Pulmonary Embolism

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Disclosures

• Conflict of Interest: None
Epidemiology

• Difficult to determine because it may remain asymptomatic, or its diagnosis may be an incidental finding
• 25% cases, the first presentation of PE may be sudden death
• Approximately 900,000 people could be affected (1 to 2 per 1,000) each year in the United States.
• Estimates suggest that 60,000-100,000 Americans die of DVT/PE
  • 10 to 30% of people will die within one month of diagnosis.
• One-third (about 33%) of people with DVT/PE will have a recurrence within 10 years.
• Approximately 5 to 8% of the U.S. population has one of several genetic risk factors
Predisposing Factors

• VTE is considered to be ‘provoked’ in the presence of a temporary or reversible risk factor
  • surgery, trauma, immobilization, pregnancy, oral contraceptive use or hormone replacement therapy within the last 6 weeks to 3 months before diagnosis

• Cancer is a well-recognized predisposing factor for VTE. The risk of VTE varies with different types of cancer
  • Hematological malignancies, lung cancer, gastrointestinal cancer, pancreatic cancer and brain cancer carry the highest risk
  • Cancer is a strong risk factor for all-cause mortality following an episode of VTE

• Infection has been found to be a common trigger for hospitalization for VTE.

• Blood transfusion and erythropoiesis-stimulating agents are also associated with an increased risk of VTE

• Hypercoagulable states

Pathophysiology

- Interferes with both the circulation and gas exchange.
- Right ventricular (RV) failure due to pressure overload is considered the primary cause of death in severe PE.
- Respiratory failure in PE is predominantly a consequence of hemodynamic disturbances.

Classification of Severity

**APPENDIX B: Classifications of Pulmonary Embolism (PE)**

<table>
<thead>
<tr>
<th>Risk Levels</th>
<th>Classifications</th>
</tr>
</thead>
</table>
| **Low Risk**      | - No hypotension and  
                    - No RV dysfunction and  
                    - No myocardial necrosis or strain |
| **Low-Intermediate Risk** | - RV dysfunction by CT or ECHO or  
                             - Myocardial necrosis or strain (elevated Troponin T or NT-proBNP) |
| **High-Intermediate Risk** | - RV dysfunction by CT or ECHO and  
                             - Myocardial necrosis or strain (elevated Troponin T or NT-proBNP) and/or  
                             - Absence of signs of hypotension or shock |
| **High Risk**     | - Sustained hypotension (SBP less than 90 mmHg) at least 15 minutes or  
                    - Persistent bradycardia (HR less than 40 bpm) or signs and symptoms of shock or  
                    - Need for inotropic support |

PE = pulmonary embolism.

*Defined as systolic blood pressure <90 mm Hg, or a systolic pressure drop by ≥40 mm Hg, for >15 minutes, if not caused by new-onset arrhythmia, hypovolaemia, or sepsis.

*Based on the estimated PE-related in-hospital or 30-day mortality.
### Revised Geneva score

<table>
<thead>
<tr>
<th>Feature</th>
<th>PE confirmed (n = 1880)</th>
<th>PE not confirmed (n = 528)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyspnoea</td>
<td>50%</td>
<td>51%</td>
</tr>
<tr>
<td>Pleuritic chest pain</td>
<td>39%</td>
<td>28%</td>
</tr>
<tr>
<td>Cough</td>
<td>23%</td>
<td>23%</td>
</tr>
<tr>
<td>Substernal chest pain</td>
<td>15%</td>
<td>17%</td>
</tr>
<tr>
<td>Fever</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Haemoptysis</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>Syncope</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>Unilateral leg pain</td>
<td>6%</td>
<td>5%</td>
</tr>
<tr>
<td>Signs of DVT (unilateral extremity swelling)</td>
<td>24%</td>
<td>18%</td>
</tr>
</tbody>
</table>

### Risk factors

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt;65 years</td>
<td>+1</td>
</tr>
<tr>
<td>Previous DVT or PE</td>
<td>+3</td>
</tr>
<tr>
<td>Surgery or fracture within 1 month</td>
<td>+2</td>
</tr>
<tr>
<td>Active cancer</td>
<td>+2</td>
</tr>
<tr>
<td>Clinical signs</td>
<td></td>
</tr>
<tr>
<td>Heart rate 75–94 beats per minute</td>
<td>+3</td>
</tr>
<tr>
<td>Heart rate &gt;90 beats per minute</td>
<td>+5</td>
</tr>
<tr>
<td>Pain on lower limb deep vein palpation and unilateral oedema</td>
<td>+4</td>
</tr>
</tbody>
</table>

### Symptoms

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unilateral lower limb pain</td>
<td>+3</td>
</tr>
<tr>
<td>Haemoptysis</td>
<td>+2</td>
</tr>
<tr>
<td>Haemoptysis</td>
<td>+1</td>
</tr>
</tbody>
</table>

### Clinical signs

<table>
<thead>
<tr>
<th>Clinical signs</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate &gt;100 beats/min</td>
<td>+1.5</td>
</tr>
<tr>
<td>Clinical signs of DVT</td>
<td>+3</td>
</tr>
<tr>
<td>Alternative diagnosis less likely than PE</td>
<td>+3</td>
</tr>
</tbody>
</table>

### Clinical probability

<table>
<thead>
<tr>
<th>Clinical probability</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0–3</td>
</tr>
<tr>
<td>Intermediate</td>
<td>4–10</td>
</tr>
<tr>
<td>High</td>
<td>&gt;11</td>
</tr>
</tbody>
</table>

### Clinical probability (dichotomised)

<table>
<thead>
<tr>
<th>Clinical probability</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE unlikely</td>
<td>0–4</td>
</tr>
<tr>
<td>PE likely</td>
<td>&gt;4</td>
</tr>
</tbody>
</table>

DVT, deep vein thrombosis.
Diagnostics

• D-Dimer
• Computed tomographic pulmonary angiography
• Ventilation–perfusion scintigraphy (V/Q scan)
• Pulmonary angiography
• Echocardiography

• Compression venous ultrasonography (Venous ultrasound)
• Troponin
• BNP
• Chest x-ray
• EKG

Diagnostics

- Felson’s sign: Pleural effusion left > right
- Hampton’s hump: Peripheral pleural based wedge-shaped density above the diaphragm due to pulmonary infarct
- Westermark’s sign: Distension of pulmonary vasculature proximal to embolism with loss of vascular markings distally (localized peripheral oligemia)
- Palla sign: Enlarged right descending pulmonary artery
- Fleischner lines: Long curvilinear densities reaching pleural surface
- Fleischner sign: Dilated pulmonary artery
Suspected PE with shock or hypotension

CT angiography immediately available

No\(^a\)

Echocardiography

RV overload\(^b\)

No

No other test available\(^b\) or patient unstable

Search for other causes of haemodynamic instability

Search for other causes of haemodynamic instability

PE-specific treatment: primary reperfusion\(^c\)

CT angiography available and patient stabilized

Yes

Positive

CT angiography

Negative

CT = computed tomographic; PE = pulmonary embolism; RV = right ventricular.

\(^a\)Includes the cases in which the patient's condition is so critical that it only allows bedside diagnostic tests.

\(^b\)Apart from the diagnosis of RV dysfunction, bedside transcardiac echocardiography may, in some cases, directly confirm PE by visualizing mobile thrombi in the right heart chambers. Ancillary bedside imaging tests include transthoracic echocardiography, which may detect emboli in the pulmonary artery and its main branches, and bilateral compression venous ultrasonography, which may confirm deep vein thrombosis and thus be of help in emergency management decisions.

\(^c\)Thrombolysis; alternatively, surgical embolectomy or catheter-directed treatment (Section 5).
CT PE Protocol Images
Treatment

- Hemodynamic and respiratory support
- Anticoagulation
- Parenteral anticoagulation
- Vitamin K antagonists
- New oral anticoagulants
- Thrombolytic treatment
- Surgical embolectomy
- Percutaneous catheter-directed treatment
- Venous filters

Duration of Therapy

• Anticoagulation:
  • Initial (0-10 days)
  • Long-Term Therapy (10 days -3 months)
    • Can be extended 6-12 months (persisting risk factors or unprovoked PE)
  • Indefinite Anticoagulation (rare)

• Outpatient Anticoagulation
  • First dose administered in the ER
    • Low Risk of Death - No history of bleeding
    • No supplemental oxygen - Normal mental status
    • No respiratory distress - No Serious Comorbid conditions

Team Response to Pulmonary Embolism

Pulmonary Embolism Response Team (PERT)
Pulmonary Embolism Response Team (PERT)

- Hematology (Benign)
- Vascular Surgery
- Pulmonary Medicine
- Critical Care
- Interventional Radiology
- Cardiology
- Thoracic Surgery
- Consulting Service
  - Emergency Medicine, Internal Medicine, Oncology Teams
INITIAL EVALUATION – INTERMEDIATE RISK

PERT First Responder\(^1\) contacted for patient with Pulmonary Embolism (PE) and Intermediate Risk\(^1,3\)

- Notify Primary Team if not already aware of PE

\[\text{Yes}\]

- Order NT-proBNP (if not done yet)
- Order Troponin T (if not done yet)
- Request routine 2D-ECHO (if not done yet)\(^2\)
- Type and screen
- EKG 12-Lead (portable)
- Ultrasound of leg or venous doppler bilaterally as clinically indicated (if not done yet)

**Contraindication to anticoagulation?**

- **Yes**
  - Start IV unfractionated heparin\(^6\)

- **No**
  - Low-Intermediate\(^3\) Risk PE
  - Low-Intermediate\(^3\) Risk PE

**TREATMENT**

- **Low-Intermediate\(^3\) Risk PE**
  - Transfer to telemetry bed (monitored bed)
  - Observe

- **High-Intermediate\(^3\) Risk PE**
  - Transfer to ICU
  - Observe

- **High-Intermediate\(^3\) Risk PE**
  - Continue IV heparin
  - Transfer to ICU
  - Observe

- **Low-Intermediate\(^3\) Risk PE**
  - Change to low molecular weight heparin\(^7\)
  - Transfer to telemetry bed (monitored bed)
  - Observe

**Temporary contraindication to anticoagulant?**

- **Yes**
  - Temporary IVC filter

- **No**
  - Permanent IVC filter

**Follow-up as clinically indicated**

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\(^1\) PERT First Responder: On-Call fellow/trainee and attending provider

\(^2\) See Appendix A: Criteria for After Hours STAT 2D-ECHO

\(^3\) See Appendix B: Classification of Pulmonary Embolism

\(^4\) See Appendix C: Contraindications to Anticoagulation Therapy

\(^5\) Criteria to consider for placement of a retrievable filter
  - If temporary/limited time (less than or equal to 2-3 months) of contraindication to anticoagulants, place a retrievable IVC filter
  - Greater than 6 months survival expected
  - Performance Status less than or equal to 1

\(^6\) Refer to Adult Heparin Infusion order set

\(^7\) See Appendix D: Low Molecular Weight Heparin (LMWH) Regimens for Treatment of Cancer Associated Thrombosis
Pulmonary Embolism Response Team (PERT)

Disclaimers: This algorithm has been developed for MD Anderson using a multidisciplinary approach considering circumstances particular to MD Anderson's specific patient population, services and structure, and clinical information. This is not intended to replace the independent medical or professional judgment of physicians or other health care providers in the context of individual clinical circumstances to determine a patient's care. This algorithm should not be used to treat pregnant women.

INITIAL EVALUATION – HIGH RISK

- PERT First Responder contacted for patient with Pulmonary Embolism (PE) and High Risk
- Notify Primary Team if not already aware of PE
- Order NT-proBNP (if not done yet)
- Order Troponin T (if not done yet)
- Request routine 2D-ECHO (if not done yet)
- Type and Screen
- EKG 12-Lead (Portable)
- Ultrasound of leg or venous doppler bilaterally as clinically indicated (if not done yet)

### Treatment

- **Contraindication to anticoagulation?**
  - Yes: Stop anticoagulation
  - No: Proceed to anticoagulation

- **Contraindication to systemic thrombolytics?**
  - Yes: TPA
  - No: TPA + heparin

- **Systolic BP greater than 90 mmHg?**
  - Yes: TPA + heparin
  - No: TPA + heparin

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1. PERT First Responder: On-call fellow/trainee and attending providers
2. See Appendix A: Criteria for After Hours STAT 2D-ECHO
3. See Appendix B: Classifications of Pulmonary Embolism
4. See Appendix C: Contraindications to Anticoagulation Therapy
5. Refer to Adult Heparin Infusion order set
6. See Appendix E: Contraindications to Systemic Thrombolysis
7. Alteplase 100 mg IV infusion over 2 hours. Institute or resume parenteral anticoagulation near the end of or immediately following the alteplase infusion when the partial thromboplastin time returns to twice normal or less.
Pulmonary Embolism Response Team (PERT)

APPENDIX A: Criteria for After Hours STAT 2D-ECHO

<table>
<thead>
<tr>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient has to be seen first by a member of the PERT team in order to confirm that none of the other imaging modalities are possible (CT angiogram or VQ scan)</td>
</tr>
<tr>
<td>Patient is hemodynamically unstable (Systolic Blood Pressure (SBP) less than 90 mmHg or receiving vasopressors)</td>
</tr>
<tr>
<td>PE has to be highly suspected and no other etiology would explain shock (no septic, hemorrhagic or hypovolemic shock)</td>
</tr>
<tr>
<td>PERT team member is to contact and discuss directly the need of the echo with the cardiologist on-call before sonographer is contacted.</td>
</tr>
</tbody>
</table>

APPENDIX C: Contraindications to Anticoagulation Therapy

<table>
<thead>
<tr>
<th>Absolute Contraindications:</th>
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</thead>
<tbody>
<tr>
<td>Cerebral hemorrhage, hemorrhage in the eye or vital organs or a drop in hemoglobin of 2 gm/dL in 24 hours</td>
</tr>
<tr>
<td>Neurosurgery, ocular surgery or intracranial bleeding within past 10 days</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Relative Contraindications:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain metastases conferring risk of bleeding (renal, choriocarcinoma, melanoma, thyroid cancer)</td>
</tr>
<tr>
<td>Spinal Procedure and/or epidural placement</td>
</tr>
<tr>
<td>Major trauma or head trauma</td>
</tr>
<tr>
<td>Major abdominal surgery within 48 hours</td>
</tr>
<tr>
<td>Severe hypertension (systolic BP greater than 200 mmHg, diastolic BP greater than 120 mmHg)</td>
</tr>
<tr>
<td>Endocarditis/pericarditis</td>
</tr>
<tr>
<td>GI, GU bleeding within past 14 days</td>
</tr>
<tr>
<td>Preexisting coagulopathy</td>
</tr>
<tr>
<td>Platelets less than 50 K/microliter</td>
</tr>
<tr>
<td>Hypersensitivity to heparin, low molecular weight heparin (LMWH) or heparin induced thrombocytopenia</td>
</tr>
<tr>
<td>Patient on active protocol that prohibits use of anticoagulation</td>
</tr>
<tr>
<td>Bleeding diathesis</td>
</tr>
</tbody>
</table>
### APPENDIX E: Contraindications to Systemic Thrombolysis

<table>
<thead>
<tr>
<th>Absolute Contraindications:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• History of hemorrhagic stroke or stroke of unknown origin</td>
</tr>
<tr>
<td>• Intracranial tumor</td>
</tr>
<tr>
<td>• Ischemic stroke in previous 3 months</td>
</tr>
<tr>
<td>• History of major trauma, surgery or head injury in previous 3 weeks</td>
</tr>
<tr>
<td>• Platelet count below 100 K/microliter</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Relative Contraindications:</td>
</tr>
<tr>
<td>• Pregnancy or first post-partum week</td>
</tr>
<tr>
<td>• Non-compressible puncture sites</td>
</tr>
<tr>
<td>• Traumatic resuscitation</td>
</tr>
<tr>
<td>• Refractory hypertension (systolic blood pressure greater than 180 mmHg; diastolic blood</td>
</tr>
<tr>
<td>pressure greater than 100 mmHg)</td>
</tr>
<tr>
<td>• Advanced liver disease</td>
</tr>
<tr>
<td>• Infective endocarditis</td>
</tr>
<tr>
<td>• Recent GI bleed (last 3 months)</td>
</tr>
<tr>
<td>• Life expectancy less than or equal to 6 months</td>
</tr>
</tbody>
</table>
The University of Texas MD Anderson Cancer Center, Houston, Texas, USA, Clinical Practice Algorithm on Pulmonary Embolism Response Team, [Internet, last updated December 2018], Available from: https://www.mdanderson.org/content/dam/mdanderson/documents/for-physicians/algorithms/clinical-management/clin-management-pert-web-algorithm.pdf
References


- The University of Texas MD Anderson Cancer Center, Houston, Texas, USA, Clinical Practice Algorithm on Pulmonary Embolism Response Team, [Internet, last updated December 2018], Available from: https://www.mdanderson.org/content/dam/mdanderson/documents/for-physicians/algorithms/clinical-management/clin-management-pert-web-algorithm.pdf
Questions?

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