ECMO-Assisted Pulmonary Embolectomy In Massive PE: Can It Replace Open Surgical Thrombo-embolectomy

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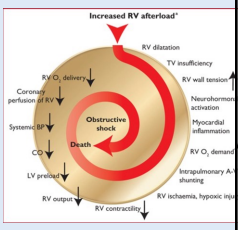
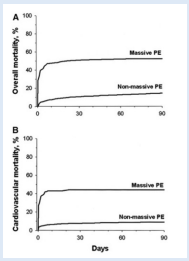
Massive pulmonary embolism

- Hemodynamically unstable pulmonary embolism (PE) with SBP < 90 mm HG, drop in SBP of >40 mm Hg from baseline for 15 min or hypotension requiring vasopressor or inotropic support, not explained by other causes (sepsis, arrhythmia, LV dysfunction, hypovolemia)
- Rising incidence 60-70 per 100,000, M > F, advanced age, high BMI



Massive pulmonary embolism



Early mortality risk		Indicators of risk: Haemodynamic instability[a]	Clinical parameters of PE severity and/or comorbidity: PESI class III–V or sPESI ≥1	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

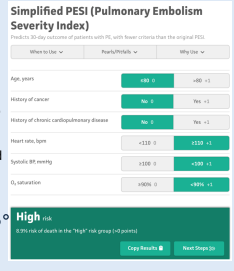
~60% 1 month mortality with massive PE presenting with cardiac arrest, shock

Risk stratification

Traditional scoring systems
sPESI (simplified Pulmonary embolism Severity Index)

- Determine if outpatient management is an option, 30 day outcome
- High sensitivity and NPV
- Lack specificity to predict early mortality as based on demographics and comorbidity
- Unclear role for massive PE with ECMO

Limited role for massive PE

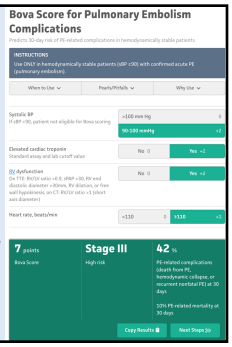


Risk stratification

BOVA score

- Pt with confirmed acute PE
- May identify intermediate low and high risk
- Helpful in triage
- To be used only in hemodynamically stable patients with SBP >90

Limited role for massive PE



Risk stratification

SOFA RV (Sequential Organ Failure Assessment)

- Includes patient criteria neurologic, blood, liver, kidney and blood pressure/hemodynamics as well as echocardiographic assessment of RC
- Combined with lactate with improved prognostic value for massive PE on ECMO
- Score <5 with <20% mortality while >14 with >95% mortality

SAVE score (Survival after VA ECMO)

- When combined with lactate, improved prognostic value
- 5 risk classes
- Helps determine value of continuation of ECMO

			Points
Age (years)	18–38		7
	39–52		4
	53–62		3
	≥63		0
Weight	<143 lbs (<65 kg)		1
	143–196 lbs (65–89 kg)		2
	>196 lbs (>89 kg)		0
Etiology of cardiogenic shock	Myocarditis	No	0
		Yes	3
	Refractory VT/VF	No	0
		Yes	2
	Post heart or lung transplantation	No	0
		Yes	3
	Congenital heart disease	No	0
		Yes	−3
Renal	Acute renal failure	No	0
		Yes	−3
	Chronic renal failure	No	0
		Yes	−6
Metabolic Acidosis	HCO_3 before ECMO ≤15 mmol/L (91.5 mg/dl)	No	0
		Yes	−3
Respiratory	Duration of intubation prior to initiation of ECMO, h	≤10	0
		11–29	−2
		≥30	−4
	Peak inspiratory pressure ≤20 cm H_2O (≤2.0 kPa)	No	0
		Yes	3
Cardiac	Pre-ECMO cardiac arrest	No	0
		Yes	−2
	Diastolic blood pressure within 6 h before ECMO cannulation ≥40 mmHg	No	0
		Yes	3
	Pulse pressure within 6 h before ECMO cannulation ≤20 mmHg	No	0
		Yes	−2
Other organ failures pre-ECMO	Liver failure	No	0
		Yes	−3
	CNS dysfunction	No	0
		Yes	−3
Lactate	<75 mg/dl	No	0
		Yes	15

Management principles

- Hemodynamic and respiratory support
  - Oxygen and ventilation (prefer non invasive ventilation, HFNC, low PEE if using mechanical ventilation)
  - Volume, vasopressors, inotropes (avoid aggressive volume loading, norepinephrine vs dobutamine)
  - Inhaled nitric oxide
  - Epoprostenol (inhaled nebulized veletri/Flolan)
  - Mechanical circulatory support (VA-ECMO)
- Anticoagulation
- Reperfusion strategies
  - Systemic thrombolysis (9.9% major bleeding, 1.7% intracranial)[1]
  - Percutaneous catheter directed thrombolysis
  - Percutaneous catheter based thrombectomy
  - Surgical embolectomy (role for combining with ECMO)[2]
- Multi disciplinary PE response teams
- IVC filter

1. Marti C, John G, Konstantinides S, Combescure C, Sanchez O, Lankeit M, Meyer G, Perrier A. Systemic thrombolytic therapy for acute pulmonary embolism: a systematic review and meta-analysis. Eur Heart J. 2015 Mar 7;36(10):605-14. doi: 10.1093/eurheartj/ehu218. Epub 2014 Jun 10. PMID: 24917641; PMCID: PMC4352209.
2. Pasrija C, Kronfli A, Rouse M, Raithel M, Bittle GJ, Pousatis S, Ghoreishi M, Gammie JS, Griffith BP, Sanchez PG, Kon ZN. Outcomes after surgical pulmonary embolectomy for acute submassive and massive pulmonary embolism: A single-center experience. J Thorac Cardiovasc Surg. 2018 Mar;155(3):1095-1106.e2. doi: 10.1016/j.jtcvs.2017.10.139. Epub 2017

Role of VA ECMO in massive PE

- First described use in 1972 to stabilize a high risk PE pt
- Expanding literature on combining with surgical
  rescue strategy after OR
- Can be placed under local anesthesia
- Temporize, stabilize, resuscitate
- Peripheral access (femoral vs axillary). Co
  perfusion. Harlequin syndrome (consider
  venous canular to SVC)
- Central access

Accepted indications for ECMO for massive PE
- Refractory cardiac shock, hypoxia
- Failed conventional therapy
- Adjunct/Bridge to thrombectomy (open or CBT)
- Post thrombectomy support

ECMO with Systemic thrombolysis

- Limited retrospective data
- ~85% short term survival, all had successful ECMO decanluation
- ~ 30% major bleeding (no intracranial hemorrhage)
- ~90 % with some residual thrombus (low tPA delivery because of high resistance vs adsorption in the ECMO circuit, flow diversion away from pulmonary circulation with VA ECMO)

Ting-Wei Lin, Meng-Ta Tsai, Yu-Ning Hu, Yi-Chen Wang, Jih-Sheng Wen, Hsuan-Yin Wu, Chwan-Yau Luo, Jun-Neng Roan, Simultaneous Thrombolysis and Extracorporeal Membrane Oxygenation for Acute Massive Pulmonary Emboli, The Annals of Thoracic Surgery, Volume 111, Issue 3,2021,Pages 923-929,ISSN 0003-4975, https://doi.org/10.1016/j.athoracsur.2020.05.155.

ECMO with Catheter intervention

- ECMO can support patients undergoing catheter-directed thrombolysis or embolectomy
- Catheter directed thrombolysis with lower mortality and major bleeding than systemic thrombolysis
- Retrospective data from 32 patients on ECMO with high risk PE with catheter directed thrombolysis had better survival than systemic thrombolysis (73%)
- Technical pitfall of working with large bore thrombectomy catheter besides ECMO canula

B. George, M. Parazino, H.R. Omar, *et al.*, A retrospective comparison of survivors and non-survivors of massive pulmonary embolism receiving veno-arterial extracorporeal membrane oxygenation support Resuscitation, 122 (2018), pp. 1-5

ECMO with Surgical embolectomy

- High risk PE with contraindications for or failure of systemic thrombolysis
- Two retrospective studies with preop ECMO followed by surgical embolectomy
- Excellent short term survival in limited studies

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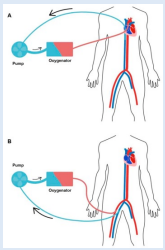
VA ECMO for postop recovery after surgery

- Peripheral vs central ECMO
- Allow for recovery from right heart failure, pulmonary edema, hemoptysis
- Usually able to wean in 2-3 days
- Can be transitioned to V-V ECMO



VA ECMO as a bridge to decision and intervention

- Multidisciplinary (PERT team) decisi
  surgeon, cardiologist, anesthesia
- Temporize and resuscitate the
  pulseless electric arrest
- Might be able to avoid intubation
- Stand-alone therapy
- Vs further interventions: thrombolysis, surgical embole , catheter-directed thrombo-embolectomy

ECMO criteria
Refractory cardiogenic shock/arrest
Tissue hypoxia, severe RV failure, RV/LV > 1.5, septal flattening, cardiac index <2.1 L/min/m² despite inotropes, sustained hypotension despite high dose vasoactive agents, no ROSC after 30 min of ACLS

Giraud R, Laurencet M, Assouline B, De Charrière A, Banfi C, Bendjelid K. Can VA-ECMO Be Used as an Adequate Treatment in Massive Pulmonary Embolism? *Journal of Clinical Medicine*. 2021; 10(15):3378. https://doi.org/10.3390/jcm10153378

Weaning from VA- ECMO

- No specific protocols
- Ensure hemodynamic stability, RV, LV recovery
- Echo guided wean (reducing ECMO flow by 50-75% while monitoring real time EV function on ECHO)
- Serum biomarkers

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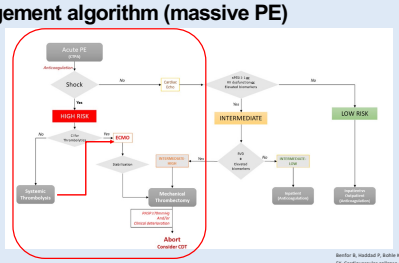
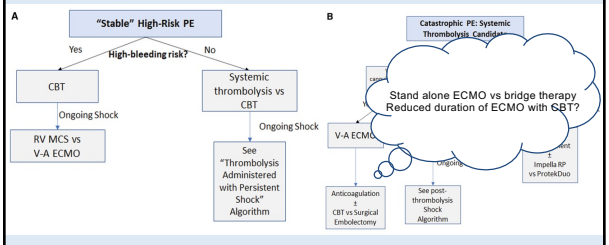
Management algorithm (massive PE)



Benfor B, Haddad F, Bohle K, Atkins MD, Lumsden AB, Peden EK. Cardiovascular collapse during mechanical thrombectomy for acute pulmonary embolism and the role of extracorporeal membrane oxygenation in patient rescue. J Vasc Surg Venous Lymphat Disord. 2023 Sep;11(5):979-985.e3. doi: 10.1016/j.jvsv.2023.03.016. Epub 2023 Apr 6. PMID: 37030443.

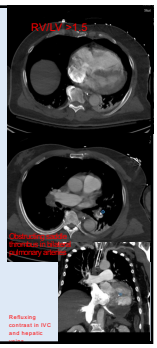
Management algorithm (massive PE common scenarios)



https://www.ahajournals.org/doi/full/10.1161/CIRCINTERVENTIONS.122.012166

Case presentation

- 73M with PEA arrest at OSH, ROSC after CPR+Epi X2, intubated in cardiogenic shock, COVID+
- NSTE-ACS considered. LHC negative. Trop, pro BNP elevated. ECHO with RV failure. Transferred to NGH
- RV/LV >1.5, PA pressure 57 mm HG, Reduced RV
- CT: IVC reflux, septal bowing, saddle PE
- Shock liver, AKI, lactic acidosis
- PERT response + Shock Alert (PCCM, CTS, Cards, Vasc Sx)
- sPESI >1, BOVA 7, PESI score 235 (10.0-24.5% mortality)



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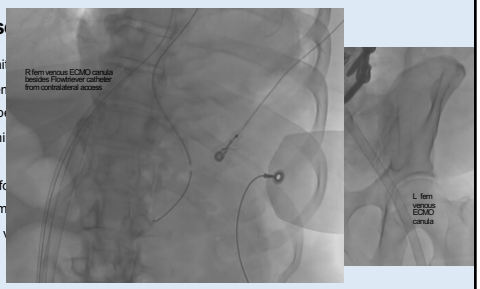
  22 Fr right fen
  right SFA rep
- 5 liters per mi
  requirement
- Resuscitate fo
- Suction throm
  right femoral v



Case presentatio

- Inari Flowtriever suction thrombectomy with flowsaver
- Large amount of thrombus removed

Case presentation

- ECMO decannulation on POD 2, Weaned off Vent on POD 4
- Transferred to step down on POD 6 after weaning HFNC
- ECHO on POD 30 with normal RV function, PA pressure 21 mm Hg
- Discharged after POD15 to SNF

Outcomes with ECMO and PE

- Yusuf et al systemic literature review(2015) with overall survival of 70.1% with massive PE supported with ECMO. Similar survival despite the thrombectomy strategy (chemical/catheter/surgical)
- 2021 Harwood. 301 pt with cardiac arrest from massive PE. 61 % survival. Unrelated to systemic tPA or not with ECMO. High mortality if >65 years of age (3X) and ECMO cannulation during CPR
- 2021 Kaso et al. Meta-analysis for massive PE with and without ECMO. 791 patients. No diff with ECMO.
- Overall no significant difference in outcomes in patients treated with or without ECMO on multiple meta-analyses. Should be combined with strategy for thrombectomy (catheter based or surgical)

Yusuff H, Zochios V, Vuylsteke A. Extracorporeal membrane oxygenation in acute massive pulmonary embolism: a systematic review. *Perfusion*. (2015) 30(8):611–6. doi: 10.1177/0267659115583377
Scott IA, Gordon M, Vender R, Pettigrew S, Desai P, Marchetti N, et al. Venoarterial extracorporeal membrane oxygenation in massive pulmonary embolism-related cardiac arrest: a systematic review. *Crit Care Med*. (2021) 49(5):760–9. doi: 10.1097/CCM.0000000000004828
Kaso ER, Pan JA, Salerno M, Kadi A, Ashrafpour C, Haskal Z, et al. Venoarterial extracorporeal membrane oxygenation for acute massive pulmonary embolism: a meta-analysis and call to action. *J Cardiovasc Trans Res*. (2022) 15:218–27. doi: 10.1007/s12265-021-10158-0

Limitations

- Limited data, no large scale randomized trials
- ECMO risks of bleeding, access complications
- Not applicable for all patients/ centers
- High cost of care
- Unmet need for portable equipment

Conclusions

- Management for massive pulmonary embolism continues to evolve
- Multidisciplinary team involvement for PERT and Shock team is important
- VA-ECMO and VV ECMO has an evolving role as an adjunct as well as a bridging therapy to stabilize unstable patients preoperatively while devising optimal thrombo-embolectomy strategy (chemical, catheter-based and surgical)
- Can it replace open surgical embolectomy? **POTENTIALLY**
- Does catheter based thrombectomy reduce duration of ECMO??
- Call for multicenter prospective registry to gather data as well as device innovation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