพยาบาลมหาวิทยาลัยขนาดใหญ่ ผลบวกจากการตรวจพบประมาณหนึ่งในสาม ผลบวกจากการตรวจพบน้อยมากในผู้ป่วยกลุ่มที่มีความน่าจะเป็นต่ำ โดยเฉพาะเมื่อไม่มีปัจจัยเสี่ยงต่อการเกิดลิ่มเลือดเลย และมีผล D-dimer ปกติ การศึกษานี้เน้นให้เห็นความสำคัญของการคัดกรองผู้ป่วยในการส่งตรวจเอกซเรย์คอมพิวเตอร์ เพื่อลดความเสี่ยงต่อรังสีและลดค่าใช้จ่ายที่ไม่จำเป็น*