ECMO and Reperfusion Strategies for High-Risk Pulmonary Embolism

순천향대학교 부속 서울병원
SOON CHUN HYANG UNIVERSITY HOSPITAL SEOUL

Soonchunhyang Univ. Hosp., Seoul, Korea
Pulmonary and Critical Care Medicine/ Thrombosis Clinic
Kim, Yang-Ki

2025.04.12.

High-risk PE ?

Reperfusion therapy in high-risk PE

Reperfusion therapy in high-risk PE

High-risk pulmonary embolism (PE) refers to a **large embolic burden causing right ventricular failure and haemodynamic instability.**

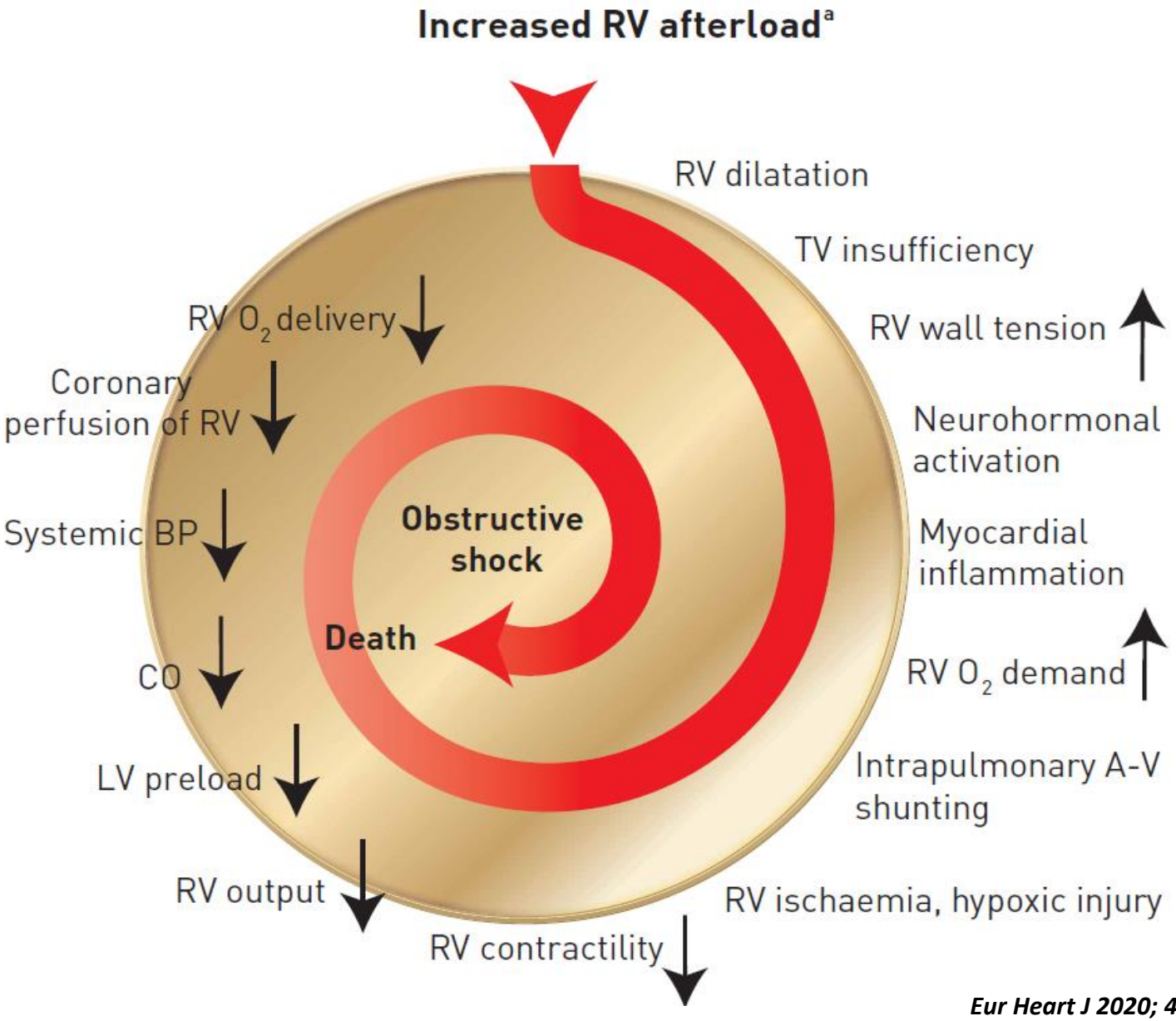
It accounts for **~5% of all PE**, but contributes significantly to the overall **mortality** associated with PE, **due to circulatory collapse**, with **in-hospital mortality rates** ranging **from 25%** in patients with cardiogenic shock **to 65%** in those requiring cardiopulmonary resuscitation.

Systemic thrombolysis is the **first-line revascularisation** therapy in high-risk PE.

Surgical embolectomy or **catheter-directed therapy** is recommended in patients with an **absolute contraindication to systemic thrombolysis.**

Eur Respir J 2022;60(5):2102977

Key factors contributing to haemodynamic collapse and death in acute PE



Eur Heart J 2020; 41(4):543-603

Classification of PE severity and the risk of early (in-hospital or 30 day) death

- **Risk assessment of acute PE** begins upon **suspicion** of the disease and **initiation** of the diagnostic workup.

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		–	–	–	Assessment optional; if assessed, negative

c. Elevation of further laboratory biomarkers, such as NT-proBNP ⩾600 ng/L, H-FABP ⩾6 ng/mL, or copeptin ⩾24 pmol/L, may provide additional prognostic information. These markers have been validated in cohort studies but they have not yet been used to guide treatment decisions in randomized controlled trials.

d. Haemodynamic instability, combined with PE confirmation on CTPA and/or evidence of RV dysfunction on TTE, is sufficient to classify a patient into the high-risk PE category. In these cases, neither calculation of the PESI nor measurement of troponins or other cardiac biomarkers is necessary.

e. Signs of RV dysfunction on TTE (or CTPA) or elevated cardiac biomarker levels may be present, despite a calculated PESI of I–II or an sPESI of 0 [234]. Until the implications of such discrepancies for the management of PE are fully understood, these patients should be classified into the intermediate-risk category.

Eur Heart J 2020; 41(4):543-603

Definition of haemodynamic instability, which delineates acute high-risk PE

(1) Cardiac arrest	Need for cardiopulmonary resuscitation
(2) Obstructive shock	**Systolic BP <90 mmHg** or **vasopressors required to achieve a BP ⩾90 mmHg despite adequate filling status** And **End-organ hypoperfusion** (**altered mental status; cold, clammy skin; oliguria/anuria; increased serum lactate**)
(3) Persistent hypotension	**Systolic BP <90 mmHg** or **systolic BP drop ⩾40 mmHg**, lasting longer than **15 min** and **not caused by new-onset arrhythmia, hypovolemia, or sepsis**

Eur Heart J 2020; 41(4):543-603

Treatment of right ventricular failure in acute high-risk PE

Strategy	Properties and use	Caveats
Volume optimization Cautious volume loading, saline, or Ringer's lactate, ⩽500 mL over 15–30 min	Consider in patients with normal–low central venous pressure (due, for example, to concomitant hypovolaemia)	Volume loading can over-distend the RV, worsen ventricular interdependence, and reduce CO
Vasopressors and inotropes Norepinephrine, 0.2–1.0 µg/kg/min Dobutamine, 2–20 µg/kg/min	Increases RV inotropy and systemic BP, promotes positive ventricular interactions, and restores coronary perfusion gradient Increases RV inotropy, lowers filling pressures	Excessive vasoconstriction may worsen tissue perfusion May aggravate arterial hypotension if used alone, without a vasopressor; may trigger or aggravate arrhythmias
Mechanical circulatory support Veno–arterial ECMO/extracorporeal life support	Rapid short-term support combined with oxygenator	Complications with use over longer periods (>5–10 days), including bleeding and infections; no clinical benefit unless combined with surgical embolectomy

Eur Heart J 2020; 41(4):543-603

Predisposing factors for VTE

Strong risk factors (OR >10)
Fracture of lower limb
Hospitalization for heart failure or atrial fibrillation/flutter (within previous 3 months)
Hip or knee replacement
Major trauma
Myocardial infarction (within previous 3 months)
Previous VTE
Spinal cord injury

Eur Heart J 2020; 41(4):543-603

Original and simplified Pulmonary Embolism Severity Index (PESI)

Parameter	Original version [226]	Simplified version [229]
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 BP <100 mmHg	+30 points	1 point
Respiratory rate >30 breaths per min	+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%)	**0 points** 30 day mortality risk 1.0% (95% CI 0.0–2.1%)
	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%)	**⩾1 point(s)** 30 day mortality risk 10.9% (95% CI 8.5–13.2%)

Eur Heart J 2020; 41(4):543-603

High-risk PE in Echocardiogram and CTPA

An **RV/LV diameter ratio ⩾1.0** and a **TAPSE <16 mm** are the findings for which an association with **unfavourable prognosis** has most frequently been reported.

Echocardiographic assessment of the **morphology** and **function** of the **RV** is widely recognized as a valuable tool for the prognostic assessment of normotensive patients with acute PE in clinical practice.

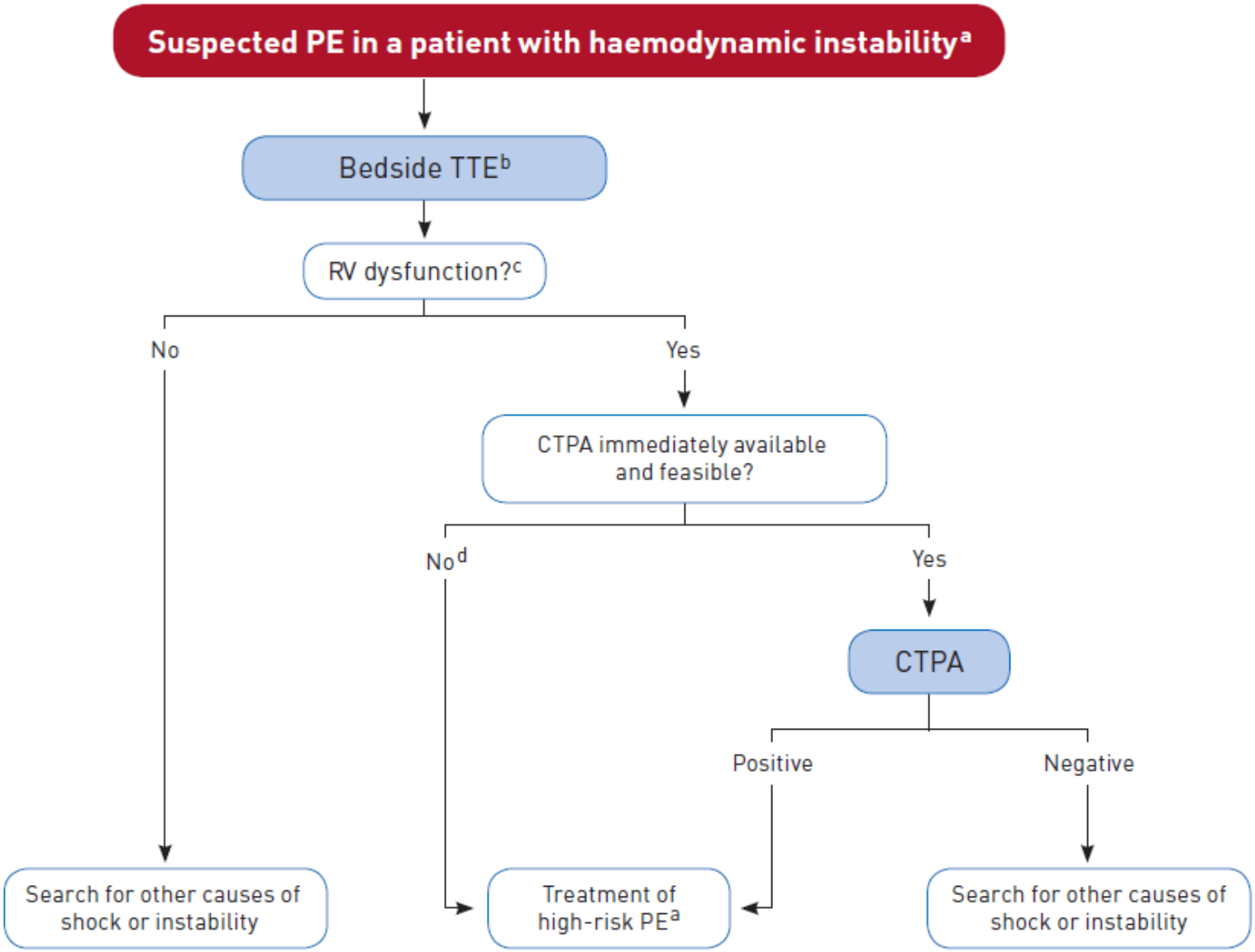
Four-chamber views of the heart by CT angiography can detect **RV enlargement** (RV end-diastolic diameter and RV/LV ratio measured in the transverse or four-chamber view) **as an indicator of RV dysfunction**.

An increased **RV/LV ratio of ⩾1.0 on CT** was associated with a **2.5-fold** increased risk for **all-cause mortality** [odds ratio ratio (OR) 2.5, 95% CI 1.8–3.5], and with a **five-fold risk for PE-related mortality** (OR 5.0, 95% CI 2.7–9.2).

TAPSE : tricuspid annular plane systolic excursion

Eur Heart J 2020; 41(4):543-603

Diagnostic algorithm for patients with suspected high-risk PE presenting with haemodynamic instability



Eur Heart J 2020; 41(4):543-603

High-risk PE에서 ECMO 의 역할

Extracorporeal membrane oxygenation (ECMO)

Extracorporeal membrane oxygenation (ECMO) provides **respiratory and haemodynamic support as a bridge to recovery** for the most critically ill PE patients with **refractory cardiogenic shock** or **cardiac arrest**.

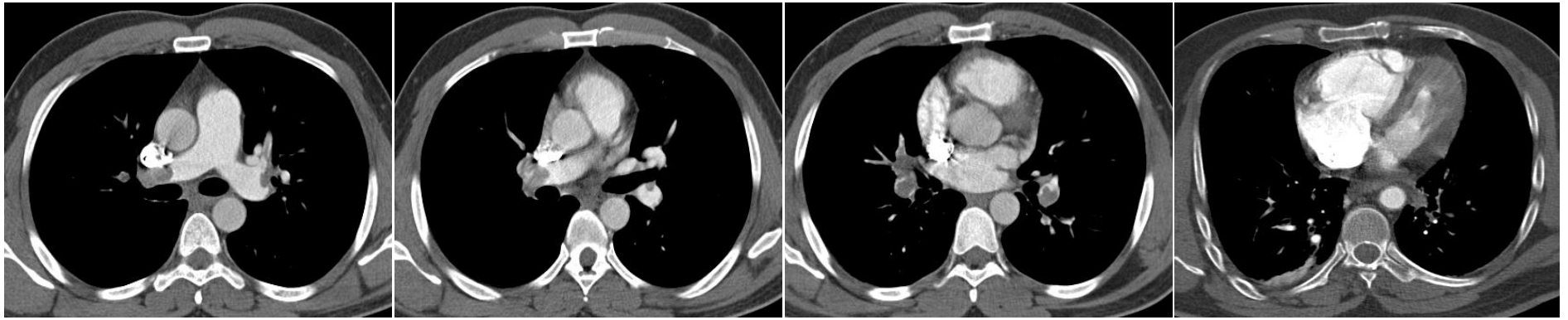
The optimal pulmonary reperfusion strategy from among mechanical reperfusion, systemic thrombolysis or catheter-directed thrombolysis (CDT), or **ECMO plus heparin as a stand-alone therapy** remains vigorously **debated**.

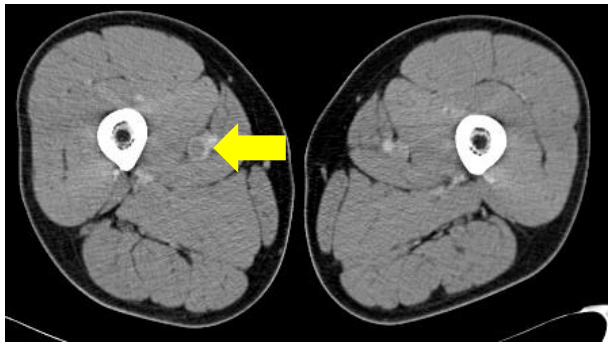
Eur Respir J 2022;60(5):2102977

Clinical Practice

Case 1. 45/M syncope, dyspnea onset : 12분전

2016-01-06





응급실 내원 후 11분에 병력 청취 중 호흡곤란, 실신 발생, 청색증

BP 62/50 mmHg, PR 100/min, RR 30/min, BT 36.4, O2 sat 88% (mask)

CK-MB 3.30 ng/mL, Troponin-T 0.044 ng/mL, D-dimer 24,092 ng/mL,

응급실 심초음파에서 D shaped LV, LV function reserve

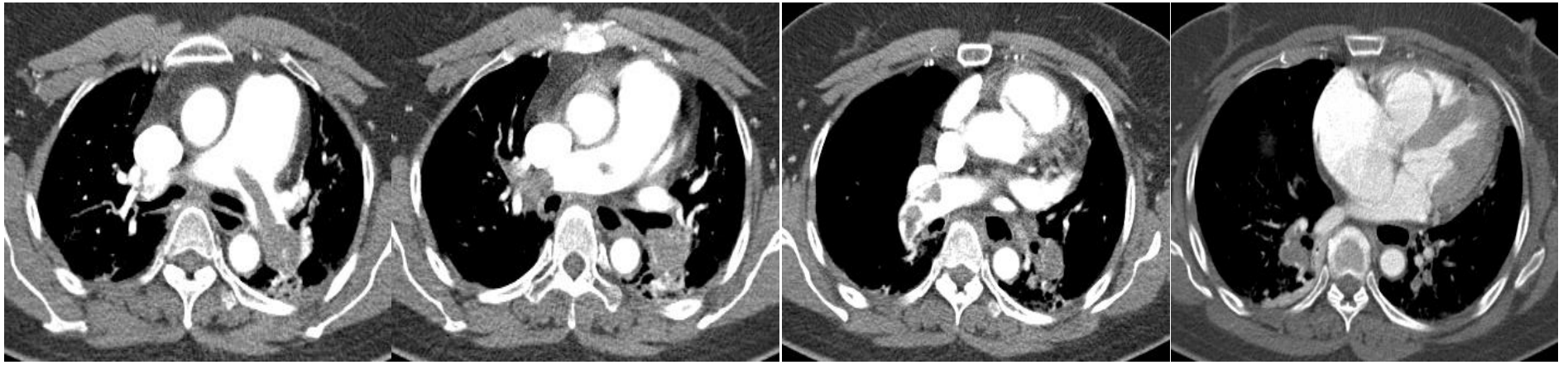
병력에서 2013년 DVT 진단 받고 치료 중 자의 중단

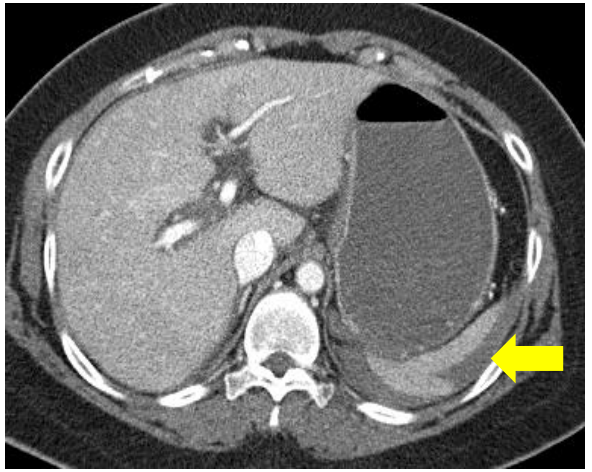
실신, 청색증 있어 기관삽관 중 cardiac arrest 로 CPR 시행 후 ROSC 되었고 ECMO 시행함.

ECMO (5일) + Heparin (5일) -> LMWH alone (2일) -> Rivaroxaban 20mg qd continue

Case 2. 49/F Confused mentality, Dyspnea onset : 1-2시간 전

2019-12-17





실신으로 화장실에 넘어지면서 이마 부종, 복부 통증 호소

119 신고로 이동시 호흡곤란 및 청색증 확인

BP 83/60 mmHg, PR 68/min, RR 24/min, BT 36.0

CK-MB 2.29 ng/mL, Troponin-T 0.003 ng/mL, NT-pro-BNP 2,797 pg/mL

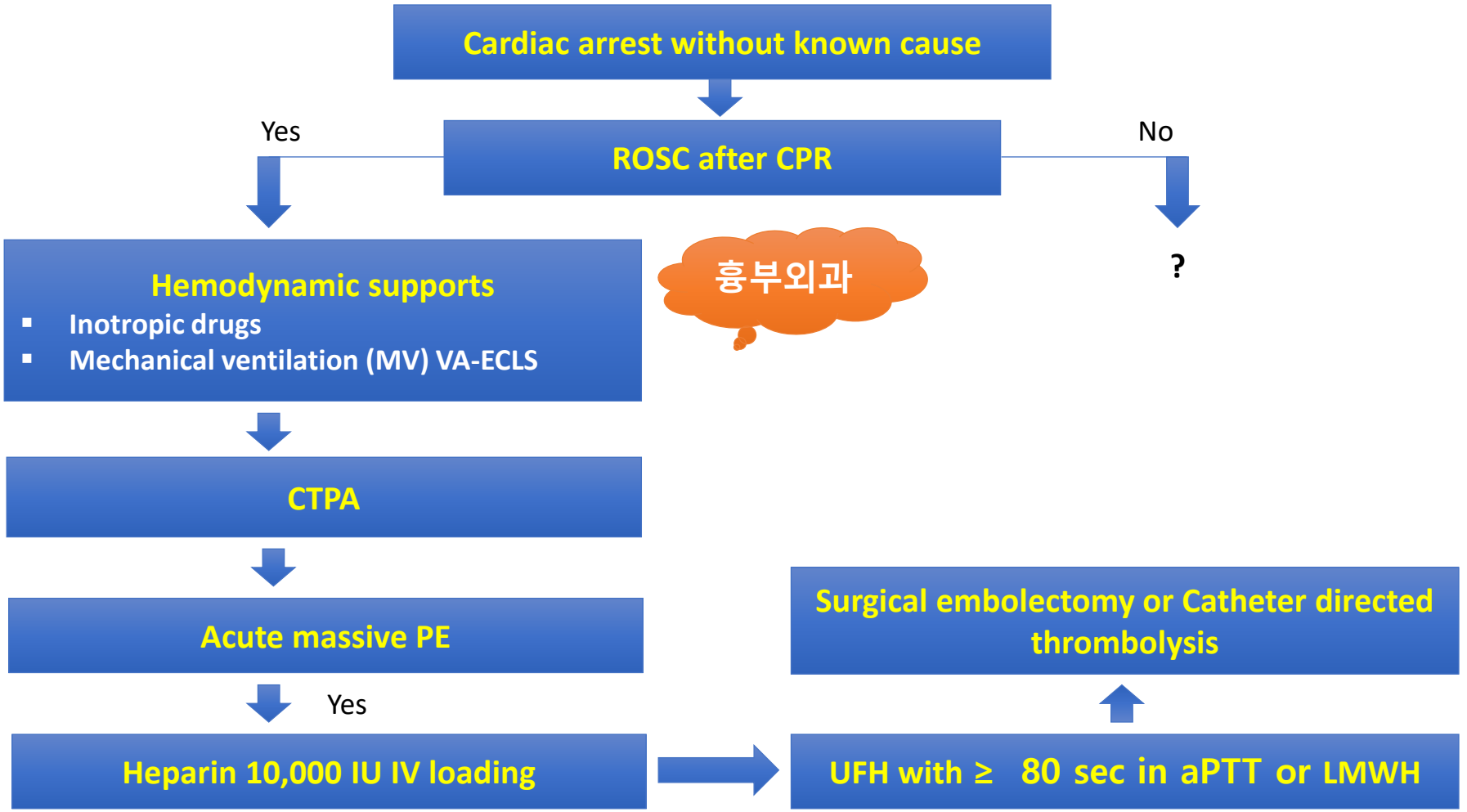
D-dimer 11,162 ng/mL, 응급실 심초음파에서 D shaped LV

청색증 및 저혈압 지속되어 기관삽관 중 cardiac arrest 로 CPR 시행 후 ROSC 되었고 ECMO 시행함.

내원당시 APCT에서 liver, spleen laceration 으로 hemoperitoneum 확인됨

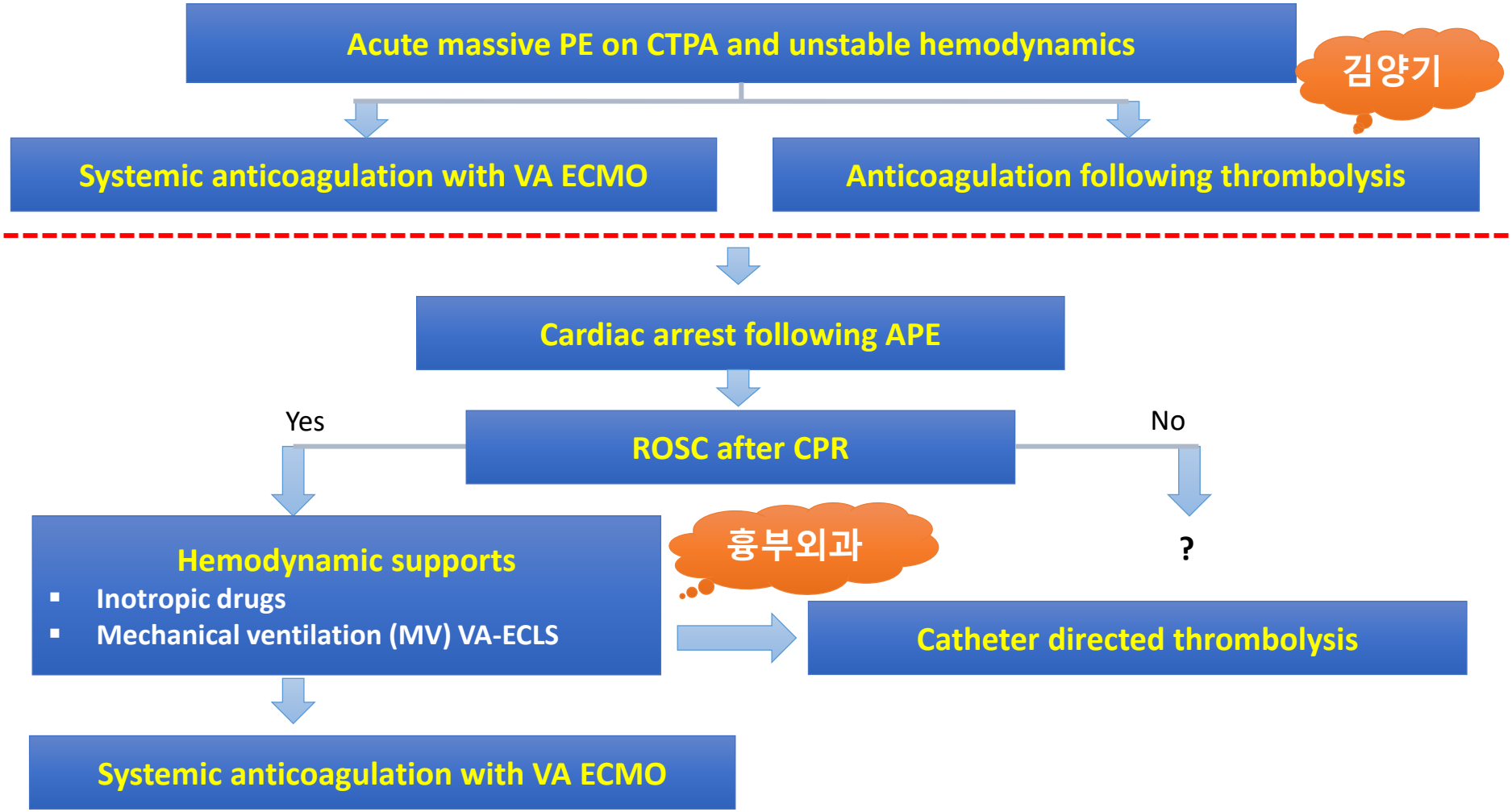
ECMO + Heparin -> HAD #41

SCH Therapeutic protocol for patients with cardiac arrest owing to acute massive PE



ROSC : return of systemic circulation, VA ECLS: venoarterial extracorporeal life support.

SCH Therapeutic protocol for patients with cardiac arrest owing to acute massive PE



ROSC : recovery of systemic circulation, VA ECLS: venoarterial extracorporeal life support.

Survivors and Non-survivors in massive PE receiving VA-ECMO

Retrospective analysis in one institution's ECMO database

high-risk PE (January 2012 and December 2015)

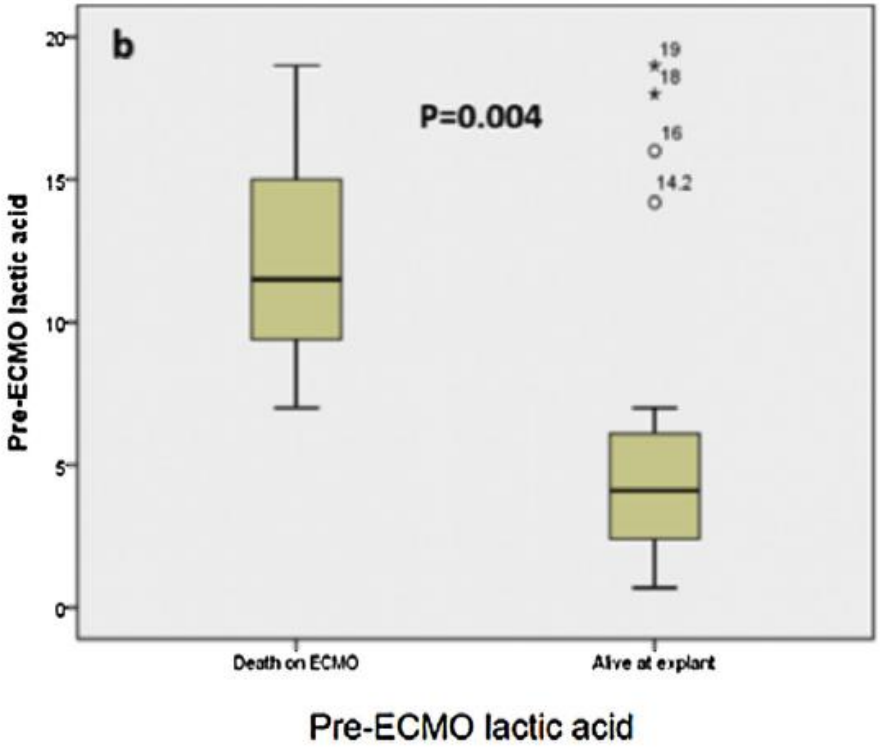
	Survived Index Hospitalization (n=17)	Died During Index Hospitalization (n=15)	p-value
Cardiac arrest before ECMO (%)	4 (25)	11 (73.3)	**0.012**
RV:LV on CT – median; (IQR)	1.1 (1, 1.6)	0.9 (0.7, 1.3)	0.143
RV:LV on echo – median; (IQR)	1 (0.9, 1.3)	0.9 (0.8, 1.2)	0.193
Peak troponin-T, ng/mL – median; (IQR)	0.26 (0.13, 0.98)	0.37 (0.17, 1.45)	0.589
Initial hemoglobin, g/dL – median; (IQR)	12.7 (10.4, 14)	11.6 (9.3, 12.7)	0.206
Initial platelet, k/uL – median; (IQR)	217 (155, 274)	174 (90, 214)	0.059
Initial creatinine, mg/dL – median; (IQR)	1.2 (1, 1.3)	1.45 (1.1, 1.69)	0.117
Lactate before ECMO, mmol/L – median (IQR)	4.1 (2, 5.5)	11.5 (7.4, 16)	**0.004**
Received systemic thrombolysis (%)	0 (0)	5 (33.3)	**0.015**
Catheter-directed thrombolysis performed (%)	11 (64.7)	4 (26.7)	**0.042**

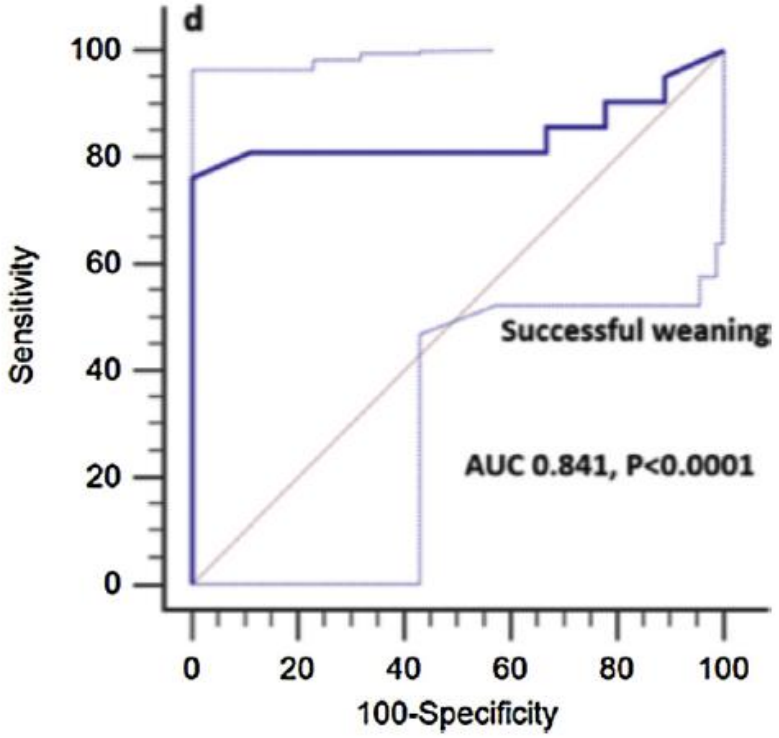
Resuscitation 2018;122:1-5

pre-ECMO lactic acid predicts weaning from ECMO

N=32 (**survived** index hospitalization **n=17**, **Died** during index hospitalization **n=15**)

Lactate level of ≤6 mmol/L



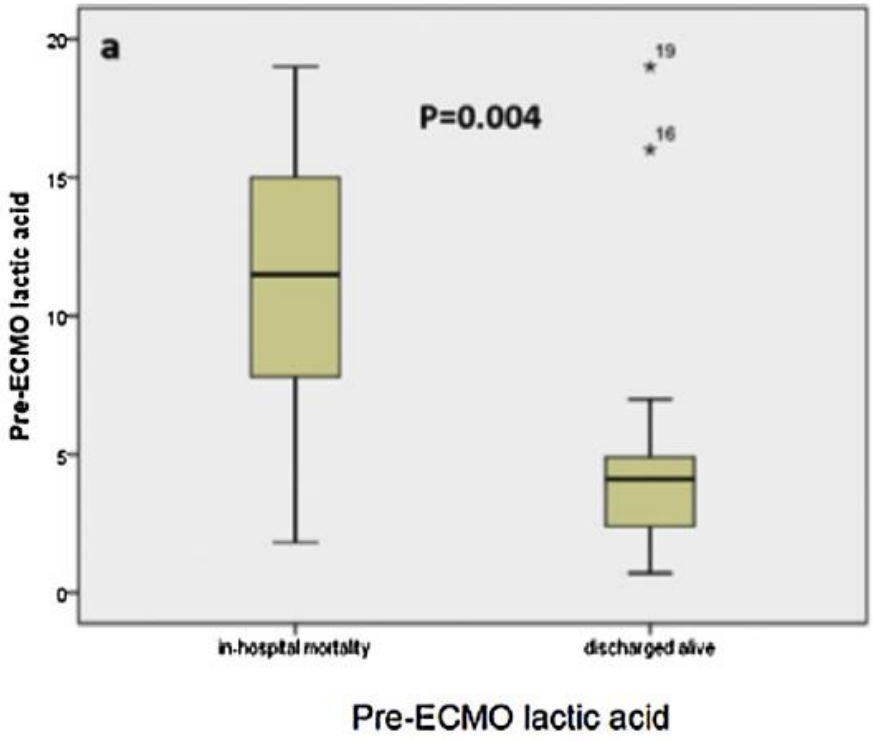


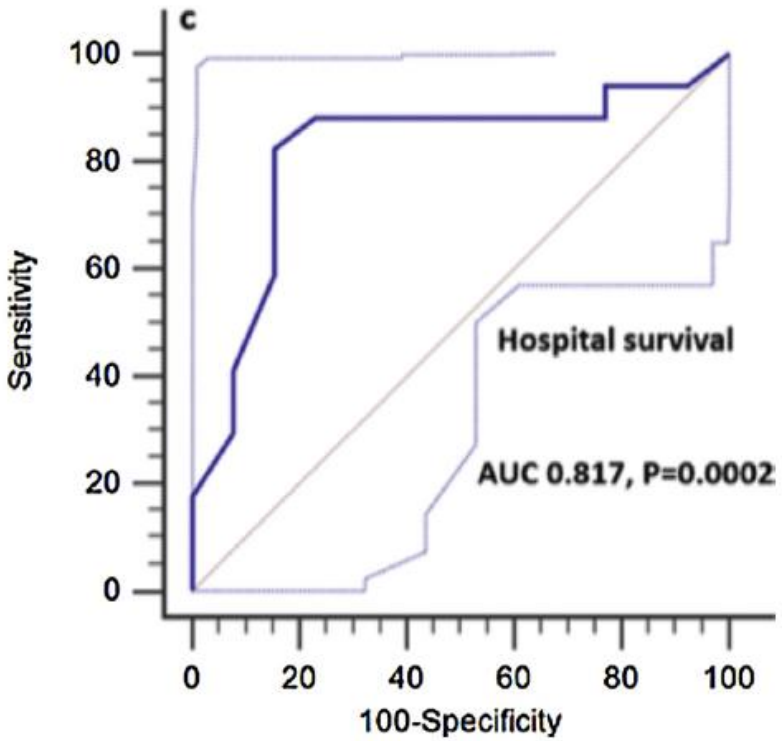
Resuscitation 2018;122:1-5

pre-ECMO lactic acid predicts survival to discharge

N=32 (**survived** index hospitalization **n=17**, **Died** during index hospitalization **n=15**)

Lactate level of ≤6 mmol/L





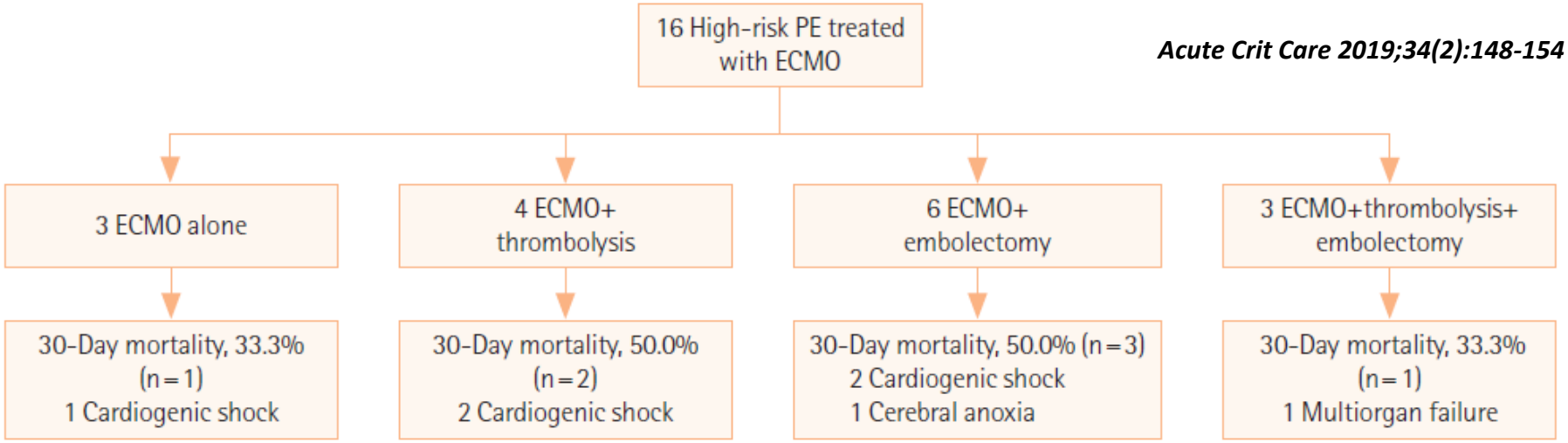
Resuscitation 2018;122:1-5

Definitive treatment for PE and survival

Definitive Treatment	Number(%)	Survival(%)
ECMO + Surgical embolectomy	13 (19.6)	9 (**69.2**)
ECMO + Catheter embolectomy	5 (7.5)	2 (40)
ECMO + Thrombolysis	16 (24.2)	7 (**43.8**)
ECMO + Surgical embolectomy + Thrombolysis	2 (3)	2 (100)
ECMO + Surgical embolectomy + Catheter embolectomy	1 (1.5)	1 (0)
ECMO + Surgical embolectomy + Catheter embolectomy + Thrombolysis	1 (1.5)	1 (100)
ECMO + Catheter embolectomy + Thrombolysis	12 (18)	8 (**66.7**)
ECMO alone	16 (24.2)	16 (**100**)
Total	66 (100)	45 (**65.15**)

Perfusion 2015;30(8):611–616

ECMO in high-risk PE in Korea



Acute Crit Care 2019;34(2):148-154

Patient No.	Age (yr)	Sex	Location of cardiac arrest	The time interval between recognition and diagnosis of PE* (min)	The time interval between hospital arrival and cardiac arrest (min)	The time taken from the first cardiac arrest to the initiation of ECMO (min)	The time taken from the first cardiac arrest to the initiation of anticoagulation (min)	Duration of CPR (min)	Outcome	Reperfusion therapy
1	76	M	Out-of-hospital	90	-	85	88	85	Died	No
2	60	F	In-hospital	321	249	52	62	18	Died	No
3	46	M	In-hospital	118	11	32	55	13	Survived	No
4	65	F	Out-of-hospital	104	-	65	57	35	Died	Systemic thrombolysis
5	22	M	Out-of-hospital	133	-	82	237	22	Died	No
6	68	M	In-hospital	85	15	30	117	3	Survived	No
7	59	M	In-hospital	180	6,547	49	229	31	Died	No
8	63	F	In-hospital	94	1	33	33	15	Died	Catheter thrombectomy
9	25	M	In-hospital	55	191	482	−33	87	Died	Systemic thrombolysis+ surgical embolectomy

Tuberc Respir Dis (Seoul) 2022;85(3):249-255

Optimal reperfusion strategy in acute high-risk PE requiring ECMO support

Systematic review and meta-analysis of evidence comparing **mechanical embolectomy** and **other strategies**, including **systemic thrombolysis, catheter-directed thrombolysis or ECMO as stand-alone therapy**, with regard to **mortality** and **bleeding outcomes**.

TABLE 2 Reperfusion strategies used across eligible studies (n=17)

First author [ref.]	Mechanical reperfusion strategy				Other reperfusion strategies				
	Total (n=106) **N=106**	Surgical embolectomy alone (n=64)	With prior thrombolysis[#] (n=27)	Catheter-based embolectomy alone (n=15)	Total (n=221) **N=221**	Systemic thrombolysis alone (n=92)	Systemic thrombolysis with CDT[¶] (n=9)	CDT alone (n=20)	Stand-alone ECMO (n=100)
Al-Bawardy [17]	4 (3.8)	2 (3.1)	2 (7.4)	0 (0)	9 (3.9)	5 (5.4)	1 (11.1)	2 (10.0)	1 (1.0)
Corsi [18]	4 (3.8)	2 (3.1)	0 (0)	2 (13.3)	13 (5.7)	8 (8.7)	0 (0)	0 (0)	5 (4.9)
Dolmatova [19]	1 (0.9)	1 (1.6)	0 (0)	0 (0)	4 (1.7)	1 (1.1)	2 (22.2)	0 (0)	1 (0.9)
George [20]	6 (5.7)	2 (3.1)	0 (0)	4 (26.6)	26 (11.3)	5 (5.4)	0 (0)	15 (75.0)	6 (5.9)
Ghoreishi [21]	11 (10.4)	10 (15.6)	1 (3.7)	0 (0)	30 (13.1)	9 (9.8)	0 (0)	0 (0)	21 (20.8)
Ius [22]	20 (18.9)	10 (15.6)	10 (37.0)	0 (0)	16 (7.0)	9 (9.8)	0 (0)	0 (0)	7 (6.9)
Kjaergaard [29]	4 (3.8)	4 (6.2)	0 (0)	0 (0)	32 (14.0)	21 (22.8)	1 (11.1)	0 (0)	10 (9.9)
Luna-Lopez [15]	5 (4.7)	0 (0.0)	4 (14.8)	1 (6.7)	6 (2.6)	3 (3.3)	0 (0)	0 (0)	3 (3.0)
Maj [16]	1 (0.9)	1 (1.6)	0 (0)	0 (0)	5 (2.2)	2 (2.2)	0 (0)	2 (10)	1 (0.9)
Malekan [12]	1 (0.9)	1 (1.6)	0 (0)	0 (0)	3 (1.3)	0 (0)	0 (0)	0 (0)	3 (3.0)
Meneveau [23]	17 (16.0)	14 (21.9)	3 (11.1)	0 (0)	35 (15.3)	17 (18.5)	0 (0)	0 (0)	18 (17.8)
Miyazaki [24]	1 (0.9)	0 (0)	0 (0)	1 (6.7)	8 (3.5)	4 (4.3)	4 (44.4)	0 (0)	0 (0.0)
Moon [13]	1 (0.9)	1 (1.6)	0 (0)	0 (0)	13 (5.7)	1 (1.1)	0 (0)	0 (0)	12 (11.9)
Munakata [28]	8 (7.5)	0 (0)	0 (0)	8 (53.3)	2 (0.9)	1 (1.1)	1 (11.1)	0 (0)	0 (0)
Oh [25]	9 (8.5)	6 (9.4)	3 (11.1)	0 (0)	7 (3.0)	4 (4.3)	0 (0)	0 (0)	3 (3.0)
Pasrija [26]	11 (10.3)	9 (14.1)	3 (11.1)	0 (0)	9 (3.9)	0 (0)	0 (0)	1 (5.0)	8 (7.9)
Swol [27]	2 (1.8)	1 (1.6)	1 (3.7)	0 (0)	3 (1.3)	2 (2.2)	0 (0)	0 (0)	1 (1.0)

Data are presented as n (%). CDT: catheter-directed thrombolysis; ECMO: extracorporeal membrane oxygenation. [#]: either systemic thrombolysis or CDT with local delivery thrombolysis; [¶]: either before or after systemic thrombolysis.

Eur Respir J 2022;60(5):2102977

Optimal reperfusion strategy in acute high-risk PE requiring ECMO support

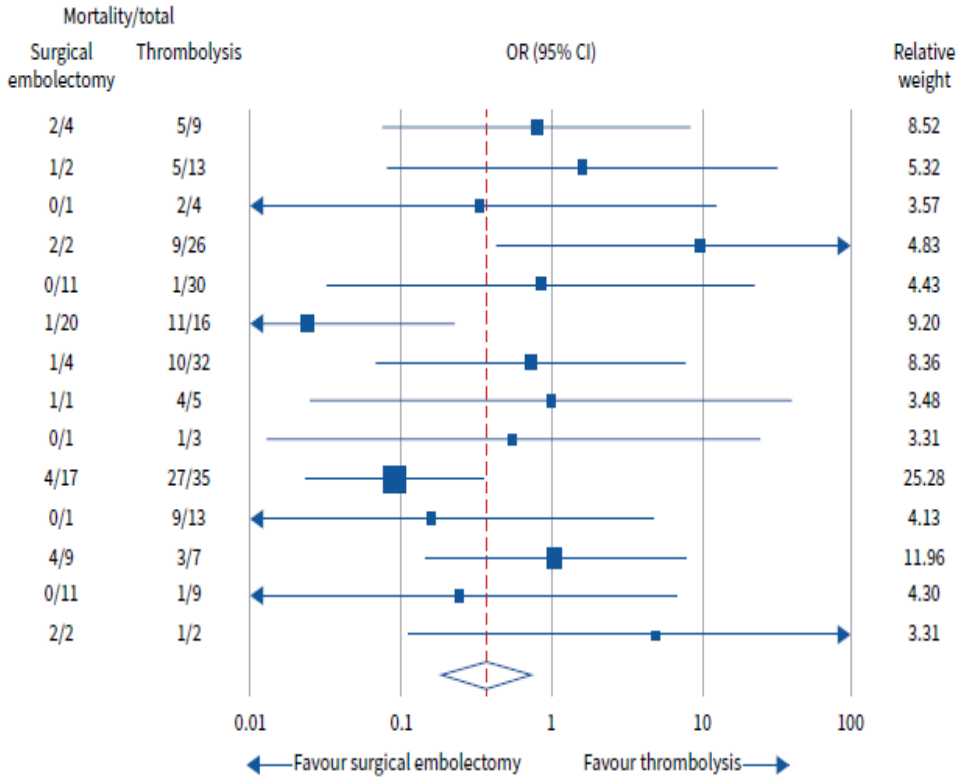
	Mechanical pulmonary reperfusion*	Other strategies
Proportion, %	32.4	67.6
Mortality rate, %	22.6	42.8
Rate of bleeding under ECMO, %	22.2	19.1

* 85.9% had surgical embolectomy

The pooled odds ratio for mortality

: mechanical reperfusion vs other reperfusion strategies 0.439 (95% CI 0.237–0.816) (p=0.009; I2=35.2%)

: surgical embolectomy vs thrombolysis 0.368 (95% CI 0.185–0.733) (p=0.004; I2=32.9%) for.

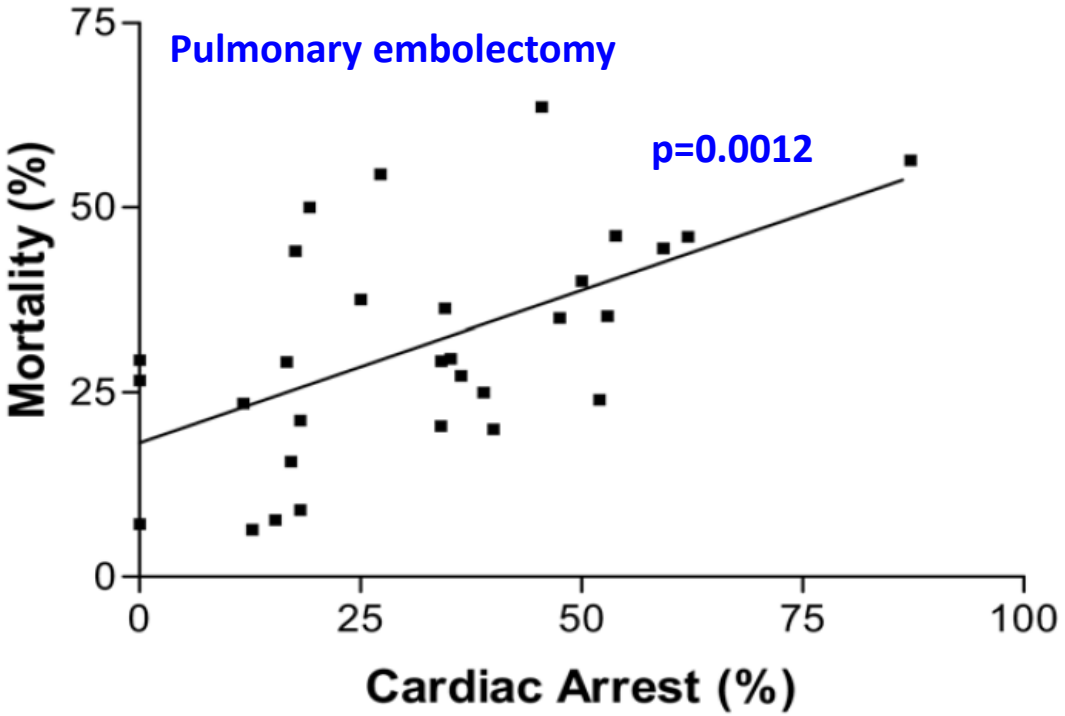


Eur Respir J 2022;60(5):2102977

Pulmonary embolectomy in preoperative cardiac arrest

46 reported case series

Mortality	1961~1984	1985~2005
Average	32% (338/1,047)	20% (51/253)
Preoperative cardiac arrest	33% (286/857)	27% (44/165)
Preoperative hemodynamic instability	74% (619/832)	74% (153/207)



Operative mortality

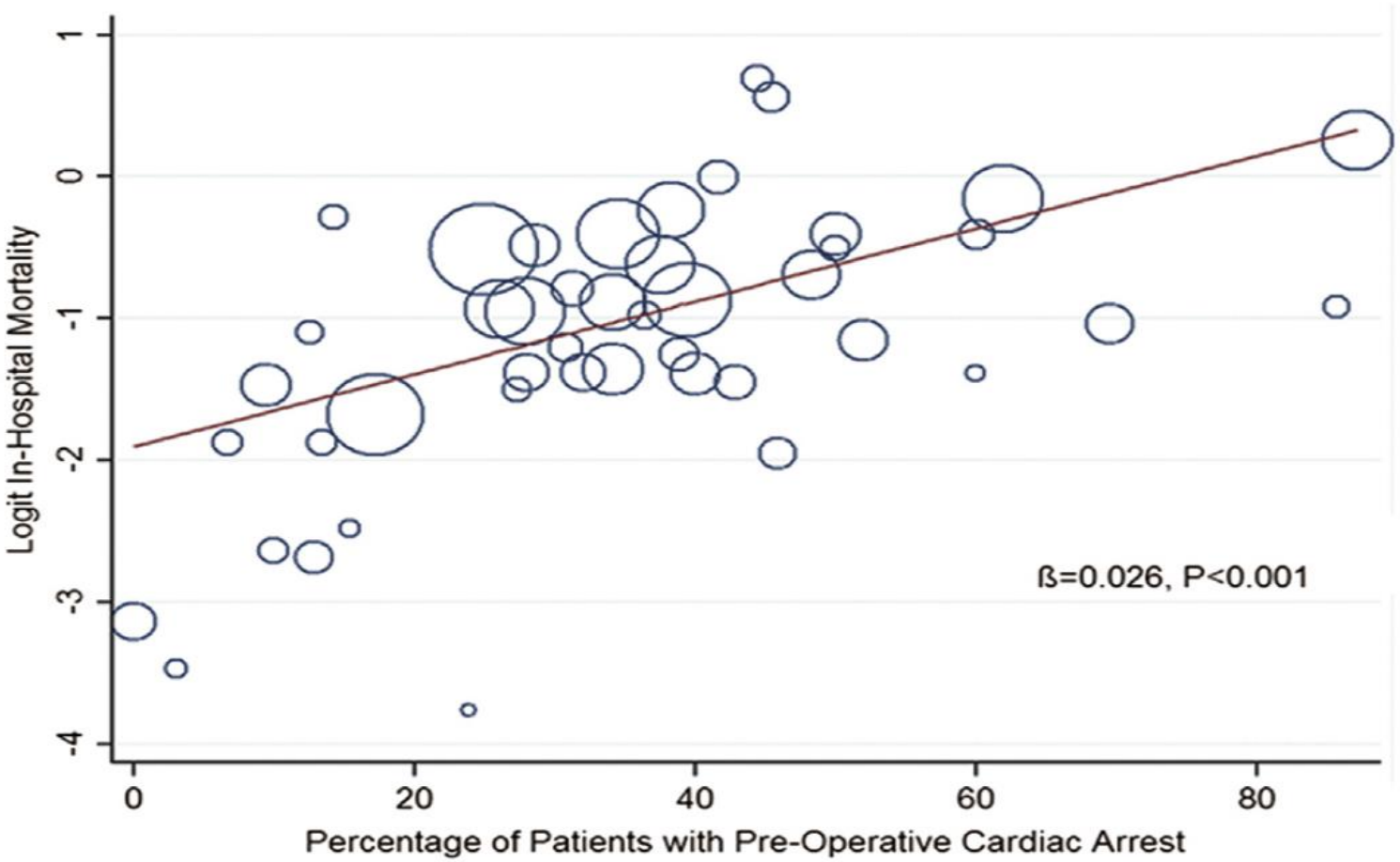
- **Cardiac arrest (O)** before pulmonary embolectomy
  - ▶ **59%** (188/317)
- **Cardiac arrest (X)** before pulmonary embolectomy
  - ▶ **20%** (201/983)

Am J Cardiol 2007;99(3):421-3

Pulmonary embolectomy in preoperative cardiac arrest

56 studies, n=1,579, No of SPE = 1,590 [Meta-regression]

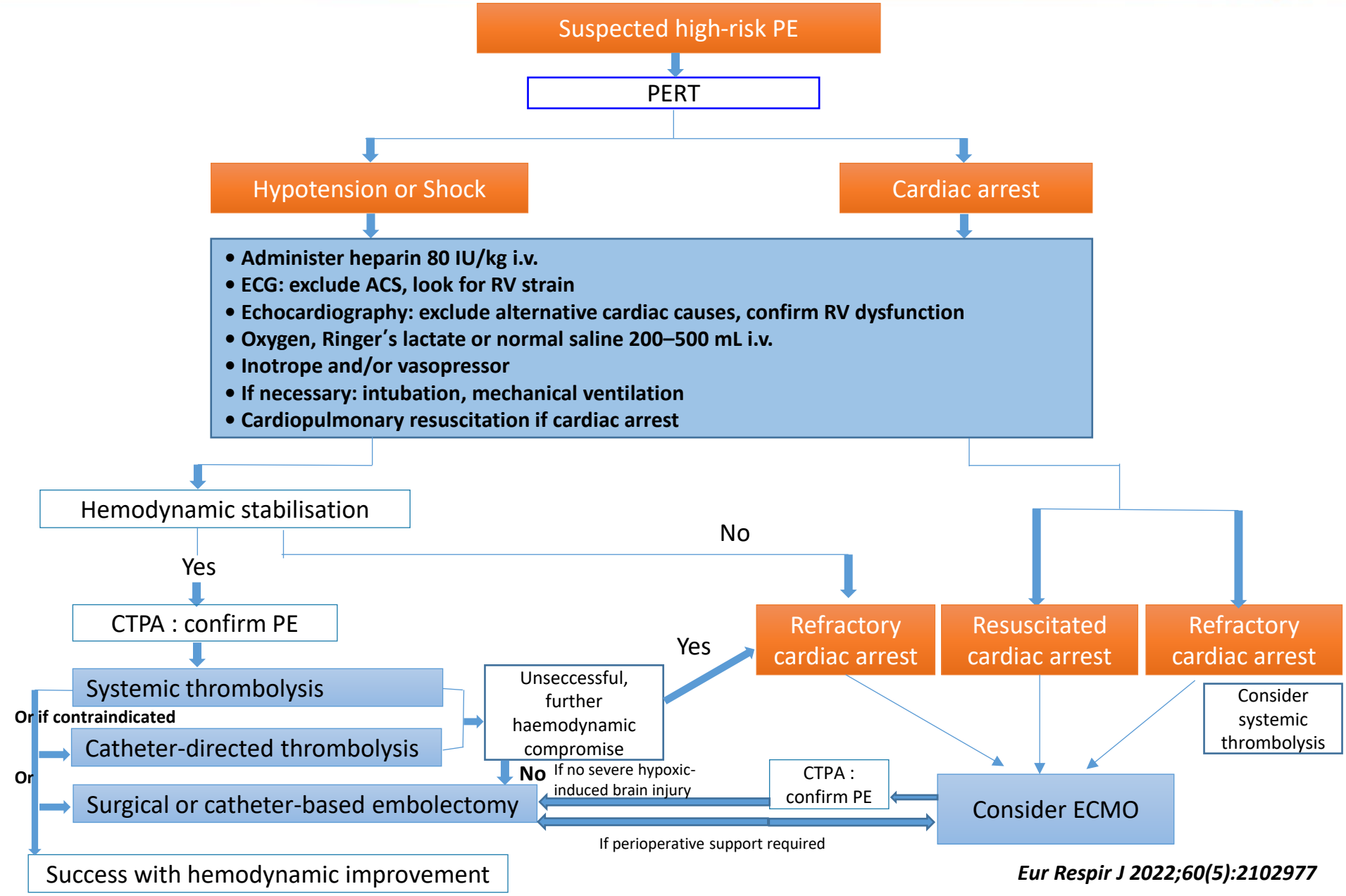
The pooled inhospital all-cause mortality rate was **26.3%** (95% CI : 22.5% to 30.5%).



SPE : surgical pulmonary embolectomy

Ann Thorac Surg 2017;103:982–90

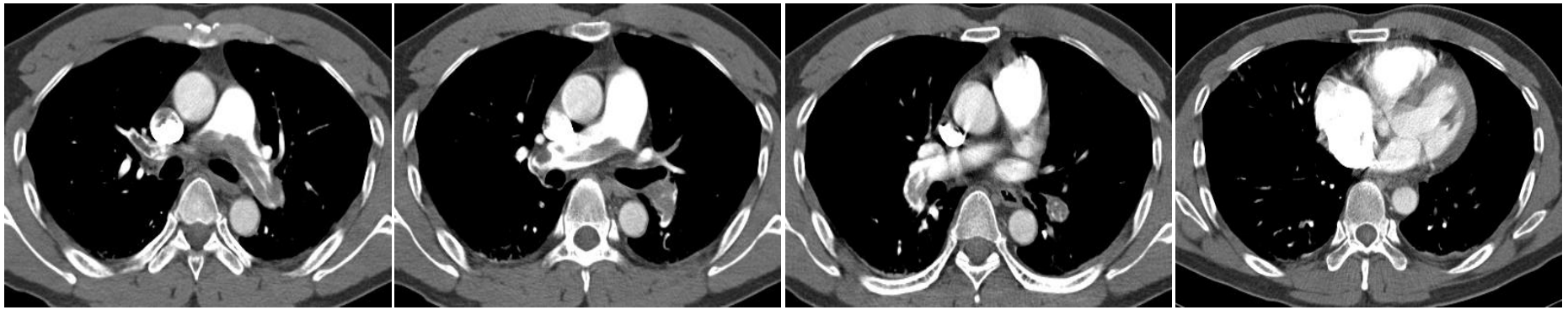
Optimal reperfusion strategy in acute high-risk PE requiring ECMO support

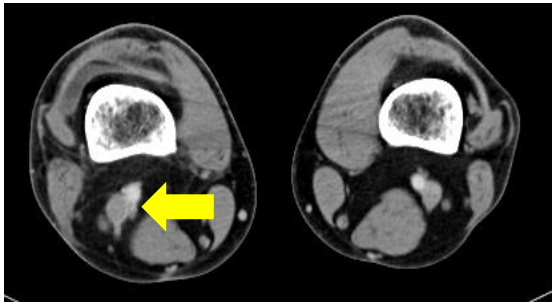


Eur Respir J 2022;60(5):2102977

Case 3. 43/M Dyspnea, chest tightness onset : 내원 당일

2022-10-26





화장실까지 걸어가고 나서 20초 동안 헐떡거릴 정도로 숨이 차서 응급실 내원함.

BP 134/85 mmHg, PR 98/min, RR 20/min, BT 36.7, O2 sat 91% (대기)

CK-MB 3.30 ng/mL, Troponin-T 0.034 ng/mL, NT-pro-BNP 2,634 pg/mL

D-dimer 24,814 ng/mL, 심초음파에서 RVE & RV dysfunction

내원 10일 전 우측 무릎 전방십자인대 파열 발생하여 석고붕대 적용 후 거의 누워 지냄.

Enoxaparin 1mg/kg SC Q12hrs start

Case 3. 43/M Dyspnea, chest tightness onset : 내원 당일

[HAD #2]

화장실에서 볼일 보던 중 의식을 잃음.

(**Syncope 2차례** 발생, 저혈압 없고 산소포화도 저하 없음)

[HAD #3]

F/U Echocardiography #1

- **D-shaped LV. Increased RA & RV size**.
- **Aggravated RV dysfunction** (TAPSE = 1.1 cm, TV lateral S = 11.2 cm/s).
- Mild TR with moderate pulmonary HTN (PG 61mmHg).

⇒ **tPA 100mg IV**

[HAD #5]

F/U Echocardiography #2

- Normalized D-shaped LV, Pulmonary HTN.
- Improved RV dysfunction and RV enlargement.

⇒ Discharge with PO medication (Rivaroxaban 15mg BID).

Classification of PE severity and the risk of early (in-hospital or 30 day) death

- **Risk assessment of acute PE** begins upon **suspicion** of the disease and **initiation** of the diagnostic workup.

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		–	–	–	Assessment optional; if assessed, negative

c. Elevation of further laboratory biomarkers, such as NT-proBNP ⩾600 ng/L, H-FABP ⩾6 ng/mL, or copeptin ⩾24 pmol/L, may provide additional prognostic information. These markers have been validated in cohort studies but they have not yet been used to guide treatment decisions in randomized controlled trials.

d. Haemodynamic instability, combined with PE confirmation on CTPA and/or evidence of RV dysfunction on TTE, is sufficient to classify a patient into the high-risk PE category. In these cases, neither calculation of the PESI nor measurement of troponins or other cardiac biomarkers is necessary.

e. Signs of RV dysfunction on TTE (or CTPA) or elevated cardiac biomarker levels may be present, despite a calculated PESI of I–II or an sPESI of 0 [234]. Until the implications of such discrepancies for the management of PE are fully understood, these patients should be classified into the intermediate-risk category.

Eur Heart J 2020; 41(4):543-603

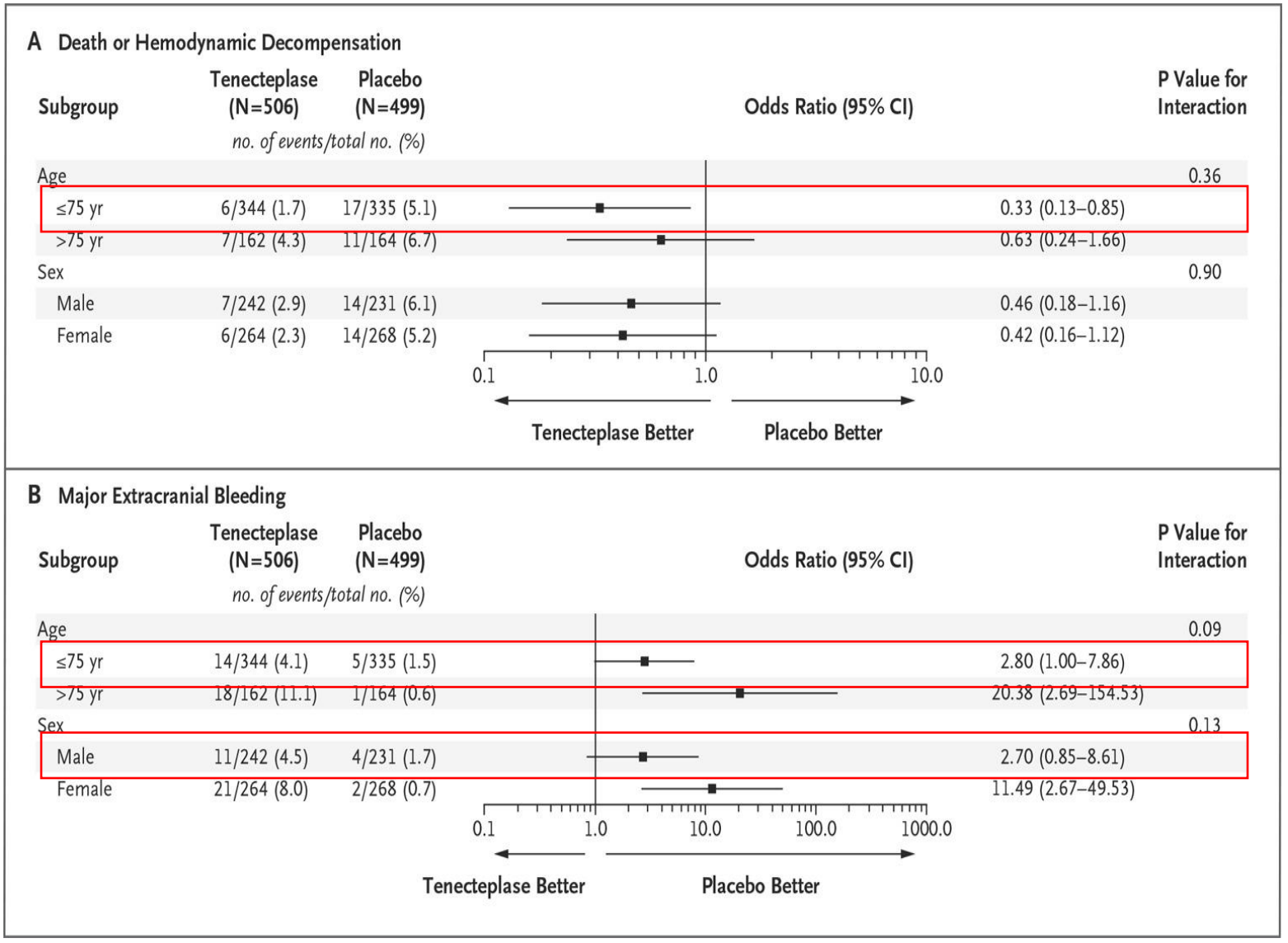
Fibrinolysis for patients with intermediate-risk PE

PEITHO trial

Efficacy outcomes				
Outcome	Tenecteplase (N = 506)	Placebo (N = 499)	Odds Ratio (95% CI)	P value
Primary outcome — no. (%)	13 (**2.6**)	28 (**5.6**)	0.44 (0.23–0.87)	0.02
Death from any cause	6 (1.2)	9 (1.8)	0.65 (0.23–1.85)	0.42
Hemodynamic decompensation	8 (**1.6**)	25 (**5.0**)	0.30 (0.14–0.68)	0.002
Death from any cause between randomization and day 30 - no. (%)	12 (2.4)	16 (3.2)	0.73 (0.34–1.57)	0.42

N Engl J Med 2014;370:1402-1411

Fibrinolysis for patients with intermediate-risk PE



N Engl J Med 2014;370:1402-1411

Saddle PE (embolus extending across the bifurcation of a vessel)

- Single center, retrospective study, between July 2006 and June 2010.
- 223 patients diagnosed with hemodynamically stable PE using CTPA in ED.
- Outcome : **Major adverse events (MAEs) within 1 month**

  (shock, intubation, mortality, thrombolysis and thrombectomy)

Table 2. Treatment and outcomes in patients with acute submassive pulmonary embolism

Variables	Non-saddle (n=207)	Saddle (n=16)	*p*-value
Treatment, n (%).			
Inferior vena cava filter	42 (20.3)	7 (43.8)	0.03
Thrombolytics	19 (9.2)	4 (25.0)	0.04
Thrombectomy	3 (1.1)	2 (7.4)	0.05
30 days all cause mortality, n (%).	26 (12.6)	4 (25.0)	0.16
Major adverse events, n (%).	57 (27.5)	10 (62.5)	0.01

Table 3. Multivariate logistic regression analysis for independent factor associated with occurrence of major adverse events in patients with acute submassive pulmonary embolism

Variables	Adjusted OR	95% CI	*p*-value
Age	1.02	0.98-1.04	0.18
Gender	1.03	0.55-1.92	0.93
D-shape left ventricle	2.94	1.39-6.22	0.01
Saddle embolism	3.75	1.22-11.31	0.02

J Korean Soc Emerg Med 2012;23(2):229-34

Saddle PE 는 더 위험한가?

❖ Meta-analysis in patients with SPE with any type of study (n=5,251 patients)

Variable	%
PE risk stratification	
Massive	9.7% (218/2248)
Submassive	**45.8%** (230/502)
Nonmassive	17.9% (90/502)
Concomitant DVT	**50.3%** (401/797)
RV dysfunction on Echo	**61.9%** (420/678)
Initial treatment of SPE	
Thrombectomy	16.0% (117/732)
Thrombolytic therapy	18.1% (854/4713)
AC alone	**71.0%** (1957/2755)
IVC filter placement	31.3% (197/629)
Outcome	
SPE-related overall mortality	**4.6%** (237/5149)
SPE recurrence (overall)	4.7% (25/528)
Late decompensation	**9.5%** (38/401)

 # Factors associated with increased mortality

- **Female sex** (61.5 % vs. 41.3 %, p = 0.019),
- **hypoxemia** (90 % vs. 59.2 %, p < 0.001),
- **massive PE features** (89.7 % vs. 30.1 %, p < 0.001),
- associated **CKD** (10.3 % vs. 1.4 %, p = 0.002),
- need for **mechanical ventilation** (28.2 % vs. 13.1 %, p = 0.02)

The use of **thrombolytic therapy**(TT) was significantly associated with **increased survival** (27.1 % vs. 12.5 %, p <0.001).

Thromb Res 2022;217:86-95

Saddle PE 는 더 위험한가?

In a multivariate logistic regression model,

- **massive PE features** significantly **increased the odds of death** (OR: **29.3**, CI: 4.86–181.81, p < 0.001), whereas, **treatment with anticoagulation (AC) alone** (OR: **0.1**, CI:0.027–0.356, p < 0.001), **TT** (OR: **0.065**, CI: 0.019–0.26, p < 0.001), **surgical thrombectomy** (ST) (OR: **0.047**, CI:(0.010–0.23), p < 0.001), or **percutaneous thrombectomy** (PT) (OR: **0.12**, CI: 0.020–0.84, p = 0.032) significantly **decreased odds of death**.

Meta-analysis of the included 17 observational studies

- overall **10 %** (95 % CI: 4.56–16.89) **SPE prevalence** among all PE cases.
- overall **SPE-related mortality rate** was **8 %** (95 % CI: 5.26–10.96)
- **massive PE** was observed in **13.3 %** (95 % CI: 5.56–23.70),
- **PE recurrence** in **5.1 %** (95 % CI: 2.22–9.05), and
- **late decompensation** in **11 %** (95 % CI: 3.43–22.34) of patients.

Despite its ominous radiologic appearance, the clinical, hemodynamic, and mortality outcomes of SPE seem **comparable** to that of other PE types **in general**.

Thromb Res 2022;217:86-95

Pulmonary Embolism in Syncope Italian Trial (PESIT)

❖ **Syncope** is defined as a **transient loss of consciousness** that has a **rapid onset, short duration (i.e., <1 minute),** and **spontaneous resolution** and is believed to be caused **by temporary cerebral hypoperfusion**.

▶ **Collapse or synonymous presyncope** were defined as **transient alteration of consciousness, but without complete loss of consciousness.** ***[Am J Emerg Med 2016;34(7):1251-7]***

❖ **Classifications of syncope**

1. Neurally mediated

▶ i.e., vasovagal, situational, or carotid-sinus syncope

2. Orthostatic hypotension

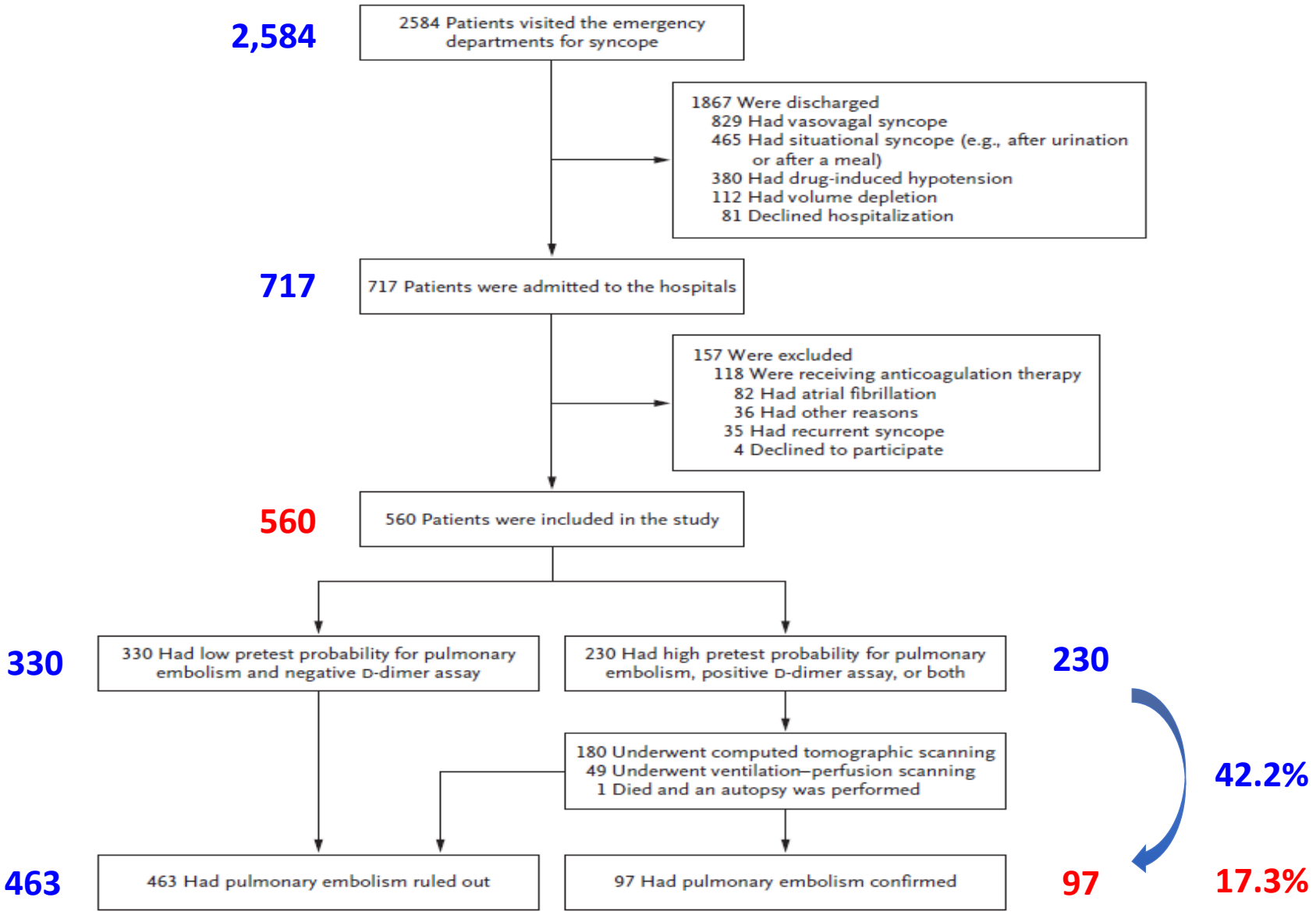
▶ i.e., drug-induced hypotension or hypotension due to primary or secondary autonomic failure or due to volume depletion

3. Cardiovascular origin

▶ i.e., arrhythmias, structural cardiovascular diseases, or pulmonary embolism

N Engl J Med 2016;375:1524-31

Workup for PE among Patients Admitted to the Hospital for Syncope



N Engl J Med 2016;375:1524-31

Demographic and Clinical Characteristics

Characteristic	All Patients (N=560)	Pulmonary Embolism Confirmed (N=97)	Pulmonary Embolism Ruled Out (N=463)	Odds Ratio (95% CI)	P Value
Clinical features — no. (%)					
Prodromal symptoms	227 (40.5)	41 (42.3)	186 (40.2)	1.09 (0.70–1.69)	0.70
Respiratory rate >20 breaths/min	77 (13.8)	44 (45.4)	33 (7.1)	10.80 (6.34–18.45)	<0.001
Heart rate >100 beats/min	107 (19.1)	32 (33.0)	75 (16.2)	2.55 (1.56–4.19)	<0.001
Systolic blood pressure <110 mm Hg	141 (25.2)	35 (36.1)	106 (22.9)	1.90 (1.19–3.04)	0.006
Clinical signs of deep-vein thrombosis	60 (10.7)	39 (40.2)	21 (4.5)	14.20 (7.79–25.71)	<0.001
Risk factors for venous thrombosis — no. (%)					
Prolonged immobility	38 (6.8)	10 (10.3)	28 (6.0)	1.79 (0.84–3.81)	0.13
Recent trauma or surgery	27 (4.8)	7 (7.2)	20 (4.3)	1.72 (0.71–4.20)	0.23
Active cancer	65 (11.6)	19 (19.6)	46 (9.9)	2.21 (1.23–3.97)	0.007
Infectious disease	49 (8.8)	12 (12.4)	37 (8.0)	1.63 (0.81–3.25)	0.17

* Plus–minus values are means ±SD. There were no missing data.
† Vasovagal syncope was identified in 86 patients, situational syncope in 51 patients, and carotid-sinus syncope in 12 patients.
‡ Hypotension due to autonomic failure was identified in 46 patients, drug-induced hypotension in 35 patients, and hypotension due to volume depletion in 31 patients.
§ Arrhythmias were identified in 49 patients, and structural disease in 45 patients.

N Engl J Med 2016;375:1524-31

Syncope in PE

❖ **Hospitalized for a first episode of syncope**

▶ high prevalence of PE among these patients

▶ PE was confirmed in approximately **one of every six** patients (17.3%)

▶ Highest among patients who presented with syncope of undetermined origin (25% of patients), almost 13% of patients with potential alternative explanations for syncope had PE.

N Engl J Med 2016;375:1524-31

경청해주셔서
감사합니다.

순천향대학교 부속 서울병원
SOON CHUN HYANG
UNIVERSITY HOSPITAL
SEOUL