ECMO AND MECHANICAL CIRCULATORY SUPPORT

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COI

- I have no conflicts relevant to this talk
- Images and discussion of catheters and mechanical support devices will be shown throughout this talk. This is not an endorsement of any device or company over another.

OBJECTIVES

- Review The Indications For ECMO And Who Should Be Referred For ECMO
- Discuss Complications Of ECMO
- Describe The Role Of ECMO And Other Devices In The Support Of The Patient In Shock

WHAT IS ECMO? TERMINOLOGY

ECMO = ExtraCorporeal Membrane Oxygenation

ECLS = ExtraCorporeal Life Support

eCPR = extracorporeal CardioPulmonary Resuscitation

VV ECMO – blood is drawn from vein and returned to vein – provides lung support

VA ECMO – blood is drawn from vein and returned to artery – provides heart and lung support

Technique for providing respiratory and/or cardiac support to patients whose native organs are so severely compromised that normal function/life is not possible

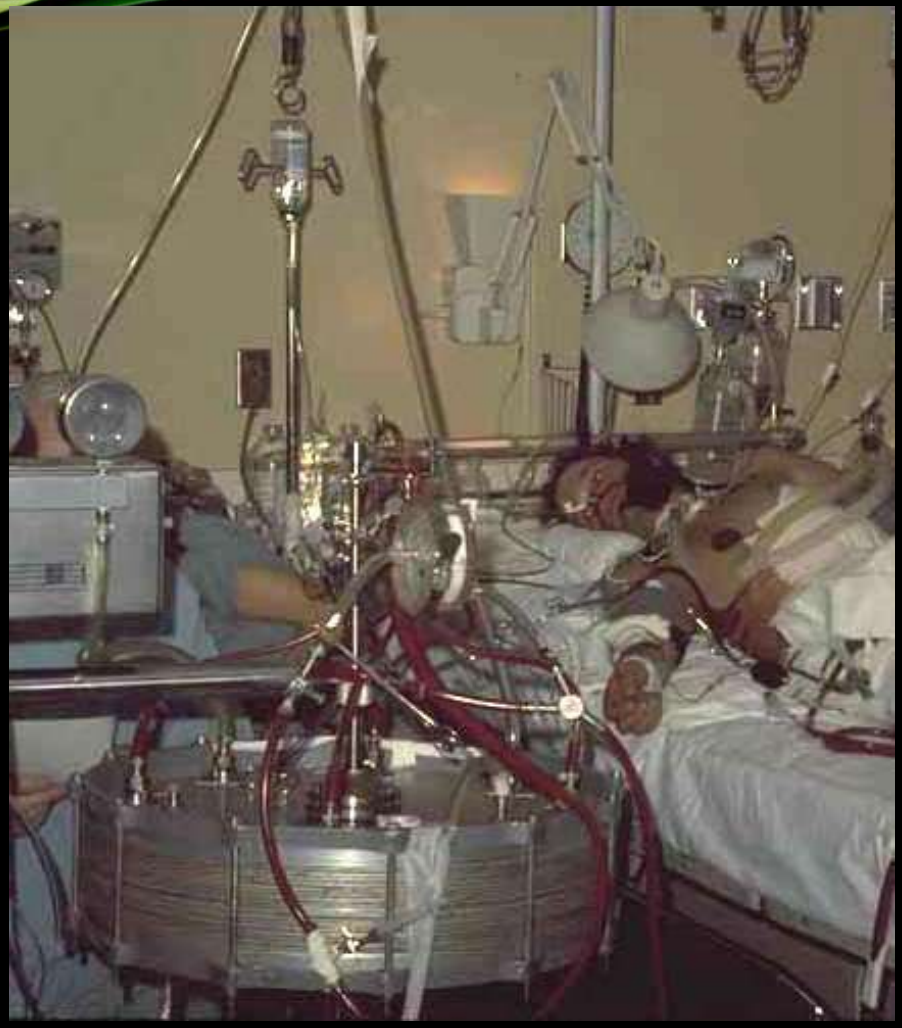
MECHANICAL CIRCULATORY SUPPORT (MCS)

- Devices that help with circulation when the heart cannot do it itself
- Examples
  - ECMO
  - Durable Ventricular Assist Device (VAD)
  - Temporary VAD
  - Cardiopulmonary Bypass
  - Intra-aortic Balloon Pumps (IABP)

- ECMO – A Brief History

FIRST SUCCESSFUL ECMO PATIENT, 1971

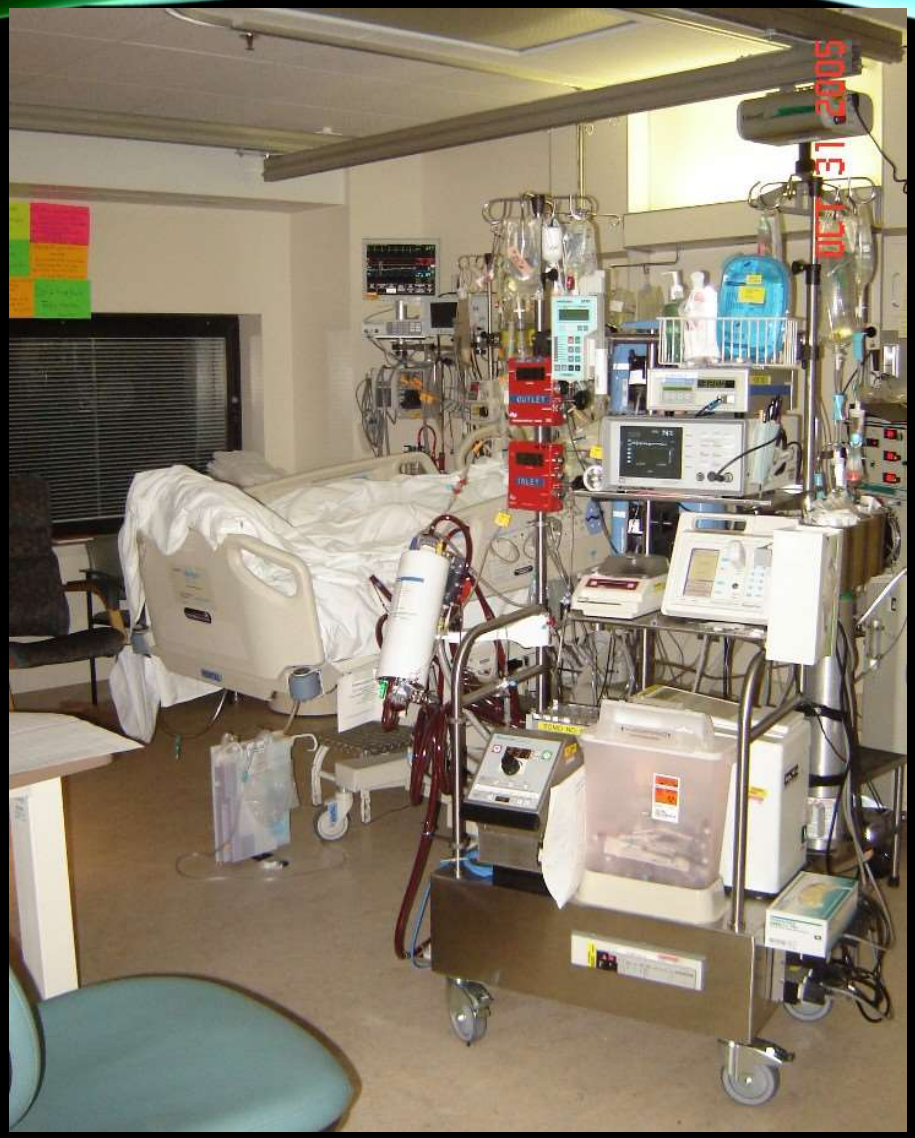
J Donald Hill MD and Maury Bramson BME, Santa Barbara, Ca, 1971. (Courtesy of Robert Bartlett, MD)



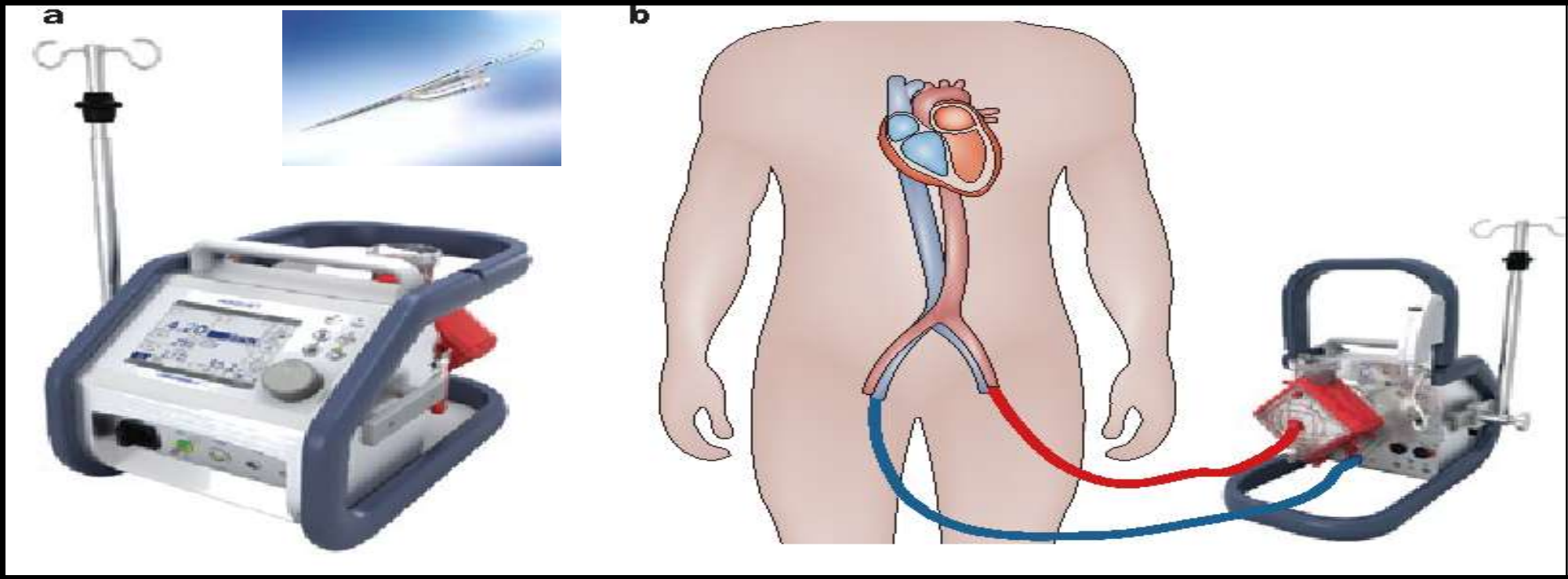
ECMO

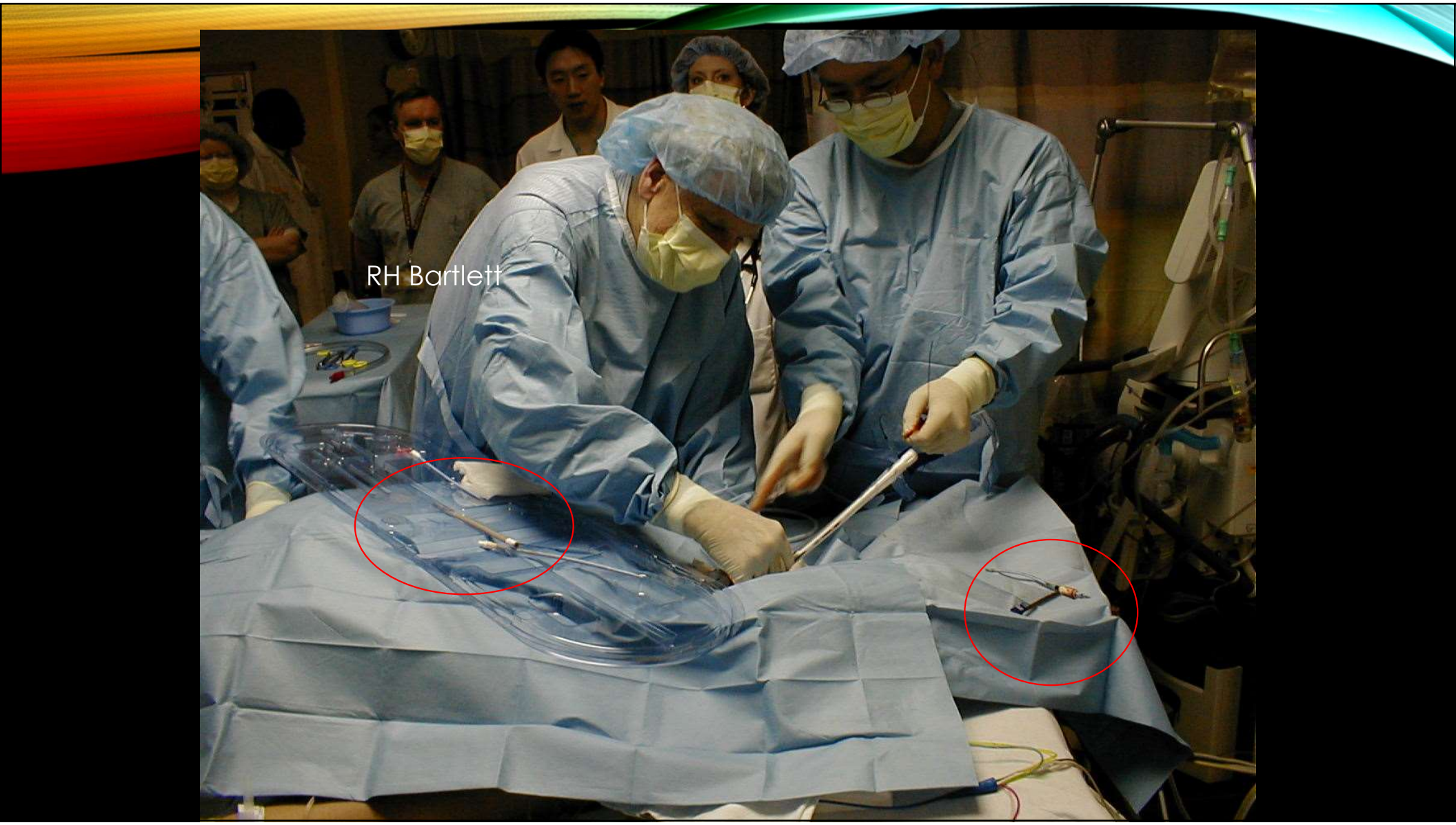
- Two primary types
  - Veno-venous support
    - Primarily respiratory
  - Veno-arterial support
    - Cardiac/cardiopulmonary support
- Components
  - Centrifugal pump
  - Membrane oxygenator
  - Tubing/canulae
  - Controller
  - Heater/Cooler

ECMO 2005

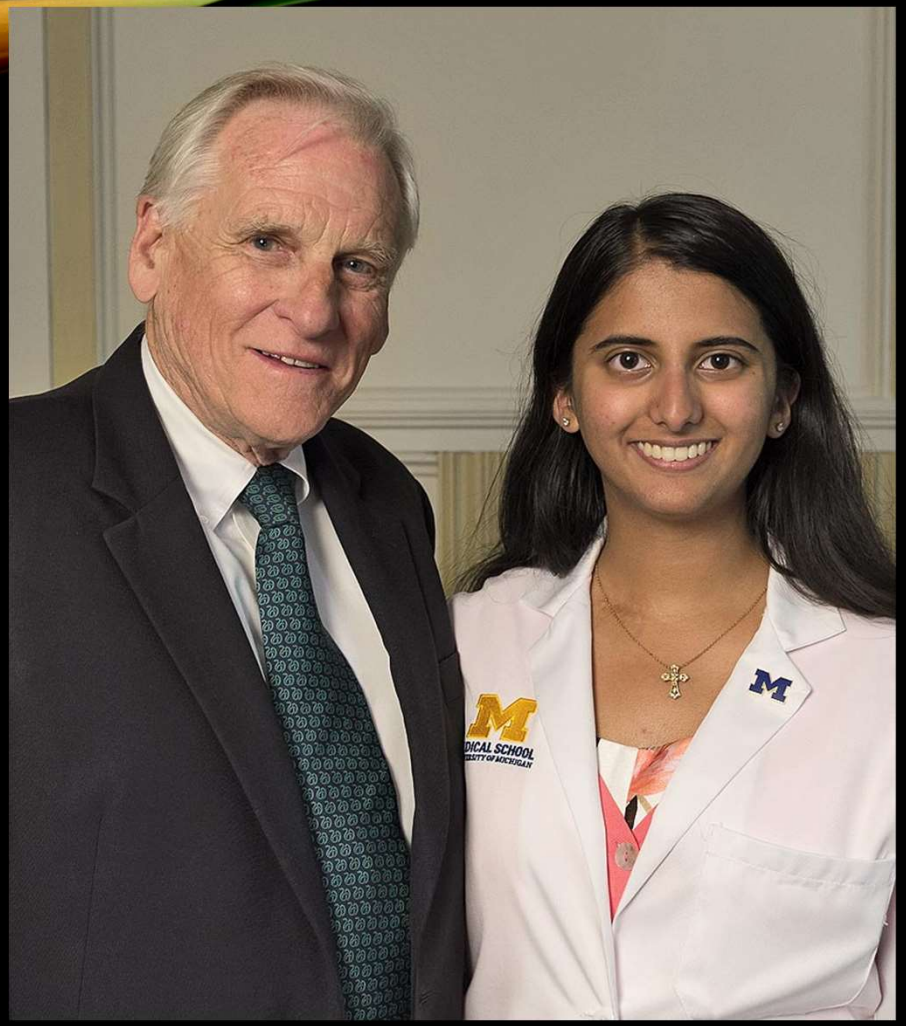


ECMO TODAY




RH Bartlett

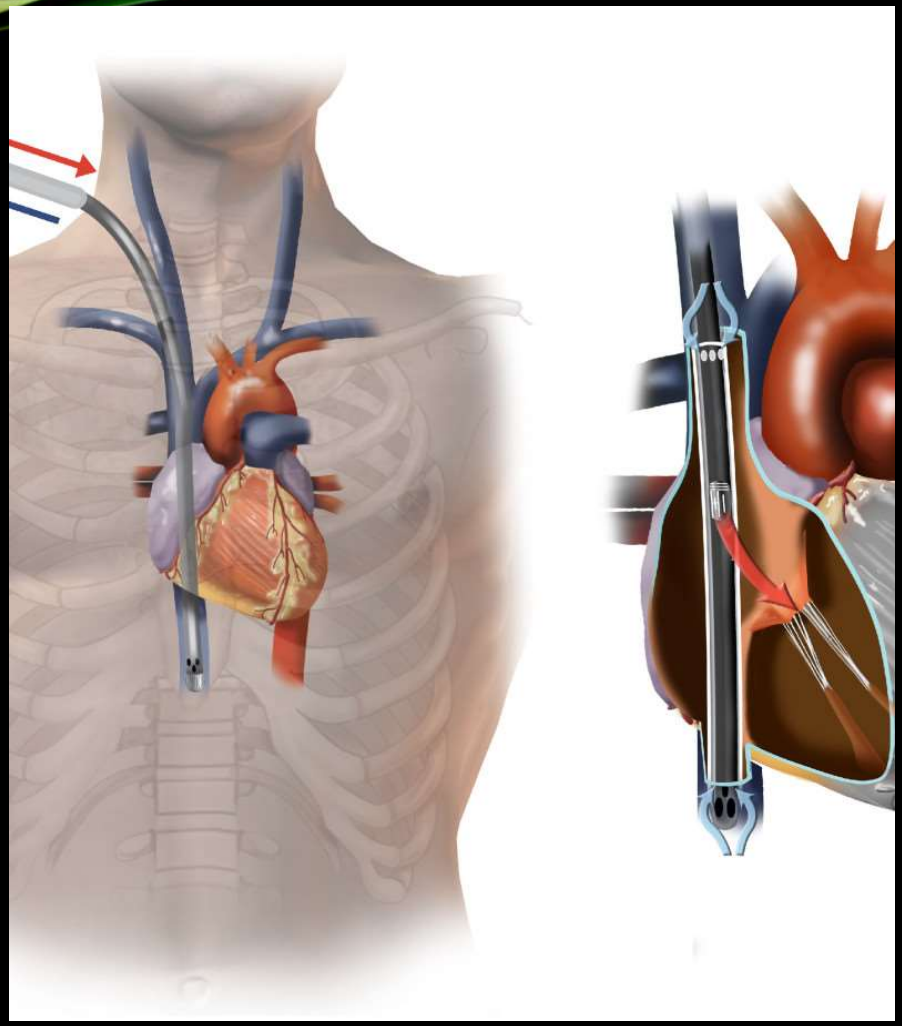
BOB BARTLETT, MD AND HANNAH CHERIYAN, MD, PHD

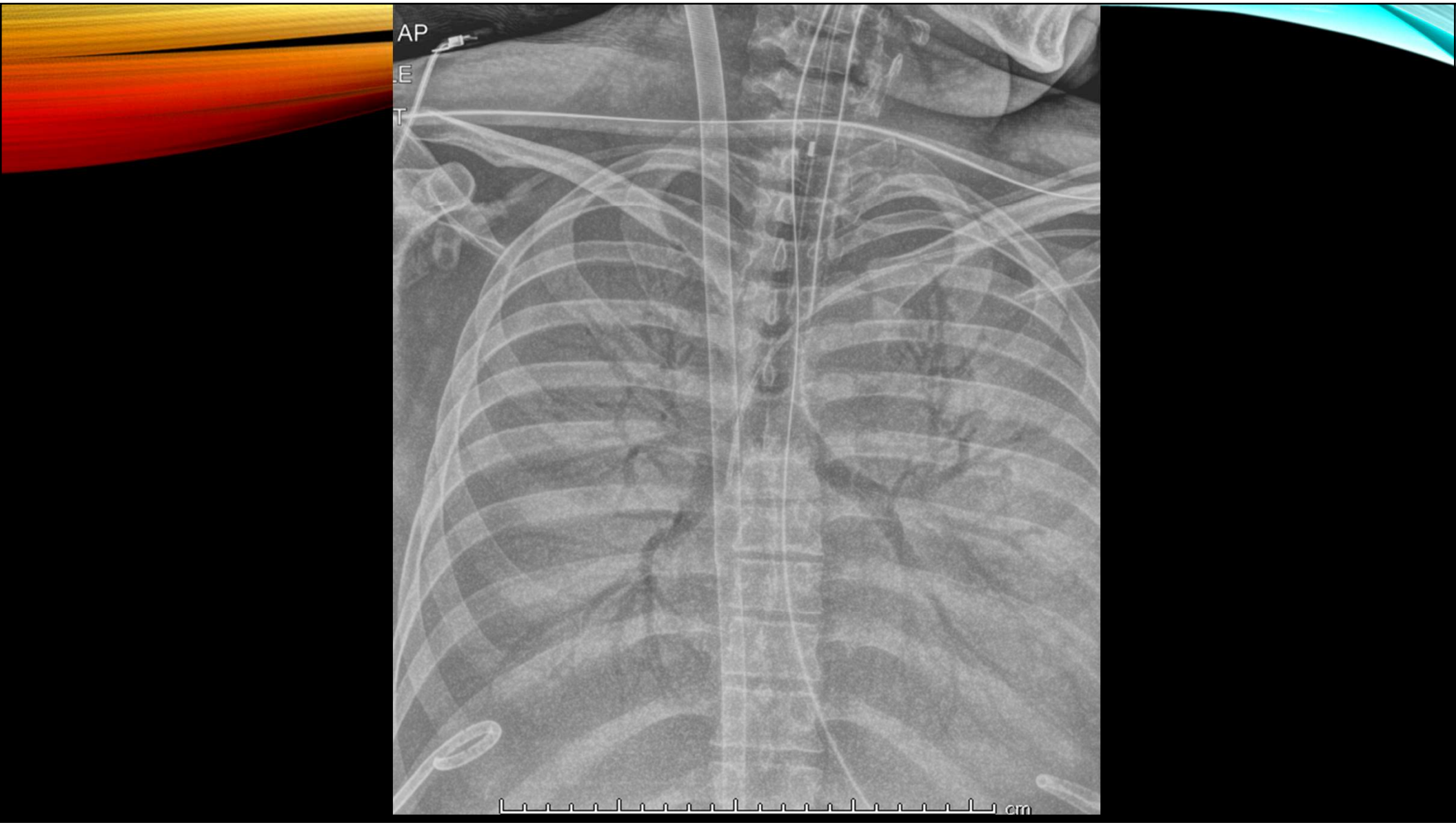


https://healthblog.uofmhealth.org/childrens-health/from-nicu-to-med-school-an-outrageous-idea-thats-saved-thousands-of-babies

VV-ECMO

Avalon Elite bicaval dual lumen cannula in correct position. From Hirose et al, 20012

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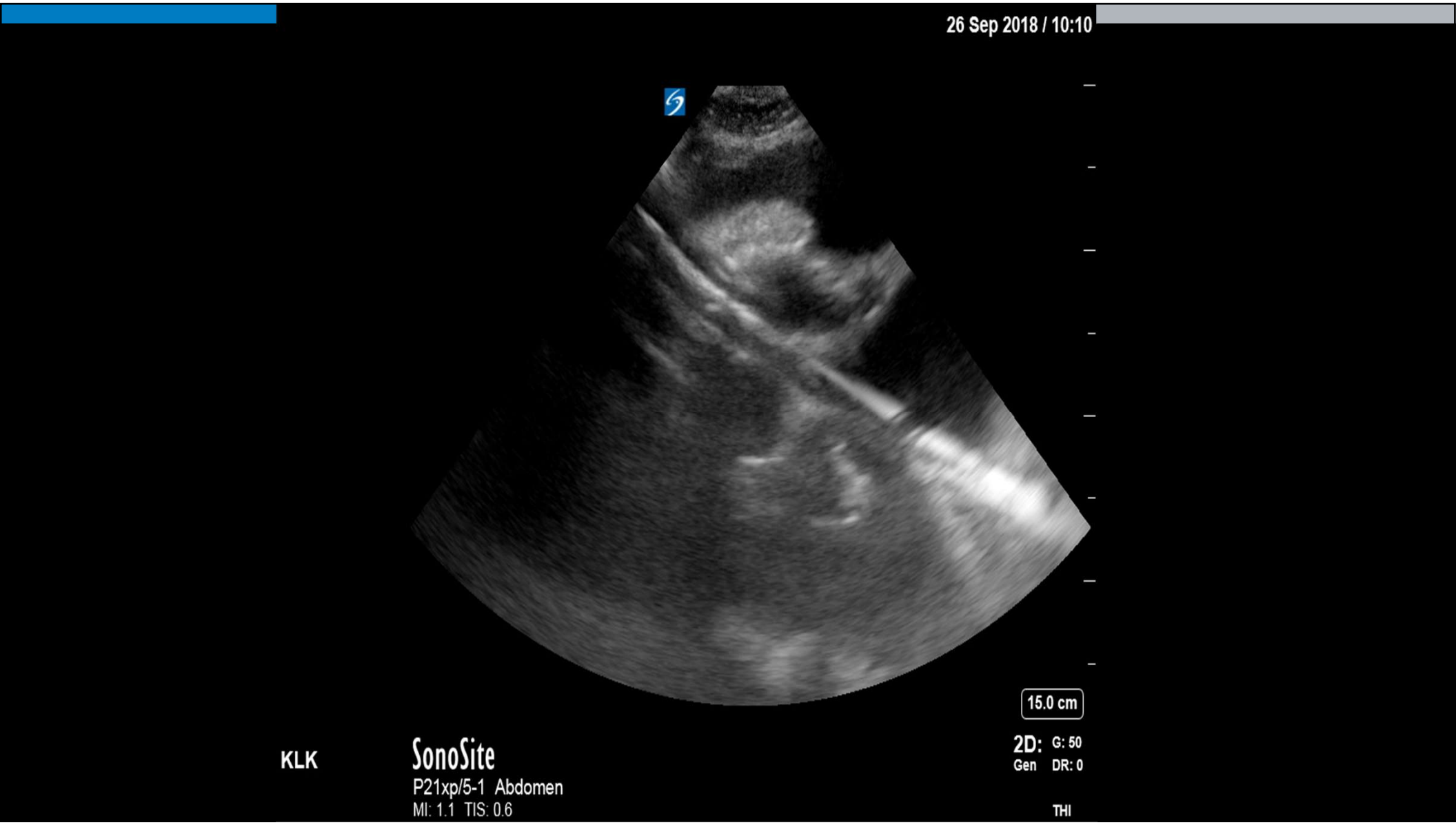

26 Sep 2018 / 10:10
15.0 cm
KLK
SonoSite
P21xp/5-1 Abdomen
MI: 1.1 TIS: 0.6
2D: G: 50
Gen DR: 0
THI

ECMO IN ADULTS

- Up until early 2000s, niche technology only used in pediatric
- Then…

CESAR - 2009

- Evaluate conventional ventilation vs. ECMO for severe respiratory failure in adults
  - Absence of severe disability at 6 mo
  - 2001-2006 in England

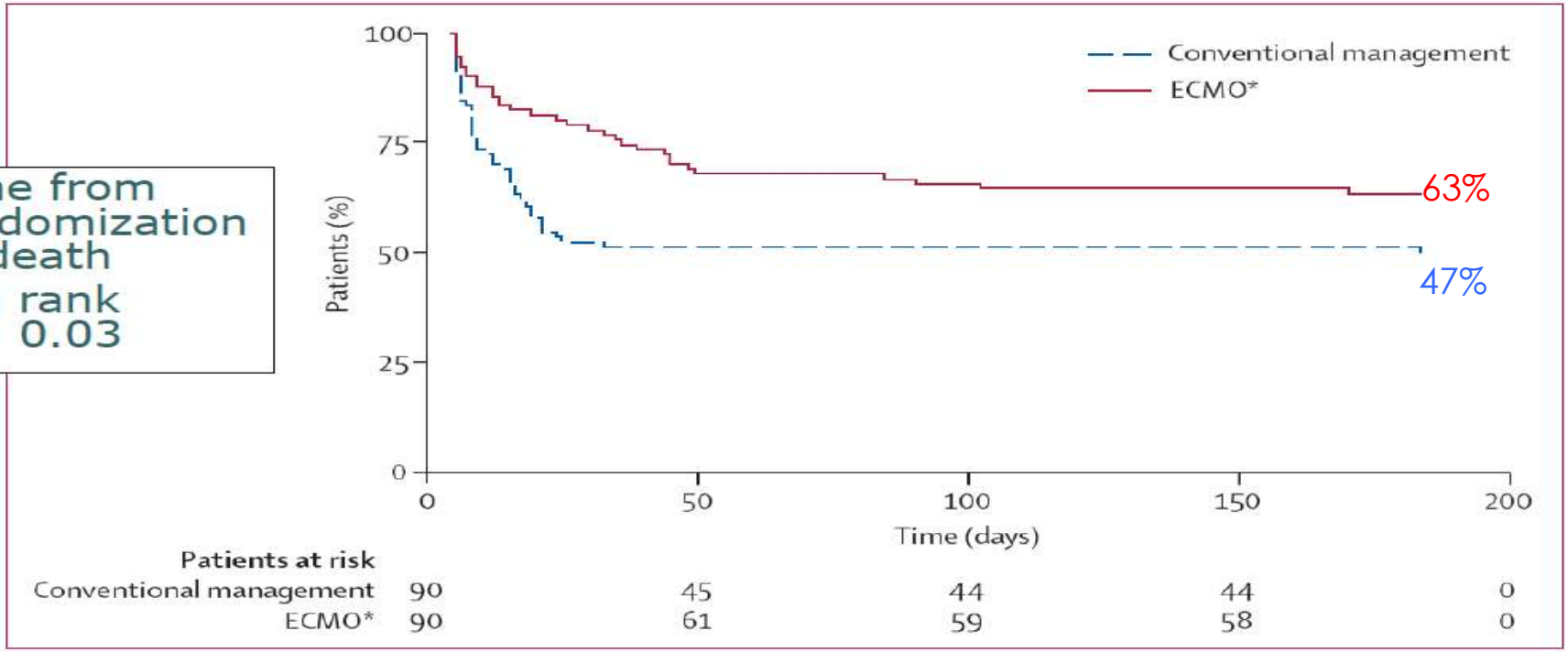
- 180 patients randomly assigned, age 18-65
- Murray score ≥ 3 or pH <7.2
  - Excluded if FiO2 >80% for 7 days or high PEEP
  - Murray-PaO2/FiO2, #quadrants CXR, PEEP, compliance
- Benefit of ECMO regardless of age, organ failure
- Knocks on trial was transfer to central site, poor ARMA adherence at OSH, and not everybody at ECMO center received ECMO

Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR): a multicentre randomised controlled trial

Giles J Peek, Miranda Mugford, Ravindranath Tiruvoipati, Andrew Wilson, Elizabeth Allen, Mariamma M Thalanany, Clare L Hibbert, Ann Truesdale, Felicity Clemens, Nicola Cooper, Richard K Firmin, Diana Elbourne, for the CESAR trial collaboration

www.thelancet.com **Published online September 16, 2009**

- Time from randomization to death
- Log rank p = 0.03



Patients at risk					
Conventional management	90	45	44	44	0
ECMO*	90	61	59	58	0

Referral to an Extracorporeal Membrane Oxygenation Center and Mortality Among Patients With Severe 2009 Influenza A(H1N1)

Moronke A. Noah, MRCS
Giles J. Peek, FRCS (CTh), MD

Context Extracorporeal membrane oxygenation (ECMO) can support gas ex-

Extracorporeal Membrane Oxygenation for 2009 Influenza A(H1N1) Acute Respiratory Distress Syndrome

The Australia and New Zealand Extracorporeal Membrane Oxygenation (ANZ ECMO) Influenza

Context The novel influenza A(H1N1) pandemic affected Australia and New Zealand during the 2009 southern hemisphere winter. It caused an epidemic of critical illness and some patients developed severe acute respiratory distress syndrome (ARDS)

Ventilatory and ECMO treatment of H1N1-induced severe respiratory failure: results of an Italian referral ECMO center

Giovanni Cianchi[1], Manuela Bonizzoli[1], Andrea Pasquini[1], Massimo Bonacchi[2], Giovanni Zagli[1*], Marco Ciapetti[1], Guido Sani[2], Stefano Batacchi[1], Simona Biondi[3], Pasquale Bernardo[2], Chiara Lazzeri[2], Valtere Giovannini[4], Alberta Azzi[5], Rosanna Abbate[6], Gianfranco Gensini[6], Adriano Peris[1]

Original Article

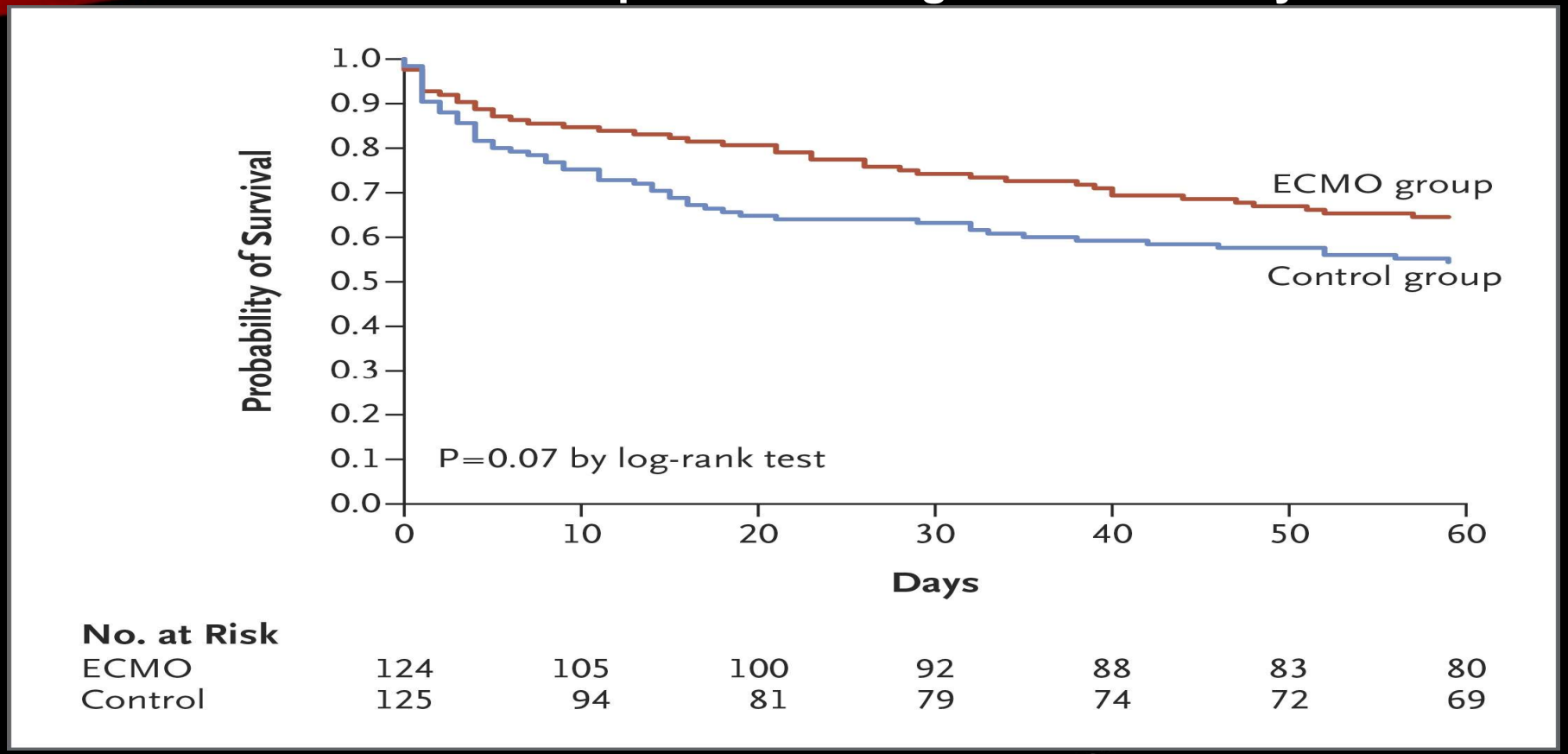
Extracorporeal Membrane Oxygenation for Severe Acute Respiratory Distress Syndrome

Alain Combes, M.D., Ph.D., David Hajage, M.D., Ph.D., Gilles Capellier, M.D., Ph.D., Alexandre Demoule, M.D., Ph.D., Sylvain Lavoué, M.D., Christophe Guervilly, M.D., Daniel Da Silva, M.D., Lara Zafrani, M.D., Ph.D., Patrice Tirot, M.D., Benoit Veber, M.D., Ph.D., Eric Maury, M.D., Ph.D., Bruno Levy, M.D., Ph.D., Yves Cohen, M.D., Ph.D., Christian Richard, M.D., Ph.D., Pierre Kalfon, M.D., Ph.D., Lila Bouadma, M.D., Ph.D., Hossein Mehdaoui, M.D., Gaëtan Beduneau, M.D., Ph.D., Guillaume Lebreton, M.D., Ph.D., Laurent Brochard, M.D., Ph.D., Niall D. Ferguson, M.D., Eddy Fan, M.D., Ph.D., Arthur S. Slutsky, M.D., Daniel Brodie, M.D., Alain Mercat, M.D., Ph.D., for the EOLIA Trial Group, REVA, and ECMONet

N Engl J Med
Volume 378(21):1965-1975
May 24, 2018

The NEW ENGLAND JOURNAL of MEDICINE

Kaplan–Meier Survival Estimates in the Intention-to-Treat Population during the First 60 Days of the Trial.



Combes A et al. N Engl J Med 2018;378:1965-1975

The NEW ENGLAND JOURNAL of MEDICINE

Table 2. End Points.*

End Point	ECMO Group (N=124)	Control Group (N=125)	Relative Risk or Difference (95% CI)†	P Value
Primary end point: mortality at 60 days — no. (%)	44 (35)	57 (46)	0.76 (0.55 to 1.04)	0.09
Key secondary end point: treatment failure at 60 days — no. (%)‡	44 (35)	72 (58)	0.62 (0.47 to 0.82)	<0.001
Other end points				
Mortality at 90 days — no. (%)	46 (37)	59 (47)	−10 (−22 to 2)	
Median length of stay (interquartile range) — days				
In the ICU	23 (13–34)	18 (8–33)	5 (−1 to 10)	
In the hospital	36 (19–48)	18 (5–43)	18 (6 to 25)	
Median days free from mechanical ventilation (interquartile range)§	23 (0–40)	3 (0–36)	20 (−5 to 32)	
Median days free from vasopressor use (interquartile range)§	49 (0–56)	40 (0–53)	9 (0 to 51)	
Median days free from renal-replacement therapy (interquartile range)§	50 (0–60)	32 (0–57)	18 (0 to 51)	
Prone position — no. (%)¶	82 (66)	113 (90)	−24 (−34 to −14)	
Recruitment maneuvers — no. (%)¶	27 (22)	54 (43)	−21 (−32 to −10)	
Inhaled nitric oxide or prostacyclin — no. (%)¶	75 (60)	104 (83)	−23 (−33 to −12)	
Glucocorticoids — no. (%)¶	80 (65)	82 (66)	−1 (−13 to 11)	

* No missing data were observed for patients' outcomes, except for the total duration of hospital stay, for which data were missing for 13 patients in the ECMO group and 14 in the control group. ICU denotes intensive care unit.
† The relative risk for the primary end point with the 95% confidence interval and the P value were corrected for the triangular test. The width of confidence intervals for median differences and absolute risk differences was not adjusted for multiple comparisons and should not be used to infer definitive treatment differences. Difference values for the other end points are presented in percentage points for differences between rates or in days, as appropriate.
‡ The key secondary end point of treatment failure at 60 days was defined as death in patients in the ECMO group and as crossover to ECMO or death in patients in the control group.
§ The number of days free from a particular intervention were calculated with the use of the assignment of 0 days free from the intervention in patients who died during the follow-up period.
¶ Data included the period from randomization to day 60.

Combes A et al. N Engl J Med 2018;378:1965-1975

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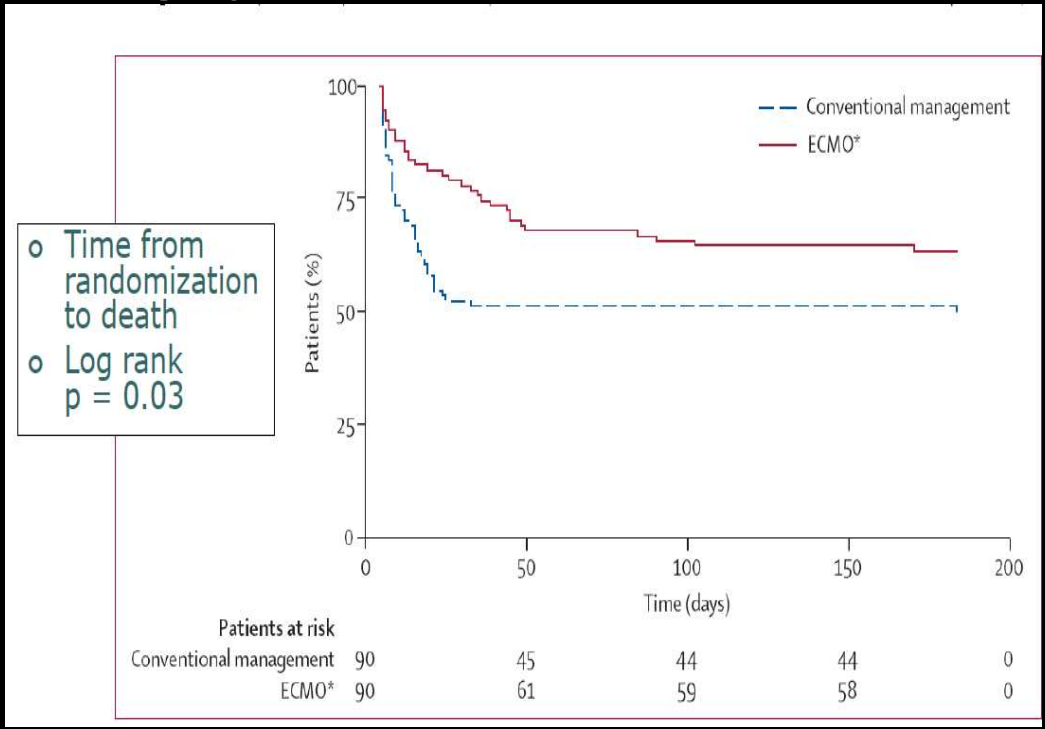
TWO STUDIES, SIMILAR RESULTS

	ECMO group (n=90)*	Conventional management group (n=90)	Relative risk (95% CI, p value)
Death or severe disability at 6 months	NA	NA	0·69 (0·05–0·97, 0·03)†
No	57 (63%)	41 (47%)‡	NA
Yes	33 (37%)	46 (53%)‡	NA

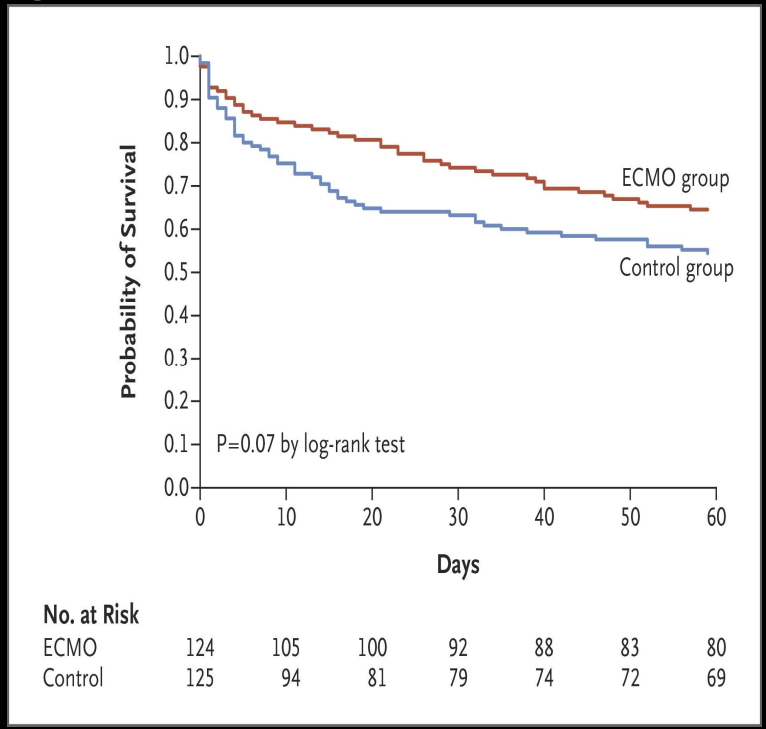
End Point	ECMO Group (N=124)	Control Group (N=125)	Relative Risk or Difference (95% CI)†	P Value
Primary end point: mortality at 60 days — no. (%)	44 (35)	57 (46)	0.76 (0.55 to 1.04)	0.09

TWO STUDIES, SIMILAR RESULTS

CESAR



EOLIA



INITIATION TIME MATTERS

Timing of ECMO Initiation Impacts Survival in Influenza-Associated ARDS

Desiree A. Steimer[1] Omar Hernandez[1] David P. Mason[1] Gary S. Schwartz[1]

[1] Department of Thoracic Surgery and Lung Transplantation, Baylor University Medical Center, Dallas, Texas, United States

Thorac Cardiovasc Surg 2019;67:212–215.

Address for correspondence Gary S. Schwartz, MD, Department of Thoracic Surgery and Lung Transplantation, Baylor University Medical Center, 3410 Worth Street, Suite 545, Dallas, TX 75246, United States (e-mail: Gary.Schwartz@BSWHealth.org).

Abstract

In the past decade, extracorporeal membrane oxygenation (ECMO) has emerged as an innovative therapy for influenza-associated acute respiratory distress syndrome (ARDS). Despite its promising results, the ideal timing of ECMO initiation for these patients remains unclear. Retrospective analysis of a single institution experience with venovenous ECMO for influenza-induced ARDS was performed. Twenty-one patients were identified and categorized into early (0–2 days), standard (3–6 days), or late (more than 7 days) cannulation cohorts. Patients cannulated within 48 hours of admission had 80% survival rate at 90 days. Comparatively, the standard and late cannulation cohorts had an observed 90-day survival rate of 60 and 16.7%, respectively.

Keywords

- extracorporeal membrane oxygenation
- ECMO
- infection
- intensive care

INITIATION TIME MATTERS - 2

- EOLIA Crossover Group
  - 57% mortality (vs 35% early ECMO vs 46% no ECMO)
  - Mean 6.5d post randomization
- COVID
  - Early in pandemic, good mortality benefit (70+ % survival)
  - Later in pandemic, drop in benefit (~57% survival)
  - Likely represents use of other modalities, delay in ECLS and placing patients in fibroproliferative ARDS on ECMO

VV-ECMO

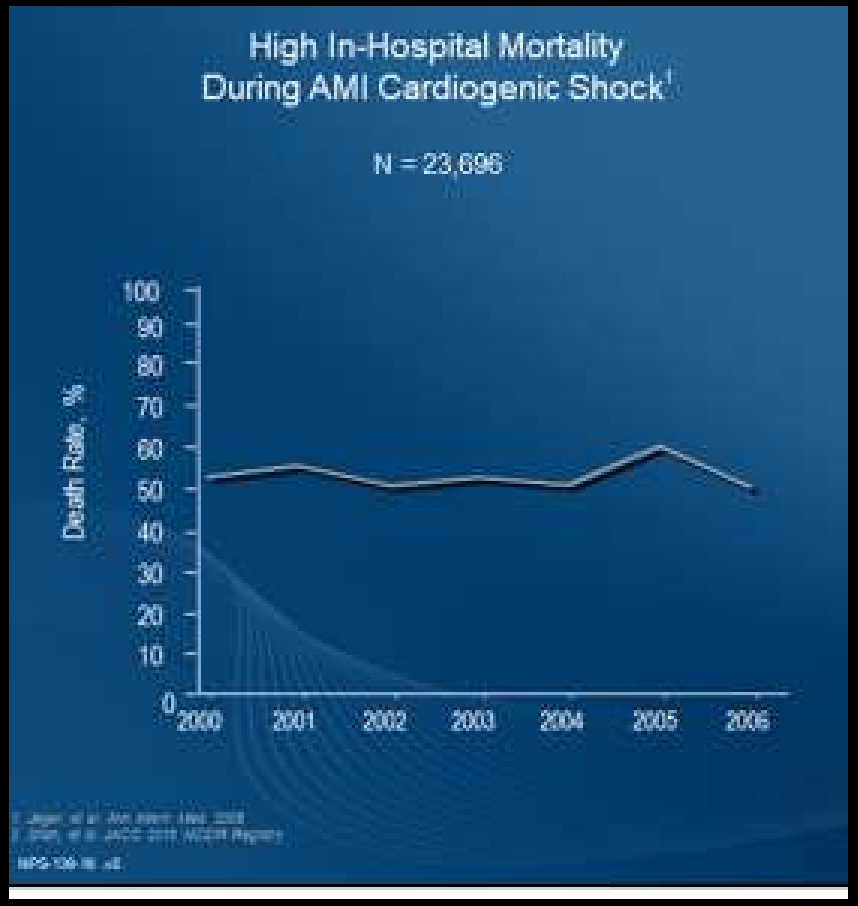
- **ELSO Guidelines V-V** Indications
  - Respiratory support-consider if mortality >50% and recommended if mortality >80%
    - ARDS/hypoxemic respiratory failure
      - PaO2 to FiO2 ratio less than 80, despite salvage therapies for 6+ hrs
    - Hypercapneic respiratory failure (severe COPD/asthma exacerbation)
    - Lung transplant candidates
    - Severe bronchopleural fistulas requiring mechanical ventilation
    - PNA
    - Sepsis?

VV ECMO CONTRAINDICATIONS

- No absolute contraindications but the following are associated with a poor outcome
  - Mechanical ventilation with high support (Fio2>90% and/or P-plat >30 for 7 days)
  - CNS hemorrhage
  - Pharmacologic immunosuppression (ANC<400)
  - Non-recoverable comorbidity
  - Risk increases with increasing age

CARDIOGENIC SHOCK

- No formal criteria
- **Inadequate tissue perfusion**
- Cardiac dysfunction of any kind
  - Post-open heart
  - MI
  - Arrhythmia
  - Valve disease
  - Chronic heart failure
  - RV outflow obstruction
- Leading cause of death in acute MI
- Incidence of shock is increasing



TRADITIONAL TREATMENT OF CARDIOGENIC SHOCK

- Diuretics
- IV inotropes
  - Doubutamine
  - Milrinone
- Vasopressors
  - Norepinephrine (levophed)
  - Phenylepherine
  - High-dose Dobutamine
- IABPp

WHY IS CARDIOGENIC SHOCK WORSE THAN SEPTIC SHOCK

- Mortality rate
  - Cardiogenic shock 50-70%
  - Septic shock 20-40%
- In sepsis
  - Pressors buy time for antibiotics to work
  - Blood cultures can determine antibiotics to use
- In cardiogenic shock
  - The heart isn't working
  - No "antibiotics" for the heart
  - Dobutamine, milrinone, and pressors actually put increased stress on the sick heart

Cardiogenic Shock – A Team Approach

Shock Team Goals:
- Early identification of cardiogenic shock patients
- Early right heart catheterization
- Early hemodynamic support with PMCS
- Minimize vasopressors/inotropes
- Heart recovery

Clinical Criteria
- Acute Coronary Syndrome or Heart Failure
  AND
- SBP < 90 mmHg (for 30 minutes) or the use of vasopressors/inotropes
- Lactate < 2 mmol/L
- Evidence of end-organ hypo-perfusion

Contraindications to PMCS
- DNR
- Terminal Illness
- Unable to anticoagulate
- Cardiac Arrest with CAHP score > 200*
- Advances multi-system organ failure

Shock Team Activation
- Call 844-504-0004 for any patient with criteria for Cardiogenic Shock
- Ongoing Vital Signs, ECGs, labs

Non-ACS
- Right heart catheterization
- Echocardiography

ACS
- Coronary angiography
- Right-heart catheterization

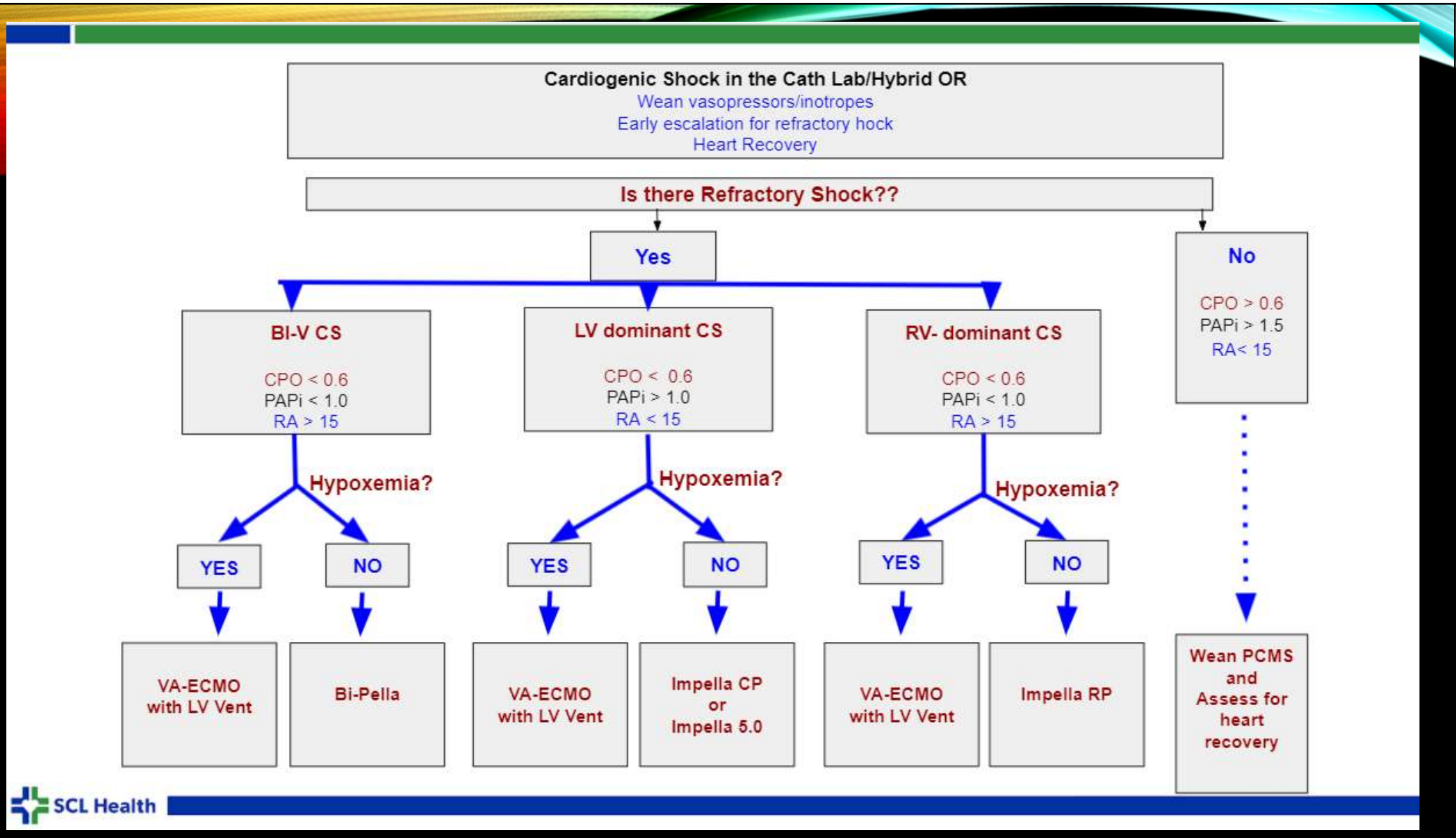
Are Hemodynamic Criteria for Cardiogenic Shock Met?
- SBP< 90 mmHg (for 30 min) or the use of vasopressors/inotropes
- CI < 1.8 (or < 2.2 L/min/m2 with inotropes
- PCWP > 18
- CPO < 0.6 (CPO = MAP x CO/ 451)
- PAPI < 1.0 (PAPI = (sPAP - dPAP) / RA

No
- Coronary revascularization
- Swan-Ganz Catheter left in place

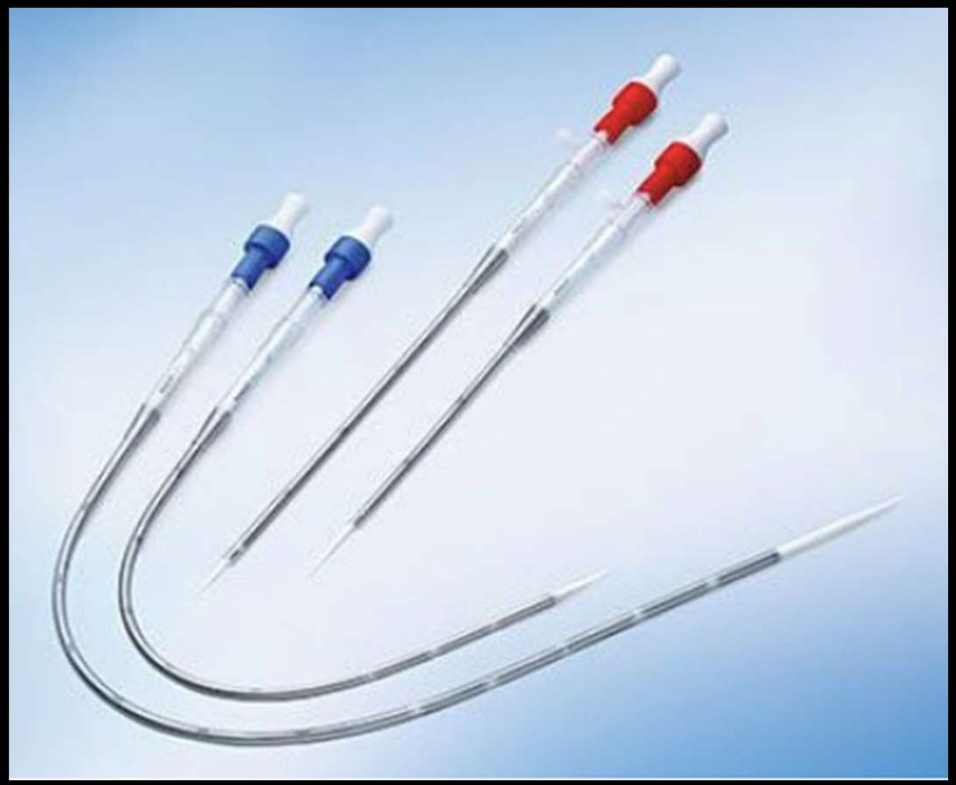
Yes
- PMCS
- Coronary revascularization
- Assess need for RV support (CPO, PAPi)

Intensive Care Unit
- Ongoing Hemodynamic Assessment
- Serial reassessment of end organ perfusion
- Assess for RV/LV recovery
- Wean vasopressors/inotropes
- Consider escalation of treatment for PAPi < 1.0 and/or CPO < 0.6

SCL Health


Cardiogenic Shock in the Cath Lab/Hybrid OR
Wean vasopressors/inotropes
Early escalation for refractory hock
Heart Recovery
Is there Refractory Shock??
Yes
No
CPO > 0.6
PAPi > 1.5
RA< 15
BI-V CS
CPO < 0.6
PAPi < 1.0
RA > 15
LV dominant CS
CPO < 0.6
PAPi > 1.0
RA < 15
RV- dominant CS
CPO < 0.6
PAPi < 1.0
RA > 15
Hypoxemia?
Hypoxemia?
Hypoxemia?
YES
NO
YES
NO
YES
NO
VA-ECMO with LV Vent
Bi-Pella
VA-ECMO with LV Vent
Impella CP or Impella 5.0
VA-ECMO with LV Vent
Impella RP
Wean PCMS and Assess for heart recovery
SCL Health

CANNULA CHOICES…LIMITLESS

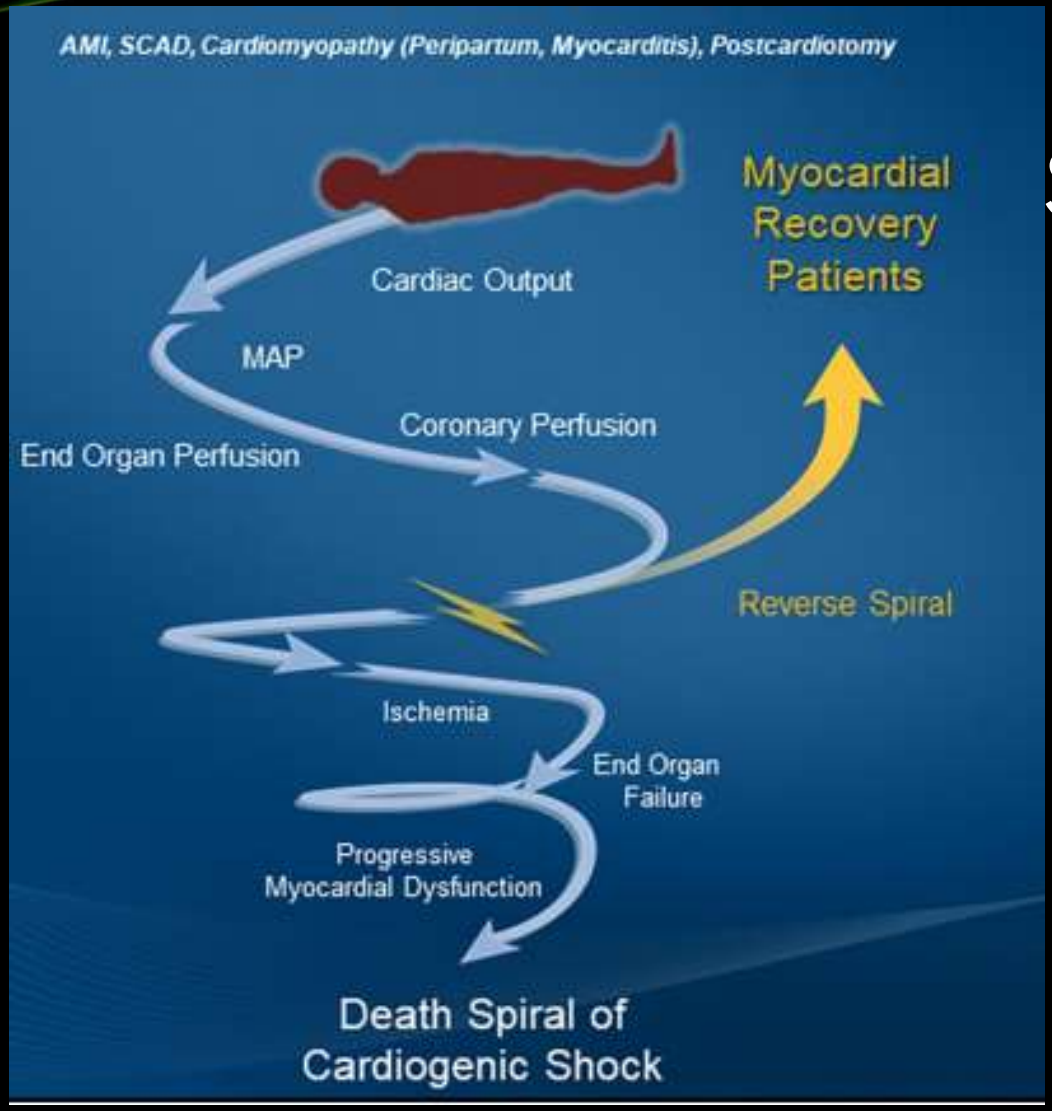


ECMO - COMPLICATIONS

- Anatomic
  - Catheter insertion
  - Lack of antegrade perfusion catheter – limb ischemia
  - **Bleeding at catheter site**
  - Body habitus can make access difficult
- Physiologic
  - Shear stress
  - Cytokine/humoral activation
  - Platelets/anticoagulation/non-catheter site bleeding
  - Harlequin Syndrome
- Mechanical
  - pump failure
  - Oxygenator failure
  - Recirculation

S

- "Golden hour" of shock
- Cardiogenic shock, even with maximal traditional therapies has very high mortality
  - For 20+ year mortality was > 50%
  - With adaptation of the Detroit Cardiogenic Shock Initiative survival is up to 70%



LOOKING FORWARD TO THE FUTURE: ECPR

- CPR is a temporizing measure
  - CPR for minimal perfusion
  - Reversible causes
    - VT/VF – deliver shocks
    - PEA – 5 H's and T's
- Longer the code the worse the outcome

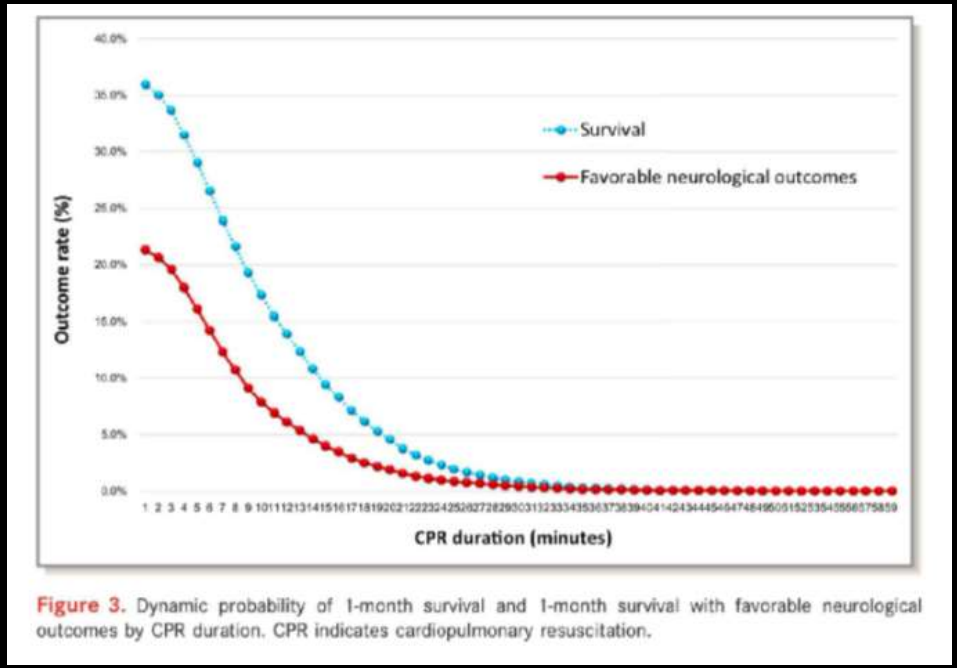
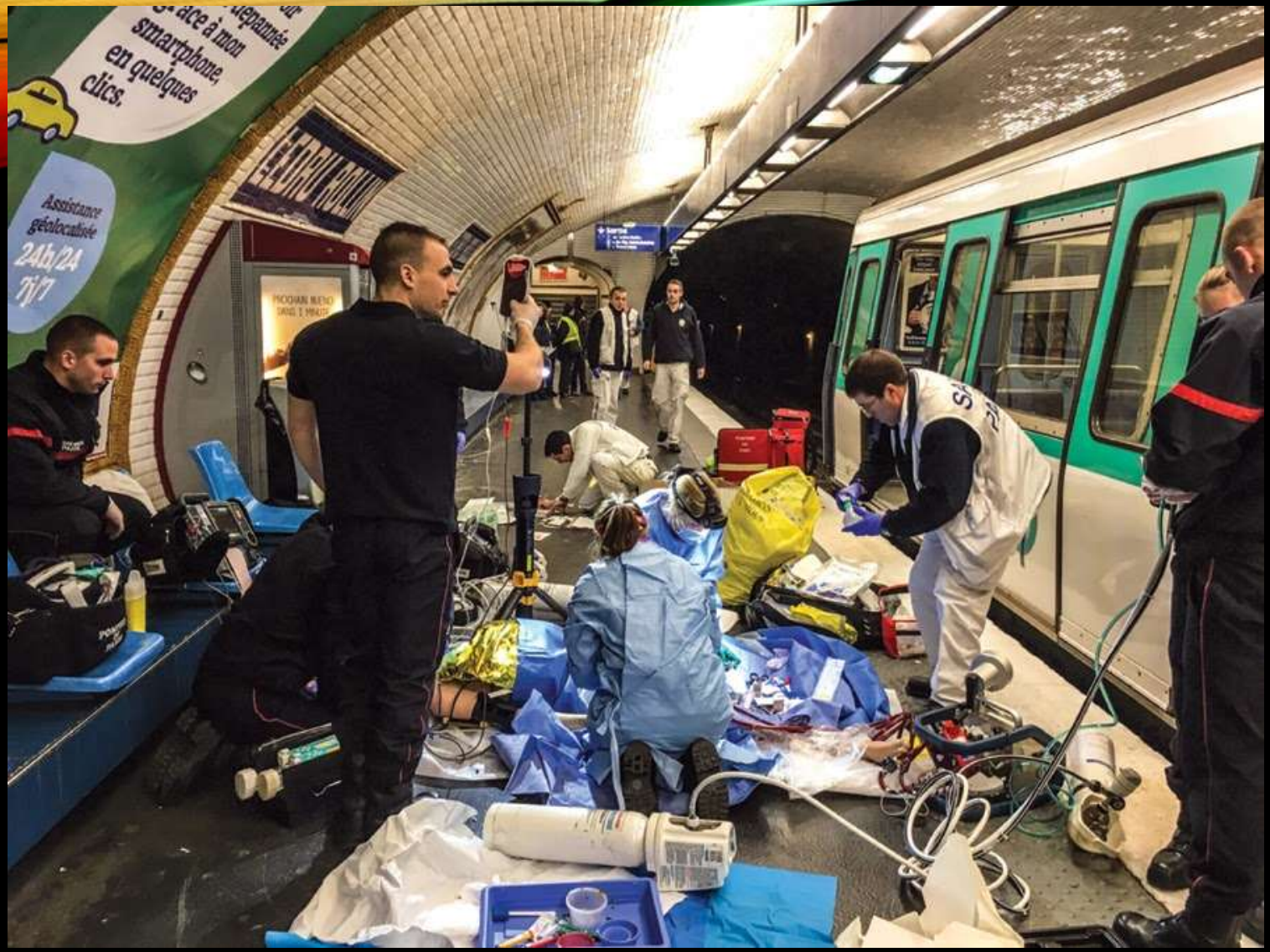


Figure 3. Dynamic probability of 1-month survival and 1-month survival with favorable neurological outcomes by CPR duration. CPR indicates cardiopulmonary resuscitation.

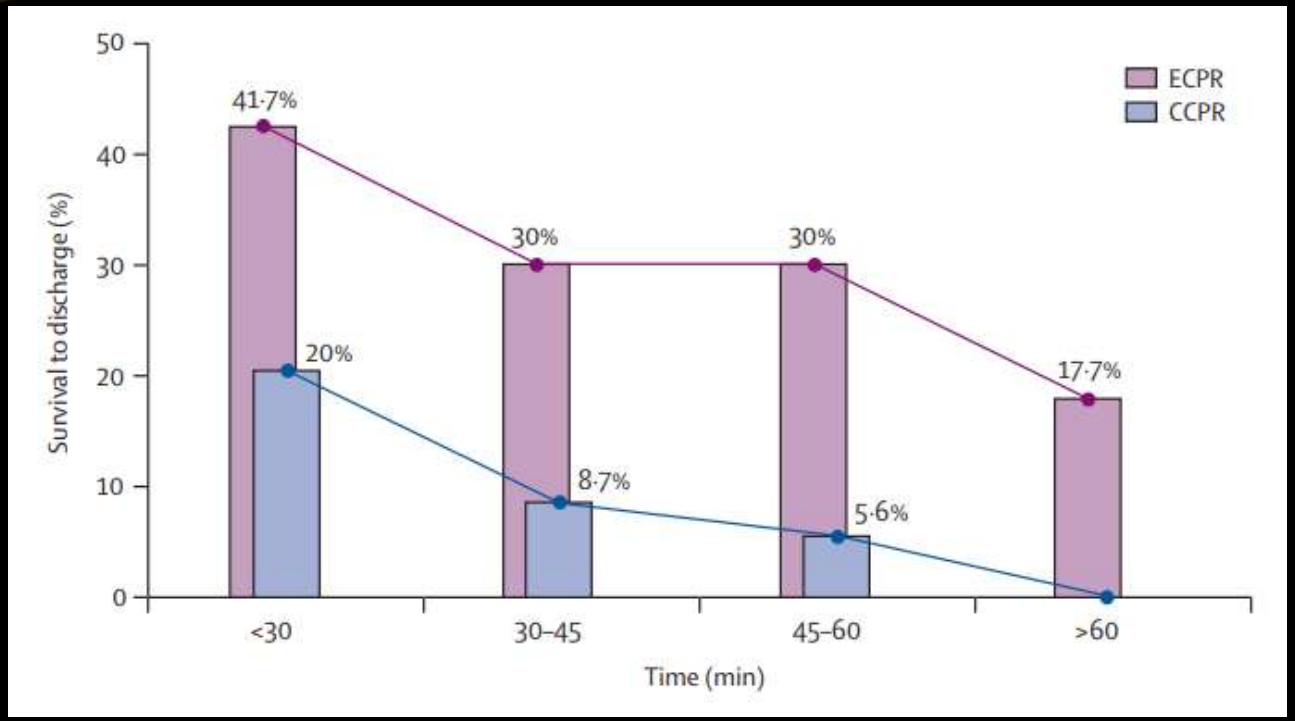
WHY ECPR?

- ECMO
  - Provide the work of the heart (flow) and lungs (oxygen)
  - Provides time to identify reversible causes
- ECMO is fast to start and can be portable
  - Smaller pumps
  - Often, no x-ray needed
- Rapid initiation in the ER/Cath lab/Paris Subway


smartphone,
en quelques
clics.
Assistance
géolocalisée
24h/24
7j/7

Cardiopulmonary resuscitation with assisted extracorporeal life-support versus conventional cardiopulmonary resuscitation in adults with in-hospital cardiac arrest: an observational study and propensity analysis

Yih-Sharng Chen*, Jou-Wei Lin*, Hsi-Yu Yu, Wen-Je Ko, Jih-Shuin Jerng, Wei-Tien Chang, Wen-Jone Chen, Shu-Chien Huang, Nai-Hsin Chi, Chih-Hsien Wang, Li-Chin Chen, Pi-Ru Tsai, Sheoi-Shen Wang, Juey-Jen Hwang, Fang-Yue Lin



- 3 year observational study
- 975 patients with in-hospital cardiac arrest
  - 113 were enrolled in the conventional CPR group
  - 59 were enrolled in the extracorporeal CPR group.
- CPR for longer than 10 min,

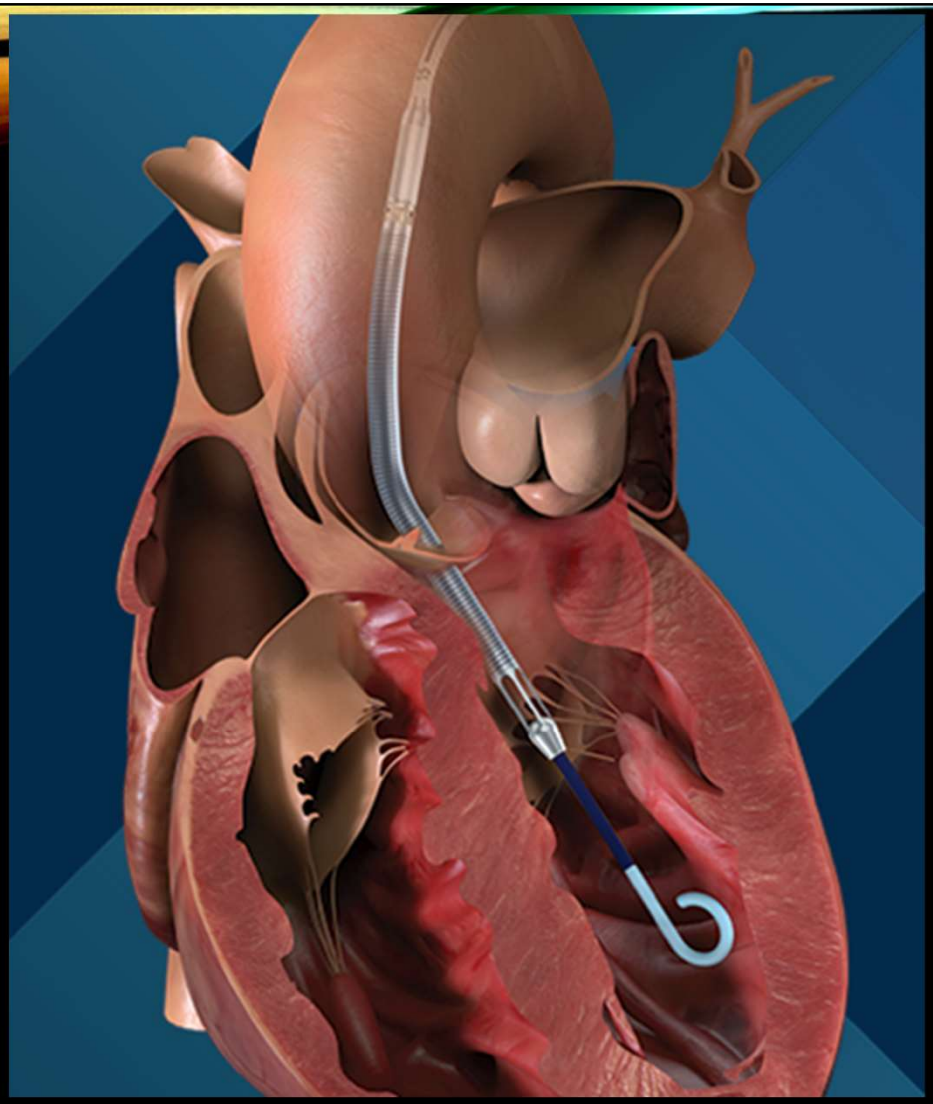
Lancet. 2008 Aug 16;372(9638)

ECPR CASE SELECTION

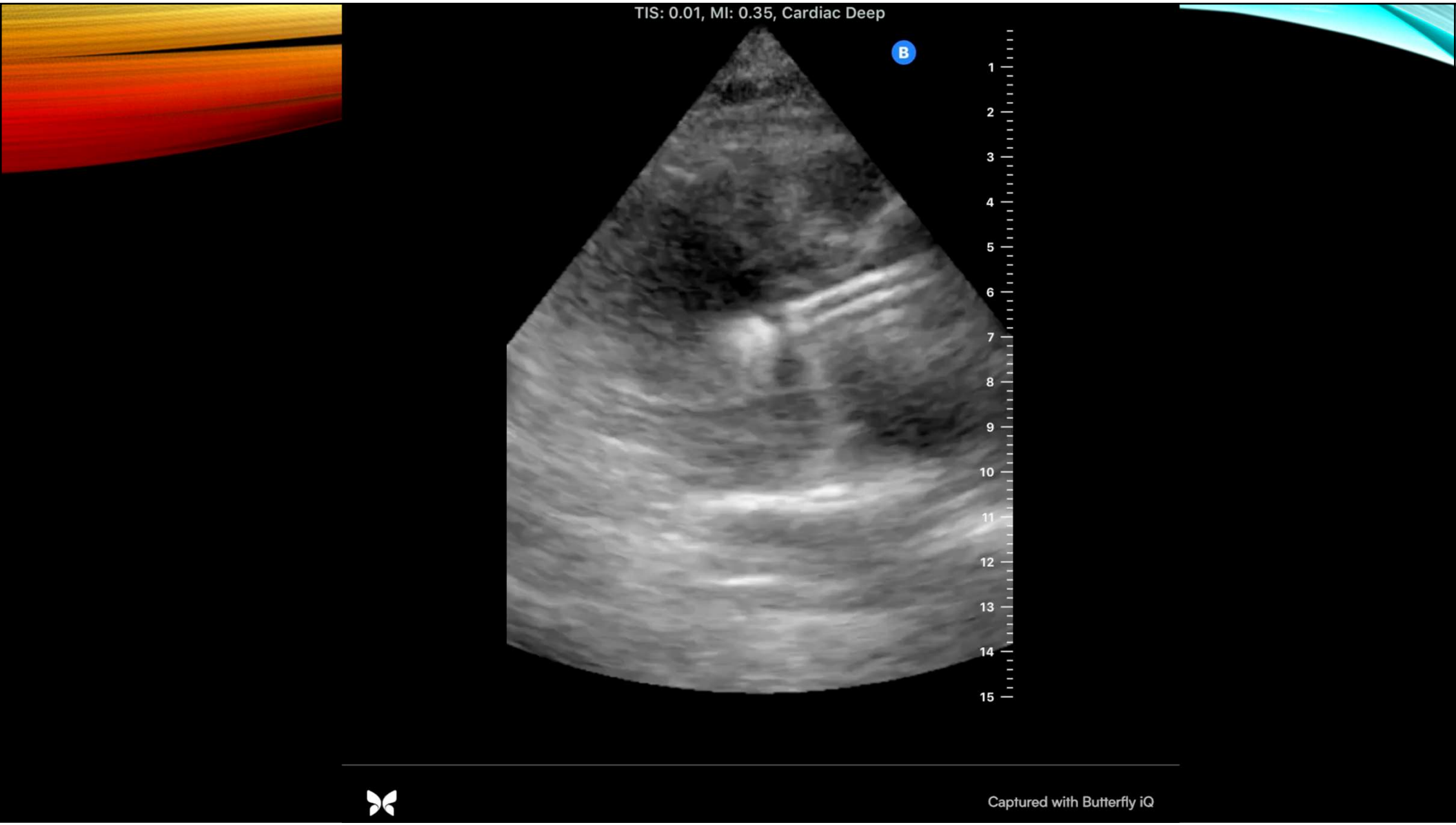
- Witnessed arrest / arrest to CPR < 10 minutes
- Arrest to ECMO support time < 60 minutes
- Likely a reversible cause
- < 70 years old
- Intermittent ROSC or recurrent VF
- Absence of known life limiting comorbidities- End stage renal/liver failure, end stage COPD, etc.

WHAT IS AN IMPELLA?

- Impella is a percutaneous VAD (pVAD)
- Can be inserted via groin or axilla (with surgical graft)
- Version available for right ventricular support
- Does not provide oxygenation



https://www.abiomed.com/products-and-services/impella


TIS: 0.01, MI: 0.35, Cardiac Deep
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Captured with Butterfly iQ


The New York Times
Heart Pump Is Linked to 49 Deaths, the F.D.A. Warns
The agency faulted the device maker for delayed notice of mounting complications, citing increasing reports of how use of the device perforated the walls of the heart.

IMPELLA - BENEFITS

- DANGER Trial - STEMI patients with decreased all cause death at day 180
- tMCS pre transplant improves renal function and survival

Moller et al. NEJGM 2024
Jang et al. Sci Rep 2023
Paghdar et al. J Geriatr Cardiol 2023

SO MANY TOOLS, HOW DO I CHOOSE?

- Team approach!
- First support the patient
- Then, rearrange support if needed to maximize support

QUESTIONS?