ECLS in CPR and Pulmonary Embolism
And how to use ECLS as a bridge to definitive therapy

John C. Gurley, MD
University of Kentucky
Gill Heart and Vascular Institute

Disclosures
None
**Education Need/Practice Gap**

Time to treatment is very critical in CPR and PE. The use of ECLS in these patients can improve survival rates. Providers need to be aware of these timelines in the decision to use ECLS.

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**Learning Objectives**

After this presentation, attendees will be able to:

Discuss advantages of ECLS in CPR and pulmonary embolism

Discuss implications of ECLS in CPR and pulmonary embolism
Expected Outcomes

The desired change/result in practice is to be able to determine if ECLS is needed in cases of CPR and PE.

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When to activate the ECLS team

Suspected PE
Pre-Hospital Cardiac Arrest

ECLS can be utilized for out-of-hospital cardiac arrest due to suspected PE.
ECPR Timeline for Patient Selection

Key time intervals in the decision to utilize ECLS for resuscitation of cardiac arrest in patients with PE

**Time to BLS**
The most important determinant of outcome.¹ Early, high-quality chest compressions determine the success of all subsequent interventions. Immediate bystander CPR or a no-flow time < 5 min.

**CPR initiates a Low Flow State**
Longer CPR yields worse outcomes.² Definition of Refractory OHCA
Unresponsive to 30 min. of CPR³

35 min.

**Cutoff Time for Switch to ECPR**
Suggested transition to ECLS at 21 minutes of CPR.⁴

**ECLS Limit**
No reasonable chance of acceptable outcome.⁵⁶

**Neuro Recovery Limit**
Acceptable neuro outcome falls to 2% after 15 minutes of CPR.⁴

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ECPR Timeline for Patient Selection

After 15 min. of conventional CPR, survival is 2% and hope of neuro recovery is fading rapidly.

When is the best time to call the ECLS team?
The proportion of patients with out-of-hospital arrest that survive to discharge with acceptable neurological function (mRS 0-3) declines rapidly with each minute of CPR

- **Immediately**
- **Not at all**
Out-of-Hospital Arrest ECLS Checklist

How to decide if ECLS is appropriate for suspected PE presenting as out-of-hospital cardiac arrest

Reasonable at the start

**Expectations?**

Overall survival very poor

Immediate CPR w/ no flow <5 minutes is an essential

**Early CPR?**

Start within 5 minutes

Meaningful neuro recovery depends on CPR duration of ≤16 minutes

**Early ROSC?**

Within 15 minutes

Unfavorable

• Age >75
• Malignancy
• $\text{Et CO}_2 < 10$
• Lactate > 6

Favorable

• Shockable rhythm
• Signs of life
• Pupil reflex
• Gasping

**Early ECLS?**

Within 20 minutes

Within 15 minutes

Survival 6-10%

Out-of-hospital

GO

When to activate the ECLS team

**Confirmed PE In-hospital Cardiac Arrest**

Cardiac arrest due to massive PE typically occurring in the ED, ICU or OR
In-Hospital Cardiac Arrest
Much better outcomes with 25% survival a reasonable expectation.

Overall survival with ECLS
Overall survival for patients who are placed on ECLS during or after cardiac arrest is about 25%.

Survival 26.6%
In-hospital arrest

Few Predictors
Most clinical variable fail to predict survival with ECLS (age, gender, prior DVT, BMI, CAD, diabetes, HTN).

Three clinical predictors of non-survival\(^1\)

1. History of malignancy
   - Predicts non-survival (p = .04).
   - The only clinical variable predictive of non-survival.\(^1,2\)

2. Systemic thrombolysis
   - Predicts non-survival (p = .015).
   - Catheter-directed lysis associated with survival.

3. Lactate level >6 mmol/L
   - Predicts non-survival (p = .004).
   - Strongest predictor of non-survival.

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Cardiogenic Shock Prior to Cardiac Arrest
ECLS for PE with progressive cardiogenic shock and impending arrest

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3. When to activate the ECLS team

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Cardiogenic Shock Prior to Cardiac Arrest

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Cardiogenic Shock Prior to Cardiac Arrest

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Cardiogenic Shock Prior to Cardiac Arrest

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Cardiogenic Shock Prior to Cardiac Arrest

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In-Hospital **Progressive Shock**

Much better outcomes with 75% survival a reasonable expectation.

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**Progressive shock without cardiac arrest**

PE patients placed on ECLS prior to cardiac arrest have much better odds of survival.

Overall Survival 76.4%

In-hospital shock without cardiac arrest

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**Survival is 3x better when ECLS is used prior to arrest.**

Patients who suffer cardiac arrest prior to ECLS cannulation have greatly reduced odds of survival. In the review by George, survival was 26.6% for patients placed on ECLS during or after cardiac arrest, compared with 76.4% survival among patients placed on ECLS prior to arrest. Yusuff also reported that initiation of ECLS while in cardiopulmonary arrest yielded a higher risk of death. When ECLS is initiated more than 30 minutes post-arrest, survival is less than 10%.

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**When to activate the ECLS team**

**Whenever You Think About Intubation**

Semi-elective ECLS is probably much safer than intubation in massive PE.

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The Intubation Hazard of Massive PE

Intubation—essentially induction of anesthesia—extremely hazardous in patients with massive PE.\(^1,^2\)

**Hemodynamic Collapse**
 Abrupt, profound hypotension and cardiac arrest requiring CPR and immediate cardiopulmonary bypass.

**AND HOW TO MANAGE IT**

1. **It’s the heart (not the lungs).**
   - RV can fail suddenly and unpredictably.
   - Sedation blunts endogenous catecholamines.
   - Positive pressure ventilation affects RV filling.

2. **Give a DO NOT INTUBATE order.**
   - Use epinephrine 50-100 mcg boluses.
   - Support BP and circulation until cannulated.

3. **Get to a safe place.**
   - OR with patient prepped and surgeon scrubbed.
   - Cath lab with access secured.

4. **Avoid the situation altogether.**
   - Patient on ECLS is immediately comfortable.
   - Does not need a ventilator.

5. **When to activate the ECLS team**

**Before You Offer Surgical Embolectomy**

ECLS makes surgery safer and may eliminate the need for surgery.

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Routine ECLS Before Surgical Embolectomy

Using ECLS to triage and optimize patients referred to the surgical service for embolectomy

Most patients referred for embolectomy can avoid surgery.¹
Despite a surgical bias, only 3 days of unfractionated heparin, and no attempt at catheter-directed lysis or thrombus extraction.

The large early hazard of surgical embolectomy is avoidable.¹
The early hazard of surgery is not offset by later benefit. Early surgery leads to significantly reduced survival at 12 months.

Good reasons for the early hazard of surgery:
- High rate of cardiac arrest with induction of anesthesia or opening pericardium.
- Difficulty separating from bypass due to RV stunning.
- Postop issues: bleeding, AKI, ventilator problems, prolonged hospital time.
- Heart surgery on patients who are brain-injured patients or have uncertain neurological status.

When Other Therapies are Contraindicated

PE patients often have contraindications to thrombolysis and surgery.

**KEY POINTS:**

1. Hospital patients are often poor candidates for thrombolytic therapy and heart surgery.
2. Systemic thrombolysis is risky: major bleeding up to 33% (intracranial up to 7.4%).
4. Anticoagulation alone has similar benefit within a few days.

**ABSOLUTE CONTRAINDICATIONS TO THROMBOLYSIS**

- Spine surgery within 3 months
- Stroke within 2 months
- History of intracranial hemorrhage
- Known intracranial neoplasm
- A-V malformation or aneurysm
- Significant head trauma
- Active internal bleeding
- Known bleeding diathesis intracranial surgery (3 months)

**RELATIVE CONTRAINDICATIONS**

- Attempted femoral access
- Prolonged CPR
- Pregnancy
- Recent surgery (3 weeks)
- Recent trauma
- Age >75 years
- Current oral anticoagulation
- Prolonged CPR
- Recent bleeding
- Current oral anticoagulation
- History uncontrolled hypertension
- Remote ischemic stroke
- Major surgery within 3 weeks

**RISK FACTORS FOR MAJOR BLEEDING**

- Recent trauma
- Recent spine surgery
- Recent joint replacement
- Low body weight
- Chronic DAPT
- History of hypertension
- History of stroke
- Aortic dissection
- Pancreatitis
- Dementia
- History of GI bleed (3 months)
- Stool occult positive
- Internal bleeding (4 weeks)
- GI bleeding in prior 3 months
- Esophageal varices
- Elevated bilirubin (>3 mg/dL)
- Coagulopathy (defined INR >1.7)
- Presence of IABP
- Femoral venous access
- Uncertain neurological status
- Prolonged CPR
- Recent bleeding
- History uncontrolled hypertension
- Remote ischemic stroke
- Major surgery within 3 weeks

Thrombolytic Contraindications: Common

Patients with PE often have associated conditions that make them poor candidates for systemic thrombolytic therapy and surgery.
Massive PE with **Thrombus-in-Transit**

Right heart thrombus is a predictor of hemodynamic decompensation, cardiac arrest and death.¹⁻⁴

- **Heparin**: 29% Mortality
- **Surgery**: 24% Mortality

**A high risk subset of PE that does not benefit from surgery.¹⁻⁴**

Right heart thrombus is a predictor of hemodynamic decompensation, cardiac arrest and death. RA or RV thrombus identifies a high risk subset of patients with PE. Surgical thrombectomy is often considered lifesaving, but cardiac surgery in this high risk population has never been shown to improve outcomes. In a meta-analysis of 177 patients with right heart thrombi, hospital mortality was 29% with anticoagulation and 24% with surgery.

Managing intracardiac thrombus

ECLS Skills
Directly Transferrable to Percutaneous Thrombus Removal

The catheter skills necessary for ECLS can be utilized for percutaneous thrombus removal. Some of these techniques such as aspiration thrombectomy, require a close, collaborative, interdisciplinary relationship. The ideal team may include CT Surgery, IC, IR, Perfusion and Intensive Care specialists.

Percutaneous Removal of Thrombus in PFO*
An unconventional approach to this problem may be appropriate when the risk of surgery is prohibitive.

*The risks and benefits of percutaneous removal are unknown, there is currently no expert consensus regarding management. There is no practice guidelines that apply to this problem.
When Team Masters Safe Cannulation

The risks of ECLS can be minimized by meticulous cannulation technique.

When to activate the ECLS team

Access Site Complications

Limb ischemia is one of the most feared and potentially irreversible complications of VA ECLS.

Access Site Complications **Avoidable**
Adapted from 2014 meta-analysis by Cheng, et al.¹

Limb Ischemia and bleeding
In meta-analysis, limb ischemia (including compartment syndrome, gangrene, toe necrosis, neuropathy, fasciotomy and amputation) is very common, occurring in about one fourth of patients on VA ECMO.¹

Major Bleeding
Bleeding, primarily related to access site, occurs in nearly half of VA ECMO patients.

Infection
Many access site-related infections can be avoided through careful percutaneous cannulation techniques.

Total Percutaneous Insertion and Removal*  
Totally percutaneous, imaging-guided insertion and removal with distal perfusion key to avoiding complications

**KEY ELEMENTS:**
1. 100% ultrasound-guided access (CO₂ or contrast angio available).
2. 100% distal perfusion (percutaneous common femoral or tibial access).
3. Routine percutaneous decannulation in vascular-capable cath lab.
4. Highly experienced operators (vascular intervention / TAVR skill sets).
When Risks of ECLS are Under 10%

ECLS becomes preferred therapy when major complications are less than 10%

Shifting Risk vs. Benefit to Favor of ECLS

The utility of VA ECLS is limited mainly by access site bleeding and limb ischemia

How to shift the risk-versus-benefit balance in favor of VA ECLS

Access site bleeding and limb ischemia are among the most common complications of VA ECLS

Eliminating limb ischemia and access site bleeding shifts the balance in favor of ECLS, permitting more liberal use. It also allows VA ECLS to be utilized before the patient develops irreversible end organ failure; this leads to better clinical outcomes.
All Patients with Unstable Massive PE

ECLS may be the safest and best option for patients with unstable massive PE.

ECLS Risk Threshold in Unstable PE

When access site risks are held under 10%, ECLS becomes the preferred modality for initial stabilization.

Patients on ECLS will not die suddenly due to acute RV failure.

When cannulation risks are held under 10%, ECLS becomes safer than any other option for patients with hemodynamically unstable PE.

Cannulation risk <5% is a reasonable expectation for an experienced team.2

Cannulation Risk Threshold 5%
Risk Tolerance and ECLS Data

Proof of efficacy requires clinical use of ECLS in a risk environment

Max. Risk Avoidance
Type II Errors
Pt deprived of beneficial therapy

Max. Risk Tolerance
Type I Errors
Pt exposed to risk without benefit

Risk Tolerance, Risk Aversion and Patient Benefit

Maybe ECLS is definitive therapy.
And everything else is second-line or adjunctive.
Thank you for listening.

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