A DIAGNOSTIC ALGORITHM FOR PULMONARY EMBOLISM

JC. Quintero, C. Pozuelo, Y. Roca, L. Monés, D. Mulattieri. Hospital Municipal de Badalona. Barcelona. Spain

PURPOSE

- To assess the value of helical CT pulmonary angiography (CTPA) in the diagnosis of the pulmonary embolism (PE).
- To develop an imaging algorithm in the evaluation of patients with suspected PE.
- To describe the imaging features of acute and chronic pulmonary thromboembolism.
- To describe the helical CT technique used in our institution in patients with suspected PE and to discuss the roles of conventional radiography, helical CT and scintigraphy in the evaluation of PE.

MATERIAL AND METHODS

Diagnosis of PE remains a major clinical problem. The annual incidence of clinically suspected PE is estimated to be 2–3 per 1,000 inhabitants in the western world. Of these patients, only approximately one-third will actually have a pulmonary embolus. Treatment of patients with PE is indicated, because the mortality of PE without treatment is 25%. Conversely, treatment of all patients will lead to unnecessary treatment in two-thirds of patients, with possible haemorrhagic complications. Hence, an accurate diagnosis is warranted to prevent unnecessary mortality and morbidity.

Between November 1999 and November 2004 155 consecutive patients (63 females and 92 males) with an average age of 53 years old were examined for suspected PE using helical CT of the chest (2.5-mm collimation, pith: 1.5, 100 ml of contrast medium, rate: 3.5 m/sec, delay: 10-15 sec). In the approximately half patients sequential scanning of the abdomen was performed using 10-mm collimation and an interval of 40 mm. Color Doppler ultrasonography of the lower limbs was done within 24 hr of CT. Three radiologists who were unaware of CT findings.

RESULTS

CLINICAL ASSESSMENT

Clinical categories

Three research groups have recently published explicit prediction rules for determining the clinical probability of PE. Wells and colleagues used an assessment of symptoms and signs, the presence of an alternative diagnosis to account for the patient's presentation and the presence of risk factors for venous thromboembolism to categorize a patient as having low, intermediate or high probability of PE *(Table 1)*.

Variable	Points
Clinical signs and symptoms of DVT (leg swelling and pain with palpation of the deep veins)	3.0
An alternative diagnosis is less likely than pulmonary embolism	3.0
Heart rate > 100 beats/minute	1.5
Immobilization or surgery in the previous 4 weeks	1.5
Previous DVT/pulmonary embolism	1.5
Hemoptysis	1.0
Malignancy (treatment ongoing or within previous 6 months or palliative)	1.0
Total points	—
Pretest probability calculated as follows:	Total points
High	> 6
Moderate	2-6
Low	< 2

Table 1. Model for determining the clinical probability of PE.

A simplified version of their original model yielded a prevalence of PE of 2% in low-probability, 19% in intermediate-probability and 50% in high-probability categories. This clinical model has been prospectively validated by its use, in conjunction with other tests, to manage outpatients with suspected PE successfully.

D-dimer

Is formed when cross-linked fibrin is lysed by plasmin, and elevated levels usually occur with PE. However, because elevations of D-dimer are nonspecific (e.g., increased by aging, inflammation, cancer), an abnormal result has a low positive predictive value. The value of D-dimer is that a negative result can help to exclude PE.

Seventy-three patients (47%) had a PE diagnosed with CT findings. Sixty-seven (43%) had a deep venous thrombosis. Other diagnostics were: neoplasm (33), infection (28) and miscellaneous (21). We designed a diagnosis algorithm from the PE who is adequate in our institution, and separate the patients in three groups: low, intermediate and right probability *(Table 2)*.

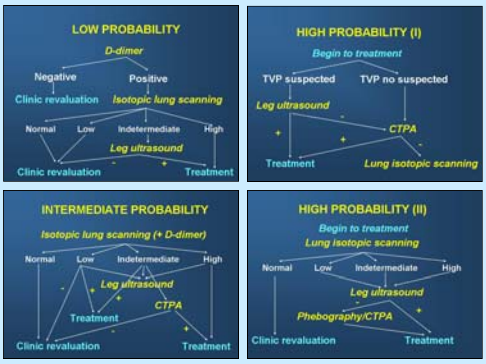


Table 2. Diagnostic algorithm from clinic suspected of the PE in our institution

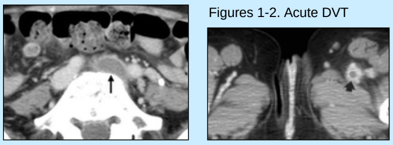
IMAGING IN PULMONARY EMBOLISM

Ventilation–perfusion lung scanning

Has been the usual initial investigation in patients with suspected PE. A normal perfusion scan excludes PE, but is found in a minority of patients. Perfusion defects are no specific, however, with only about 33% of patients with defects having PE. The probability that perfusion defects are due to PE increases with increasing size and number, the presence of a wedged shape and the presence of a normal ventilation scan ("mismatched" defect).

Leg ultrasound and CT

Detection of asymptomatic deep vein thrombosis (DVP) is an indirect way to diagnose PE. In the presence of acute PE, deep vein thrombosis is detectable by bilateral ascending venography in about 75% of patients and by compression ultrasonography of the proximal veins in about 50% of patients Acute DVT was identified as venous dilatation caused by low-attenuation clot; the venous wall was sharply defined and enhanced in some cases, presumably because of the arterially supplied vasa vasorum *(Figs. 1-2)*. Cronic DVT remains a problematic diagnosis.



Figures 1-2. Acute DVT

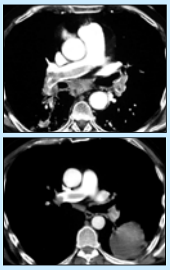
Computed tomographic pulmonary angiography (CTPA)

Acute PE

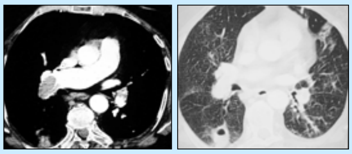
Arterial occlusion with failure to enhance the entire lumen due to a large filling defect *(Figures 5-8)*; the artery may be enlarged compared with adjacent patent vessels. A partial filling defect surrounded by contrast material *(Figures 3-4)*, producing the "polo mint" sign on images acquired perpendicular to the long axis of a vessel and the "railway track" sign on longitudinal images of the vessel. A peripheral intraluminal filling defect that forms acute angles with the arterial wall *(Figures 9-11)*.

Chronic PE

Imaging findings include: complete occlusion of a vessel that is smaller than adjacent patent vessels, a peripheral, crescent-shaped intraluminal defect that forms obtuse angles with the vessel wall, contrast material flowing through thickened, often smaller arteries due to recanalization, a web or flap within a contrast material–filled artery; and secondary signs, including extensive bronchial or other systemic collateral vessels, an accompanying mosaic perfusion pattern, or calcification within eccentric vessel thickening.

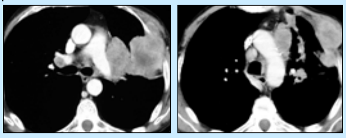


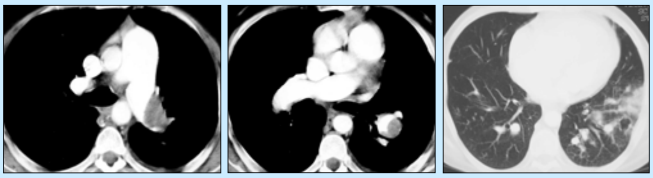
Figures 3-4. Partial defect filling (acute PE)



Figures 5-6. Acute PE. Axial CT demostrates enlarged right pulmonary artery with a cavitate infarct in right low

Figures 7-8. A 65-year-old man affected of an oat-cell carcinoma with mediastinal nodes involvement with chest pain. Axial CT demostrates acute PE.





Figures 9-11. AIDS with partial occlusion of the left pulmonary artery and secondarily an pulmonary infarct

Magnetic resonance imaging

MR pulmonary angiography.

In the 1990s, MRPA involved mainly two-dimensional time-of-flight (TOF) techniques with limited anatomic coverage. The advent of faster gradients and better reconstruction algorithms has made three-dimensional contrast MR angiography feasible. These scans can be completed in 10 to 30 seconds.

MR venography.

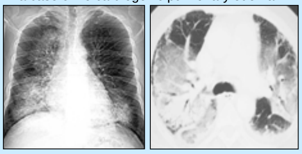
MRV may be used to evaluate central venous pathology, anatomic variants, and DVT of the extremities. MRV shares with CTV the advantage of better delineating the IVC and pelvic veins than does sonography, and does not require venous compression.

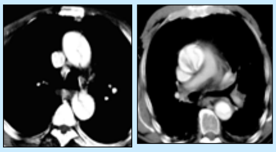
Differential diagnosis

In our series we encountered any cases in the definitive diagnostic was not embolism pulmonary: neoplasm (33) *(Figures 12-14)*, infection (28), and miscellaneous (21) including: cardiogenic and no cardiogenic pulmonary edema *(Figures 15-16)*, emphysema, aortic disection *(Figures 17-18)*, anemia, pneumotorax and cardiogenic shock.

Figures 12-14. Chest radiography and axial CT in a patient affect of bronchogenic carcinoma

Figures 15-16. Chest radiography and axial CT in a case of no cardiogenic pulmonary edema





Figures 17-18. Axial CT in a patient with an type B aortich disection.

Having been introduced in the late 1980s, helical CT is rapidly replacing scintigraphy as the imaging modality of choice in the assessment of patients with suspected PE. It is more accurate than scintigraphy and is rapid, noninvasive, and readily available. Helical CT directly demonstrates intraluminal clot as a filling defect. In addition, in patients without PE, helical CT often provides alternative diagnoses. With the advent of multidetector row helical CT scanners, even the subsegmental pulmonary arteries can now be evaluated. Another advantage of CT is that it allows evaluation of DVT in the abdomen, pelvis, thighs, and calves. Such evaluation can be performed without intravenous injection of additional contrast material by scanning the lower limbs 3–4 minutes after scanning the pulmonary vessels (indirect CT venography).

CONCLUSION

- PE is a major cause of morbidity and mortality. Clinical diagnosis remains difficult because of the absence of specific symptoms. Imaging plays a critical role in the diagnosis of this potentially fatal condition. Enhanced helical CT has greatly contributed to the evolution in the noninvasive imaging of PE. In addition, CT often provides alternative explanations for cardiopulmonary symptoms when pulmonary embolism is not present.
- Recent technical advances in computed tomography, magnetic resonance imaging and laboratory findings have raised new possibilities in the diagnosis of pulmonary embolism.
- In summary, several results of different diagnostic algorithms, evaluated in several studies are variable but acceptable and the choice for which strategy to use is highly dependent on the availability of the diagnostic tests within a local hospital.

Poster presentat al Primer Congrés Mondial de Radiologia Toràcica i Diagnòstic de Malalties Toràciques. Florencia, 7-10 Maig 2005