

Case conference

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Discussion

Pulmonary embolism



Pulmonary embolism (PE)

- A clot that formed hours, days, or weeks earlier in the deep veins
- Dislodges, travels through the venous system, traverses the RV
- Lodges in the pulmonary vasculature
- With a highly variable symptoms
- About 1 in 500-1000 ED patients
- 10% die within 30 days



Pathophysiology of PE

- Pulmonary vascular tree: low resistance
- A young man could tolerate 30% obstruction
- Pulmonary infarction:
 - A clot lodged in a segmental artery
 - 1/16 of entire pulmonary vascular circuit
 - Focal, sharp, pleuritic pain
 - Over several day: consolidation, pleural effusion



Pathophysiology of PE

- Chest pain
 - In 70% PE patient
 - Highly variable and vague
- Dyspnea
 - In 90% PE patient
 - Constant and oppressive/ intermittent/ only with exertion



Hypoxemia in PE

- Ventilation-perfusion inequality
- Venous admixture
- Increased A-a gradient of oxygen
- Hypoxemia ($SpO_2 < 95\%$) in most patient
 - If PE is diagnosed, hypoxemia = predictor of outcome



Pulmonary Embolism Rule-out Criteria (PERC rule)

- Low pretest probability for PE by the treating clinician's unstructured estimate, plus:
 - Age < 50 y/o
 - HR < 100 bpm
 - SpO₂ > 94%
 - No hemoptysis
 - No unilateral leg swelling
 - No recent major surgery or trauma
 - No prior pulmonary embolism or deep venous thrombosis
 - No hormone use

Hemodynamics

- Tachycardia due to impaired LV filling
- Increased RV pressure
 - Less elastic response as compared with LV
 - RV dilation with hypokinesis
 - RV damage for at least 6 months in 40% pt
- Hypotension
 - In 10% pt; 4X↑ in mortality
- If PE obstruct the RV outflow ENTIRELY
 - PEA; survival rate: very very low

Classic risk factors and physiologic finding for PE

Factor	Mechanism	Strength of association with PE
Inherited thrombophilia	Hypercoagulability	++
Carcinoma	Hypercoagulability	+
Limb or generalized immobility	Stasis	++
Prior PE or DVT	Multiple	+
Trauma within past 4 wk requiring hospitalization	Inflammation, venous injury and stasis	+++
Surgery within past 4 wk requiring general anesthesia	Inflammation, venous injury and stasis	++++
Estrogen	Hypercoagulability	++
Smoking	Inflammation	Minimal
Pregnancy/postpartum	Hypercoagulability	minimal

Factor	Mechanism	Strength of association with PE
Symptoms		
Chest pain	Ischemia, muscle strain	Minimal
Dyspnea	V/Q mismatch	+
Hemoptysis	Infarction	+++
Syncope	Vascular obstruction	Minimal
Signs		
HR >100 bpm	Cardiac stress, baroreceptors	+++
SpO ₂ <95%	V/Q mismatch	+++
Unilateral leg or arm swelling	Venous obstruction	++++

TABLE 56-1 Classic Risk Factors for Thrombosis

Hypercoagulability
Malignancy
Nonmalignant thrombophilia
Pregnancy
Postpartum status (<4 wk)
Estrogen
Antiphospholipid antibodies
Genetic mutations Factor V
Leiden mutation Prothrombin mutation
Methylenetetrahydrofolate reductase gene mutation
Factor VIII mutations
Factor VII mutations
Functional or antigenic protein C deficiency
Functional or antigenic protein S deficiency
Venous stasis Bedrest >48 h Cast or external fixation Recent hospitalization Long-distance automobile or air travel Venous injury
Recent surgery requiring endotracheal intubation
Recent trauma requiring hospitalization (especially lower extremity, pelvis)

Diagnosis of PE

- CXR
 - For alternative diagnosis: pneumonia, CHF, pneumothorax
 - Unilateral basilar atelectasis
 - Hampton's hump: apex-central, pleural-based, wedge-shaped area of infiltrate
 - Westermark's sign: unilateral lung oligemia



Hampton's hump



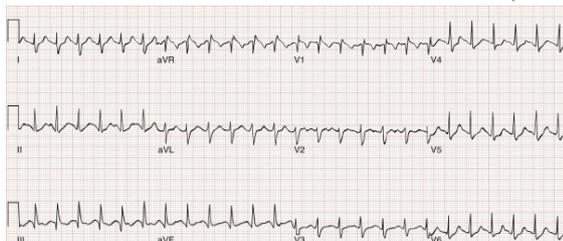
Westermark's sign

Diagnosis of PE

- EKG
 - PE → acute or subacute pul HTN → EKG change
 - Rapid HR: 常見 sinus tachycardia
 - symmetrical T-wave inversion in V1-V4
 - McGinn-White S1Q3T3 pattern
 - A large S wave in lead I, a large Q wave in lead III, an inverted T wave in lead III
 - Incomplete or complete RBBB

- Sinus tachycardia
- S1 QIII TIII – deep S wave in I, Q wave in III, inverted T wave in III
- Complete or incomplete RBBB
- Right axis deviation
- Right ventricular strain pattern: T wave inversions in V1-3, sometimes extending to V4
- Simultaneous T wave inversions in the inferior (II, III, aVF) and right precordial leads (V1-3).
- Right atrial enlargement (“P pulmonale”): peaked P wave in lead II > 2mm in height
- Clockwise rotation: shift of the R/S transition point towards V6, persistent S wave in V6
- Atrial tachyarrhythmias: AF, flutter, atrial tachycardia

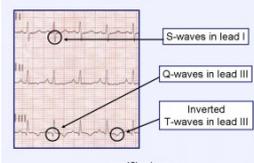
Typical ECG for PE



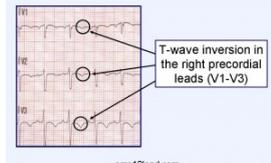
- Tachycardia, S1Q3T3, incomplete RBBB



S1Q3T3



Right ventricular strain?



EKG in Pulmonary Embolism

Key Points:

- The EKG is often abnormal in PE, but the findings are insensitive and non-specific.
- The most common findings are sinus tachycardia and/or non-specific ST-T changes.
- Anterior (V₁-V₄) T-wave inversions have reasonable sensitivity and specificity for massive PE.

Ferrazzi et al. The ECG in pulmonary embolism. Chest 1997;111:537-543

- 80 consecutive hospitalized CCU patients with acute PE, all underwent pulmonary angiography
- Excluded 17 pts with "a history of cardiopulmonary disease that could have modified the ECG"

Finding	Percentage of patients with EKG finding
T waves neg V ₁ -V ₄	68%
S1 Q1 T1 pattern	50%
Peripherally low voltage	39%
Sinus tachycardia	26%
Complete/incomplete RBBB	22%
Pulmonary P wave	5%
Normal	9%

- In massive PE (determined angiographically), anterior ischemic pattern was noted in 83% of patients versus 19% in nonmassive PE; no other parameter correlated with severity
- Anterior T-wave inversions has a sensitivity of 83%, specificity of 81%, PPV of 93%, and a NPV of 65% for massive PE in patients w/ suspected PE.

Rodger et al. Diagnostic value of the electrocardiogram in suspected pulmonary embolism. Am J Cardiol 2000;86:807-809.

Diagnosis of PE: S/S

- Symptoms
 - Dyspnea, atypical chest pain, syncope, seizure
- Sign
 - Respiratory distress, altered consciousness, tachycardia, tachypnea, hypoxemia

Wells score

- Clinically suspected DVT: 3.0 points
- Alternative diagnosis is less likely than PE: 3.0 points
- Tachycardia: 1.5 points
- Immobilization/surgery in previous 4 weeks: 1.5 points
- History of DVT or PE: 1.5 points
- Hemoptysis: 1.0 points
- Malignancy (treatment for within 6 months, palliative): 1.0 points

Wells score

- Score >6.0: high (probability 59%)
- Score 2.0-6.0: moderate (probability 29%)
- Score <2.0: low (probability 15%)

Original Geneva score

- Age
 - 60-79 y/o: 1
 - 80+ y/o: 2
- Previous venous thromboembolism: DVT or PE: 2
- Previous surgery within 4 weeks: 3
- Heart rate >100 bpm: 1
- PaCO₂:
 - <35 mmHg: 2
 - 35-39 mmHg: 1
- PaO₂
 - <49 mmHg: 4
 - 49-59 mmHg: 3
 - 60-71 mmHg: 2
 - 72-82 mmHg: 1
- CXR
 - Band atelectasis: 1
 - Elevation of hemidiaphragm: 1

Original Geneva score

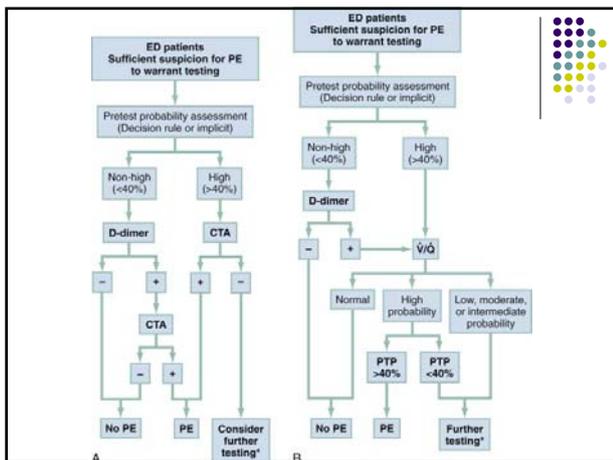
- <5 points: low probability of PE
- 5-8 points: moderate probability of PE
- >8 points; high probability of PE

Revised Geneva score

- Age ≥ 65 y/o: 1
- Previous DVT or PE: 3
- Surgery or fracture within 1 month: 2
- Active malignant condition: 2
- Unilateral lower limb pain: 3
- Hemoptysis: 2
- HR 75-94 bpm: 3
- HR ≥ 95 bpm: 5
- Pain on deep palpation of lower limb and unilateral edema: 4

Revised Geneva score

- 0-3 points: lower probability (8%)
- 4-10 points: intermediate probability (28%)
- ≥ 11 points: high probability (74%)



Management of PE

- Anticoagulation
- Thrombolytic therapy

Anticoagulation

- Initiated when
 - High-probability V/Q scan
 - Positive CTPA
 - Ultrasound evidence of DVT with S/S suggesting PE
- Unfractionated heparin: 80 U/kg IV bolus, then 18 U/Kg/hr IV infusion
- Fractionated heparin: e.g. enoxaparin (Clexane), 1 mg/kg SC or IV Q12H
- Factor Xa inhibitor: e.g. fondaparinux, 5-10 mg

Anticoagulation

- Heparin
 - Reduction in formation of new clots
 - Reduce the theoretical transient hypercoagulable effect of warfarin treatment
 - Anti-inflammation
- Start Before the results of imaging
- Give warfarin in ED!

If there is contraindication for heparin...

- E.g. recent cerebral hemorrhage, large cerebral infarction....
- Urgent placement of an IVC filter
- If IVC filter could not be placed within 12 hr:
 - Perform baseline head CT scan
 - Then start unfractionated heparin infusion at 18 U/kg/hr without a bolus



Thrombolytic therapy

- Controversial
- Alteplase
 - More rapid symptomatic improvement
 - More rapid normalization of RV function
 - Increase the risk of hemorrhage
- May have benefit in massive PE
 - Hypotension: SBP <90 mmHg, >15 minutes
 - For HTN pt: SBP <100 mmHg, or ↓ >60 mmHg



TABLE 56-6 Factors That Can Help Prognose the Short-Term Outcome of Normotensive Patients with Pulmonary Embolism

Good Outcome Likely	Adverse Outcome More Likely
No syncope or seizure at presentation	Syncope or seizure with respiratory distress at presentation
Age <50 y	Age >70 y
Absence of COPD, CHF, or prior PE	Presence of COPD, CHF, or prior PE
<50% pulmonary vascular occlusion	>50% pulmonary vascular occlusion; floating thrombus in the RV or right atrium observed on echocardiography or CT angiography
Normal ECG	ECG with T-wave inversion in V ₁ -V ₄ and a new incomplete right bundle branch block
Heart rate/systolic blood pressure <0.8	Heart rate/systolic blood pressure >1.0
Pulse oximetry reading >94% breathing room air	Pulse oximetry reading <94% breathing room air
Troponin I concentration <0.4 µg/L	Troponin I concentration >1.0 µg/L
Normal RV function and size	RV dilation or hypokinesis, or an estimated RV systolic pressure >40 mm Hg



Predictors of short-term complications from PE

Predictor	Criteria	Sensitivity (%)	Specificity (%)
Trop-I	>0.4 ng/ml	60	85
SpO ₂	<95%, breathing room air	90	64
BNP	>90 pg/ml	85	75
ECG	RV dilation or hypokinesis	86	39



Thanks for your attention

