2022 Hospital Medicine Update
May 11-14

Hospital management of Acute Pulmonary Embolism

An update of current practices

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Disclosures

- I have no financial disclosures or conflicts of interest with the presented material in this presentation

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Objectives

- Pulmonary Embolism Classification
- Acute Management
- IVC Filter Indications
- Home Treatment

CASE

What is the next best step in this patient's management?

A. VQ Scan

B. Obtain CT Angiogram PE Protocol and start UFH or LMWH

C. 2D Echocardiogram

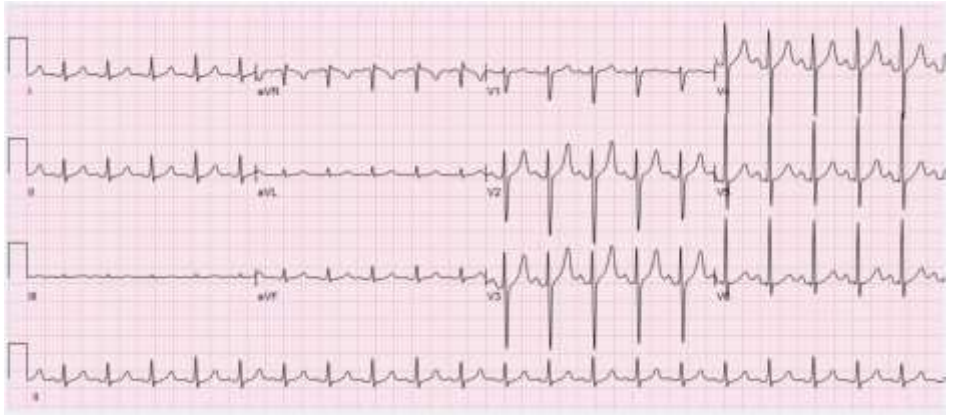
D. COVID19 swab

64 year old fe
exacerbation
two days afte

Her oxygen needs re[illegible]ed from 2 to 6 lpm to maintain SpO2 greater 88%.

She has a non productive cough and inspiratory chest pain.

studies	
	< 250 pg/mL
Troponin	0.18 ng/mL
Hgb	14.6 g/dl
Procalcitonin	0.03 ng/mL
Lactate	2.6 mmol/L



CASE C

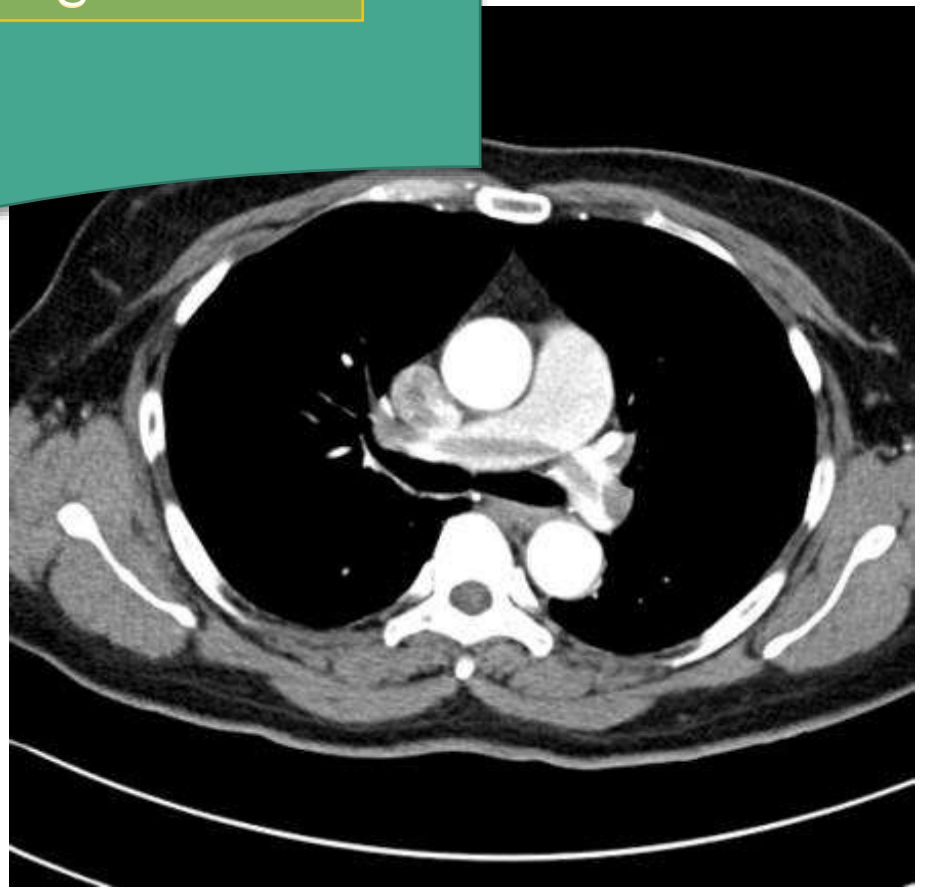
Based on ESC 2019 Guidelines what classification of pulmonary embolism does this patient have?

A. Low risk/Non-massive
B. Intermediate low risk/Sub-massive
C. Intermediate high risk/Sub-massive high risk
D. High risk/Massive

CT Angiogra
bilateral pulr
ratio 1.3 with

Laboratory studies	
BNP	< 250 pg/mL
Troponin	0.18 ng/mL
Hgb	14.6 g/dl
Procalcitonin	0.03 ng/mL
Lactate	2.6 mmol/L

Vitals	
HR	103
BP	122/74 mmHg
RR	18
SpO2	92% 6 lpm



PE Classification

Risk Stratification

Epidemiology

- 3rd leading cause of cardiovascular death and the incidence is rising.
- 10-30% mortality within one month
- > 33% of patients will have recurrence of VTE within 10 years

Risk Factors

Acquired

- Obesity
- Surgery / Immobility
- Malignancy
- Peripartum
- Antiphospholipid syndrome

Inherited

- Factor V leiden
- Prothrombin gene mutation
- Protein C & S deficiency

Presenting Symptoms

(PIOPED II)

- Dyspnea (73%)
- Tachypnea (54%)
- Pleuritic pain (44%)
- Calf pain (44%)
- Tachycardia (24%)

Beckman MG, Hooper WC, Critchley SE, Ortel TL. Venous thromboembolism: a public health concern. Am J Prev Med. 2010 Apr;38(4 Suppl):S495-501. doi: 10.1016/j.amepre.2009.12.017. PMID: 20331949.

Stein PD, Beemath A, Matta F, Weg JG, Yusen RD, Hales CA, Hull RD, Leeper KV Jr, Sostman HD, Tapson VF, Buckley JD, Gottschalk A, Goodman LR, Wakefied TW, Woodard PK. Clinical characteristics of patients with acute pulmonary embolism: data from PIOPED II. Am J Med. 2007 Oct;120(10):871-9. doi

PE Classification

Pulmonary Embolism in Acute Exacerbation of COPD

Most exacerbations are due to infectious etiology

Up to 30% of AE-COPD patients the etiology remains unknown (1)

Systemic Review and meta-analysis of published articles demonstrated the prevalence of VTE during acute exacerbations is 19.9% (2)

In two separate articles exclusive to patients admitted for acute exacerbation, the prevalence was 25.5% (2)

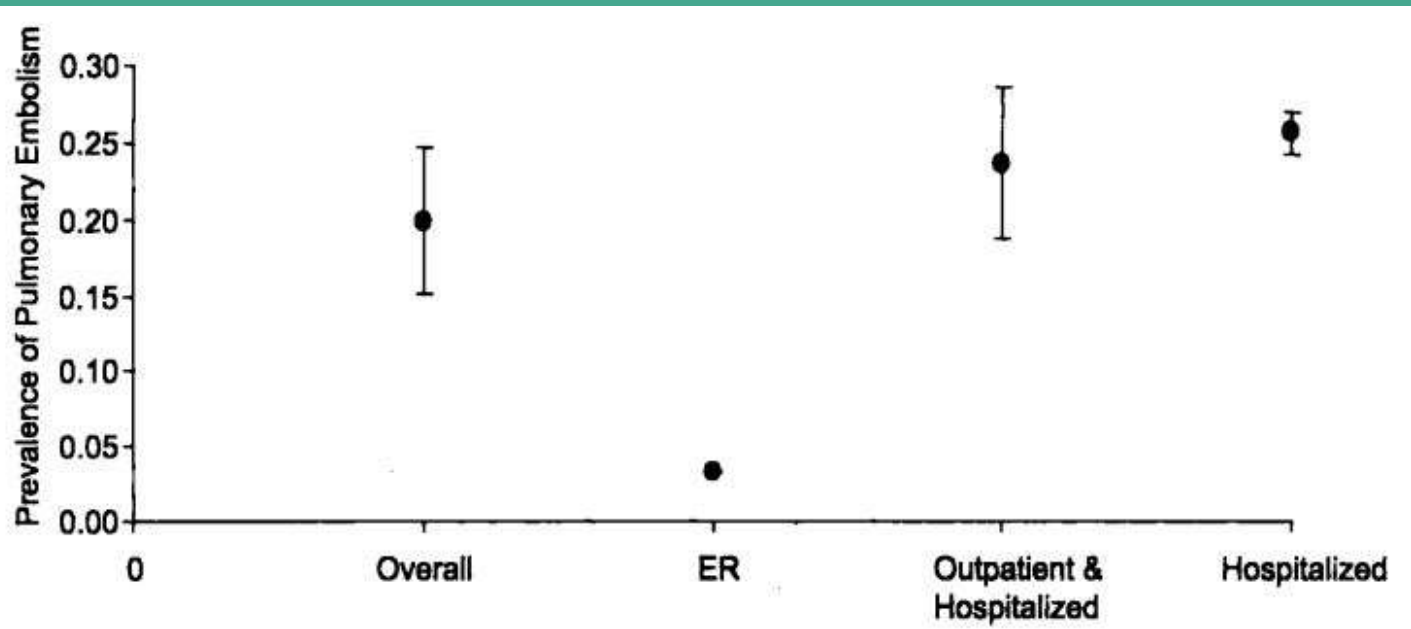


FIGURE 2. The prevalence of PE across different sites. The filled circles represent the mean, and the line bars represent SE; p value for overall = 0.014; p value for emergency department (ER) is not calculable because there was only one study; p value for studies that evaluated inpatients and outpatients = 0.133; p value for studies that evaluated only hospitalized patients = 0.034.

[1] Sapey E, Stockley RA (2006) COPD exacerbations. 2: aetiology. Thorax 61:250–258
[2] Jacques Rizkallah,S.F. Paul Man,Don D. Sin Prevalence of Pulmonary Embolism in Acute exacerbations of COPD CHEST Journal VOLUME 135, ISSUE 3, P786-793, MARCH 01, 2009

PE Classification

ESC Guidelines on Severity Classification

Early mortality risk		Indicators of risk			
		Haemodynamic instability[a]	Clinical parameters of PE severity and/or comorbidity: PESI class III–V or sPESI ≥I	RV dysfunction on TTE or CTPA[b]	Elevated cardiac troponin levels[c]
High		+	(+)[d]	+	(+)
Intermediate	Intermediate–high	-	+[e]	+	+
	Intermediate–low	-	+[e]	One (or none) positive	
Low		-	-	-	Assesment optional; if assessed, negative

©ESC 2019

Konstantinides SV, Meyer G, Becattini C, Bueno H, Geersing GJ, Harjola VP, Huisman MV, Humbert M, Jennings CS, Jiménez D, Kucher N, Lang IM, Lankeit M, Lorusso R, Mazzolai L, Meneveau N, Ní Áinle F, Prandoni P, Pruszczyk P, Righini M, Torbicki A, Van Belle E, Zamorano JL; ESC Scientific Document Group. 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS). Eur Heart J. 2020 Jan 21;41(4):543-603. doi: 10.1093/eurheartj/ehz405. PMID: 31504429.

Pulmonary Embolism Severity Index (PESI) Score

- Predictor for 30-day mortality.
- Has not been studied for risk of in-hospital death.
- Over stratifies elderly patients, and under stratifies the young.

Parameter	Original version[214]	Simplified version[218]
Age	Age in years	1 point (if age >80 years)
Male sex	+10 points	–
Cancer	+30 points	1 point
Chronic heart failure	+10 points	1 point
Chronic pulmonary disease	+10 points	
Pulse rate ≥110 b.p.m.	+20 points	1 point
Systolic blood pressure <100 mm Hg	+30 points	1 point
Respiratory rate >30 breaths per minute	+20 points	–
Temperature <36 °C	+20 points	–
Altered mental status	+60 points	–
Arterial oxyhaemoglobin saturation <90%	+20 points	1 point
	Risk strata[a]	
	Class I:≤65 points very low 30-day mortality risk (0–1.6%) **Class II: 66–85 points** low mortality risk (1.7–3.5%) **Class III: 86–105 points** moderate mortality risk (3.2–7.1%) **Class IV: 106–125 points** high mortality risk (4.0–11.4%) **Class V: >125 points** very high mortality risk (10.0–24.5%)	**0 points**= 30-day mortality risk 1.0% (95% CI 0.0%–2.1%) **≥1 point(s)**= 30-day mortality risk 10.9% (95% CI 8.5%–13.2%)

Yamashita Y, Morimoto T, Amano H, Takase T, Hiramori S, Kim K, Oi M, Akao M, Kobayashi Y, Toyofuku M, Izumi T, Tada T, Chen PM, Murata K, Tsuyuki Y, Saga S, Sasa T, Sakamoto J, Kinoshita M, Togi K, Mabuchi H, Takabayashi K, Shiomi H, Kato T, Makiyama T, Ono K, Kimura T. Validation of simplified PESI score for identification of low-risk patients with pulmonary embolism: From the COMMAND VTE Registry. Eur Heart J Acute Cardiovasc Care. 2020 Jun;9(4):262-270.

Early initiation of anticoagulation is associated with reduced mortality for acute pulmonary embolism.

Retrospective single tertiary center cohort study of 400 consecutive patients in ER diagnosed with acute PE by CT angiography at Mayo Clinic.

June 2002 to September 2005

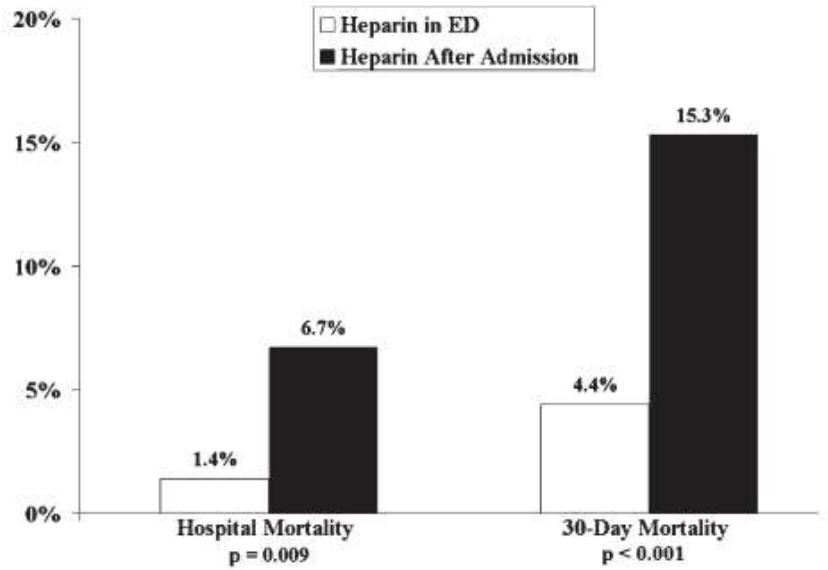


FIGURE 1. Hospital and 30-day mortality rates for patients who received heparin in the ED compared with those who received heparin after admission.

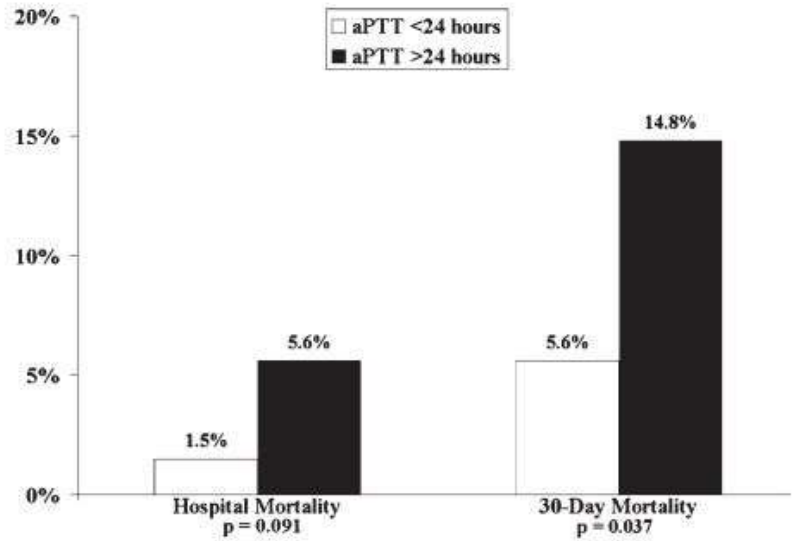


FIGURE 2. Hospital and 30-day mortality rates for patients who achieved a therapeutic aPTT prior to 24 h from ED arrival compared with those who achieved a therapeutic aPTT after 24 hours. aPTT = activated partial thromboplastin time.

Patients who received early heparin in the ED had lower in hospital and 30 day mortality.

Smith SB, Geske JB, Maguire JM, Zane NA, Carter RE, Morgenthaler TI. Early anticoagulation is associated with reduced mortality for acute pulmonary embolism. *Chest*. 2010;137(6):1382-1390. doi:10.1378/chest.09-0959

CASE C

What is the next best step in the acute management?

A. Intubate
B. Place patient on non-invasive ventilation
C. Administer 1L saline bolus
D. Place patient on high flow nasal cannula

5 hours after
patients con
breather mo

Consultation to the [illegible] Embolism Response Team (PERT) is activated. She appears euvolemic on examination.

BG	
	41
pCO2	21 mmHg
pO2	58 mmHg
	mEq/L
HCO3	22
Vitals	
HR	115
BP	92/50 mmHg
RR	28
SpO2	90% (15 lpm)

Acute Management

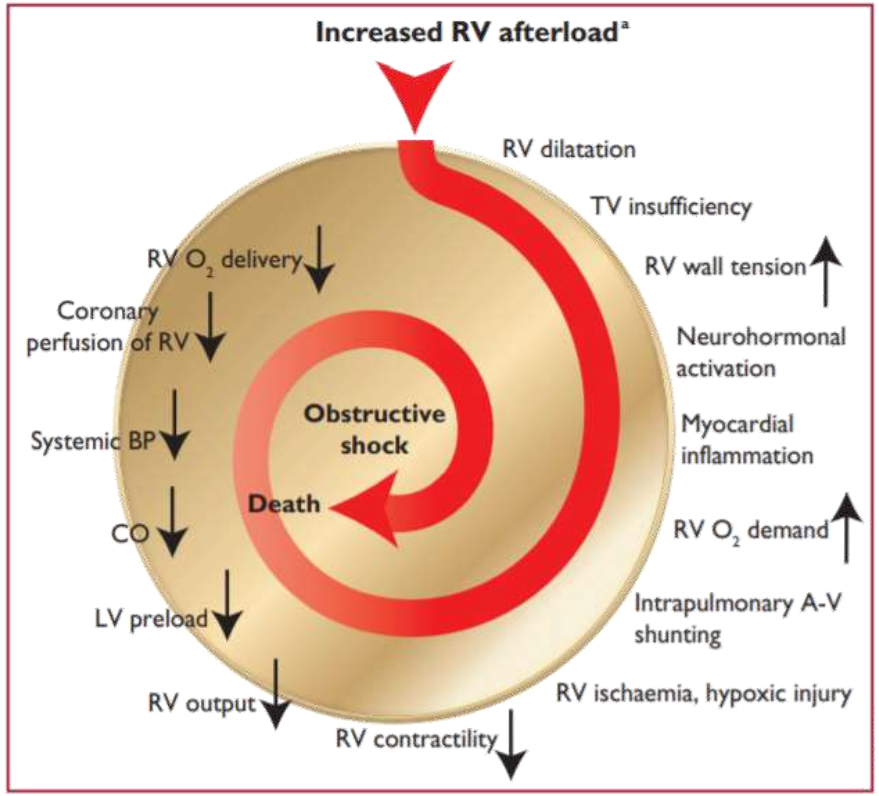
High-Risk Pulmonary Embolism

- ✓ Avoid intubation or non-invasive ventilation unless necessary
- ✓ Use high flow nasal cannula
- ✓ Caution volume loading, saline, or ringer's lactate < 500 mL over 15-30 minutes
- ✓ Early initiation of vasopressors (norepinephrine)

Konstantinides SV, Meyer G, Becattini C, Bueno H, Geersing GJ, Harjola VP, Huisman MV, Humbert M, Jennings CS, Jiménez D, Kucher N, Lang IM, Lankeit M, Lorusso R, Mazzolai L, Meneveau N, Ní Áinle F, Prandoni P, Pruszczyk P, Righini M, Torbicki A, Van Belle E, Zamorano JL; ESC Scientific Document Group. 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS). Eur Heart J. 2020 Jan 21;41(4):543-603. doi: 10.1093/eurheartj/ehz405. PMID: 31504429.

Acute Management

Complete RV Failure



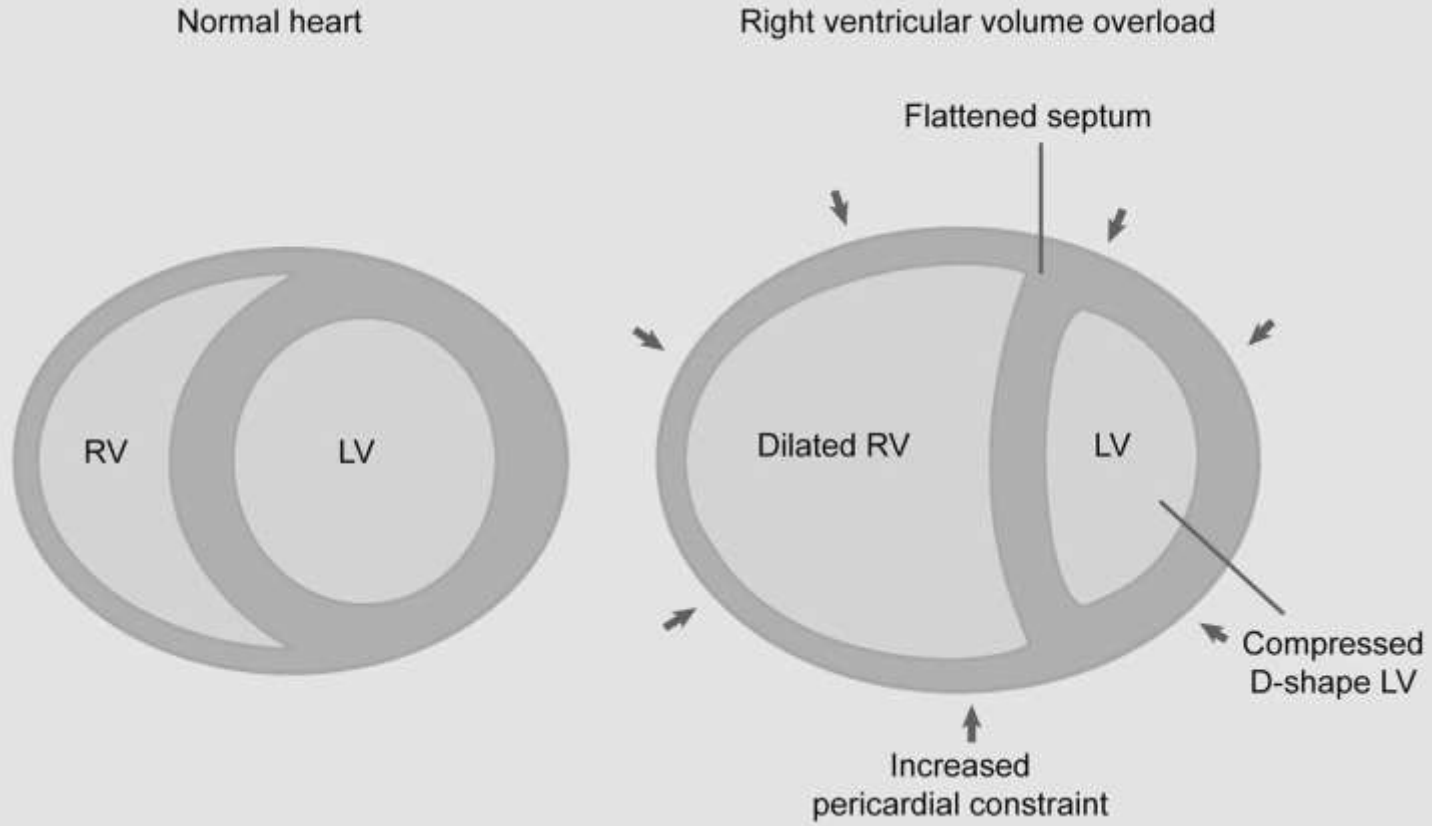
25% Percent of patients who have evidence of right ventricular dysfunction on presentation

45% Of those with evidence of right ventricular dysfunction, 45% will have right ventricular failure

65% Mortality rate among those with hypotension

. Konstantinides SV, Torbicki A, Agnelli G, Danchin N, Fitzmaurice D, Galie N, Gibbs JS, Huisman MV, Humbert M, Kucher N, Lang I, Lankeit M, Lekakis J, Maack C, Mayer E, Meneveau N, Perrier A, Pruszczyk P, Rasmussen LH, Schindler TH, Svitil P, Vonk NA, Zamorano JL, Zompatori M. 2014 ESC Guidelines on the diagnosis and management of acute pulmonary embolism. Eur Heart J 2014;35:30333073

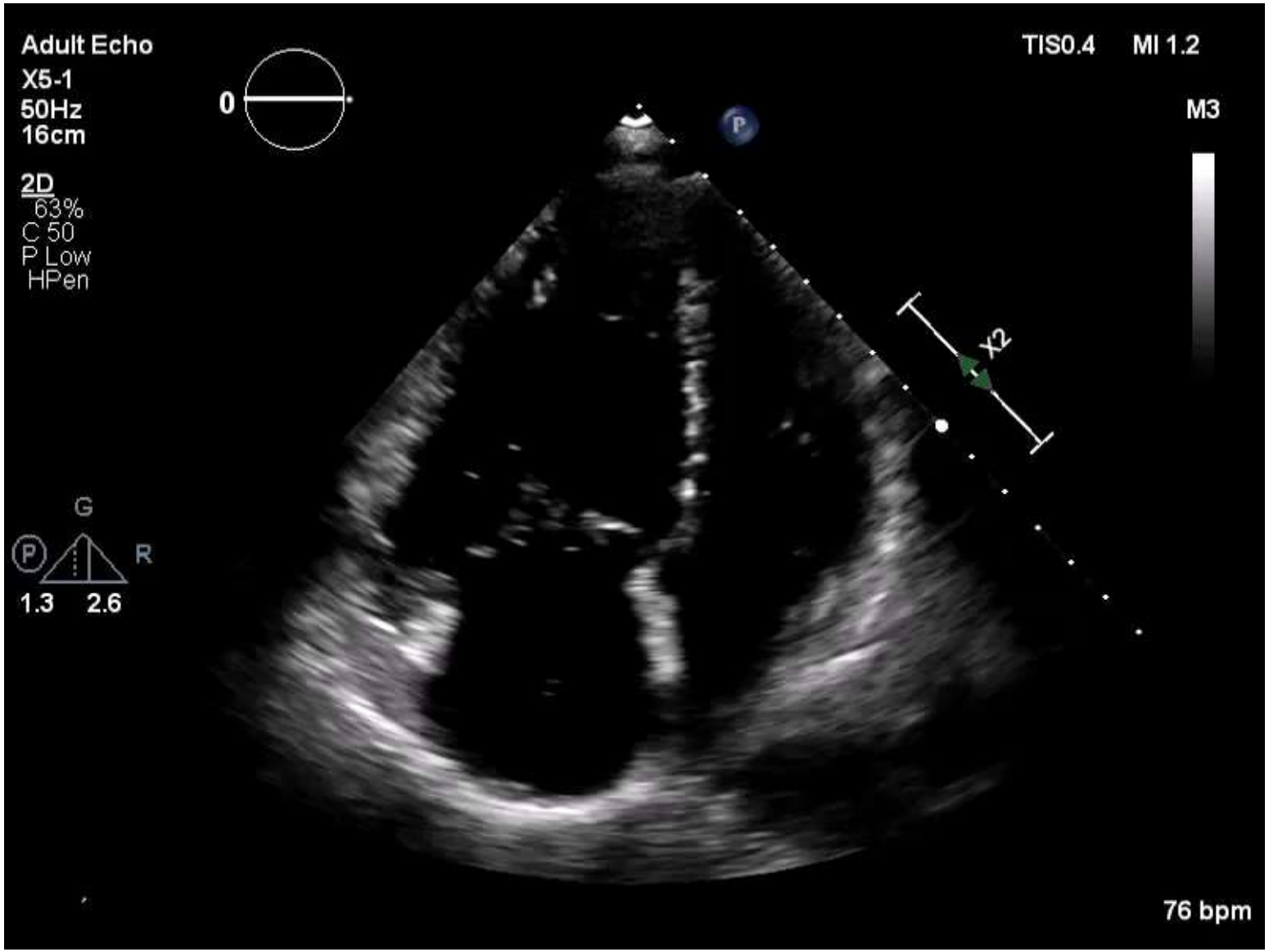
Acute Management Dysfunction



Bryce YC, Perez-Johnston R, Bryce EB, Homayoon B, Santos-Martin EG. Pathophysiology of right ventricular failure in acute pulmonary embolism and chronic thromboembolic pulmonary hypertension: a pictorial essay for the interventional radiologist. *Insights Imaging*. 2019;10(1):18. Published 2019 Feb 13. doi:10.1186/s13244-019-0695-9

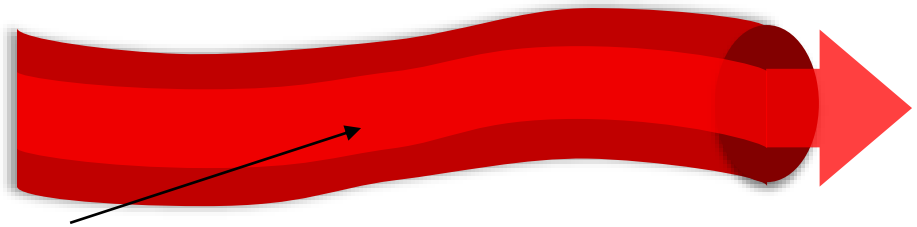
Acute Management

Right Ventricular Dysfunction

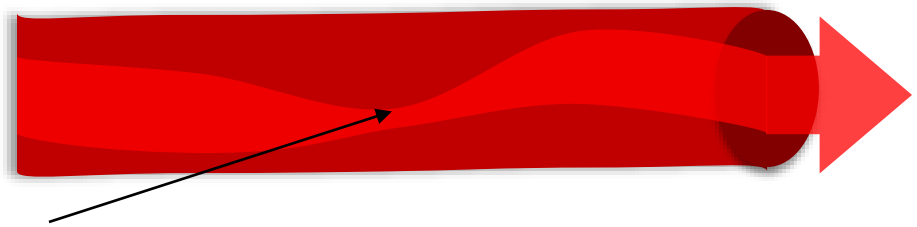


Acute Management

Coronary Perfusion and Troponin Elevation



Normal pressure and folds in the RV wall resulting in unimpeded coronary artery flow



Increased pressure and straightening of the folds in the RV wall resulting in impedance of the coronary artery flow

Coronary Perfusion Pressure = MAP - CVP

Cardiac Output = **HR** x **SV**

Bryce YC, Perez-Johnston R, Bryce EB, Homayoon B, Santos-Martin EG. Pathophysiology of right ventricular failure in acute pulmonary embolism and chronic thromboembolic pulmonary hypertension: a pictorial essay for the interventional radiologist. *Insights Imaging*. 2019;10(1):18. Published 2019 Feb 13. doi:10.1186/s13244-019-0695-9

CASE C

What is the next best step in management of this patient?

A. Intubate

B. Give Systemic thrombolysis

C. Place central line

D. 1 liter normal saline bolus

After placen
cannula the
improves bu

She is neurologic
history of GI bleed or recent surgery.

INR level is normal.

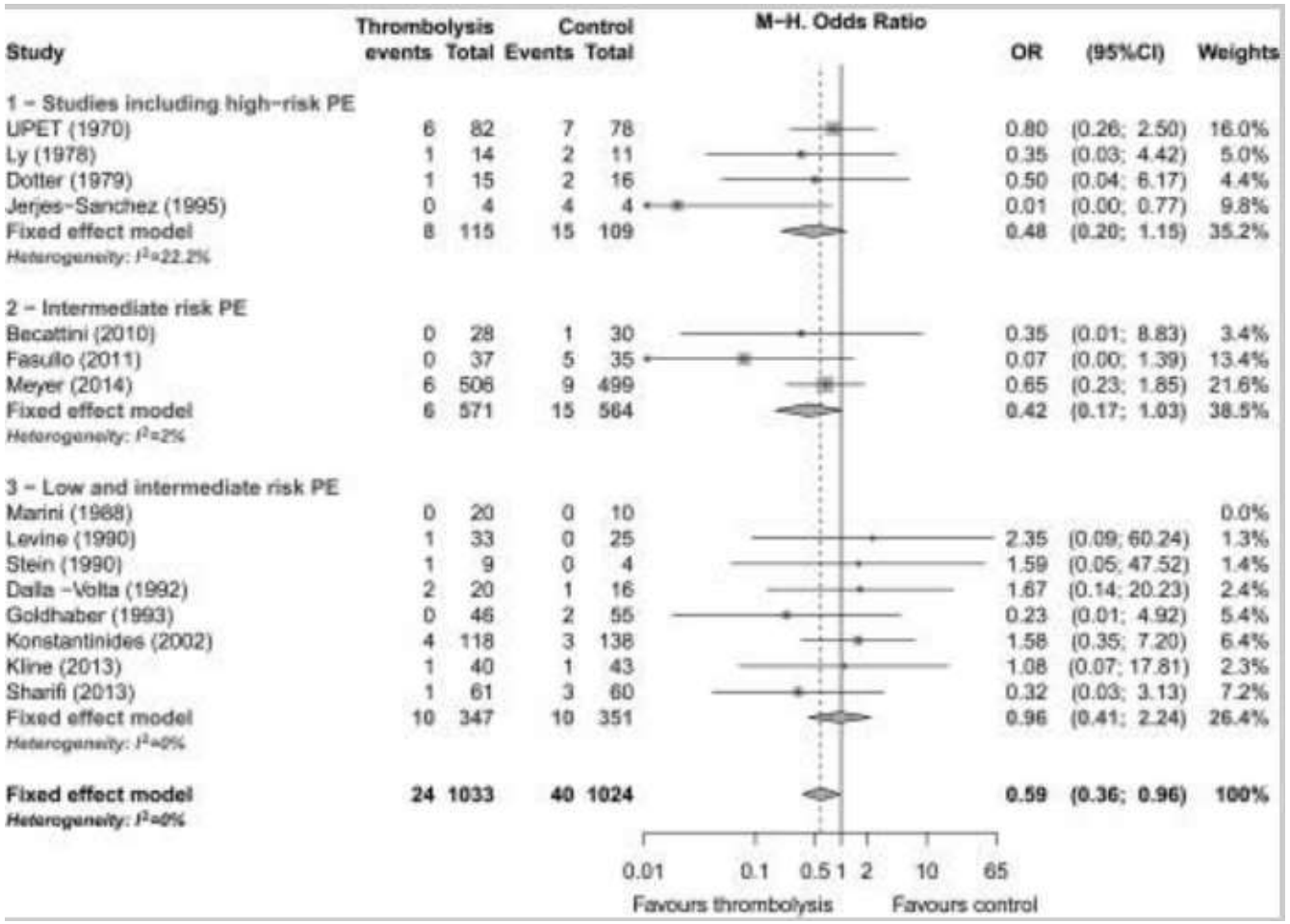
	s
	20
BP	88/50 mmHg
RR	30
SpO2	93%

Marti C, John G, Konstantinides S, et al. Systemic thrombolytic therapy for acute pulmonary embolism: a systematic review and meta-analysis. *Eur Heart J.* 2015;36:605–614

Acute Management

Systemic Thrombolysis

- Systemic review of 15 studies including 2057 patients reported early (≤30 days) all-cause mortality.
- Mortality was 2.3% (24/1033) in the thrombolysis group and 3.9% (40/1024) in the control group



Marti C, John G, Konstantinides S, et al. Systemic thrombolytic therapy for acute pulmonary embolism: a systematic review and meta-analysis. *Eur Heart J.* 2015;36:605–614

Acute Management Advanced Therapies

In select patients (intermediate high and high risk/massive)

Ekos – Ultrasound accelerated catheter directed thrombolysis

Randomized Controlled Trial > JACC Cardiovasc Interv. 2018 Jul 23;11(14):1401-1410. doi: 10.1016/j.jcin.2018.04.008.

A Randomized Trial of the Optimum Duration of Acoustic Pulse Thrombolysis Procedure in Acute Intermediate-Risk Pulmonary Embolism: The OPTALYSE PE Trial

Victor F Tapson [1], Keith Sterling [2], Noah Jones [3], Mahir Elder [4], Uttam Tripathy [5], Jayson Brower [6], Robert L Maholic [7], Charles B Ross [8], Kannan Natarajan [9], Pete Fong [10], Lee Greenspon [11], Houman Tamaddon [12], Amir R Piracha [13], Tod Engelhardt [14], John Katopodis [15], Vasco Marques [16], Andrew S P Sharp [17], Gregory Piazza [18], Samuel Z Goldhaber [18]

Affiliations + expand

PMID: 30025734 DOI: 10.1016/j.jcin.2018.04.008

Angiodynamics alphavac

Surgical embolectomy

Inari Flotriever, Clotriever

A Prospective, Single-Arm, Multicenter Trial of Catheter-Directed Mechanical Thrombectomy for Intermediate-Risk Acute Pulmonary Embolism: The FLARE Study

Peripheral

Thomas Tu, Catalin Toma, Victor F. Tapson, Christopher Adams, Wissam A. Jaber, Mitchell Silver, Sameer Khandhar, Rohit Amin, Mitchell Weinberg, Tod Engelhardt, Monica Hunter, David Holmes, Glenn Hoots, Hussam Hamdalla, ... SEE ALL AUTHORS

J Am Coll Cardiol Intv. 2019 May, 12 (9) 859–869

Penumbra

Indigo Aspiration System for Treatment of Pulmonary Embolism: Results of the EXTRACT-PE Trial

Peripheral

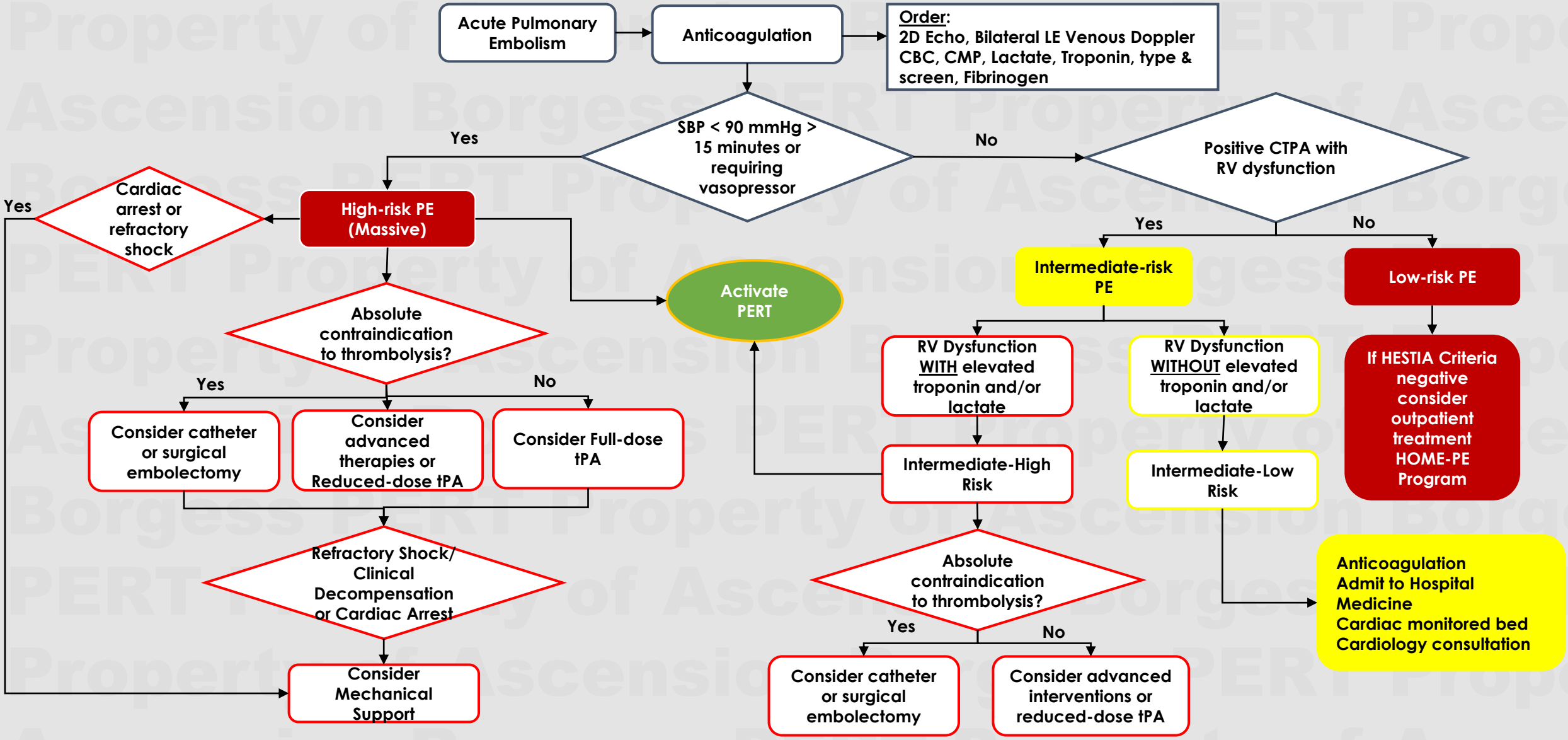
Akhilesh K. Sista, James M. Horowitz, Victor F. Tapson, Michael Rosenberg, Mahir D. Elder, Brian J. Schiro, Suhail Dohad, Nancy E. Amoroso, David J. Dexter, Christopher T. Loh, Daniel A. Leung, Bruce Kirke Bieneman, ... SEE ALL AUTHORS

J Am Coll Cardiol Intv. 2021 Feb, 14 (3) 319–329

Acute Management

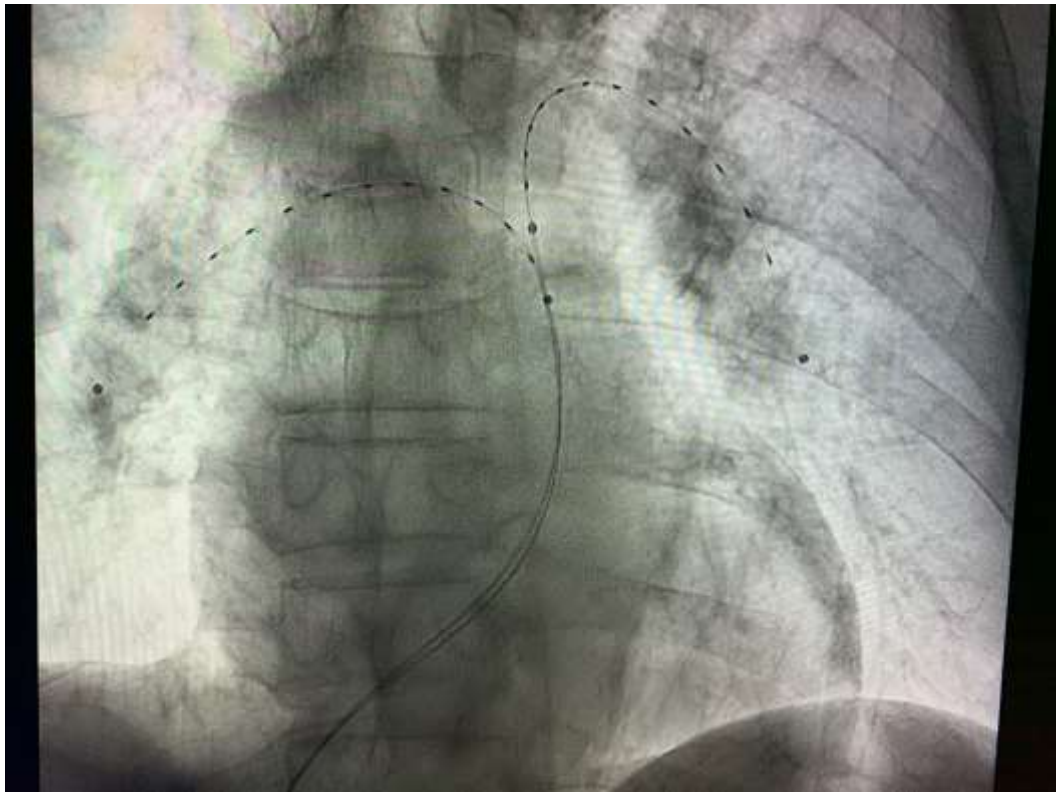
PERT Activation & Treatment Algorithm

Ascension Borgess Hospital



Stavros V Konstantinides, Guy Meyer, Cecilia Becattini, Héctor Bueno, Geert-Jan Geersing, Veli-Pekka Harjola, Menno V Huisman, Marc Humbert, Catriona Sian Jennings, David Jiménez, Nils Kucher, Irene Marthe Lang, Mareike Lankeit, Roberto Lorusso, Lucia Mazzolai, Nicolas Meneveau, Fionnuala Ní Áinle, Paolo Prandoni, Piotr Pruszczyk, Marc Righini, Adam Torbicki, Eric Van Belle, José Luis Zamorano, ESC Scientific Document Group, 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS): The Task Force for the diagnosis and management of acute pulmonary embolism of the European Society of Cardiology (ESC), *European Heart Journal*, Volume 41, Issue 4, 21 January 2020, Pages 543–603,

Acute Management Interventions



Ekos Ultrasound accelerated catheter directed thrombolysis

Inari Flowtriever

CASE C

What is the next best step in management?

A. Place IVC filter

B. Continue anticoagulation

C. Catheter directed thrombolysis and/or mechanical thrombectomy

D. Continue mechanical compression devices

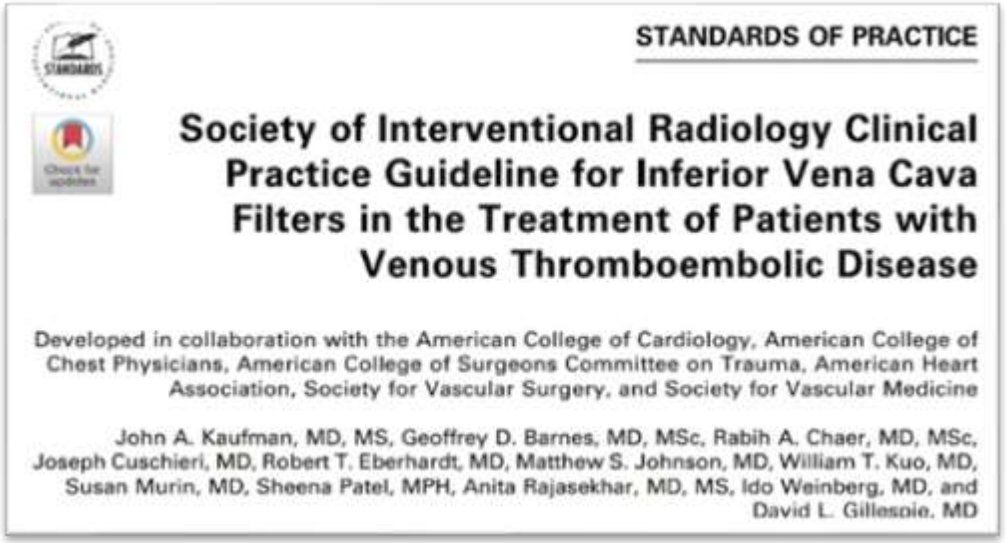
Patient impr
the next 24 h
right mid-fen
lower extrem

nproved over
emonstrated
sensation and pulses in

IVC Filter Indications

Questions to ask before considering IVC filter:

- Is there a major contraindication to anticoagulation?
- How will IVC filter mitigate risk?
- Does the benefit outweigh the risk?



STANDARDS OF PRACTICE

Society of Interventional Radiology Clinical Practice Guideline for Inferior Vena Cava Filters in the Treatment of Patients with Venous Thromboembolic Disease

Developed in collaboration with the American College of Cardiology, American College of Chest Physicians, American College of Surgeons Committee on Trauma, American Heart Association, Society for Vascular Surgery, and Society for Vascular Medicine

John A. Kaufman, MD, MS, Geoffrey D. Barnes, MD, MSc, Rabih A. Chaer, MD, MSc, Joseph Cuschieri, MD, Robert T. Eberhardt, MD, Matthew S. Johnson, MD, William T. Kuo, MD, Susan Murin, MD, Sheena Patel, MPH, Anita Rajasekhar, MD, MS, Ido Weinberg, MD, and David L. Gillespie, MD

Guidelines are based on weak recommendations.

Current data is variable and often confusing.

Inability to anticoagulate ≠ IVC filter placement.

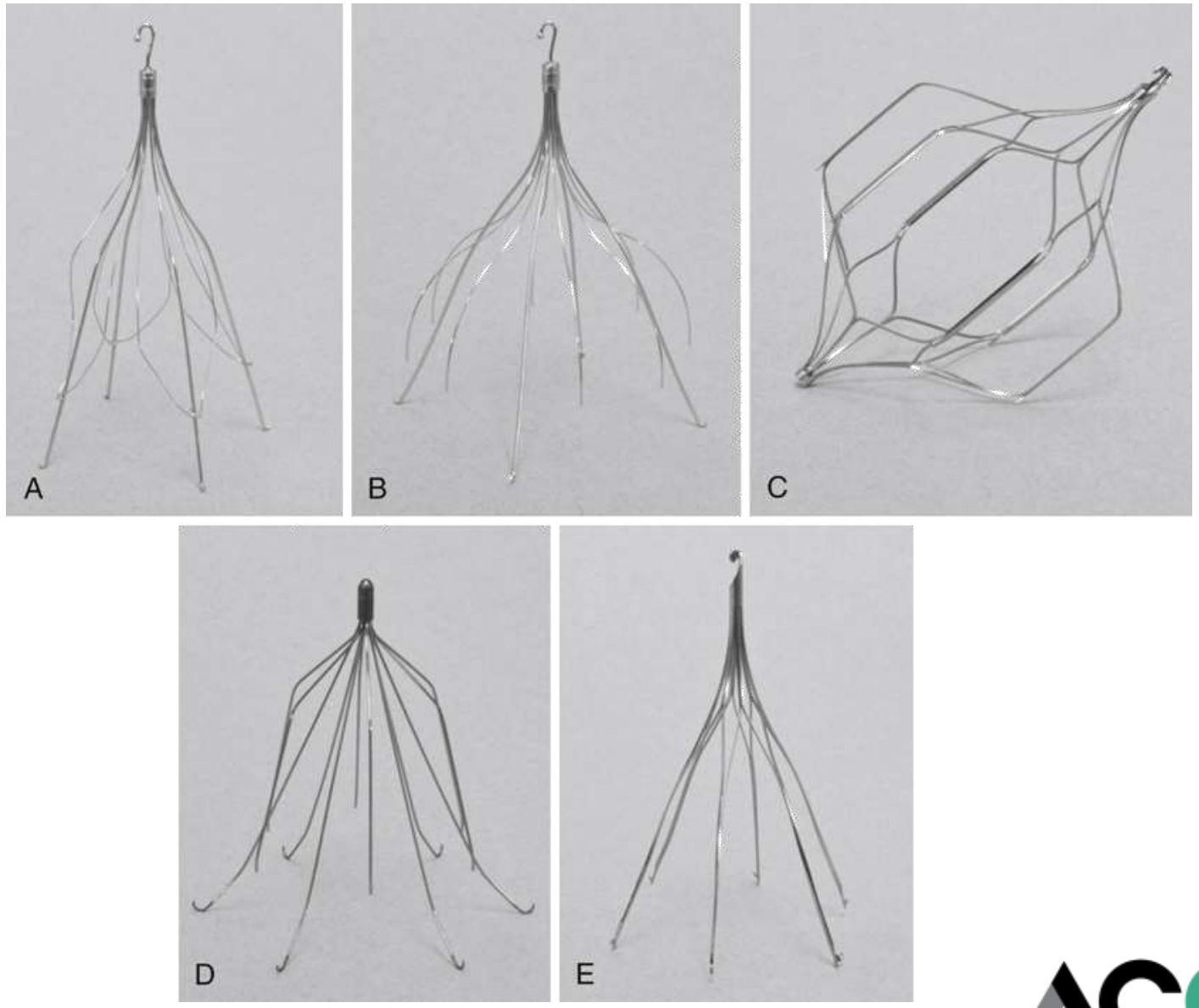
IVC Filter Indications

Guideline Recommendations

		Strength of Recommendation	
Acute PE	*In patients with acute PE with contraindication to anticoagulation therapy, we suggest an IVC filter to be considered based on various clinical risk factors, as outlined in the rationale.*	Limited	★★☆☆
Acute DVT	*In patients with acute DVT without PE and with a contraindication to anticoagulation therapy, that an IVC filter be considered based on various clinical risk factors, as outlined in the rationale.*	Consensus	★☆☆☆
Recurrent VTE	*In patients who are receiving therapeutic anticoagulation for VTE (DVT, PE), who experience a recurrent VTE, we suggest that a filter not be placed, with few exceptions. Reasons for anticoagulation failure should always be addressed.*	Consensus	★☆☆☆
Routine IVC Filter Placement	*In patients with acute VTE (DVT, PE) who are being treated with therapeutic anticoagulation, we recommend against routine placement of an IVC filter.*	Moderate	★★★☆
Indwelling IVC Filters with Mitigated PE Risk	*In patients with indwelling retrievable/convertible IVC filter whose risk of PE has been mitigated or who are no longer at risk for PE, we suggest filters be routinely removed/converted unless risk outweighs benefit.*	Consensus	★☆☆☆
	In patients with indwelling permanent IVC filters whose risk of PE has been mitigated or who are no longer at risk for PE, we suggest against routine removal of filters.	Consensus	★☆☆☆

Most importantly:

IVC filters <u>DO NOT</u> prevent Pulmonary Embolism.



CASE

What is the next best step in management?

A. Admit patient to Cardiac floor, start parental UFH/LWMH

B. Activate Pulmonary Embolism Response Team

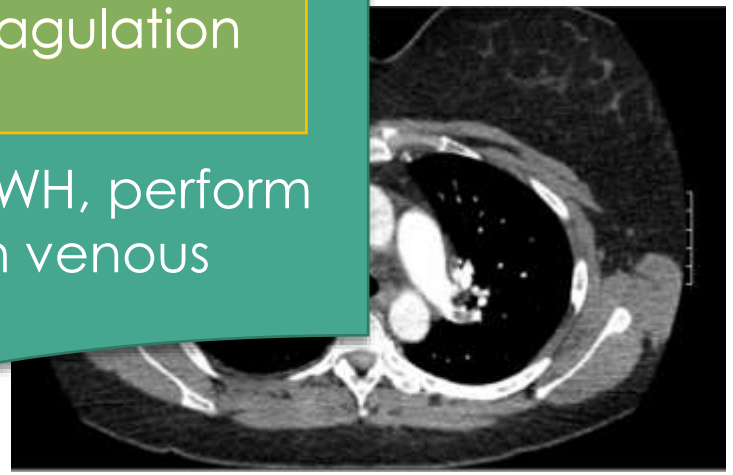
C. Discharge patient from ER with anticoagulation and outpatient management

D. Admit patient to observation, start LMWH, perform hypercoagulable work up, and obtain venous dopplers

56 year old f
progressive
Angiogram
pictured. RV
negative. Sh

- **PmHx**: Forn
  cancer. She has good social support system.

The ER attending on call speaks with you the admitting physician to admit the patient.



Vitals	
HR	68
BP	130/70 mmHg
RR	14
SpO2	99% Room Air

Home Treatment

Supporting Clinical Evidence: Home-PE Trial

Study Design

- Prospective Randomized Trial (Hestia vs sPESI) of normotensive patients with PE in 26 hospitals in 4 European Countries.
- Outcomes: 30 day composite recurrence of VTE, major bleeding, all-cause death, and rate of discharge home with 24 hours of randomization
- January 2017 through July 2019
- 1975 patients were included

Conclusions:

Hestia Rule vs sPESI had similar safety and effectiveness with triaging PE patients for discharge

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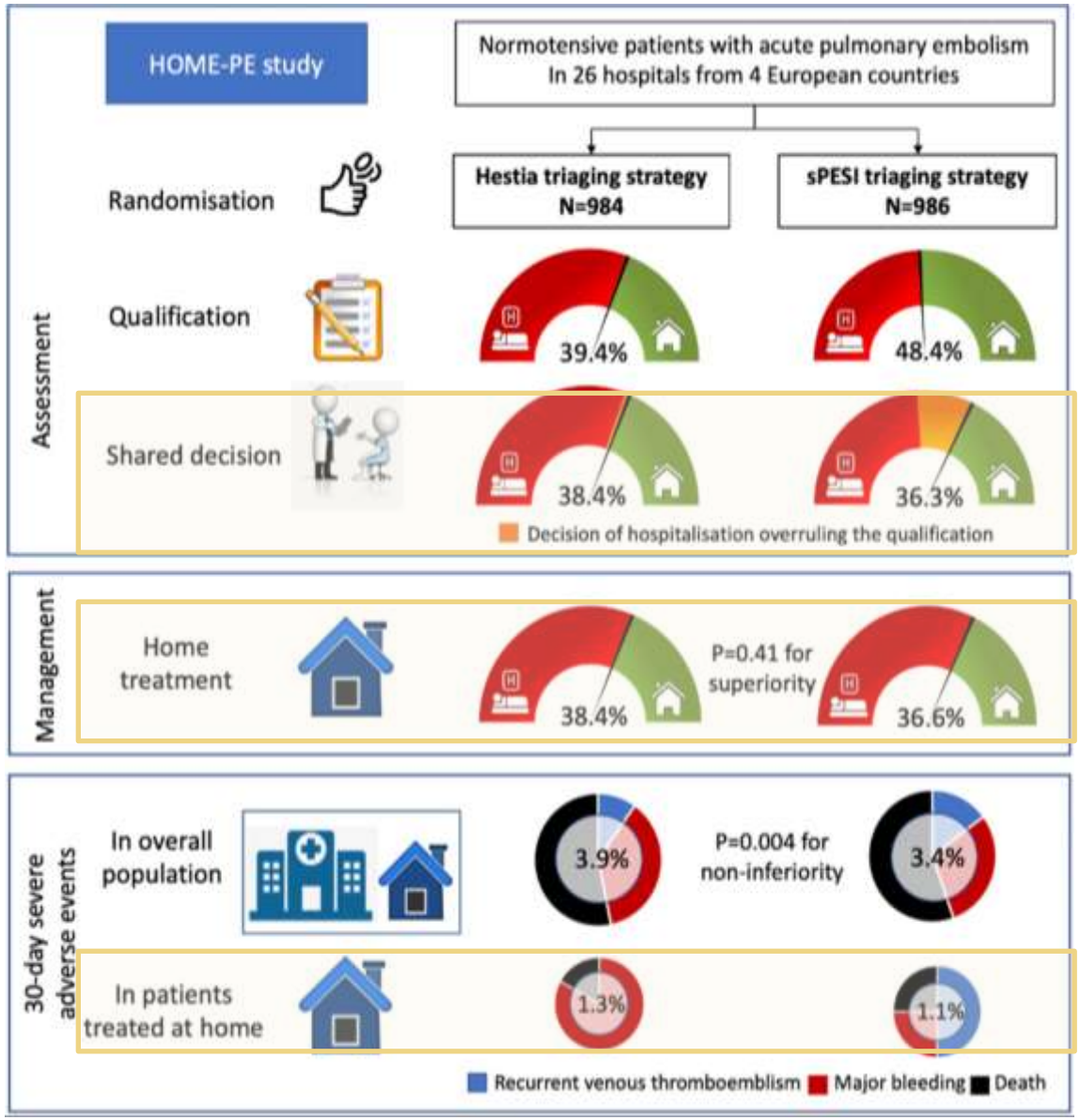
>⅓ of patients enrolled were discharged home with low incidence of complications

Triaging acute pulmonary embolism for home treatment by Hestia or simplified PESI criteria: the HOME-PE randomized trial, *European Heart Journal*, Volume 42, Issue 33, 1 September 2021, Pages 3146–3157, https://doi.org/10.1093/eurheartj/ehab373

Home-PE Trial: Hestia vs sPESI

What is the best strategy for triaging patients with acute pulmonary embolism for home treatment?



Eur Heart J, Volume 42, Issue 33, 1 September 2021, Pages 3146–3157,
https://doi.org/10.1093/eurheartj/ehab373

Home Treatment

Important considerations for discharge

Social

Financial, poor support system, homelessness, history of alcohol or drug dependence, neglect. Lack of access for follow up.

Psychological

Untreated mental health, concerns for noncompliance.

Special Circumstances

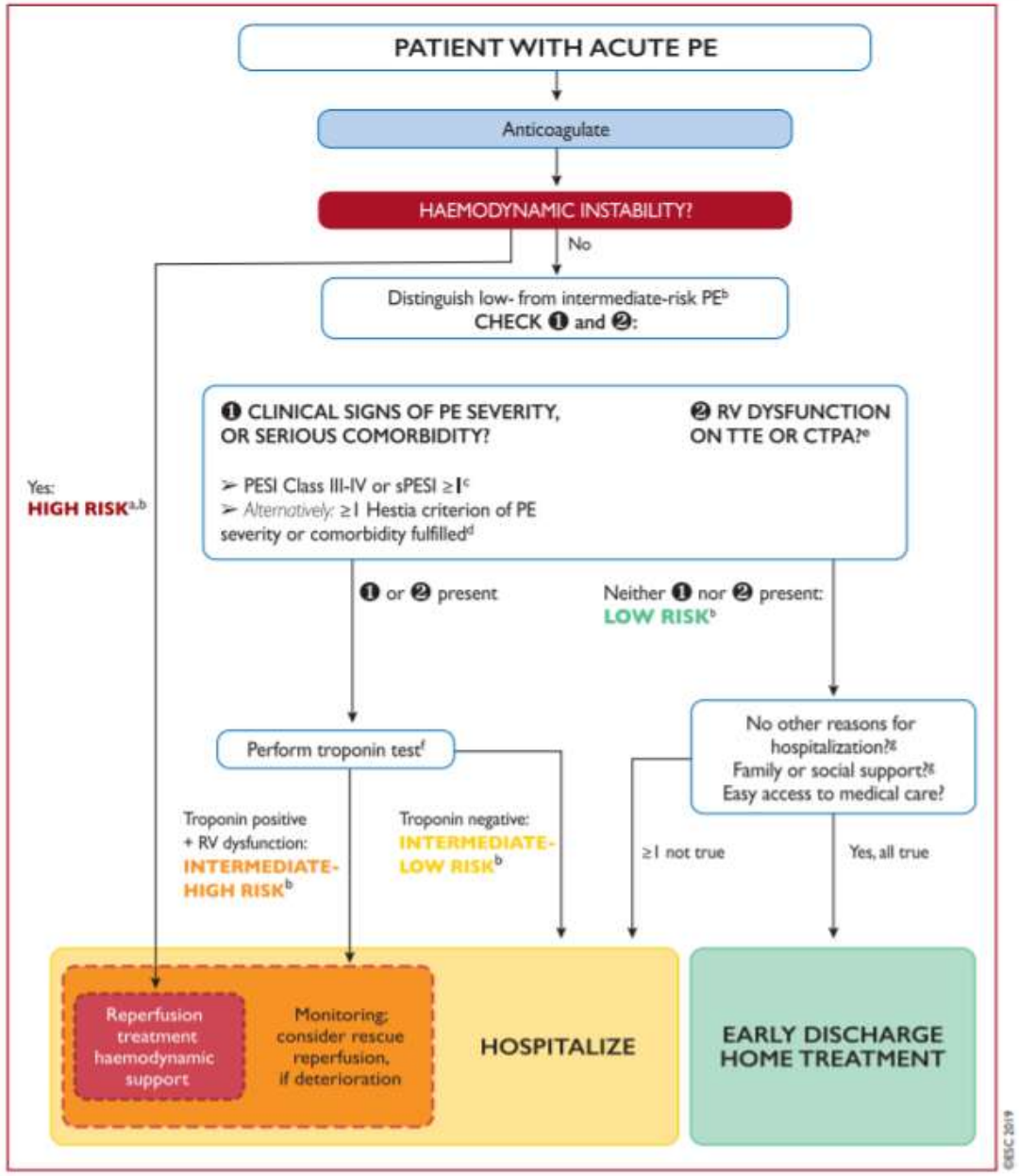
Active Malignancy or diagnosis of new medical conditions necessitating hospitalization.

Availability of a Pulmonary Embolism follow-up clinic.

Hestia Criteria
1. Hemodynamically unstable?
2. Thrombolysis or embolectomy necessary?
3. Active bleeding or high risk of bleeding?
4. Oxygen supply to maintain oxygen saturation > 90% > 24 h?
5. Pulmonary emoblism diagnosed during anti-coagulant treatment?
6. Intravenous pain medication > 24 h?
7. Medical or social reason for treatment in the hospital > 24 h?
8. Creatinine clearance of less than 30 mL/min?
9. Severe liver impairment?
10. Pregnant?
11. Documented history of heparin-induced thrombocytopenia?
If one of the questions is answered with **YES**, the patient can NOT be treated at home.

Home Treatment

ESC Treatment Guidelines



Konstantinides SV, Meyer G, Becattini C, Bueno H, Geersing GJ, Harjola VP, Huisman MV, Humbert M, Jennings CS, Jiménez D, Kucher N, Lang IM, Lankeit M, Lorusso R, Mazzolai L, Meneveau N, Ní Áinle F, Prandoni P, Pruszczyk P, Righini M, Torbicki A, Van Belle E, Zamorano JL; ESC Scientific Document Group. 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS). Eur Heart J. 2020 Jan 21;41(4):543-603. doi: 10.1093/eurheartj/ehz405. PMID: 31504429.

Thank you!