Disclaimer: 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.

Pulmonary Embolism (PE) Response Team (PERT)

**Pulmonary Embolism (PE)**

- **Low Risk**
  - NO Need to Contact PERT Team
- **Intermediate Risk**
  - See Page 2
- **High Risk**
  - See Page 3

APPENDIX A: Classifications of Pulmonary Embolism (PE) ................................................................. Page 4
APPENDIX B: Considerations for Pediatric Patients ................................................................. Page 5
APPENDIX C: Criteria for After Hours STAT 2D-ECHO .......................................................... Page 6
APPENDIX D: Contraindications to Anticoagulation Therapy .................................................. Page 6
APPENDIX E: Low Molecular Weight Heparin (LMWH) Regimens for Treatment of Cancer Associated Thrombosis ................................................................. Page 7
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Pulmonary Embolism Response Team (PERT)

INITIAL EVALUATION – INTERMEDIATE RISK

PERT First Responder\(^1\) contacted for patient with Pulmonary Embolism (PE) and Intermediate Risk\(^2\):
- Notify Primary Team (if not already aware of PE)
- For Pediatric considerations, see Appendix B

Obtain the following (if not already done):
- NT-proBNP, troponin T, type and screen
- Routine 2D-ECHO\(^3\)
- EKG 12-Lead (portable)
- Ultrasound of leg or venous doppler bilaterally as clinically indicated

Absolute contraindication\(^4\) to anticoagulation?

\[RR \geq 30 \text{ breaths/minute or } O_2 \text{ saturation on room air } < 90\% \text{ or } HR \geq 110 \text{ beats/minute or } SBP < 100 \text{ mmHg or } AMS\]

A

Risk stratification assessed by PESI score\(^5\)

- High-Intermediate\(^2\) Risk PE and PESI score < 86 or Low-Intermediate\(^2\) Risk PE
- High-Intermediate\(^2\) Risk PE and PESI score ≥ 86

\- Transfer the patient to cardiac monitoring bed
\- Observe

Intermediate Risk PE and PESI score ≥ 86

\- Transfer the patient to ICU
\- Observe

TREATMENT

Temporary contraindication to anticoagulant?

Yes

- Start IV unfractionated heparin\(^7,8,9\)
- Risk stratification assessed by PESI score\(^5\)

- Yes

- Continue anticoagulation
- Transfer the patient to ICU
- Observe

- No

- Permanent IVC filter

Follow-up as clinically indicated

No

- Start LMWH \(^{9,10}\) twice daily\(^{11}\)
- High-Intermediate\(^2\) Risk PE and PESI score ≥ 86
- High-Intermediate\(^2\) Risk PE and PESI score < 86 or Low-Intermediate\(^2\) Risk PE

- Yes

- Continue anticoagulation
- Transfer the patient to ICU
- Observe

- No

- Retrievable IVC filter\(^6\)

- PERT virtual meeting considerations:
  - Life expectancy and Performance Status
  - Mechanical thrombectomy
  - Low dose catheter directed thrombolysis
  - IVC filter

- Yes

- No

- Follow-up as clinically indicated

- Yes

- No

\(^{1}\)PERT First Responder: On-Call fellow/trainee and attending provider
\(^{2}\)See Appendix A: Classifications of Pulmonary Embolism
\(^{3}\)See Appendix C: Criteria for After Hours STAT 2D-ECHO
\(^{4}\)See Appendix D: Contraindications to Anticoagulation Therapy
\(^{5}\)PESI score calculators:

\(^{6}\)Criteria to consider for placement of a retrievable filter:
  - If temporary/limited time (≤ 2-3 months) of contraindication to anticoagulants
  - Greater than 6 months survival expected
  - Performance Status ≤ 1

\(^{7}\)Refer to Adult Heparin Infusion order set

\(^{8}\)If patient has a history of heparin induced thrombocytopenia (HIT), see Heparin Induced Thrombocytopenia (HIT) Treatment algorithm for management

\(^{9}\)May consider Low Intensity dosing of IV unfractionated heparin for patients with relative contraindication to anticoagulation therapy (see Appendix D).

\(^{10}\)If the risk is still too high, see Box A for Absolute contraindication to anticoagulation

\(^{11}\)Twice daily dose is applicable for enoxaparin only (not dalteparin)

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Approved by The Executive Committee of the Medical Staff on 04/20/2021
INITIAL EVALUATION – HIGH RISK

PERT First Responder\(^1\) contacted for patient with Pulmonary Embolism (PE) and High Risk\(^2\)
- Notify Primary Team (if not already aware of PE)
- For Pediatric considerations, see Appendix B

- Obtain the following (if not already done):
  - NT-proBNP, troponin T, type and screen
  - Routine 2D-ECHO\(^3\)
  - EKG 12-Lead (portable)
  - Ultrasound of leg or venous Doppler bilaterally as clinically indicated
- Transfer the patient to ICU

Start IV unfractionated heparin\(^5,6\)

Contraindication\(^4\) to anticoagulation?

Yes

No

Contraindication\(^4\) to systemic thrombolytics?\(^5\)

Yes

No

Treat with systemic thrombolytics\(^8\)

Systolic BP > 90 mmHg?

No

Yes

Follow-up as clinically indicated

PERT virtual meeting considerations:
- Life expectancy and Performance Status
- Mechanical thrombectomy
- Low dose catheter directed thrombolysis
- IVC filter placement
- Transfer to a cardiac center for surgical thrombectomy

\(\text{\textsuperscript{1}}\)PERT First Responder: On-call fellow/trainee and attending providers
\(\text{\textsuperscript{2}}\)See Appendix A: Classifications of Pulmonary Embolism
\(\text{\textsuperscript{3}}\)See Appendix C: Criteria for After Hours STAT 2D-ECHO
\(\text{\textsuperscript{4}}\)See Appendix D: Contraindications to Anticoagulation Therapy
\(\text{\textsuperscript{5}}\)Refer to Adult Heparin Infusion order set
\(\text{\textsuperscript{6}}\)If patient has a history of HIT, see Heparin Induced Thrombocytopenia Treatment (HIT) algorithm for management
\(\text{\textsuperscript{7}}\)See Appendix F: Contraindications to Systemic Thrombolysis

\(\text{\textsuperscript{8}}\) If patient is on heparin infusion, hold heparin infusion and administer alteplase 100 mg IV infusion over 2 hours. Check aPTT immediately after alteplase infusion is complete and restart heparin infusion without bolus if aPTT is \(\leq 80\) seconds. If aPTT is \(> 80\) seconds, continue to hold heparin infusion and check aPTT every 2 hours until aPTT is \(\leq 80\) seconds.
- If patient is on LMWH prior to alteplase, discontinue LMWH and start heparin infusion without a bolus at the time of the next scheduled dose of LMWH
- If patient is on a direct-acting oral anticoagulants (DOAC) prior to alteplase, discontinue DOAC and start heparin infusion without a bolus at the time of the next scheduled dose of DOAC
# APPENDIX A: Classifications of Pulmonary Embolism (PE)

<table>
<thead>
<tr>
<th>Risk Levels</th>
<th>Classifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Risk</td>
<td>- No hypotension and&lt;br&gt;- No RV dysfunction and&lt;br&gt;- No myocardial necrosis or strain</td>
</tr>
<tr>
<td>Low-Intermediate Risk</td>
<td>- RV dysfunction by CT or ECHO or&lt;br&gt;- Myocardial necrosis or strain (elevated Troponin T or NT-proBNP)</td>
</tr>
<tr>
<td>High-Intermediate Risk</td>
<td>- RV dysfunction by CT or ECHO and&lt;br&gt;- Myocardial necrosis or strain (elevated Troponin T or NT-proBNP) and/or&lt;br&gt;- Absence of signs of hypotension or shock</td>
</tr>
<tr>
<td>High Risk</td>
<td>- Sustained hypotension (SBP less than 90 mmHg) at least 15 minutes or&lt;br&gt;- Persistent brady cardia (HR less than 40 bpm) or signs and symptoms of shock or&lt;br&gt;- Need for inotropic support</td>
</tr>
</tbody>
</table>
APPENDIX B: Considerations for Pediatric Patients (< 18 years old)

- PESI score was not validated in pediatric patients. To determine PE risk category, level of care, and management – consult general pediatrics. For unstable patients, contact the pediatric intensive care unit provider.
- If heparin is used in the management of pediatric patients, refer to the Pediatric Treatment of VTE with Unfractionated Heparin Infusion order set
- The preferred LMWH in pediatric patients is enoxaparin 1 mg/kg subcutaneous every 12 hours. Doses should be held for platelets < 30 K/microliter
- Dosing of alteplase for pediatrics patients: 0.5 mg/kg/hour IV infusion over 6 hours
- Vital sign considerations for pediatric patients:

<table>
<thead>
<tr>
<th>Age</th>
<th>Normal awake Heart Rate Beats/minute</th>
<th>Normal Respiratory Rate Breaths/minute</th>
<th>Definition of Hypotension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn (up to 1 months)</td>
<td>100-205</td>
<td>30-53</td>
<td>SBP &lt; 60 (applies to 0 to 28 days)</td>
</tr>
<tr>
<td>Infant (1 - 12 months)</td>
<td>100-180</td>
<td>30-53</td>
<td>SBP &lt; 70 (applies to 1 - 12 months)</td>
</tr>
<tr>
<td>Toddler (1 - 2 years)</td>
<td>98-140</td>
<td>22-37</td>
<td>SBP &lt; 70 + (age in years x 2) (applies to 1 - 10 years)</td>
</tr>
<tr>
<td>Preschooler (3 - 5 years)</td>
<td>80-120</td>
<td>20-28</td>
<td>SBP &lt; 70 + (age in years x 2) (applies to 1 - 10 years)</td>
</tr>
<tr>
<td>Child (6 - 11 years)</td>
<td>75-118</td>
<td>18-25</td>
<td>SBP &lt; 70 + (age in years x 2) (applies to 1 - 10 years)</td>
</tr>
<tr>
<td>Adolescent (12 - 18 years)</td>
<td>60-100</td>
<td>12-20</td>
<td>SBP &lt; 90 (applies to &gt; 10 years)</td>
</tr>
</tbody>
</table>
APPENDIX C: 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 ventilation-perfusion (VQ) scan)</td>
</tr>
<tr>
<td>Patient is hemodynamically unstable (Systolic Blood Pressure (SBP) &lt; 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 D: Contraindications to Anticoagulation Therapy

<table>
<thead>
<tr>
<th>Absolute Contraindications</th>
<th>Relative Contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major active bleeding (e.g. bleeding requiring ≥ 2 units of packed red blood cells (PRBC) transfusion, decrease in hemoglobin ≥ 2 g/dL, or bleeding in a critical area or organ)</td>
<td>Brain metastases conferring risk of bleeding (renal, choriocarcinoma, melanoma, thyroid cancer)</td>
</tr>
<tr>
<td>Platelet &lt; 25 K/microliter, consult to benign hematology</td>
<td>Intracranial or central nervous system (CNS) bleeding within the past 4 weeks</td>
</tr>
<tr>
<td>Spinal procedure and/or epidural placement</td>
<td>Recent high-risk surgery or bleeding event</td>
</tr>
<tr>
<td>Severe uncontrolled malignant hypertension</td>
<td>Active but non-life threatening bleeding</td>
</tr>
<tr>
<td></td>
<td>Active GI ulceration at high risk of bleeding</td>
</tr>
<tr>
<td></td>
<td>Platelets &lt; 50 K/microliter, consider consult to benign hematology</td>
</tr>
<tr>
<td></td>
<td>Patient currently on active protocol that prohibits use of anticoagulation</td>
</tr>
</tbody>
</table>
### APPENDIX E: Low Molecular Weight Heparin (LMWH): Regimens for Treatment of Cancer Associated Thrombosis

<table>
<thead>
<tr>
<th>DRUG</th>
<th>DOSE / ROUTE / FREQUENCY</th>
<th>MONITORING</th>
<th>DOSE ADJUSTMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dalteparin (Fragmin)</strong>&lt;sup&gt;*&lt;/sup&gt;</td>
<td>Round to nearest International Units (IU) dose, given subcutaneously daily</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>FDA approved for cancer patients</em></td>
<td>Actual Body Weight (kg)</td>
<td>Month 1 200 IU/kg</td>
<td>Months 2-6 150 IU/kg</td>
</tr>
<tr>
<td>Hold in patients with platelets &lt; 25 K/microliter</td>
<td>≤ 56</td>
<td>10,000 IU</td>
<td>7,500 IU</td>
</tr>
<tr>
<td></td>
<td>57-68</td>
<td>12,500 IU</td>
<td>10,000 IU</td>
</tr>
<tr>
<td></td>
<td>69-82</td>
<td>15,000 IU</td>
<td>12,500 IU</td>
</tr>
<tr>
<td></td>
<td>83-98</td>
<td>18,000 IU</td>
<td>15,000 IU</td>
</tr>
<tr>
<td></td>
<td>≥ 99</td>
<td>Consider monitoring anti-Xa levels and adjust dose as needed. Limited data suggests dalteparin 200 IU/kg based on actual body weight (with no dose capping) in one or two divided doses&lt;sup&gt;3&lt;/sup&gt;. An alternative option is enoxaparin 1 mg/kg twice daily (see below).</td>
<td>Same as above</td>
</tr>
<tr>
<td><strong>Enoxaparin (Lovenox)</strong>&lt;sup&gt;®&lt;/sup&gt;</td>
<td>1 mg/kg subcutaneously every 12 hours</td>
<td>Limited data suggest once per day dosing is inferior in cancer patients and may increase risk of bleeding</td>
<td><strong>Platelets:</strong> Limited data suggest the following enoxaparin dose modification:</td>
</tr>
<tr>
<td>Hold in patients with platelets &lt; 25 K/microliter</td>
<td>Limited data suggest dose of 0.75-0.85 mg/kg every 12 hours in obese patients (BMI ≥ 40 kg/m²)</td>
<td>Limited data suggest once per day dosing is inferior in cancer patients and may increase risk of bleeding</td>
<td>For platelet count &gt; 50 K/microliter: full-dose, 1 mg/kg twice daily</td>
</tr>
<tr>
<td></td>
<td>Same as above</td>
<td>Limited data suggest dose of 0.75-0.85 mg/kg every 12 hours in obese patients (BMI ≥ 40 kg/m²)</td>
<td>For platelet count 25-50 K/microliter: half-dose, 0.5 mg/kg twice daily</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>For platelet count &lt; 25 K/microliter, hold all anticoagulants</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Renal:</strong> If creatinine clearance &lt; 30 mL/minute: 1mg/kg daily</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Weight:</strong> Obtain anti-Xa level in patients weighing &gt; 150 kg or &lt; 50 kg, or BMI ≥ 40 kg/m²&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• For 1 mg/kg every 12 hour dosing regimen: adjust dose to obtain anti-Xa level of 0.6-1 IU/mL (4-6 hours after fourth dose)</td>
</tr>
</tbody>
</table>

<sup>1</sup>Notes:
- LMWH are preferred agents
- Patients who tolerate anticoagulation should be continued on it indefinitely or until active cancer resolves
- Patients should be observed closely for bleeding and signs and symptoms of neurological impairment if therapy is administered during or immediately following diagnostic lumbar puncture, epidural anesthesia, or spinal anesthesia
- If lab results indicate heparin induced thrombocytopenia, follow management guideline per Heparin Induced Thrombocytopenia (HIT) Treatment algorithm
- Multi-dose vials not recommended for home use

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Department of Clinical Effectiveness V3
Approved by The Executive Committee of the Medical Staff on 04/20/2021
APPENDIX F: Contraindications to Systemic Thrombolysis

<table>
<thead>
<tr>
<th>Absolute Contraindications:</th>
<th>Relative Contraindications:</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Active bleeding</td>
<td>● Age &gt; 75 years old</td>
</tr>
<tr>
<td>● History of hemorrhagic stroke or stroke of unknown origin</td>
<td>● Pregnancy or first post-partum week</td>
</tr>
<tr>
<td>● Intracranial tumor</td>
<td>● Non-compressible puncture sites</td>
</tr>
<tr>
<td>● Ischemic stroke within the past 3 months</td>
<td>● Traumatic cardiopulmonary resuscitation</td>
</tr>
<tr>
<td>● Recent brain or spinal surgery(^1) and/or head or facial trauma</td>
<td>● Recent major surgery, invasive procedure, and/or trauma (within 1 month)</td>
</tr>
<tr>
<td>● Suspected or confirmed aortic dissection</td>
<td>● Refractory hypertension (SBP &gt; 180 mmHg, DBP &gt; 110 mmHg)</td>
</tr>
<tr>
<td>● Platelet count below 100 K/microliter</td>
<td>● Known bleeding diathesis or acquired coagulopathy</td>
</tr>
<tr>
<td></td>
<td>● Significant non-intracranial bleeding within 1 month</td>
</tr>
</tbody>
</table>

\(^1\) Discussion with neurosurgery for recent brain or spinal surgery
SUGGESTED READINGS


This practice consensus statement is based on majority expert opinion of the PERT work group at the University of Texas MD Anderson Cancer Center for the patient population. These experts included:

- Kamran Ahrar, MD (Interventional Radiology) *
- Teresa Moon Calderon, MD (Anesthesiology & PeriOperative Med)
- Saadia Faiz, MD (Pulmonary Medicine)
- Olga N. Fleckenstein *
- Susan Gaeta, MD (Emergency Medicine)
- Cristina Gutierrez, MD (Critical Care & Respiratory Care)
- Sajid Haque, MD (Critical Care & Respiratory Care)
- Steven Y. Huang, MD (Interventional Radiology)
- Tam Thi Thanh Huynh, MD (Thoracic & Cardiovascular Surgery)
- Thoa Kazantsev, MSN, RN, OCN *
- Michael Kroll, MD (Benign Hematology)
- Joshua D. Kuban, MD (Interventional Radiology)
- Elie Mouhayar, MD (Cardiology)
- George Pismisis, MD (Thoracic & Cardiovascular Surgery)
- Nidra I. Rodriguez Cruz, MD (Pediatrics)
- Boris Sepesi, MD (Thoracic Surgery)
- Rahul A. Sheth, MD (Interventional Radiology)
- Alda L. Tam, MD (Interventional Radiology)
- Katy Toale, PharmD (Pharmacy Quality - Regulatory)
- Saroj Vadhan, MD (Cytokine & Supportive Oncology)
- Carol Wu, MD (Diagnostic Radiology – Thoracic Imaging)
- SWamique Yusuf, MD (Cardiology)
- Ali Zalpour, PharmD (Pharmacy Clinical Programs)

* Core Development Team Lead
* Clinical Effectiveness Development Team

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