Pulmonary Embolism (PE)

Pulmonary thromboembolism refers to obstruction in the pulmonary arteries due to a thrombus/emboli, tumor, air, or fat.

Acute PE refers to an emboli identified on radiographic imaging within 14 days of PE symptoms.

- Central PE: includes saddle and emboli located in the main or lobar pulmonary arteries
    - A saddle PE is described as an emboli located in the main pulmonary artery that traverses the right and left pulmonary arteries
- Distal PE: emboli located in the segmental and subsegmental branches of the pulmonary arteries.

DIAGNOSTIC STRATEGIES (see algorithm 1)

The first step is to determine the clinical probability of PE based on:

- Provider implicit sense
- Pulmonary Embolism Rule-out Criteria (PERC)
- Wells score

PE is excluded and no further tests are needed if PERC is negative (none of the 8 clinical items) and the provider has the implicit sense that it is not PE.

PERC and Clinical Probability Scores

Wells score	Points
PE is the most likely diagnosis	3.0
Signs and symptoms of DVT	3.0
Heat rate >100 beats/min	1.5
In previous 4 wk, immobilization for >3 days or surgery	1.5
Previous DVT or PE	1.5
Hemoptysis	1.0
Active cancer	1.0

YEARS items

- PE is the most likely diagnosis
- Hemoptysis
- Clinical signs of DVT

PERC

(If any items are present, PERC test is positive)

- Age ≥50 yr
- Heart rate ≥100 beats/min
- Oxygen saturation <95% while patient is breathing room air
- Swelling in one leg
- Hemoptysis
- Surgery or trauma within past 4 wk
- Previous DVT or PE
- Hormone use

If PERC is positive OR the provider has the implicit sense that could be PE, calculate the Wells score and request D-dimmer.

D-dimer normal value

- Less than 0.5 µg/ml or age-adjusted if over 50 years (age x 10 in µg/L)

Wells score

- Traditional clinical probability
    - Low <2, moderate 2 to 6, and high >6
- Simplified clinical probability
    - PE unlikely ≤4, PE likely >4

If Wells score ≤4, use D-dimer threshold of 1 µg/ml; if >4, use age-adjusted D-dimer threshold

PE can be excluded without imaging studies if there is a low likelihood for PE and D-dimer level of less than 1 mcg/mL or if there is a moderate likelihood for PE and a D-dimer is below the age-adjusted threshold

- D-dimer <1 mcg/mL and Wells score ≤4, **or**
- D-dimer <age-adjusted D-dimmer cutoff and Wells score >4

Present guidelines recommend no need for D-dimer in patients with high probability of PE (Wells score >6). However, new data suggests that D-dimer may also be useful.

- Post hoc analysis of three European studies (PROPER, MODIGLIANI, and TRYSPEED)
    - Among the 12,300 patients included, 651 had high clinical probability of PE (31.3%). Seventy of the 651 patients (10.7%) had negative D-dimer levels (<0.5 mcg/mL age-adjusted) and none of them had a PE after follow-up

Based on the above data PE can also be excluded if:

- D-dimer <0.5 mcg/ml and Wells score >6

If PE is suspected based on clinical probability, request chest imaging studies

- CTA chest
- Consider V/Q scan in patient with clear CXR and GFR <30 ml/min/m^3
    - Relatively low sensitivity for PE and lack the ability to identify alternative diagnoses and limited accuracy in patients with abnormal CXR

If PE is confirmed

- *Determine the associated mortality risk* (algorithm 2) (sPESI, SSI, respiratory status, end organ dysfunction)
    - Calculate the sPESI score
        - Patients with sPESI ≥ 1 should undergo cardiac biomarker testing (troponin, pro-BNP) and imaging for RV dysfunction (RV/LV ratio or reflux of contrast into the IVC and hepatic veins on CT and RV size and function on echocardiography)
        - Routine performance of echocardiogram or laboratory testing (or both) in the presence of a low risk (sPESI score 0) is usually not considered necessary because it is unlikely to direct management
    - Calculate the systolic shock index (SSI), assess respiratory status (oxygenation, tachypnea), and end-organ tissue perfusion (lactate, sCr)

- *Determine the bleeding risk*
    - Presence of severe anemia or thrombocytopenia
    - Calculate VTE-BLEED and/or HAS-BLED scores
        - Although there are currently no well validated scoring systems that can be used to assess bleeding risk across interventional radiologic procedures, the VTE-BLEED and HAS-BLED scores (available in MDCalc) are often used in clinical practice as a general guide
            - VTE -BLEED score ≥2: higher bleeding risk
            - HAS-BLED ≥3: higher bleeding risk

- *Determine is the PE is central or distal*

CLASSIFICATION AND ASSESSMENT (see algorithms 2 through 6)

There is no universal classification system for PE severity and variation exists among international guidelines. The more accepted guidelines are the European Society of Cardiology (ESC) published in 2019 and the American Heart Association (AHA) endorsed by multiple societies published in 2026.

1. The ESC designed PE guidelines focus on short term PE-related mortality (see figure 1 below).
    - One of the major advantages of the ESC classification of PE is the focus on short term PE-related mortality.
    - To integrate patients' clinical status and comorbidities, ESC guidelines recommend the best validated simplified Pulmonary Embolism Severity Index (sPESI) score.
        - *Any patient with a positive sPESI score is not low risk*.

sPESI score

Parameter	**Points**
• Age >80 yr	1 point
• History of cancer	1 point
• History of Chronic cardiopulmonary disease*	1 point
• HR >110 beats/min	1 point
• SBP <100 mm Hg	1 point
• Oxygen saturation <90% on RA	1 point

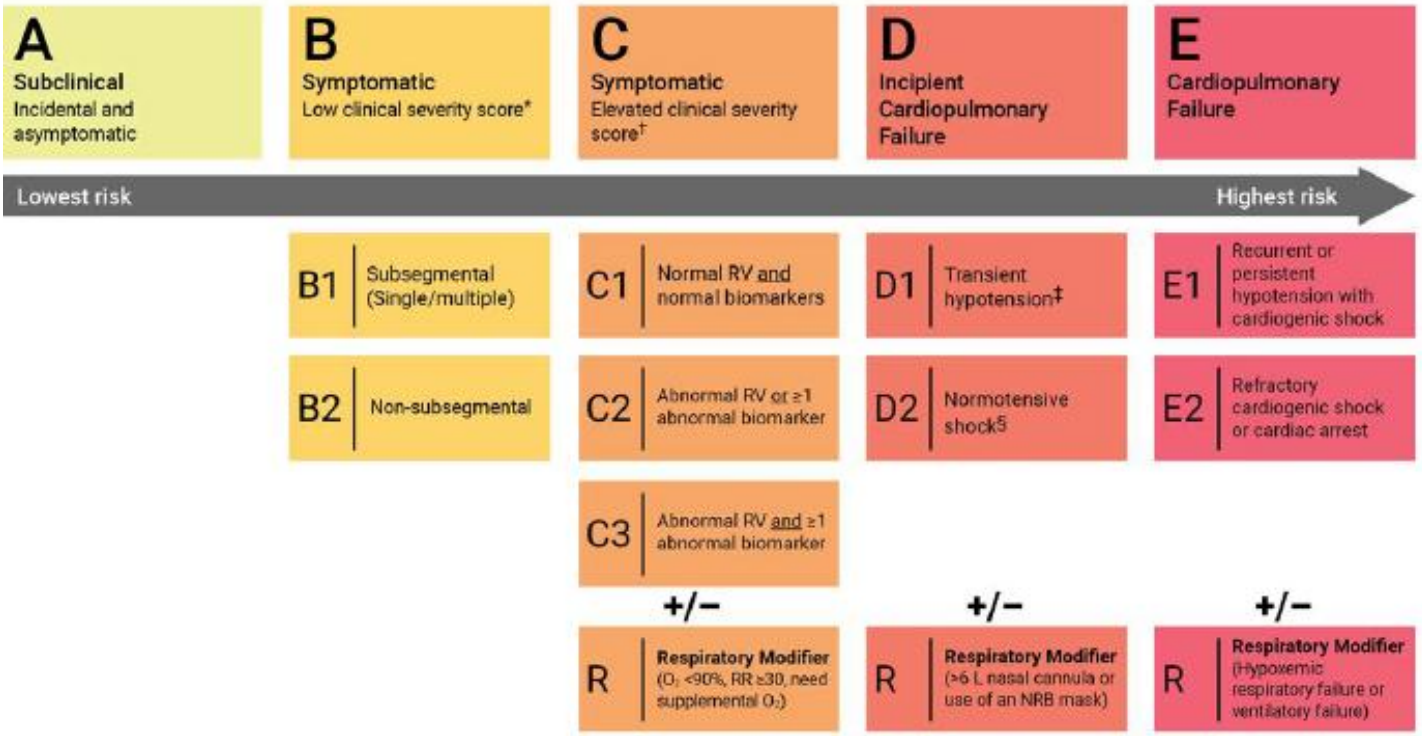
*Chronic cardiopulmonary disease (history of chronic lung disease, or history of heart failure, or history of both).

ESC - Mortality Risk Stratification

	Shock	sPESI	RV dysfunction or troponin elevation
Low risk	No	0	None
Intermediate Low	No	1 or more	Either one or none positive
Intermediate High	No	1 or more	Both positive
High Risk	Yes	1 or more	Both positive

2. The American Heart Association (AHA) and seven other specialty societies including the American College of Cardiology (ACC) and the American College of Chest Physicians (ACCP) designed PE guidelines to describe the severity and prognosis of PE by integrating various clinical, laboratory, and imaging parameters.

AHA/ACC Acute PE Clinical categories



From 2026 Adults With Acute Pulmonary Embolism

Category A-E and subcategory 1-3 designations are selected according to the most severe clinical, laboratory, and imaging indicators.

- Patients may transition among such categories as they are reassessed over time.
- A respiratory modifier (R) can be added to a subcategory or designated its own subcategory in patients with prominent respiratory abnormalities.

Category A

- Focuses on asymptomatic and incidentally diagnosed PE. Patients with Category A acute PE are typically identified on a CT performed for another indication and in the absence of clinical suspicion of PE.

Category B

- Focuses on patients with symptomatic acute PE and low risk of adverse outcomes by validated severity indices (eg, PESI or simplified PESI).
    - Category B1 includes patients with single or multiple subsegmental PEs
    - Category B2 includes patients with segmental and more proximal PEs.
        - The intent for distinguishing subsegmental PEs is to recognize that triage (ie, home versus hospital) and the decision to anticoagulate may differ based on the location of the acute PE and the concomitant presence of DVT.

Category C

- Focuses on symptomatic disease with increased risk of adverse outcomes by validated severity index (eg, PESI and sPESI).
    - The subcategories allow for recognition of the absence or presence of cardiopulmonary dysfunction.
        - **C1**: with normal RV function and biomarkers
        - **C2**: Either an abnormal RV size or function (determined by echocardiogram or CT) or elevated biomarkers (troponin and proBNP)
        - **C3**: With both abnormal RV function and elevated biomarker

Category D

Focuses on pre-cardiopulmonary failure states, such as normotensive shock or approaching need for ventilatory support. The subcategories differentiate cardiovascular and pulmonary compromise.

- Category D1
    - Transient hypotension *without* tissue hypoperfusion
        - Identifies patients with transient or recurrent hypotension (including relative hypotension compared with the patient's baseline blood pressure) that is short-lived or responds to volume expansion (a trial of intravenous fluids is generally considered 500 to 1000 mL of IV crystalloids) and is not accompanied by any signs of reduced perfusion or end-organ dysfunction.

- Category D2
    - Transient hypotension *with* tissue hypoperfusion
        - Requires a marker of decreased perfusion or end-organ dysfunction (eg, AKI, persistently elevated lactate) accompanied by transient hypotension (short-lived or responds to volume expansion).

Category E

- Focuses on cardiopulmonary failure states. The subcategories differentiate patients with recurrent or persistent hypotension with cardiogenic shock from patients with refractory cardiogenic shock or cardiac arrest.
    - Category E1 is compatible with SCAI SHOCK stage C 3
    - Category E2 is defined by refractory cardiogenic shock (SCAI D-E) or cardiac arrest without restoration of spontaneous circulation after 30 minutes of resuscitation.
    - Respiratory failure in category E-R is defined by the need for noninvasive or invasive positive pressure ventilation.

Respiratory Modifier - R

Patients with more severe PE ("C", "D", and "E") with respiratory symptoms and signs crossing a certain threshold tailored to each category receive an "R+" (or "R-" for lacking that degree of respiratory failure):

- **C:** O_2 <90% and/or RR ≥30 and/or need supplemental O_2
- **D:** >6 L nasal cannula or NRB mask
- **E:** hypoxemic respiratory failure or ventilatory failure

AHA/ACC Top Take-home Messages

1. A new clinical classification scheme is presented, entitled "Acute Pulmonary Embolism Clinical Categories," with 5 categories (A-E) and subcategories, ranging from low to high risk for adverse outcomes, in order to enhance the precision of severity classification, prognosis assessment, and evidence-based therapeutic decision-making for patients presenting with acute pulmonary embolism (PE).

2. Patients with acute PE who are asymptomatic (AHA/ACC PE Category A) can safely be discharged home from the emergency room and do not need to be hospitalized.

3. Early hospital discharge is generally recommended for patients with acute PE who are symptomatic but have a low clinical severity score (AHA/ACC PE Category B).

4. Symptomatic patients with acute PE and an elevated clinical severity score, including those with elevated biomarkers and/or right ventricular dysfunction (AHA/ACC PE Category C), incipient cardiopulmonary failure (AHA/ACC PE Category D), and those with cardiopulmonary failure characterized by persistent hypotension (AHA/ACC PE Category E) should be hospitalized to optimize treatment strategies.

5. Advanced therapies, including systemic thrombolysis, catheter-based thrombolysis, mechanical thrombectomy, and surgical embolectomy are reasonable for patients with acute PE in AHA/ACC PE Category E1 and can be considered for patients with acute PE in AHA/ACC PE Category D1-2.

6. PE response teams (PERTs) are recommended to improve timeliness of care.

7. In patients with acute PE who require initial parenteral anticoagulant therapy, low-molecular-weight heparin (LMWH) is recommended over unfractionated heparin (UFH).

8. In patients with acute PE who are eligible for oral anticoagulation, direct oral anticoagulants (DOACs) are recommended over vitamin K antagonists (VKAs), unless contraindicated, to prevent recurrent venous thromboembolism (VTE) and reduce major bleeding.

9. In patients with a first acute PE without a major reversible risk factor and in those with a persistent risk factor, continuing anticoagulation beyond the initial treatment phase (3-6 months) into the extended phase is recommended.

10. Patients who have had acute PE should be asked about PE-related symptoms and functional limitations at every visit for at least 1 year to screen for chronic thromboembolic pulmonary disease (CTEPD) or other causes of dyspnea and functional limitation.

Shock: persistent SBP <90 mmHg x15 min after IVF not explained by other causes such as hypovolemia, sepsis, arrhythmia, or known baseline heart failure.

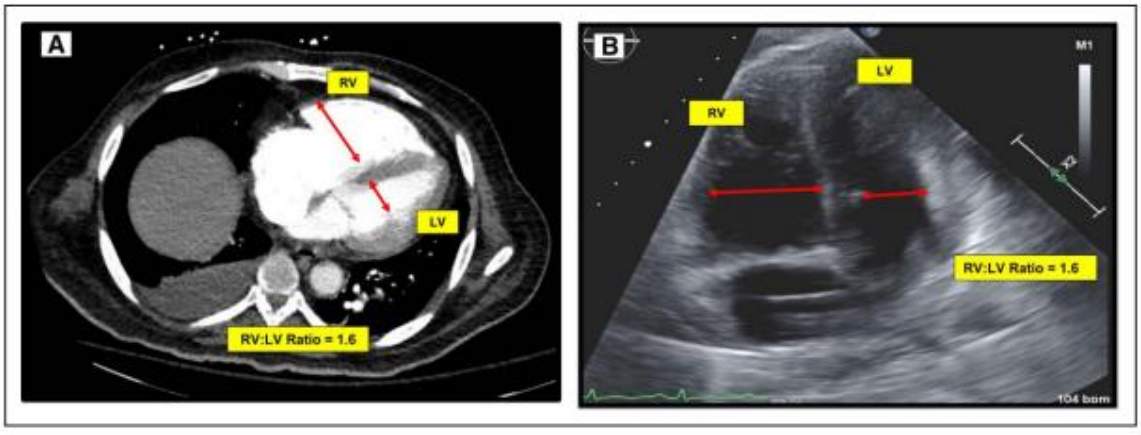
Systolic shock index (SSI): HR/SBP >1 predicts high mortality.

RV dysfunction - concomitant RV dysfunction on CTA and echocardiogram are better predictors of an adverse outcome.

- CTA chest: RV:LV ratio >1 or reflux of contrast into the IVC and hepatic veins
- Echocardiogram:
    - RV dilatation.
    - RV free wall hypokinesis with apical sparing (McConnell's sign).
    - Interventricular septal flattening is a sign of severity.
    - Decreased RV function: TAPSE <1.6 cm (1.6-1.8 cm is borderline RV dysfunction).
    - Elevated estimated sPAP: TR max velocity >2.8 m/s suggest pulmonary hypertension.

The picture below shows acute RV dilation associated with pulmonary embolism as seen on CT and TTE.

- Other than contrast in the liver, chest CTA chest is imprecise for RV assessment. CTA chest findings of RV enlargement should prompt echocardiography.



Biomarkers – Elevation of biomarkers carries an independent risk of short-term mortality and RV dysfunction.

- Myocardial injury-ischemia: elevated troponin
- RV strain - pressure overload: elevated BNP

The location of the thrombus or clot burden seen on a CTA is in general not part of risk stratification because not all of the central including saddle PEs are associated with RV dysfunction.

However, they should be considered in the decision-making process because:

- Most patients with RV dysfunction have central PE
- In contrast, isolated clots at the segmental or more distal level are less commonly associated with RV dysfunction and an alternate cause should be considered when present

TREATMENT OF ACUTE PE

Anticoagulation

Parenteral

- Low molecular-weight heparin (LMWH)
- Unfractionated heparin (UFH)
    - LMWH is preferable to UFH unless GFR <30 ml/min/m^3:
        - Better bioavailability and longer half-life which allows a simplified dose and predictable anticoagulation response
        - Lower risk of HIT

Oral anticoagulation

- Usually with DOACs
- Warfarin for antiphospholipid syndrome

Rapid reperfusion therapy

- Thrombolysis
    - Systemic
    - Catheter directed thrombolysis (CDT)
- Thrombectomy
    - Mechanical thrombectomy (MT)
    - Surgical thrombectomy
- After reperfusion therapy, either MT or thrombolysis, start anticoagulation with LMWT over UFH.
    - If UFH infusion is used adjust the rate to maintain an anti-Xa of 0.3–0.7 IU/mL or PTT of 2.0–2.5 times the upper limit of normal.

Category A – asymptomatic, ***low risk mortality***

- Initiate DOAC
- Patients can be treated in the outpatient setting, rapid reperfusion not clinically indicated

Category B - symptomatic with low clinical severity score (sPESI 0), **low risk mortality**

- **B1** - single or multiple subsegmental PEs
    - Initiate DOAC

    - Patients can be treated in the outpatient setting
    - Rapid reperfusion not clinically indicated

- **B2 -** segmental and more proximal PEs
    - Initiate DOAC
    - Rapid reperfusion not clinically indicated

Category C - symptomatic with elevated clinical severity score (sPESI >0)

- **C1** - normal RV size/function and troponin, **intermediate-low risk mortality**
    - Initiate LMWH – Enoxaparin
    - Rapid reperfusion therapy is not recommended over anticoagulation alone to improve clinical outcomes or symptoms.

- **C2 -** either an abnormal RV size or function (determined by echocardiogram or CT) or elevated troponin, **intermediate-low risk mortality**
    - Initiate LMWH – Enoxaparin
    - Rapid reperfusion therapy is not recommended over anticoagulation alone to improve clinical outcomes or symptoms

- **C3 -** with both abnormal RV size/function and elevated troponin, **intermediate-high risk *mortality***
    - Initiate LMWH – Enoxaparin
    - The benefit of CDT or MT plus anticoagulation compared with anticoagulation alone is unclear in preventing further deterioration or mortality or improving long term functional capacity

Category D1 - Transient hypotension, **intermediate-high risk mortality**

- Initiate LMWH – Enoxaparin
- MT plus anticoagulation or thrombolysis if acceptable bleeding risk are superior to anticoagulation alone to prevent further deterioration, however no mortality benefits
    - MT plus anticoagulation may be considered over systemic thrombolysis to reduce bleeding risks.

Category D2- Normotensive shock, **intermediate-high risk mortality**

- Initiate LMWH – Enoxaparin
- MT plus anticoagulation or thrombolysis if acceptable bleeding risk are superior to anticoagulation alone to prevent further deterioration, however no mortality benefits
    - MT plus anticoagulation may be considered over systemic thrombolysis to reduce bleeding risks.

Category E1- Recurrent or persistent hypotension with cardiogenic shock, **high risk mortality**

- Initiate LMWH – Enoxaparin
- MT plus anticoagulation or thrombolysis if acceptable bleeding risk are superior to anticoagulation alone to prevent further deterioration.

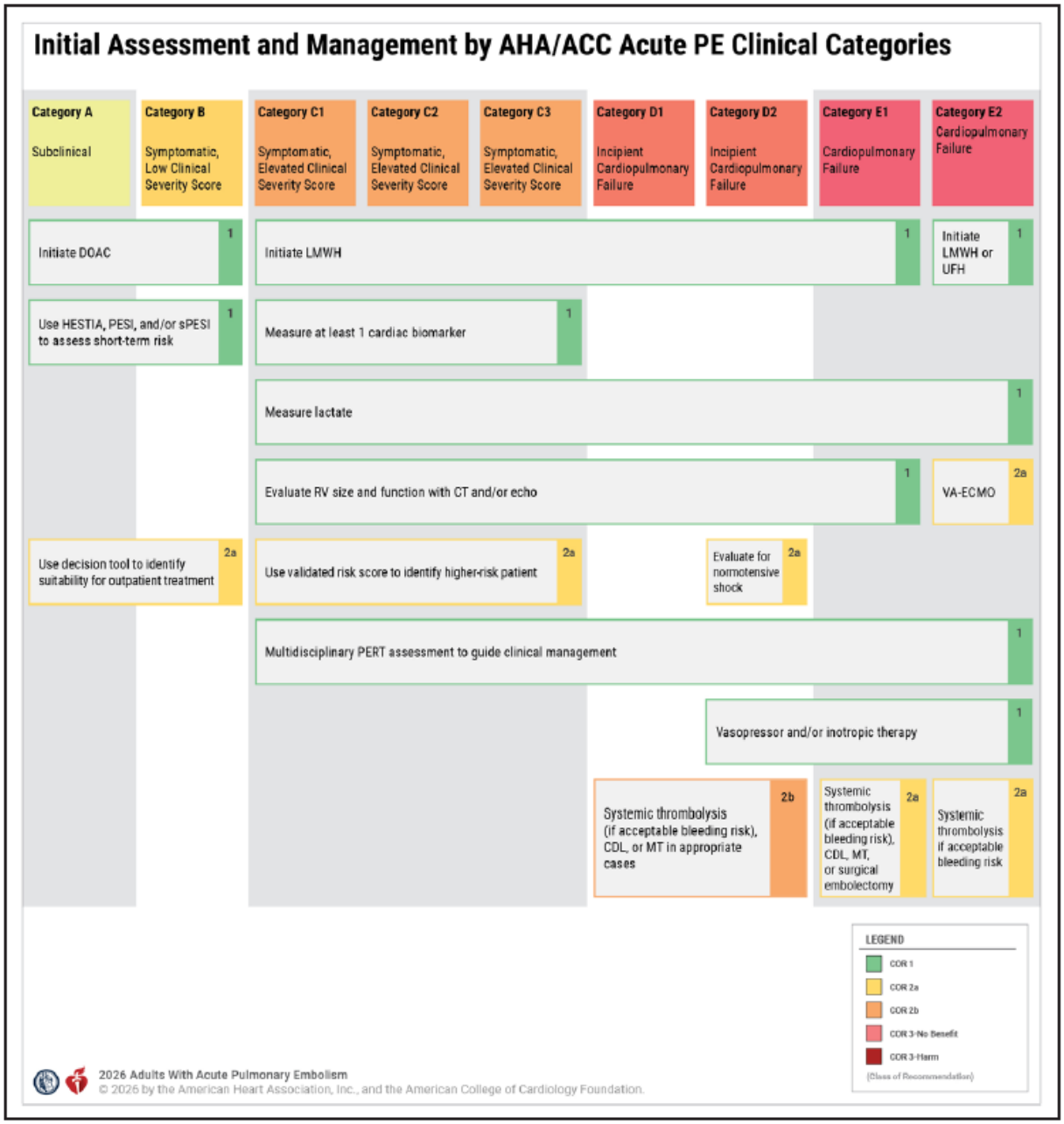
Category E2- refractory cardiogenic shock or cardiac arrest, high risk mortality

- Initiate LMWH – Enoxaparin or UFH - Heparin IV continuous infusion

- Systemic thrombolysis if acceptable bleeding risk

Respiratory Modifiers

- The R modifier does not change the category designations but signals a patient who may be closer to clinical deterioration, for instance, a category C3 patient whose respiratory status escalates from low-flow O_2 to >6 L NC or NRB mask may be considered for rapid reperfusion therapy to prevent clinical deterioration.



General supportive care

- Cautious IVF – usually 250 -500 ml crystalloids in 15 -30 min.
    - Excessive IVF can promote ventricular interdependence and LV failure
- Inopressors with norepinephrine and vasopressin, occasionally cautious use of inodilator with dobutamine-milrinone.
- If refractory hypoxemia or hypotension or RV failure.
    - Pulmonary vasodilators – prostacyclins/Flolan.
    - Mechanical circulatory support devices.
        - VV ECMO for respiratory failure or VA ECMO if there is hemodynamic compromise due to LV dysfunction.
            - Allow the RV to beat in a decompressed state with minimal preload and afterload while augmenting systemic perfusion.
            - Relative to the severity of illness at presentation, survival and RV recovery are excellent.
        - MCS/Impella RP
            - The experience and data are insufficient to draw meaningful conclusions about its safety and efficacy in the setting of acute PE, however, in individual cases may be useful.
            - An important limitation in the setting of acute PE is that by diverting RV preload into the obstructed pulmonary circulation, the RV may not be able to adequately empty against an increased afterload.

Patients with relative contraindications for anticoagulation* or thrombolysis**

- Distal PE
    - Weigh the risks and benefits of using anticoagulation or reduced-dose systemic thrombolysis
    - Retrievable IVC filter if anticoagulation or thrombolysis not used with retrieval once the contraindication resolves
- Central PE
    - MT and IVC filter

With absolute contraindications for anticoagulation* or thrombolysis**

- Distal PE
    - Retrievable IVC filter with retrieval once the contraindication resolves
- Central PE
    - MT and IVC filter

***Contraindication for anticoagulation**

- Absolute
    - Any of the conditions stated as absolute contraindication for thrombolysis
- Relative
    - VTE -BLEED score ≥2 and or HAS-BLED ≥3

****Contraindications for thrombolysis**

- Absolute
    - Prior intracranial hemorrhage
    - Known structural cerebral vascular lesion

    - Known malignant intracranial neoplasm
    - Ischemic stroke within 3 months (excluding stroke within 3 hours*)
    - Suspected aortic dissection
    - Active bleeding or bleeding diathesis (excluding menses)
    - Significant closed-head trauma or facial trauma within 3 months
- Relative
    - Age >75
    - History of chronic, severe, poorly controlled hypertension
    - Severe uncontrolled hypertension on presentation (SBP >180 mmHg or DBP >110 mmHg)
    - History of ischemic stroke >3 months prior
    - Traumatic or prolonged (>10 minutes) CPR or major surgery <3 weeks
    - Recent (within 2 to 4 weeks) internal bleeding
    - Noncompressible vascular punctures
    - Recent invasive procedure
    - Pregnancy
    - Active peptic ulcer
    - Pericarditis or pericardial fluid
    - Diabetic retinopathy
    - Current use of anticoagulants
        - Warfarin with an elevated INR >1.7
        - Antiplatelet therapy including DAPT increases the risk of bleeding but, in isolation, is not a contraindication to thrombolytic therapy
        - DOACs need to be assessed on a case-by-case basis

Thrombolytic dosing

When thrombolytics are used clinical improvement is typically noted within the first hour of the infusion.

- Guidelines recommend the use of tPA-Alteplase for continuous infusion
- TNK - Tenecteplase IV push is reserved for emergency cases as a lifesaving maneuver for suspected PE-induced or impending cardiac arrest

Choosing the dose

- CDT or systemic thrombolysis
    - Reduced dose tPA-Alteplase:
        - Peripheral IV infusion of 18 mg alteplase as a 4-mg bolus followed by 14 mg infused over 6 hours
    - If the patient is already receiving therapeutic LMWH, no anticoagulation is needed during CDT
    - If the patient is already receiving therapeutic UFH
        - UFH infusion dose to 300 to 500 units/hour while infusing tPA

CDT and MT procedure

Choosing how many catheters to place, whether a bolus of thrombolytic agent is administered before the infusion, and whether lysis should be combined with other clot removal procedures is individualized and dependent on the operator/IR, their experience, and the location and volume of emboli. For instance:

- The presence of large central main pulmonary artery thrombus in addition to significant peripheral segmental/subsegmental thrombus might prompt debulking with percutaneous clot extraction devices followed by infusion with CDT lysis
- For those with just central main pulmonary artery embolus or right atrial clot in transit, mechanical clot extraction alone may be enough
- For thrombolytic infusions, one catheter is typically placed per affected lung (ie, two for bilateral PE and one for unilateral PE)

Anticoagulation post rapid reperfusion therapy
Patients should be fully anticoagulated.

- The 2026 AHA/ACC guideline's general recommendation favors **LMWH over UFH** for acute PE, and this applies to the post-procedural period after thrombectomy or after thrombolytic infusion is complete.
  - If UFH is used after MT, start the infusion after sheath removal once hemostasis is secured (usually within 5 to 30 minutes) and aPTT is ≤2× normal.
  - If UFH is used after thrombolysis start the infusion without a bolus immediately once the aPTT is ≤2× normal.
  - Adjust the UFH infusion rate to maintain an anti-Xa of 0.3–0.7 IU/mL or aPTT of 2.0–2.5 times the upper limit of normal.
- Repeat echocardiogram in 24 hours to assess RV size and function
- After 24-48 hours of stability and clinical response patients can be switched to DOACs

Monitoring and treatment of bleeding after thrombolysis
Signs of major bleeding (eg, hemodynamic compromise, mental status changes, reduction in hemoglobin [eg, 1 to 2 g/dL], need for transfusion, or copious amounts of bleeding) are indications to immediately stop the infusion and investigate, locate, and treat the source

- When considering reversal, the relative severity of the bleeding and the thromboembolic process must be weighed in view of the potential to exacerbate thrombosis. In general, if patients continue to have significant or refractory bleeding despite cessation of the thrombolytic agent:
  - Transfuse 10 units of cryoprecipitate with or without two units of fresh frozen plasma and then reassess
  - In addition, protamine, should be considered to reverse the effect of any heparin that may remain in the patient's plasma

Complications during percutaneous embolectomy include haemodynamic decompensation, respiratory failure, alveolar hemorrhage, pulmonary artery perforation, and hematomas at the vascular access site, all dependent on the technique and system that were utilized

EVALUATION AFTER INITIAL TREATMENT (see algorithm 7)

Clinical status should be evaluated following the unit's policy protocols and with the NEWS2 score 24 to 48 hours after anticoagulation, 2 to 4 hours after the completion of thrombolysis, and immediately after MT.

- A NEWS2 score of 5 or higher is a key trigger threshold for urgent clinical re-evaluation and action
  - NEWS2 score includes 7 physiological parameters:
    - Respiratory rate

        - Hypercapnic respiratory failure
        - Oxygen saturation
        - Temperature
        - Systolic blood pressure
        - Heart rate

Treatment success

- Initial treatment results in improvement of initially compromised haemodynamic, oxygenation, and tissue perfusion status i.e., decrease in HR and RR, increase in systemic BP, O2 Sat, and UO, and clearance of lactate with NEWS score <5
    - No escalation of therapy is required

Treatment failure

Initial treatment does not result in clinical improvement if it is compromised or there is clinical deterioration

- NEWS2 score 5 or 6
    - Urgent close monitoring with consideration for rescue rapid reperfusion therapy
- NEWS2 score ≥7 or the patient develops overt cardiorespiratory instability necessitating CPR, mechanical ventilation, vasopressors, or mechanical circulatory support (ECMO or Impella RP)
    - Rescue rapid reperfusion therapy is indicated if it has not been done
        - Systemic thrombolysis after anticoagulation for distal PE
        - MT for central PE after anticoagulation or thrombolysis

SPECIFIC CONSIDERATIONS FOR TREATMENT

Cardiac arrest or impending arrest

Thrombolytic therapy for patients with PE-related cardiac arrest given simultaneously with unfractionated heparin infusion can be considered.

Tenecteplase-TNK single IV dose given over five seconds based on patient weight, as follows:

<60 kg – 30 mg
≥60 to <70 kg – 35 mg
≥70 to <80 kg – 40 mg
≥80 to <90 kg – 45 mg
≥90 kg – 50 mg

Retrievable Inferior vena cava filter

Should be reserved for patients with:

- Acute PE and absolute contraindications for anticoagulation
- Recurrent PE despite therapeutic levels of anticoagulation

Clot-in-transit

- Free-floating thrombus in the RA or RV
- Thrombus in a PFO.

Treatment options include anticoagulation alone, thrombolysis, catheter-directed or surgical thrombectomy or combinations.

- Most groups prefer an individualized approach depending on hemodynamic status, size of the clot and bleeding risk

- For instance, patients with small thrombi and hemodynamically stable may be simply anticoagulated, alternatively, patients with a large thrombus in the RA or RV at risk for deterioration and the consequence of embolization may require catheter directed thrombectomy together with CDT

Subsegmental PE

Management of single or multiple subsegmental PE without more proximal PE or DVT is uncertain.

- Some guidelines suggest clinical surveillance instead of anticoagulation but a recent prospective cohort study involving such patients who were treated without anticoagulation therapy showed a higher-than expected incidence of recurrent VTE without anticoagulation.
- Clinical Surveillance vs. Anticoagulation for Low-risk Patients with Isolated Subsegmental Pulmonary Embolism (SAFE-SSPE) is an ongoing trial of clinical surveillance as compared with anticoagulation in this patient population

Pregnancy

Diagnosis

- CTA chest and V/Q scan present no measurable increased risk of fetal death or developmental abnormalities.
    - This is according to the International Commission of Radiologic Protection.
- Regarding fetal safety, CTA chest and V/Q scan are interchangeable, but some debate remains.
    - CTA chest may deliver higher doses of radiation to maternal breast tissue, which may be more susceptible to radiation-induced damage during the high mitotic period of pregnancy.
        - Therefore, the American Thoracic Society, the American College of Obstetricians and Gynecologists, and the American Society of Hematology acknowledge that the evidence is weak but recommend lung scintigraphy over CTA chest for pregnant individuals with normal CXR.
        - Conversely, the ESC believes that CTA chest no longer poses the cancer risk to maternal breast tissue that it once did.
- Regarding the V/Q scan, the perfusion-only component performs well and is safer than the combined V/Q. The perfusion-only scan is the recommended diagnostic strategy in pregnant patients.
- Negative D-dimer in pregnant patients with low suspicion exclude PE.
    - Although D-dimer becomes less useful with gestational age because levels increase during the course of a normal pregnancy, most groups agree with this statement using a cutoff value of < <500 ng/mL

Treatment

- The drug of choice in pregnancy for both prophylaxis and therapeutic anticoagulation is subcutaneous LMWH over IV or subcutaneous UFH
- Vitamin K antagonists should not be used antepartum because of teratogenicity, particularly in early pregnancy, but can be used during lactation
- DOAC are not as well studied and should not be used during pregnancy or lactation
- There are some data regarding the use of fondaparinux in pregnancy or during lactation, and it can be used in cases of heparin allergy or heparin-induced thrombocytopenia

Treatment for patients with life-threatening PE

- The principles are the same as for nonpregnant patients depending on the risk of bleeding:
    - Thrombolysis if there is no contraindication
        - While pregnancy is listed as a relative contraindication to thrombolysis, case reports and anecdotal evidence suggest successful use when reserved for life-threatening PE.
    - Thrombectomy for patients with contraindication for thrombolysis

VTE prophylaxis

- Indications:
    - History of a pregnancy related VTE
    - History of a VTE that was associated with another hormonal risk factor (such as estrogen or oral contraceptive related)
    - History of a single idiopathic, unprovoked VTE; and in those with a history of multiple VTEs, regardless of the cause
- Not indicated if previous VTE associated with a nonhormonal, temporary provoking risk factor such as trauma, immobility, surgery, and no additional risk factors
    - Low-dose LMWH throughout the pregnancy and generally for at least 6 weeks after delivery
    - LMWH is preferred over UFH because of convenience and reliability and lower risks of osteoporosis/osteopenia, and thrombocytopenia

POST ACUTE PE MANAGEMENT

Anticoagulation

- The presence and determination of reversibility of risk factors are required to guide duration of anticoagulation treatment

Predisposing factors for venous thromboembolism

Risk Factors for Venous Thromboembolism

Major Reversible Risk Factor	Minor Reversible Risk Factor	Persistent Risk Factor
Surgery with general anesthesia ≥30 minutes	Surgery with general anesthesia <30 minutes	Active cancer with or without ongoing treatment
Hospitalization for acute medical illness ≥72 hours while confined to hospital bed	Hospitalization for acute medical illness <72 hours	Autoimmune disease (eg, rheumatoid arthritis, systemic lupus erythematous)
Cesarean section	Out-of-hospital acute medical illness ≥72 hours while confined to bed	Inflammatory bowel disease
Lower limb fracture	Estrogen therapy (hormone replacement or contraceptive)	Chronic immobility
	Peripartum period	
	Trauma with decreased mobility ≥72 hours	

PE associated with reversible risk factors

- Surgery with general anesthesia lasting >30 minutes
- Confinement to bed in the hospital for ≥3 days due to an acute illness
- Major trauma or fracture
    - Three months full-dose DOAC anticoagulation
        - Consider low-dose DOAC anticoagulation for additional 9 months to complete one year

- Consider six months anticoagulation if the PE was very large or associated with RV dysfunction or persistent residual symptoms, some experts recommend that treatment extend to 6 months

PE associated with persistent risk factors

- Indefinite anticoagulation
  - Full dose DOAC (i.e., rivaroxaban or apixaban) for 6 months.
  - Low-dose DOAC regimens (i.e., rivaroxaban or apixaban) after an initial 6 months.
    - Not applicable for patients with cancer, those with anatomically extensive pulmonary embolism, or those at high risk for recurrent PE.

If a decision to continue anticoagulation indefinitely is made, it should be reassessed at least annually. Anticoagulation may need to be discontinued if the risk of bleeding increases, a major bleeding event occurs, or the patient prefers to stop treatment.

PE without identified risk factors

- Indefinite anticoagulation.
- Time-limited treatment may be appropriate for some patients depending on bleeding risk and PE recurrent risk.

Adjuncts to anticoagulation

Aspirin and sulodexide therapy have been evaluated to prevent recurrence of VTE after discontinuation of anticoagulation treatment with evidence favoring sulodexide

- Sulodexide is a mixture of glycosaminoglycans (GAGs) that enhances antithrombin III activity, inhibits thrombin formation, and promotes fibrinolysis.
- Studies have shown that sulodexide can reduce the recurrence of VTE with a low risk of bleeding.

Screening for hypercoagulable states

- In patients without identifiable risk factors, it is recommended age-appropriate cancer screening.
- In patients <55 y/o or family history of thrombosis it might be reasonable to perform testing for genetic and acquired thrombophilia if the results are anticipated to change management or better inform family risk discussions.

Thrombo-embolic pulmonary disease (CTEPD)

Patients should be evaluated at 3 to 6 months after acute PE to assess dyspnea or functional limitation, which may indicate the development of CTEPD with or without PH.

- CTEPD with or without PH was officially introduced, acknowledging the presence of similar symptoms, perfusion defects, and organized fibrotic obstructions in patients with or without PH at rest.
- Chronic thrombo-embolic pulmonary hypertension (CTEPH) is defined as:
  - mPAP greater than 20 mm Hg
  - Pulmonary capillary wedge pressure less than 15 mm Hg
  - And at least one (segmental) perfusion defect detected on a V/Q, scan, CTA, or pulmonary angiogram after 3 months of effective anticoagulation

Summary of Recent Trials Evaluating Rapid Reperfusion Therapy

PEERLESS Trial: Large-Bore Mechanical Thrombectomy Versus Catheter-Directed Thrombolysis in the Management of Intermediate-Risk Pulmonary Embolism

Circulation 2025;151:260–273.

Methods

Prospective, multicenter, RCT: Enrolled 550 patients (LBMT 274 and CDT 276

- Compared large-bore mechanical thrombectomy (LBMT) and catheter-directed thrombolysis (CDT) in pts with intermediate-high risk PE
    - LBMT arm underwent aspiration/mechanical thrombectomy using the FlowTriever System (Inari Medical, Irvine, CA)
    - CDT arm underwent thrombolysis treatment per local standard for device selection and thrombolytic dosing
- Inclusion criteria
    - Symptom duration ≤14 days and intervention planned ≤72 hours from diagnosis
    - Proximal filling defect in ≥1 main or lobar pulmonary artery
    - RV dilatation or dysfunction on CTPA or echocardiogram
    - Elevated troponin
    - And ≥1 of the following:
        - History of heart failure or chronic lung disease
        - HR ≥110 bpm
        - SBP<100 mm Hg
        - RR ≥30 rpm
        - O2 Sat <90%
        - Syncope related to PE
        - Elevated lactate

The primary end point, assessed at the sooner of hospital discharge or 7 days after the procedure, was a composite of the following 5 variables:

- All-cause mortality
- Intracranial hemorrhage
- Major bleeding
- Clinical deterioration and/or escalation to bailout
- Postprocedural intensive care unit admission and length of stay

End points through 30 days included

- Total hospital stay
- All-cause readmission, and
- All-cause mortality

Results

- The primary end point occurred significantly less frequently with LBMT compared with CDT

- There were no significant differences in mortality, intracranial hemorrhage, or major bleeding between strategies.

Conclusions

- LBMT had lower rates of clinical deterioration and/or bailout, and postprocedural ICU use compared with CDT, with no difference in mortality or bleeding

Caveats

- The finding of the composite primary end point favoring LBMT was driven by 2 components:
    - Lower rates of clinical deterioration and/or escalation to bailout therapy
    - Less frequent ICU admissions and shorter postprocedural ICU lengths of stay
        - The ICU stay is an intuitive outcome given that many hospital protocols like ours require ICU monitoring for patients undergoing thrombolysis
- There were no significant differences in in-hospital mortality, ICH, or major bleeding between arms
- A positive finding across treatment arms was the overall low rate of all-cause mortality, ICH, and major bleeding, which were similar for LBMT and CDT
    - Mortality 0.4% and 0.8%
    - ICH 0.7% and 0.4%
    - Major bleeding 6.9% and 6.9%
- Major limitations of this study
    - The lack of comparison with anticoagulation alone as the standard of care for intermediate-risk PE
        - Several RCTs are investigating this important question, including the ongoing PEERLESS II trial, HI-PEITHO trial (Higher-Risk Pulmonary Embolism Thrombolysis), and PE-TRACT trial (Pulmonary Embolism–Thrombus Removal With Catheter-Directed Therapy

HI-PEITHO trial: Ultrasound-Facilitated, Catheter-Directed Fibrinolysis for Acute Pulmonary Embolism
NEJM March 28, 2026; 394: 1979-1990.

Compared US-facilitated, catheter-directed fibrinolysis with alteplase plus anticoagulation with anticoagulation alone

- Most patients received 18 mg alteplase as a 4-mg bolus followed by 14 mg infused over seven hours
    - The alteplase was infused *locally* into the bilateral pulmonary arteries
- Inclusion Criteria
    - Central PE (thrombus in at least one main or proximal lobar pulmonary artery on CT scan
    - Intermediate-high risk PE
        - RV end-diastolic diameter to LV end-diastolic diameter of ≥1.0
        - Elevated troponin level

    - At least two indicators of cardiorespiratory distress
        - SBP of ≤110 mm Hg
        - HR of ≥100
        - RR of >20
- Conclusion
    - US-facilitated catheter-directed fibrinolysis in pts with central PE with intermediate-high risk mortality led to a lower risk of the composite of pulmonary embolism–related death, cardiopulmonary decompensation or collapse, or symptomatic recurrence of pulmonary embolism within 7 days than anticoagulation alone
        - The effect was driven primarily by a lower risk of cardiorespiratory deterioration defined using a NEWS2 score or collapse in the intervention group
    - No bleeding difference between groups and no intracranial hemorrhage occurred in either group
- Take home messages
    - Catheter-directed fibrinolysis using ~18 mg alteplase over ~6 hours is reasonably safe, reduces the risk of hemodynamic deterioration and might accelerate recovery with regard to short-term functional status.
    - The subset of patients who may benefit from this treatment is *small*.
    - Central PE (this helps eliminate patients with chronic pulmonary hypertension plus a small acute PE) with intermediate-high risk mortality with at least two of the three signs of cardiorespiratory instability: SBP <110; HR >100; hypoxemia or respiratory rate >20.
    - Absence of risk factors for bleeding (possibly including an age <75 years old).
    - Patients who are not candidates Inari FlowTriever embolectomy.
- Caveat
    - There is no evidence that catheter-directed alteplase is superior to peripheral administration of the same alteplase dose.
    - Consequently, peripheral alteplase administration should be faster, easier, cheaper, and safer.

STORM-PE Trial: Lookstein RA Randomized Controlled Trial of Mechanical Thrombectomy with Anticoagulation Versus Anticoagulation Alone for Acute Intermediate-High Risk Pulmonary Embolism: Primary Outcomes From the STORM-PE Trial. *Circulation* 2026 Jan 6;153(1):21-34.

First reported multicenter RCT evaluating the efficacy and safety of mechanical thrombectomy, specifically computer-assisted vacuum thrombectomy (CAVT) with anticoagulation compared to anticoagulation alone.

- Inclusion Criteria
    - Intermediate-high risk pulmonary embolism who were normotensive, had an RV/LV ratio ≥ 1.0, and had elevated cardiac biomarkers
- Primary and Clinical Outcomes
    - STORM-PE was primarily an imaging/hemodynamic efficacy trial. Its primary endpoint was the difference between groups in the reduction of the RV/LV diameter ratio on CT at 48 hours. It was not powered to demonstrate differences in mortality, clinical deterioration, or major bleeding.

- 100 total patients randomized to CAVT with anticoagulation (n=47) or anticoagulation alone (n=53).
- Conclusion
    - The thrombectomy group demonstrated a significantly greater reduction and more frequent normalization of RV/LV ratio in conjunction with normalization of patient vital signs and hemodynamics.

Ongoing Clinical Trials

PEERLESS II

- Will test FlowTriever™ plus anticoagulation against anticoagulation alone in up to 1200 patients with intermediate-risk PE

PEITHO-3

- Will assess reduced-dose alteplase with standard heparin anticoagulation in up to 650 patients with intermediate-risk PE
- Alteplase 0.6 mg/kg IV, maximum 50 mg, infused over 15 minutes

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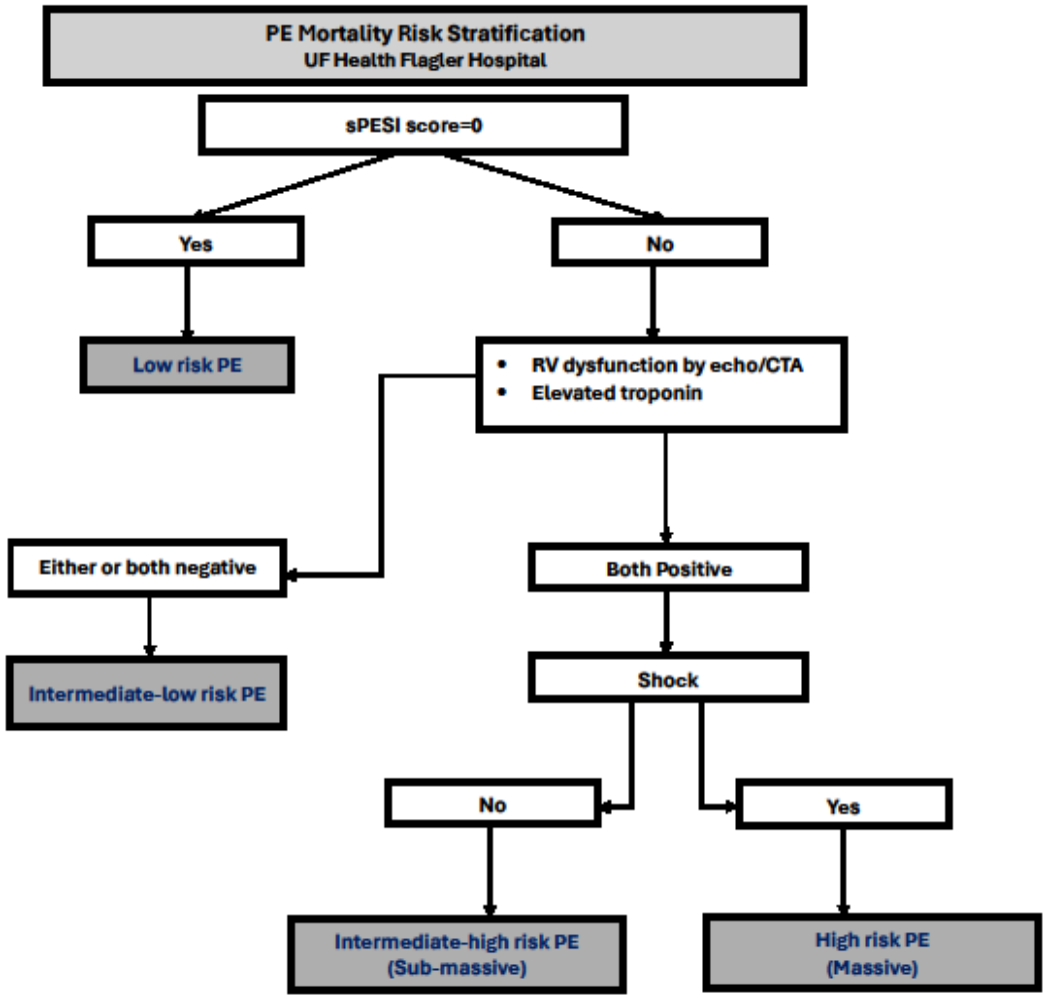
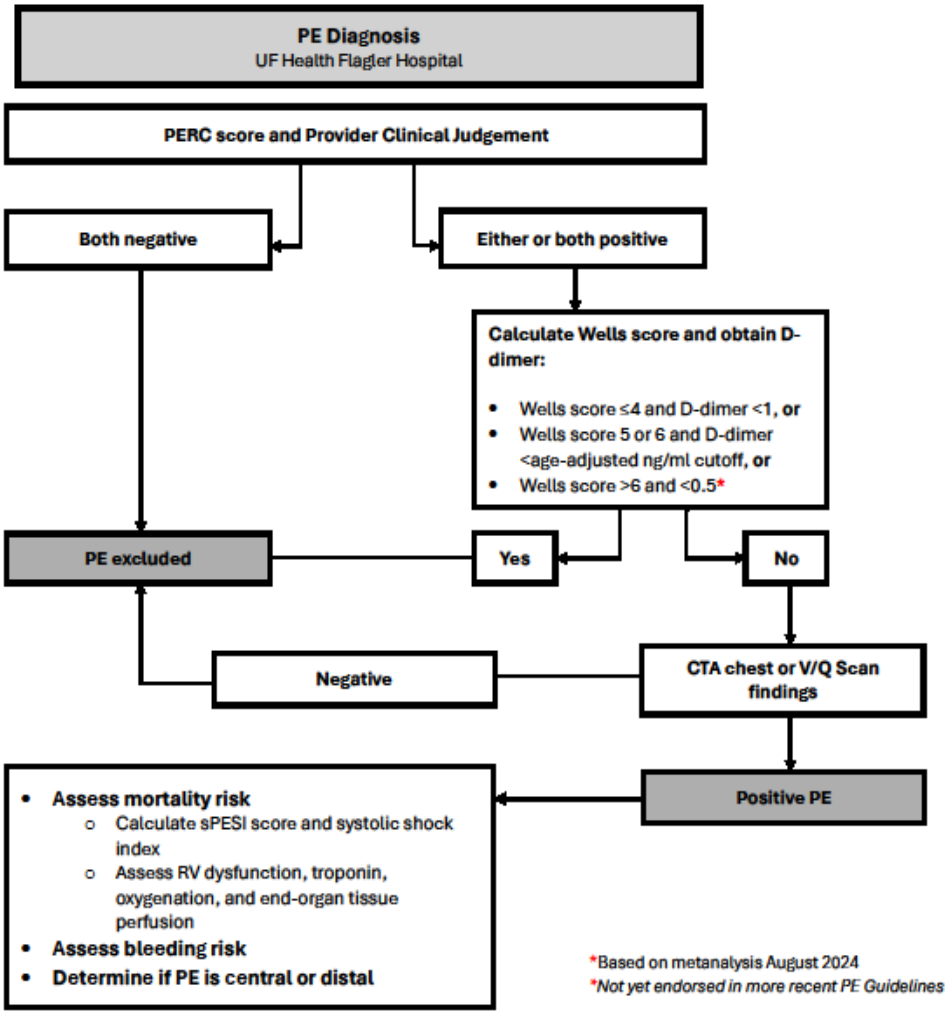
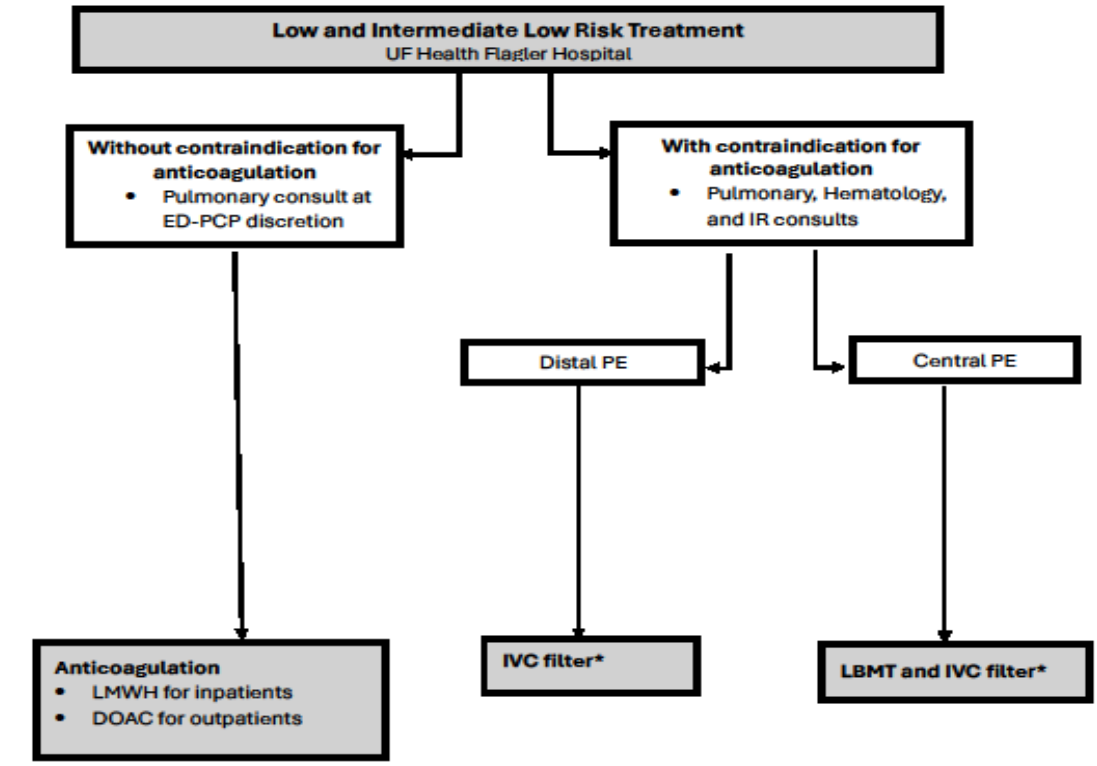
Algorithm 1


PE Mortality Risk Stratification
UF Health Flagler Hospital
sPESI score=0
Yes
No
Low risk PE
RV dysfunction by echo/CTA
Elevated troponin
Either or both negative
Both Positive
Intermediate-low risk PE
Shock
No
Yes
Intermediate-high risk PE
(Sub-massive)
High risk PE
(Massive)

Algorithm 2

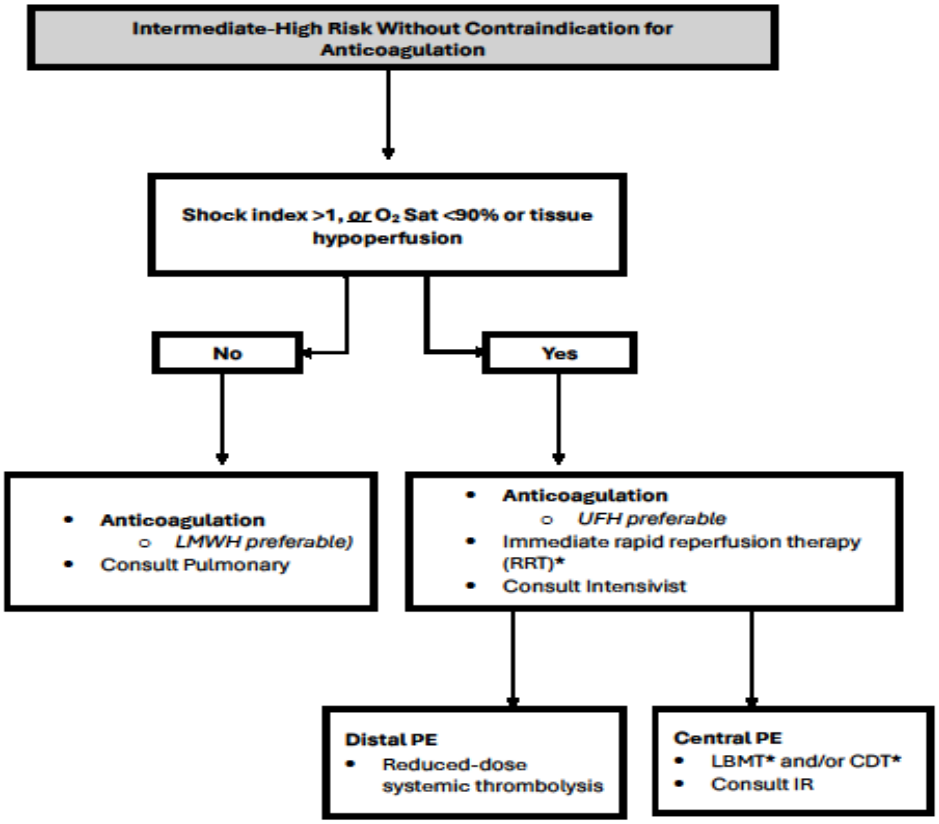

PE Diagnosis
UF Health Flagler Hospital
PERC score and Provider Clinical Judgement
Both negative
Either or both positive
Calculate Wells score and obtain D-dimer:
Wells score ≤4 and D-dimer <1, or
Wells score 5 or 6 and D-dimer <age-adjusted ng/ml cutoff, or
Wells score >6 and <0.5*
PE excluded
Yes
No
Negative
CTA chest or V/Q Scan findings
Positive PE
Assess mortality risk
Calculate sPESI score and systolic shock index
Assess RV dysfunction, troponin, oxygenation, and end-organ tissue perfusion
Assess bleeding risk
Determine if PE is central or distal
*Based on metanalysis August 2024
*Not yet endorsed in more recent PE Guidelines

Algorithm 3



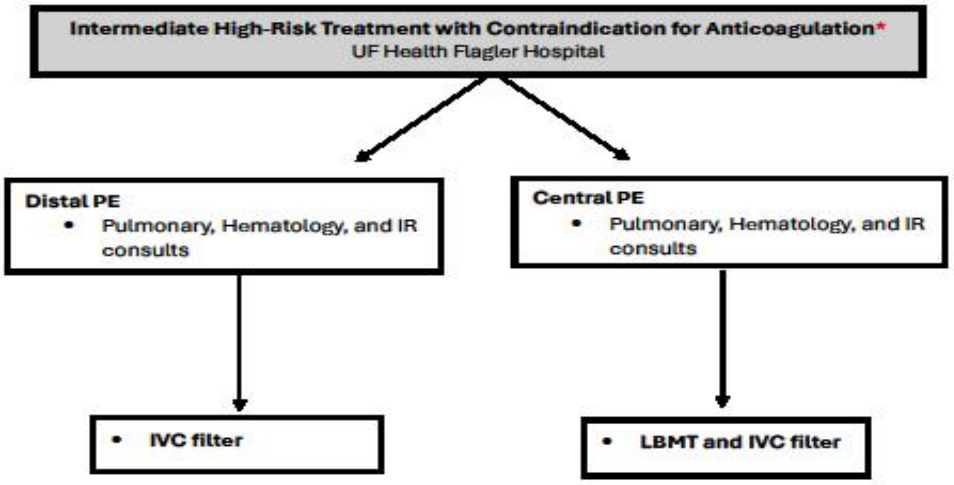
*If only relative contraindication, consider anticoagulation on case-by case analysis

Algorithm 4



***RRT**
- Systemic thrombolysis
- LBMT (large bore mechanical thrombectomy)
- CDT (catheter directed thrombolysis)

Algorithm 5

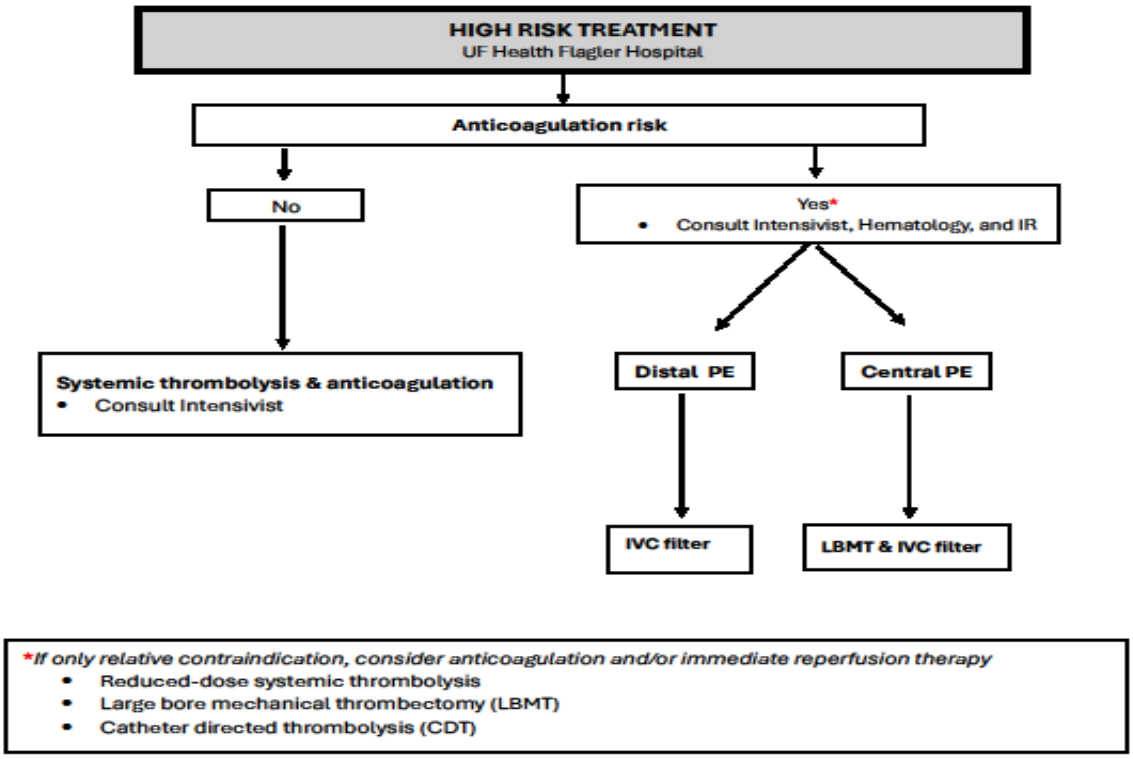


** If only relative contraindication, consider anticoagulation and/or immediate reperfusion therapy in a case-by-case analysis.*

Reperfusion therapy

- Reduced-dose systemic thrombolysis
- LBMT (large bore mechanical thrombectomy)
- CDT (catheter directed thrombolysis)

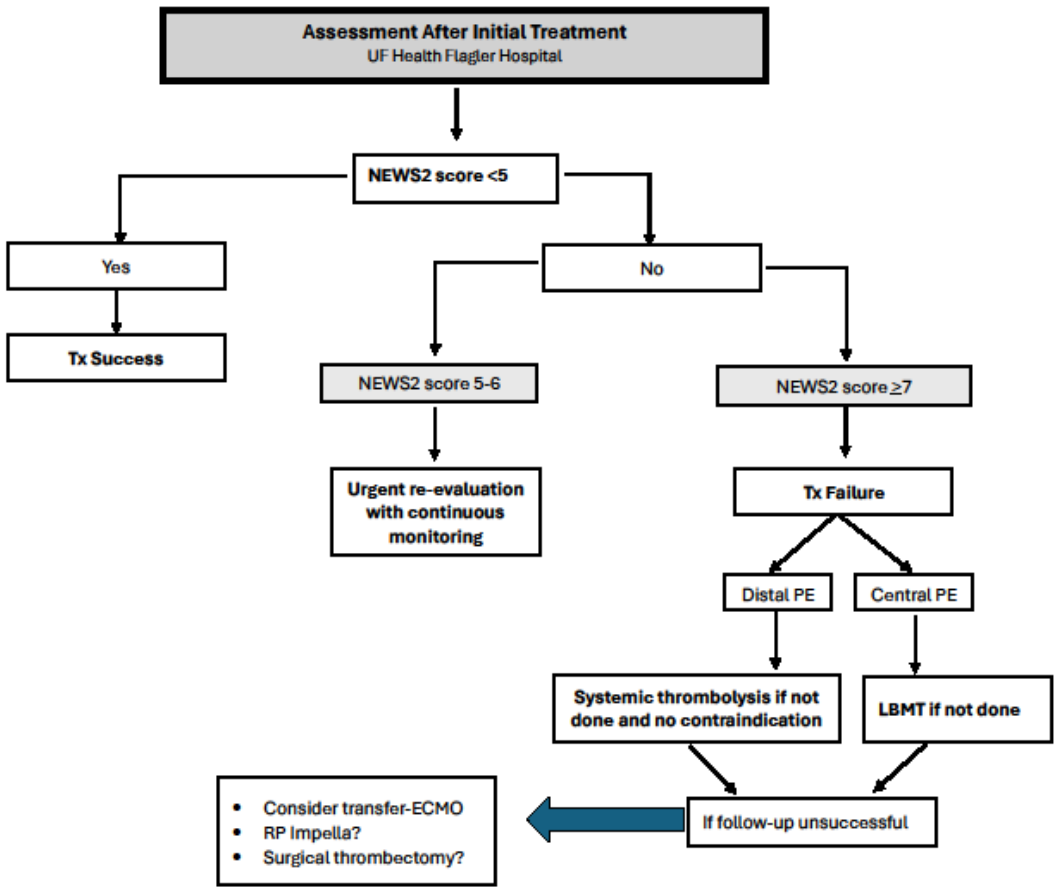
Algorithm 6



**If only relative contraindication, consider anticoagulation and/or immediate reperfusion therapy*

- Reduced-dose systemic thrombolysis
- Large bore mechanical thrombectomy (LBMT)
- Catheter directed thrombolysis (CDT)

Algorithm 7


Assessment After Initial Treatment
UF Health Flagler Hospital
NEWS2 score <5
Yes
Tx Success
No
NEWS2 score 5-6
Urgent re-evaluation with continuous monitoring
NEWS2 score ≥7
Tx Failure
Distal PE
Central PE
Systemic thrombolysis if not done and no contraindication
LBMT if not done
If follow-up unsuccessful
Consider transfer-ECMO
RP Impella?
Surgical thrombectomy?