Acute Pulmonary Embolism: Evaluation and Management

Guideline Introduction

Bibliography | Summary of Version Changes | Restrictions Disclaimers

Inclusion Criteria for this Guideline:

- Meets definition for clinical suspicion for Pulmonary Embolism (Clinical Symptoms: dyspnea, chest pain, hypoxemia, hemoptysis, shock or cardiac arrest)
- Increased suspicion in patients with Risk Factors (see below)

Exclusion Criteria for this Guideline:

- > 18 yo of age – Apply Wells Criteria to assess risk and activate the PERT team at NH.

This guideline is intended to be used for patients with pulmonary embolism regardless of location at NCH who meet the below inclusion criteria.

Key to using guideline

- *This is a guideline, not a policy. Patient variation and other factors may impact management decisions. Patients must meet inclusion criteria and not meet one or more of the exclusion criteria.*
- Blue boxes at bottom of page will contain hyperlinks to other pages of the guidelines. Clicking on the underlined word or phrase will take you to the page.
- Green boxes represent steps in an algorithm
- Yellow shapes represent decision branch points or key points of concern/caution

Table of Contents

Acute Pulmonary Embolism: Evaluation and Management

Diagnostic and initial treatment algorithm: ED and Inpatient

Bibliography | Summary of Version Changes | Restrictions Disclaimers

Inclusion Criteria for this Guideline
Exclusion Criteria for this Guideline

Suspect PE based on clinical presentation and risk factors and patient < 18 yo.

- Routine monitoring including continuous pulse oximetry
- Supplemental oxygen
- Place PIV
- Initial Labs: CBC, PT/PTT/INR, fibrinogen, D dimer, BNP, lactate, troponin
- CXR and EKG

Shock or hypotension[3]

Stat bedside ECHO

RV Strain[b]

yes

Stable for CTA Ped Protocol[c]

no

PE confirmed

no

yes

Consider and treat other causes

no

Good hemodynamics

CTA PE Protocol demonstrates PE

yes

RV dilation on CTA

yes

Distal PE, Good hemodynamics

yes

- Heparin 75 units/kg over 10 min followed by
- Heparin infusion
  - Less than 1 yr: 28 units/kg/hr
  - 1 yr or older and <30kg: 20 units/kg/hr
  - 1yr or older and >30kg: 18 units/kg/hr

no

Stat bedside ECHO

yes

RV Strain[b]

no

Low risk PE

Hemodynamic decompensation

High Risk PE

Intermediate Risk PE

Table of Contents

[a]Do not delay treatment of ABC interventions awaiting diagnostic work up. If patient is too unstable for diagnostic work up, stabilize patient and then re-enter diagnostic pathway.

[b]Echo cannot rule out all PE, especially small distal PE that are not hemodynamically significant. However, in a patient with ongoing undifferentiated shock, lack of RV strain by echo should prompt consideration and treatment of other causes of shock.

[c]If definitive imaging (CTA) is immediately available and performed safely and more rapidly than echo in a patient with shock and acute PE is confirmed and the patient remains in shock, obtaining an echo should not delay life saving therapy and continue to treatment.

Acute Pulmonary Embolism: Evaluation and Management

Disposition and treatment based on PE risk category

Bibliography | Summary of Version Changes | Restrictions Disclaimers

High Risk PE
Admit to CICU

- Vasoactive infusion(s) as indicated
- Supplemental oxygen[a]
- iNO
- If intubation required, prepare for hemodynamic collapse[b]
- Mechanical ventilation: minimize Paw

- Activate PE Huddle
- Make patient ECMO watcher
- Decide embolectomy+ vs high dose systemic alteplase*

cardiac arrest or periarrest
-consider bolus systemic alteplase*

VA ECMO

*Alteplase: Recommended within 2 hours of diagnosis if not thrombolysis contraindications

Intermediate Risk PE Admit to PICU (no known structural heart disease or repaired fully) or CICU (known structural heart disease)

- Activate Ped Huddle
- Decide embolectomy vs heparin infusioin vs low dose systemic alteplase*
- Factors to consider when deciding PED treatment
- Patient condition
- Degree RV strain
- Troponin levels
- Bleeding risk
- Other patient factors

- Correct severe thrombocytopenia and coagulopathy in conjunction with antithrombotic therapy
- Duration of alteplase infusion influenced by patient factors including stability results of hypercoagulable evaluation
- Consult Hematology.
- Hypercoagulable evaluation
- Anticoagulation medication choice at discontinuation of alteplase infusion
- Long-term follow-up of patient after discharge

Low risk PE
Admit to PICU or 7W

Heparin:
- 75 units/kg bolus if not already bolused followed by:
  - Less than 1 yr: 28 units/kg/hr
  - 1 yr or older and <30kg: 20 units/kg/hr
  - 1yr or older and >30kg: 18 units/kg/hr

- Consult Hematology/ Oncology
  - Hypercoagulable evaluation
  - Duration of heparin infusion
  - Anticoagulation choice at discontinuation of heparin
  - Long-term follow-up of patient after discharge

[a]Noninvasive ventilation may be used for enhanced oxygen delivery and may mitigate the risks of attempting intubation.

[b]When intubation is indicated caution should be taken given the high risk of cardiac arrest in acute right heart failure. IV fluids, vasoactive infusions, resuscitation medications, equipment, and appropriate personnel should be present at the bedside. Induction medications with favorable hemodynamic profiles should be used.

Table of Contents

Heparin and Alteplase dosing

Bibliography | Summary of Version Changes | Restrictions Disclaimers

Medication	Dosing	Considerations
Heparin	<1 yr old • Bolus: 75 units/kg over 10 min • Infusion: 28 units/kg/hr ≥ 1 yr old AND <30 kg • Bolus: 75 units/kg over 10 min • Infusion: 20 units/kg/hr ≥ 1 yr old AND ≥≥30 kg • Bolus: 75 units/kg over 10 min • Infusion: 18 units/kg/hr	• Monitor PTT • PTT goal 59-97 • Use actual body weight
Alteplase	High dose (High Risk PE) • Patients <33.3 kg: 0.5 mg/kg/hr, Intravenous, Continuous, For 6 hours • Patients >33.3 kg: 16.7 mg/hr, Intravenous, Continuous, For 6 hours • Reduce heparin infusion by 50% during Alteplase infusion and then increase to prior dose. • Patients may receive one to two additional doses of alteplase in cases of ongoing instability. Low dose (Intermediate Risk PE) • Patients <27.7 kg: 0.3 mg/kg/hr, Intravenous, Continuous, For 6 Hours • Patients >27.7 kg: 8.33 mg/hr, Intravenous, Continuous, For 6 Hours Bolus dose (Arresting Patient) • 0.5 mg/kg over 2 min • Maximum bolus dose = 50 mg	• Monitor CBC, platelets, fibrinogen q6h

Table of Contents

Acute Pulmonary Embolism: Evaluation and Management

Risk factors and risk category description

Bibliography | Summary of Version Changes | Restrictions Disclaimers

Risk Factors for Pulmonary Embolism

- Painful leg swelling recent history of DVT
- Family history of DVT/PE
- Personal history of DVT/PE
- Known thrombophilia predisposing to DVT/PE
- Recent or current central venous catheter
- Pregnancy or OCP use
- Recent or current immobility
- Recent orthopedic surgery/trauma
- Acute of chronic inflammatory conditions

PE Category	Description
High Risk (Massive) PE	Acute PE causing cardiopulmonary arrest, sustained hypotension (systolic BP < 5th percentile by age for at least 15 min or requiring vasoactive support), or normotension with signs or symptoms of shock
Intermediate Risk (Submassive) PE	Acute PE without hypotension or compensated shock, but evidence of RV strain by imaging (CTA or echo), myocardial necrosis by elevated cardiac troponin levels, or both
Low Risk PE	Acute PE not meeting criteria for high-risk or intermediate-risk PE

Table of Contents

PE Huddle description

Bibliography | Summary of Version Changes | Restrictions Disclaimers

PE Huddle

• Huddle attendees
  • CICU and/or PICU Attending
  • CV Surgery Attending
  • Interventiona Cardiology Attending
  • ECMO Primer oncall
  • Hematology Attending
  • Pharmacist
• Huddle location: patient bedside (usually the PICU or CICU) or by phone/digital technology if all attendees not present in the hospital
• Huddle occurs before delivery of systemic hrombolysis
• Goal of huddle is to determine best treatment method: systemic thrombolysis vs surgical intervention vs catheter-based embolectomy.

Table of Contents

Acute Pulmonary Embolism: Evaluation and Management

Treatment considerations by risk category

Bibliography | Summary of Version Changes | Restrictions Disclaimers

High Risk PE Considerations: Admission to CICU

Favor Embolectomy:	**Favor Thrombolysis**:
· Suspected tumor embolus (patients with Wilms Tumor, Ewing Sarcoma, osteosarcoma) or other non- thrombotic sources · Patients with contraindications to thrombolysis · Patients with concomitant intracardiac thrombus · Patients with intracardiac communications on echo · Patients on ECMO	· Thrombi extending distally which are not amenable to surgical embolectomy · Patients with comorbidities that confer additional surgical or anesthetic risk · Patients in whom surgical embolectomy is not readily available (within 2 hours from diagnosis of PE)

Surgical vs Catheter based Embolectomy: to be discussed by team at Huddle

Intermediate Risk PE Considerations: Admission to PICU or CICU

· Call CICU Attending if needed for help in initiating of PE Huddle.
· Catheter Based Therapy in the Cardiac Cath Lab is preferred for most patients with intermediate-risk PE who require primary reperfusion.
· If unavailable or patient is a poor candidate, anticoagulation with Heparin ALONE is often preferred over systemic thrombolysis given associated risks and lack of evidence supporting benefits in adult patients with intermediate-risk PE.
· Individual patient considerations to consider include: anticipated bleeding risk, patient's clinical condition, degree of RV strain, presence of elevated troponin.
· If systemic thrombolysis is used, low-dose alteplase may be used to mitigate bleeding risks. Low-dose alteplase = 0.1 to 0.3 mg/kg/h x6 hours (total = 0.6 to 1.8 mg/kg; max dose = 50 mg).
· Monitor patients for risk of decompensation highest 48-72 hours after start of treatment with Heparin alone.

Other Considerations

· If diagnosed with a high risk or intermediate risk PE at outside facility with CTA, start Heparin drip and transfer to NCH. Do not initiate thrombolysis at outlying facility.
· If diagnosed with a low risk PE at outside facility transfer to NCH ED for further diagnostic work up
· If outside facility is a Norton Children's facility consider direct admission to PICU/CICU, if outside facility is not Norton affiliated, admit to NCH ED for further diagnostic work up.

Table of Contents

Acute Pulmonary Embolism: Evaluation and Management

Background and Rationale

Acute pulmonary embolism (PE) is a form of venous thromboembolism (VTE) that is common and sometimes fatal. PE refers to obstruction of the pulmonary artery or one of its branches by material (eg. thrombus, tumor, air, or fat) that originated elsewhere in the body. Historically, pediatric PE was thought to be related to infections, though it has become clear that PE is increasingly related to cancer (particularly acute lymphoblastic leukemia), congenital heart disease, acquired and inherited thrombophilias, and central line placements.

Epidemiology

Studies examining the incidence of PE in children report an incidence of 8.6-57 in 100,000 hospitalized children, and 0.14-0.9 in 100,000 when studying the general population of non-hospitalized children. However, it is likely that these numbers are underestimate due to the silent nature of PE in children. In one study that centered on autopsy data, PE was considered in only 15% of patients that were diagnosed with PE post-mortem.

Pathophysiology

Similar to any generation of thrombus, Virchow's triad (venous stasis, endothelial injury, and hypercoagulable state) leads to the initial clot. A PE is simply the embolization of said clot to the pulmonary arteries, though there is some growing belief that pediatric PE is not always caused by embolization. Most emboli are thought to arise from lower extremity proximal veins (iliac, femoral, and popliteal), and more than 50% of patients with proximal vein deep thrombosis (DVT) have concurrent PE at presentation.

After a thrombus has broken off and embolized to the pulmonary arteries, infarction, abnormal gas exchange, and cardiovascular compromise can occur. In terms of cardiovascular collapse, hypotension is due to diminished stroke volume and, therefore, lower cardiac output. In these patients, pulmonary vascular resistance (PVR) is increased due to physical obstruction of the vascular bed with thrombus and hypoxic vasoconstriction within the pulmonary arterial system. This process subsequently diminishes output from the RV, reducing left ventricle preload, and finally compromising cardiac output.

Table of Contents

Bibliography

Bibliography | Summary of Version Changes | Restrictions Disclaimers

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Table of Contents

Acute Pulmonary Embolism: Evaluation and Management

Version History

Bibliography | Summary of Version Changes | Restrictions Disclaimers

Version	Date	Guideline Owner	Summary of Edits	Next Revision Due
1	June 2023	Dr. Jamie Furlong-Dillard	Original	
2	June 2025	Dr. Jamie Furlong-Dillard	1. Updated references 2. No changes to content	June 2029

Table of Contents

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Table of Contents

Acute Pulmonary Embolism: Evaluation and Management

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Table of Contents