

## Electrocardiographic Features

The ECG changes associated with acute pulmonary embolism may be seen in any condition that causes acute pulmonary hypertension, including hypoxia causing pulmonary hypoxic vasoconstriction. These findings include:

- **Sinus tachycardia** – the most common abnormality; seen in 44% of patients.
- **Complete or incomplete RBBB** – associated with increased mortality; seen in 18% of patients.
- **Right ventricular strain pattern** – T wave inversions in the right precordial leads (V1-4) ± the inferior leads (II, III, aVF). This pattern is seen in up to 34% of patients and is associated with high pulmonary artery pressures.
- **Right axis deviation** – seen in 16% of patients. Extreme right axis deviation may occur, with axis between zero and -90 degrees, giving the appearance of left axis deviation (“pseudo left axis”).
- **Dominant R wave in V1** – a manifestation of acute right ventricular dilatation.
- **Right atrial enlargement (P pulmonale)** – peaked P wave in lead II > 2.5 mm in height. Seen in 9% of patients.
- **S<sub>I</sub> Q<sub>III</sub> T<sub>III</sub> pattern** – deep S wave in lead I, Q wave in III, inverted T wave in III. This “classic” finding is neither sensitive nor specific for pulmonary embolism; found in only 20% of patients with PE.
- **Clockwise rotation** – shift of the R/S transition point towards V6 with a persistent S wave in V6 (“pulmonary disease pattern”), implying rotation of the heart due to right ventricular dilatation.
- **Atrial tachyarrhythmias** – AF, flutter, atrial tachycardia. Seen in 8% of patients.
- **Non-specific ST segment and T wave changes**, including ST elevation and depression. Reported in up to 50% of patients with PE.

*Simultaneous T wave inversions in the inferior (II, III, aVF) and right precordial leads (V1-4) is the most specific finding in favour of PE, with reported specificities of up to 99% in one study.*

## Compared to findings of Acute Coronary Syndrome

While T wave inversions are commonly associated with acute coronary syndromes, there are several findings associated with pulmonary embolism that differentiate this diagnosis from ACS.

- ACS is rarely associated with tachycardia
- Both ACS and PE will present with elevated troponin
- Ultrasonography may be useful in differentiating the two
- Kosuge et al have shown that simultaneous inversion in III and V1 are diagnostically significant:

“negative T waves in leads III and V1 were observed in only 1% of patients with ACS compared with 88% of patients with Acute PE (p less than 0.001). The sensitivity, specificity, positive predictive value, and negative predictive value of this finding for the diagnosis of PE were 88%, 99%, 97%, and 95%, respectively. In conclusion, the presence of negative T waves in both leads

III and V1 allows PE to be differentiated simply but accurately from ACS in patients with negative T waves in the precordial leads.”

### **Mechanisms**

ECG changes in PE are related to:

- Dilation of the right atrium and right ventricle with consequent shift in the position of the heart.
- Right ventricular ischaemia.
- Increased stimulation of the sympathetic nervous system due to pain, anxiety and hypoxia.

### **Clinical Usefulness**

- The ECG is neither sensitive nor specific enough to diagnose or exclude PE.
- Around 18% of patients with PE will have a completely normal ECG.
- However, with a compatible clinical picture (sudden onset pleuritic chest pain, hypoxia), an ECG showing new RAD, RBBB or T-wave inversions may raise the suspicion of PE and prompt further diagnostic testing.
- In patients with radiologically confirmed PE, there is evidence to suggest that ECG changes of right heart strain and RBBB are predictive of more severe pulmonary hypertension; while the resolution of anterior T-wave inversion has been identified as a possible marker of pulmonary reperfusion following thrombolysis.

### **Differential Diagnosis**

The ECG changes described above are not unique to PE. A similar spectrum of ECG changes may be seen with any cause of acute or chronic *cor pulmonale* (i.e. any disease that causes right ventricular strain / hypertrophy due to hypoxic pulmonary vasoconstriction).

#### **Acute cor pulmonale**

- Severe pneumonia
- Exacerbation of COPD / asthma
- Pneumothorax
- Recent pneumonectomy
- Upper airway obstruction

#### **Chronic cor pulmonale**

- Chronic obstructive pulmonary disease
- Recurrent small PEs
- Cystic fibrosis
- Interstitial lung disease
- Severe kyphoscoliosis and Obstructive sleep apnoea