Clinical Characteristics of Patients With Acute Pulmonary Embolism Stratified According to Their Presenting Syndromes*

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Purpose: **The purpose of this investigation is to determine the characteristics of the history, physical examination, chest radiograph, and ECG, and the ventilation/perfusion ($\dot{V}/\dot{Q}$) lung scan probability in patients with pulmonary embolism (PE) stratified according to their presenting syndrome.**

Background: **In considering a possible diagnosis of acute PE, it is helpful to consider the patient in terms of the presenting syndrome (pulmonary infarction, isolated dyspnea, or circulatory collapse). In assessing the possibility of acute PE, it would be more useful to know the detailed characteristics of the particular syndrome rather than the clinical characteristics of all patients with PE.**

Methods: **Patients described in this investigation participated in the national collaborative trial of the Prospective Investigation of Pulmonary Embolism Diagnosis (PIOPED). All had PE diagnosed by pulmonary angiography. None had prior cardiopulmonary disease. All examinations and laboratory tests were obtained within 24 h of the pulmonary angiogram and most were within 12 h of the pulmonary angiogram.**

Results: **Among patients with the pulmonary infarction syndrome, 14 of 119 (12%) had neither dyspnea nor tachypnea. Some patients with circulatory collapse did not have dyspnea, tachypnea, or pleuritic pain. A normal ECG was more prevalent among patients with pulmonary infarction syndrome, 45 of 97 (46%), than among patients with isolated dyspnea syndrome, 2 of 21 (10%) ($p<0.01$). A PaO_2 >80 mm Hg was also more prevalent in patients with the pulmonary infarction syndrome, 27 of 99 (27%), than in patients with the isolated dyspnea syndrome, 2 of 19 (11%). A high-probability $\dot{V}/\dot{Q}$ lung scan was less prevalent among the pulmonary infarction group, 38 of 119 (32%), than the isolated dyspnea group, 20 of 31 (65%) ($p<0.001$).**

Conclusion: **Many of the findings in the various syndromes of PE can be understood in terms of the severity of PE as it increases from mild with the pulmonary infarction syndrome to moderate with the isolated dyspnea syndrome to severe with circulatory collapse. The prevalence of various clinical and laboratory characteristics of patients with the syndrome of pulmonary infarction, isolated dyspnea, or circulatory collapse may give clues to the diagnosis or suggest characteristics that may reduce the likelihood of inadvertently discarding the diagnosis of PE.**

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Key words: pulmonary embolism; shock; thromboembolism; ventilation/perfusion lung scan

Abbreviations: PIOPED=Prospective Investigation of Pulmonary Embolism Diagnosis; PE=pulmonary embolism; $\dot{V}/\dot{Q}$ scan=ventilation/perfusion lung scan

In considering a possible diagnosis of acute pulmonary embolism (PE), it is helpful to consider the patient in terms of the mode of presentation.[1] Among patients with no prior cardiopulmonary disease who survive long enough to a undergo diagnostic evaluation, 65% present with the syndrome of pulmonary hemorrhage or infarction characterized by pleuritic pain or hemoptysis.[2] The syndrome of isolated dyspnea, in the absence of circulatory collapse or pleuritic pain or hemoptysis, occurs in 22%. Circulatory collapse among patients who survived long enough for diagnostic evaluation was observed in only 8%. However, approximately one third of patients with acute PE die within 2.5 h.[3] In about 5% of patients, the diagnosis is made in asymptomatic

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Table 1—*Age

Age, yr	Pulm Infarct (n=119), No. (%)	Isolated Dysp (n=31), No. (%)
<21	1 (1)	1 (3)
21-30	20 (17)	3 (10)
31-40	15 (13)	3 (10)
41-50	16 (13)	4 (13)
51-60	27 (23)	6 (19)
61-70	27 (23)	7 (23)
71-80	9 (8)	7 (23)†
81-90	4 (3)	0 (0)

*Patients with circulatory collapse ranged between age 31 and 90 years. Pulm Infarct=pulmonary infarction syndrome; Isolated Dysp=isolated dyspnea syndrome.
†$p<0.02$, pulmonary infarction vs isolated dyspnea.

Table 3—*Symptoms

	Pulm Infarct (n=119), No. (%)	Isolated Dysp (n=31), No. (%)	Circ Collapse (n=5), No. (%)
Dyspnea	86 (72)	31 (100)†	2 (40)
Pleuritic pain	115 (97)†	0 (0)†	0 (0)
Cough	52 (44)	11 (35)	2 (40)
Leg swelling	33 (28)	12 (39)	2 (40)
Leg pain	30 (25)	10 (32)	2 (40)
Hemoptysis	25 (21)†	0 (0)†	0 (0)
Palpitations	11 (9)	5 (16)	0 (0)
Wheezing	10 (8)	5 (16)	1 (20)
Angina-like pain	5 (4)	2 (6)	0 (0)

*Circ Collapse=circulatory collapse syndrome. Other abbreviations are expanded in Table 1 footnotes.
†Presence or absence of symptom defines syndrome.

patients with deep venous thrombosis[2] or, particularly in elderly patients, the diagnosis is suggested on the basis of unexplained radiographic abnormalities in asymptomatic patients.[4]

If a patient presents with a syndrome compatible with acute PE, it would be more useful to know the detailed characteristics of the particular syndrome rather than the clinical characteristics of all patients with PE. The purpose of this investigation, therefore, is to determine the characteristics of the history, physical examination, chest radiograph, ECG, and the ventilation/perfusion ($\dot{V}/\dot{Q}$) lung scan probability of PE in patients with PE stratified according to their presenting syndrome.

Materials and Methods

Patients described in this investigation participated in the national collaborative study of the Prospective Investigation of Pulmonary Embolism Diagnosis (PIOPED).[5] In the present investigation, we describe only patients with PE diagnosed by pulmonary angiography. We evaluated patients from both arms of PIOPED: (1) patients who consented to obligatory pulmonary angiography if their $\dot{V}/\dot{Q}$ lung scans were abnormal, and (2) patients who underwent pulmonary angiography at the request of their attending physicians. Patients referred for pulmonary angiography were not selected for sensitivity and specificity analyses of their $\dot{V}/\dot{Q}$ scans. There were 103 patients from the obligatory angiography arm and 52 were from the referred arm. We evaluated only patients who had no history or evidence of preexisting cardiac or pulmonary disease as defined previously.[2]

Among patients with no prior cardiopulmonary disease and angiographically diagnosed PE, there were 119 with a syndrome of pulmonary infarction or hemorrhage, defined as patients with pleuritic pain or hemoptysis. There were 31 patients who presented with isolated dyspnea, defined as dyspnea in the absence of hemoptysis, pleuritic pain, or circulatory collapse. There were only five patients who presented with circulatory collapse on the day of admission to PIOPED. Circulatory collapse was defined as loss of consciousness or BP <80 mm Hg. We included this small number of well patients with circulatory collapse because important clinical clues to the diagnosis were suggested even in this small but well-studied group. The characteristics of these five patients with circulatory collapse have been included in a book on PE.[6]

Symptoms suggestive of PE were within 24 h of entry into the study.[5] A clinical assessment of the likelihood of acute PE was based on all available noninvasive data with the exception of the $\dot{V}/\dot{Q}$ lung scan. The basis for arriving at the clinical likelihood estimate was individual clinical judgment, and not any specific predetermined criteria.

All examinations and laboratory tests were obtained within 24 h of the pulmonary angiogram and most were within 12 h of the pulmonary angiogram.[5] The methods for obtaining chest radiographs and for obtaining and interpreting $\dot{V}/\dot{Q}$ lung scans and pulmonary angiograms were described in the original PIOPED report.[5] Interpretations of ECGs were those of the local hospital electrocardiographers. In the present investigation, we report the partial pressure of oxygen in arterial blood (PaO_2), partial pressure of carbon dioxide in arterial blood ($PaCO_2$), and pH of arterial blood only in patients breathing room air.

Statistical Methods

A χ^2 test was used to compare the prevalence of clinical and laboratory features among patients with different presenting

Table 2—*Predisposing Factors

	Pulm Infarct (n=119), No. (%)	Isolated Dysp (n=31), No. (%)
Immobilization	63 (53)	19 (61)
Surgery	61 (51)	14 (45)
Malignancy	23 (19)	4 (13)
Thrombophlebitis, ever	15 (13)	8 (26)
Trauma, lower extremity	22 (18)	2 (6)
Estrogen	11 (9)	4 (13)
Stroke	8 (7)	3 (10)
Postpartum ≤3 months	5 (4)	2 (6)
None of above	18 (15)	4 (13)

*Only five patients had circulatory collapse. Two had no apparent predisposing factor. By definition, none of these patients had prior cardiopulmonary disease, which in some instances may predispose to PE. Abbreviations are expanded in Table 1 footnotes.

Table 4—*Signs

	Pulm Infarct (n=119), No. (%)	Isolated Dysp (n=31), No. (%)	Circ Collapse (n=5), No. (%)
Tachypnea (≥20/min)	84 (71)	20 (65)	2 (40)
Rales (crackles)	67 (56)†	6 (19)	1 (20)
Tachycardia (>100/min)	28 (24)‡	14 (45)	3 (60)
Increased pulmonary component of second sound	32 (27)	10 (32)	0 (0)
Deep venous thrombosis	11 (9)	3 (10)	1 (20)
Diaphoresis	8 (7)	5 (16)	1 (20)
Temperature >38.5°C	7 (6)	2 (6)	0 (0)
Wheezes	8 (7)	2 (6)	0 (0)
Homans' sign	2 (2)	2 (6)	1 (20)
Pleural friction rub	6 (5)	0 (0)	0 (0)
Third heart sound	2 (2)	2 (6)	0 (0)
Cyanosis	2 (2)	1 (3)	0 (0)

*Abbreviations are expanded in Table 1 and Table 3 footnotes.
†$p<0.001$, pulmonary infarction vs isolated dyspnea.
‡$p<0.02$, pulmonary infarction vs isolated dyspnea.

syndromes of PE. Comparisons of continuous variable means were made with Student's *t* test. Because of the large number of comparisons made in this analysis, the likelihood that a difference might occur by chance is greater than the reported probabilities suggest.

Results

The mean ages of patients with pulmonary infarction syndrome, isolated dyspnea, and circulatory collapse were 51±17 years (mean±SD), 55±17 years, and 66±18 years, respectively. Differences of ages between groups were not statistically significant. Few patients were younger than 21 years of age; but patients were excluded from PIOPED if they were 17 years of age or younger (Table 1).

Predisposing Factors

There were no statistically significant differences of predisposing factors among the three groups (Table 2). Absence of predisposing factors was observed in 13% and 15% of patients with pulmonary infarction or isolated dyspnea syndrome, respectively. Two of five patients with circulatory collapse had no predisposing factors. By definition, none of these patients had prior cardiac or pulmonary disease, which in some instances may predispose them to PE.

Symptoms

There were no statistically significant differences of symptoms between the groups, excluding differences due to the defining characteristics (Table 3). Dyspnea was absent in some patients with circulatory collapse.

Signs

Rales were more prevalent in the pulmonary infarction group, 67 of 119 (56%), than in the isolated dyspnea group, 6 of 31 (19%) ($p<0.001$)

Table 5—*ECG Manifestations

	Pulm Infarct (n=97), No. (%)	Isolated Dysp (n=21), No. (%)	Circ Collapse (n=5), No. (%)
Normal ECG	45 (46)†	2 (10)	1 (20)
ST segment or T-wave changes	39 (40)	12 (57)	3 (60)
Left axis deviation	13 (13)	3 (14)	0 (0)
Complete right bundle branch block	3 (3)	2 (10)	2 (40)‡
Left ventricular hypertrophy	9 (9)	0 (0)	0 (0)
Incomplete right bundle branch block	4 (4)	2 (10)	0 (0)
Acute myocardial infarction pattern	2 (2)	1 (5)	0 (0)
Low-voltage QRS	3 (3)	1 (5)	1 (20)
P pulmonale	1 (1)	1 (5)	1 (20)
Right axis deviation	1 (1)	0 (0)	0 (0)
Right ventricular hypertrophy	1 (1)	1 (1)	0 (0)

*Abbreviations are expanded in Table 1 and Table 3 footnotes. Some patients had more than one abnormality.
†$p<0.01$, pulmonary infarction vs isolated dyspnea.
‡$p<0.001$, pulmonary infarction vs circulatory collapse.

Table 6—*Plain Chest Radiograph

	Pulm Infarct (n=119), No. (%)	Isolated Dysp (n=31), No. (%)	Circ Collapse (n=5), No. (%)
Atelectasis or pulmonary parenchymal abnormality	89 (75)†	16 (52)	1 (20)§
Pleural effusion	67 (56)‖	8 (26)	0 (0)¶
Pleural-based opacity	43 (36)	7 (23)	0 (0)
Elevated diaphragm	31 (26)	6 (19)	1 (20)
Decreased pulmonary vascularity	24 (20)	8 (26)	0 (0)
Prominent central pulmonary artery	17 (14)	5 (16)	0 (0)
Cardiomegaly	10 (8)	5 (16)	2 (40)¶
Westermark's sign†	7 (6)	2 (6)	0 (0)
Pulmonary edema	3 (3)	1 (3)	0 (0)
Normal chest radiograph	17 (14)	8 (26)	2 (40)

*Abbreviations are expanded in Table 1 and Table 3 footnotes.
†Prominent central pulmonary artery and decreased pulmonary vascularity.
‡$p<0.02$, pulmonary infarction vs isolated dyspnea.
§$p<0.01$, pulmonary infarction vs circulatory collapse.
‖$p<0.01$, pulmonary infarction vs isolated dyspnea.
¶$p<0.02$, pulmonary infarction vs circulatory collapse.

(Table 4). Tachycardia was more prevalent in patients with PE who had isolated dyspnea, 14 of 31 (45%), than in the pulmonary infarction group, 28 of 119 (24%) ($p<0.02$).

Combinations of Signs and Symptoms

Among patients with the pulmonary infarction syndrome, 14 of 119 (12%) had neither dyspnea nor tachypnea. Even some patients with circulatory collapse had neither dyspnea nor tachypnea, two of five (40%). These two patients also had no pleuritic pain.

Clinical Assessment

Physicians were confident of the diagnosis of PE (80 to 100% clinical likelihood) in only 14 to 23% of patients irrespective of the presenting syndrome. Physicians thought PE was probably absent (0 to 19% clinical likelihood) in 10% or fewer patients irrespective of the group.

Table 7—*Pulmonary Artery Mean Pressure, PaO_2, $PaCO_2$, and pH on Room Air

	Pulm Infarct	Isolated Dysp	Circ Collapse
Mean PA pressure, mm Hg	20.1±8.1† (n=115)	24.5±9.3 (n=30)	25.8±5.9 (n=5)
Mean PaO_2, mm Hg	72.6±14.2‡ (n=99)	63.2±12.9 (n=19)	56.5±2.7‖ (n=4)
Mean $PaCO_2$, mm Hg	34.6±5.2 (n=99)	34.8±4.3 (n=19)	34.5±4.7 (n=4)
Mean pH	7.45±0.04§ (n=99)	7.42±0.08 (n=19)	7.41±0.07‖ (n=4)

*PA=pulmonary artery; other abbreviations are expanded in Table 1 and Table 3 footnotes.
†$p<0.02$, pulmonary infarction vs isolated dyspnea.
‡$p<0.01$, pulmonary infarction vs isolated dyspnea.
§$p<0.02$, pulmonary infarction vs isolated dyspnea.
‖$p<0.05$, pulmonary infarction vs circulatory collapse.

ECG Manifestations

A normal ECG was more prevalent among patients with pulmonary infarction syndrome, 45 of 97 (46%), than among patients with isolated dyspnea syndrome, 2 of 21 (10%) ($p<0.01$) (Table 5). Right bundle branch block was more prevalent among patients with circulatory collapse than patients with pulmonary infarction syndrome, 2 of 5 (40%) vs 3 of 97 (3%) ($p<0.001$).

Plain Chest Radiograph

The pulmonary infarction group tended to have a higher prevalence of atelectasis or pulmonary parenchymal abnormalities, 89 of 119 (75%), than the isolated dyspnea group, 16 of 31 (52%) ($p<0.02$), and it had a higher prevalence than the circulatory collapse group, 1 of 5 (20%) ($p<0.01$) (Table 6). The pulmonary infarction group also had a higher prevalence of pleural effusion, 67 of 119 (56%), than the isolated dyspnea group, 8 of 31 (26%) ($p<0.01$), and it tended to have a higher prevalence than the circulatory collapse group, 0 of 5 (0%) ($p<0.02$) (Table 6). The circulatory collapse group tended to have a higher prevalence of cardiomegaly, 2 of 5 (40%), than the pulmonary infarction group, 10 of 119 (8%) ($p<0.02$) (Table 6).

Table 8—*V̇/Q̇ Lung Scan

V̇/Q̇ Scan Probability	Pulm Infarct (n=119), No. (%)	Isolated Dysp (n=31), No. (%)	Circ Collapse (n=5), No. (%)
High	38 (32)†	20 (65)	4 (80)‡
Intermediate	63 (53)†	4 (13)	0 (0)‡
Low	15 (13)	4 (13)	1 (20)
Near normal/normal	3 (3)	3 (10)	0 (0)

*Abbreviations are expanded in Table 1 and Table 3 footnotes.
†$p<0.001$, pulmonary infarction vs isolated dyspnea.
‡$p<0.05$, pulmonary infarction vs circulatory collapse.

Pulmonary Artery Pressure, PaO_2, $PaCO_2$, and pH

The pulmonary infarction group had a higher mean PaO_2 (72.6±14.2 mm Hg) than the isolated dyspnea group (63.2±12.9 mm Hg) ($p<0.01$) (Table 7). A PaO_2 >80 mm Hg was observed in 27 of 99 (27%) patients with pulmonary infarction and 2 of 19 (11%) with isolated dyspnea. A trend showed that the pulmonary infarction group had a lower pulmonary artery mean pressure than the isolated dyspnea group (20.1±8.1 mm Hg vs 24.5±9.3 mm Hg, $p<0.02$).

V̇/Q̇ Lung Scan

A high-probability V̇/Q̇ lung scan was more prevalent among the isolated dyspnea group than the pulmonary infarction group, 20 of 31 (65%) vs 38 of 119 (32%) ($p<0.001$) (Table 8). Intermediate-probability V̇/Q̇ lung scans were most prevalent among patients with pulmonary infarction syndrome.

Discussion

Once patients with suspected PE are stratified into syndromes of pulmonary infarction, isolated dyspnea, or circulatory collapse, a physician can better assess the likelihood of PE knowing the detailed clinical characteristics of each group. Patients with submassive PE more commonly have the pulmonary infarction syndrome than patients with massive PE.[7] Patients with pulmonary infarction were shown to have less severe PE than patients with isolated dyspnea based on an objective pulmonary angiography scoring system.[1] Patients with circulatory collapse had the most severe PE based on the angiographic score, but the score was not statistically significantly higher than in patients with isolated dyspnea.[1] Many of the findings in the various syndromes of PE can be understood in terms of the severity of PE as it increases from mild with the pulmonary infarction syndrome to moderate with the isolated dyspnea syndrome to severe with circulatory collapse.

With increasing severity of PE, from pulmonary infarction to isolated dyspnea to circulatory collapse, trends suggest that the prevalence of a high-probability V̇/Q̇ lung scan increased, and the pulmonary artery mean pressure increased while the PaO_2 decreased.

Clues that may assist physicians in assessing the possibility of PE are as follows. (1) Some patients with PE and circulatory collapse do not have dyspnea or tachypnea or pleuritic pain. (2) Rales are more prevalent among patients with pulmonary infarction and tend to be less prevalent among patients with isolated dyspnea or circulatory collapse. We previously showed that rales are associated with patients who have radiographic evidence of a parenchymal abnormality.[2] (3) A normal ECG is frequently seen in patients with the pulmonary infarction syndrome, but a normal ECG is uncommon in patients with isolated dyspnea. (4) Abnormalities on the chest radiograph, although more common among patients with pulmonary infarction, are often observed in patients with isolated dyspnea. (5) Patients with circulatory collapse may have a normal chest radiograph. (6) A high-probability interpretation of the V̇/Q̇ scan occurs in a minority of patients with the pulmonary infarction syndrome, but it is found in the majority of patients with isolated dyspnea. (7) A low-probability interpretation of the V̇/Q̇ scan may occur in patients with PE and circulatory collapse. (8) A PaO_2 higher than 80 mm Hg is not uncommon in patients with the pulmonary infarction syndrome, but such levels are uncommon in patients with isolated dyspnea.

Among patients who died of PE, the diagnosis frequently was unsuspected antemortem.[3] Many have suggested that physicians need to maintain a high level of suspicion to make the diagnosis of PE. The prevalence of various clinical and laboratory characteristics of patients with the syndrome of pulmonary infarction, isolated dyspnea, or circulatory collapse may give clues to the diagnosis or suggest characteristics that may reduce the likelihood of inadvertently discarding the diagnosis.

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