Indications for ECMO

Jay Menaker MD

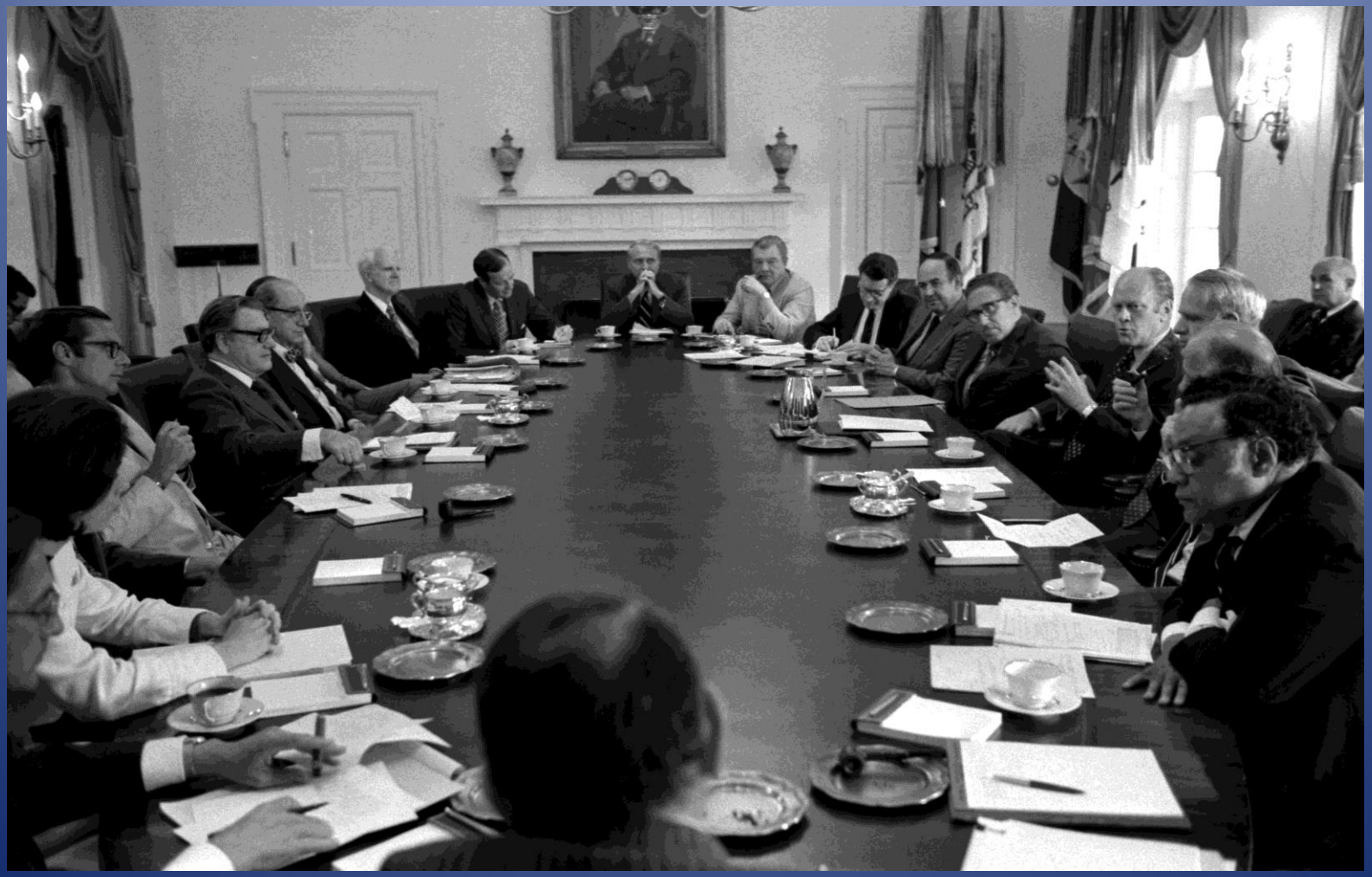
74th AAST Annual Meeting

Lunch Session

September 10, 2015

- I have no disclosures

Indications for ECMO



Indications for ECMO

- No absolutes
- Multiple studies with similar but variable indications
- Institution specific

NATIONAL HEART AND LUNG INSTITUTE

DIVISION OF LUNG DISEASES

PROTOCOL

FOR

EXTRACORPOREAL SUPPORT FOR RESPIRATORY INSUFFICIENCY

COLLABORATIVE PROGRAM

May 15, 1974

Indications for ECMO

Extracorporeal Membrane Oxygenation in Severe Acute Respiratory Failure

A Randomized Prospective Study

Warren M. Zapol, MD; Michael T. Snider, MD, PhD; J. Donald Hill, MD; Robert J. Fallat, MD; Robert H. Bartlett, MD; L. Henry Edmunds, MD; Alan H. Morris, MD; E. Converse Peirce II, MD; Arthur N. Thomas, MD; Herbert J. Proctor, MD; Philip A. Drinker, PhD; Philip C. Pratt, MD; Anna Bagniewski, MA; Rupert G. Miller, Jr, PhD

JAMA, Nov 16, 1979—Vol 242, No. 20

Inclusion criteria

- PaO_2 less that 50 mm HG for more than 2 hours with FiO_2 100% and PEEP > 5
  - (Fast criteria)
- PaO_2 < 50 mm HG for > 12 hours with FiO_2 60% ***and*** PEEP ≥ 5 cm H_20 ***and***
- Pulmonary shunt > 30%
  - When FiO_2 100% and PEEP ≥ 5 cm H_2O

Exclusion criteria

- Age < 12 years or > 65 years
- Pulmonary insult > 21 days
- PCWP > 25 mm HG
- Severe burns
- Rapidly fatal malignance
- Chronic systemic disease
  Heart, liver, renal failure

Indications for ECMO

Low-Frequency Positive-Pressure Ventilation With Extracorporeal CO_2 Removal in Severe Acute Respiratory Failure

Luciano Gattinoni, MD; Antonio Pesenti, MD; Daniele Mascheroni, MD; Roberto Marcolin, MD; Roberto Fumagalli, MD; Francesca Rossi, MD; Gaetano Iapichino, MD; Giuliano Romagnoli, MD; Ljli Uziel, MD; Angelo Agostoni, MD; Theodor Kolobow, MD; Giorgio Damia, MD

JAMA, Aug 15, 1986—Vol 256, No. 7

Inclusion criteria

- Similar to 1979 Zapol et al study
- Differences
  - Needed static compliance less < 30 ml/cmH_20

Exclusion criteria

- Similar to 1979 Zapol et al study
- Differences
  - Age extreme not a limitation
  - Time of pulmonary insult not a limitation

Indications for ECMO

Efficacy of Extracorporeal Life Support in the Setting of Adult Cardiorespiratory Failure

THOMAS PRANIKOFF, RONALD B. HIRSCHL, CYNTHIA N. STEIMLE, HARRY L. ANDERSON III, AND ROBERT H. BARTLETT

ASAIO Journal 1994

Table 1. ECLS Selection Criteria for Cardiopulmonary Failure in Adults

Indications	
Transpulmonary shunt (Qsp/Qt) ≥30%	Despite and after optimal care
Lung compliance <0.5 ml/cm H_2O/kg	
Diffuse infiltrates on CXR	
Cardiac failure not manageable by inotropic support/IABP	
Contraindications	
Age >60 yr	
Incurable condition	
Pre ECLS ventilation >10 days	
Relative Contraindications	
Multiple organ failure	
Pre ECLS ventilation >7 days	

Optimal Care

PCV, PEEP

Diuresis

Prone

Sedation

Paralysis

Indications for 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

(Lancet 2009;374:1351-63)

- CESAR Trial
  - Prospective
  - Randomized
    - Conventional management
    - Referral for ECMO consideration

Indications for ECMO – CESAR Trial

Inclusion Criteria

- 18-65 years old
- Severe but potentially reversible respiratory failure
  - Murray score > 3 or
  - Uncompensated hypercarbia with pH < 7.20

Exclusion criteria

- High pressure (PIP> 30 cm H_20) for > 7 days
- High FiO_2 (80%) > 7 days
- Intracranial hemorrhage
- Inability to tolerate heparin
- Contraindication to continuing treatment

Indications for ECMO

TABLE 2

COMPONENTS AND INDIVIDUAL VALUES OF THE LUNG INJURY SCORE*

		Value
1. Chest roentgenogram score		
No alveolar consolidation		0
Alveolar consolidation confined to 1 quadrant		1
Alveolar consolidation confined to 2 quadrants		2
Alveolar consolidation confined to 3 quadrants		3
Alveolar consolidation in all 4 quadrants		4
2. Hypoxemia score		
Pa_{O_2}/FI_{O_2}	≥300	0
Pa_{O_2}/FI_{O_2}	225–299	1
Pa_{O_2}/FI_{O_2}	175–224	2
Pa_{O_2}/FI_{O_2}	100–174	3
Pa_{O_2}/FI_{O_2}	<100	4
3. PEEP score (when ventilated)		
PEEP	≥5 cm H_2O	0
PEEP	6–8 cm H_2O	1
PEEP	9–11 cm H_2O	2
PEEP	12–14 cm H_2O	3
PEEP	≥15 cm H_2O	4
4. Respiratory system compliance score (when available)		
Compliance	≥80 ml/cm H_2O	0
Compliance	60–79 ml/cm H_2O	1
Compliance	40–59 ml/cm H_2O	2
Compliance	20–39 ml/cm H_2O	3
Compliance	≤19 ml/cm H_2O	4

The final value is obtained by dividing the aggregate sum by the number of components that were used

	Score
No lung injury	0
Mild-to-moderate lung injury	0.1–2.5
Severe lung injury (ARDS)	>2.5

* Abbreviations: Pa_{O_2}/FI_{O_2} = arterial oxygen tension to inspired oxygen concentration ratio; PEEP = positive end-expiratory pressure.

Murray et al. An Expanded definition of the adult respiratory distress syndrome
Am Rev Respir Dis 1988 Sep;138(3):720-3

Indications for ECMO

The Italian ECMO network experience during the 2009 influenza A(H1N1) pandemic: preparation for severe respiratory emergency outbreaks

Table 1 List of recommended national clinical criteria for early patient centralization and for ECMO eligibility

Recommended criteria for early patient centralization

From primary and secondary hospitals to tertiary hospitals with ARDS treatment experience

Suspected H1N1 infection with one of the following:

1. Need for invasive mechanical ventilation with PEEP
2. $FiO_2 > 0.6$

From any non-ECMO center to ECMOnet centers

Suspected H1N1 infection with one of the following:

1. $HbO_2 < 85\%$
2. OI > 25
3. $PaO_2/FiO_2 < 100$ with PEEP ≥ 10 cmH_2O
4. Hypercapnia and respiratory acidosis with pH < 7.25
5. SvO_2 or $SvcO_2 < 65\%$ despite Ht > 30 and administration of vasoactive drugs

ECMO criteria

Inclusion criteria

All adult and pediatric patients with severe ARDS related to suspected influenza A(H1N1) presenting with at least one of the following criteria despite the use of available rescue therapies:

1. OI > 30
2. $PaO_2/FiO_2 < 70$ with PEEP ≥ 15 cmH_2O (in patient already admitted to one of the ECMOnet centers)
3. $PaO_2/FiO_2 < 100$ with PEEP ≥ 10 cmH_2O (in patients still to be transferred)
4. pH < 7.25 for at least 2 h
5. Hemodynamic instability

Exclusion criteria

Absolute

1. Intracranial bleeding or other major contraindication to anticoagulation
2. Previous severe disability
3. Poor prognosis because of the underlying disease (i.e., unresolved malignancy)

Relative

1. MV > 7 days

PEEP Positive end-expiratory pressure, *FiO_2* inspired oxygen fraction, *HbO_2* oxygenated hemoglobin, *PaO_2/FiO_2* arterial partial pressure of oxygen to FiO_2 ratio, *OI* oxygenation index (computed as FiO_2 × mean airway pressure × 100/PaO_2), *MV* mechanical ventilation

Indications for ECMO

EOLIA Trial (*ECMO to rescue Lung Injury in severe ARDS)*

Inclusion criteria

- PaO_2/FiO_2 < 50 mm HG with FiO_2 ≥80% for > 3 hours
- PaO_2/FiO_2 < 80 mm HG with FiO_2 ≥80% > 6 hours
- pH < 7.25 for > 6 hours with Pplat ≤ 32 cm H_20

Despite optimal mechanical ventilation

Exclusion criteria

- Mechanical ventilation ≥ 7 days
- Age < 18 years
- Pregnant
- BMI > 45 kg/m^2
- Prior O_2 dependence
- History of HITT
- Malignancy and fatal prognosis within 5 years
- Neurologic devastation
- DNR

Indications for ECMO – ELSO

- ***Inclusion criteria***
  - Hypoxic respiratory failure
    - ECMO ***considered*** at 50% mortality risk
      - $PaO_2/FiO_2 < 150$, $FiO_2 > 90\%$ and/or
      - Murray Score 2-3
    - ECMO ***indicated*** (most circumstances) at 80% mortality risk
      - $PaO_2/FiO_2 < 100$, $FiO_2 > 90\%$ and/or
      - Murray score 3-4 despite optimal care for at least 6 hours
  - CO_2 retention on mechanical ventilation despite high Pplat (> 30 cm H_2O)
  - Severe air leak syndrome
  - Need for intubation on a patient on lung transplant list

ELSO – Extracorporeal Life Support Organization – Guidelines for Adult Respiratory Failure December 2013

Indications for ECMO – ELSO

- ***Exclusion criteria***
  - ***No absolute contraindications***
  - Relative contraindications
    - Mechanical ventilation at high settings (> 90% FiO_2, Pplat > 30 cm H_2O) for > 7 days
    - Major pharmacologic immunosuppression (ANC < 400/mm^3)
    - Pre-exiting conditions which affect quality of life
      - CNS hemorrhage that is recent or expanding
      - Terminal malignancy
    - Age – no specific contraindication, but increasing risk with increasing age

ELSO – Extracorporeal Life Support Organization – Guidelines for Adult Respiratory Failure December 2013

Predicting Survival after Extracorporeal Membrane Oxygenation for Severe Acute Respiratory Failure

The Respiratory Extracorporeal Membrane Oxygenation Survival Prediction (RESP) Score

American Journal of Respiratory and Critical Care Medicine Volume 189 Number 11 | June 1 2014

Table 3: The RESP Score at ECMO Initiation

Parameter	Score
Age, yr	
18 to 49	0
50 to 59	−2
⩾60	−3
Immunocompromised status*	−2
Mechanical ventilation prior to initiation of ECMO	
<48 h	3
48 h to 7 d	1
>7 d	0
Acute respiratory diagnosis group (select only one)	
Viral pneumonia	3
Bacterial pneumonia	3
Asthma	11
Trauma and burn	3
Aspiration pneumonitis	5
Other acute respiratory diagnoses	1
Nonrespiratory and chronic respiratory diagnoses	0
Central nervous system dysfunction†	−7
Acute associated (nonpulmonary) infection‡	−3
Neuromuscular blockade agents before ECMO	1
Nitric oxide use before ECMO	−1
Bicarbonate infusion before ECMO	−2
Cardiac arrest before ECMO	−2
Pa_{CO_2}, mm Hg	
<75	0
⩾75	−1
Peak inspiratory pressure, cm H_2O	
<42	0
⩾42	−1
Total score	−22 to 15

Hospital Survival by Risk Class		
Total RESP Score	**Risk Class**	**Survival**
⩾6	I	92%
3 to 5	II	76%
−1 to 2	III	57%
−5 to −2	IV	33%
⩽−6	V	18%

Table 2: Pre-ECMO Factors Associated with Survival to Hospital Discharge (Candidate Factors for the RESP Score) in Multivariate Analysis

Pre-ECMO Support	Odds Ratio (95% CI)	*P* Value
Age	0.98 (0.97–0.99)	<0.0001
Immunocompromised*	0.64 (0.42–0.95)	0.029
Bacterial pneumonia	2.12 (1.63–2.75)	<0.0001
Viral pneumonia	2.26 (1.62–3.14)	<0.0001
Asthma	17.7 (3.72–83.8)	<0.0001
Trauma and burn	1.82 (1.22–2.71)	0.003
Aspiration pneumonitis	3.45 (1.82–6.53)	<0.0001
Others acute respiratory diagnoses	1.29 (1.02–1.62)	0.032
Central nervous system dysfunction†	0.15 (0.10–0.22)	<0.0001
Acute nonpulmonary-associated infection‡	0.46 (0.34–0.62)	<0.0001
Renal dysfunction§	0.77 (0.61–0.98)	0.038
Cardiac arrest	0.62 (0.45–0.85)	0.003
Mechanical ventilation time prior to initiation of ECMO, d	0.989 (0.980–0.998)	0.017
Neuromuscular blockade agents	1.40 (1.14–1.66)	0.001
Inhaled nitric oxide	0.68 (0.54–0.85)	0.001
Bicarbonate infusion	0.69 (0.54–0.88)	0.002
Peak inspiratory pressure	0.992 (0.986–0.998)	0.009
Pa_{CO_2}	0.996 (0.993–0.999)	0.020

The PRESERVE mortality risk score and analysis of long-term outcomes after extracorporeal membrane oxygenation for severe acute respiratory distress syndrome

Intensive Care Med (2013) 39:1704–1713

Table 4 The PRESERVE score calculated with parameters available at the time of decision to initiate ECMO

Parameter	Score
Age (years)	
<45	0
45–55	2
>55	3
Body mass index >30	−2
Immunocompromised	2
SOFA >12[a]	1
MV >6 days	1
No prone positioning before ECMO	1
PEEP < 10 cm H_2O	2
Plateau pressure >30 cm H_2O	2
Total score[c]	0–14

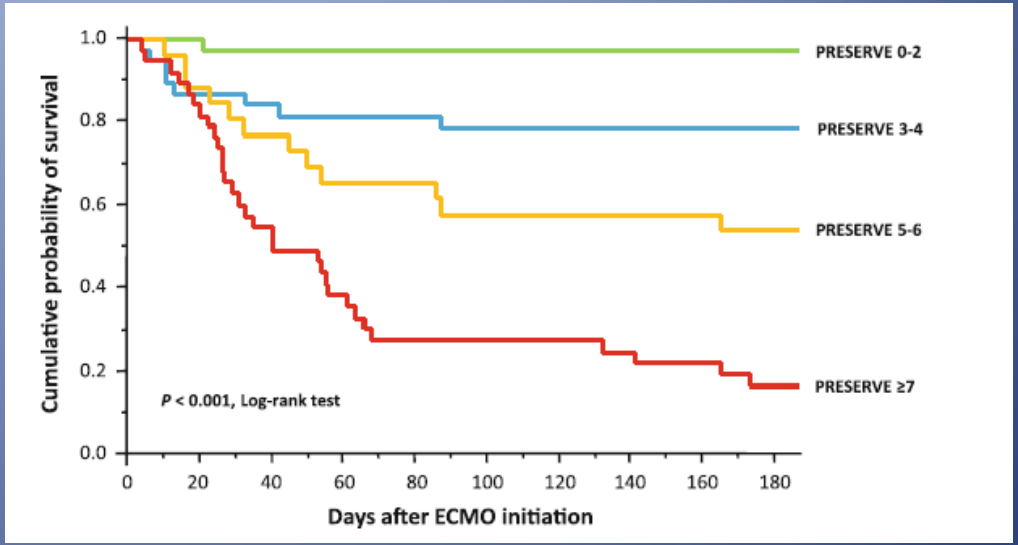


Table 3 Factors available at ECMO institution independently associated with death by 6 months post-ICU discharge

Factor	OR (95 % CI)	*p*-Value
Age	1.08 (1.04–1.12)	<0.001
Body mass index	0.90 (0.84–0.97)	0.004
Immunocompromised[a]	4.33 (1.55–12.12)	0.005
SAPS II[b]	1.04 (1.00–1.08)	0.028
Days of MV	1.07 (1.01–1.14)	0.015
No prone positioning before ECMO	2.93 (1.04–8.25)	0.043
PEEP, cm H_2O	0.84 (0.71–0.99)	0.039
Plateau pressure, cm H_2O	1.18 (1.05–1.32)	0.006

Indications for ECMO after Trauma

Venovenous extracorporeal membrane oxygenation for acute lung failure in adults

Christof Schmid, MD,[a] Alois Philipp,[a] Michael Hilker, MD,[a] Leopold Rupprecht, MD,[a] Matthias Arlt, MD,[b] Andreas Keyser, MD,[a] Matthias Lubnow, MD,[c] and Thomas Müller, MD[c]

The Journal of Heart and Lung Transplantation, Vol 31, No 1, January 2012

Inclusion criteria*

PaO_2/FiO_2< 80 mmHG

PEEP 18 cm H_20

Refractory respiratory acidosis, pH < 7.25

*Despite recruitment maneuver proning, inhaled vasodilators, HFOV

Variable[a]	Trauma with ARDS (n = 14)
Age, years	27.8 ± 12.5
Body mass index, kg/m²	28.0 ± 5.8
Pre-ECMO ventilation, days	4.4 ± 8.8
$Pa0_2/FI0_2$	56 ± 13
$Pac0_2$, mm Hg	72 ± 29
pH	7.2 ± 0.2
PIP max, cm H_20	38 ± 5
PEEP, cm H_20	19 ± 6
Resp minute volume, liters/min	11.2 ± 4.0
Lung Injury Score	3.5 ± 0.4

Indications for ECMO after Trauma

Venovenous extracorporeal life support improves survival in adult trauma patients with acute hypoxemic respiratory failure: A multicenter retrospective cohort study

Derek M. Guirand, MD, Obi T. Okoye, MD, Benjamin S. Schmidt, MD, Nicky J. Mansfield, BS, James K. Aden, PhD, R. Shayn Martin, MD, Ramon F. Cestero, MD, Michael H. Hines, MD, Thomas Pranikoff, MD, Kenji Inaba, MD, *and* Jeremy W. Cannon, MD, *San Antonio, Texas*

J Trauma Acute Care Surg
Volume 76, Number 5

Inclusion criteria
- Age 16-55 years
- $PaO_2/FiO_2 < 80$ with $FiO_2 > 90\%$
- No evidence of cardiogenic pulmonary edema
- Murray score ≥ 3.0

Exclusion criteria
- Non trauma
- Cardiogenic shock
- Acute intracranial hemorrhage
- Expired within 24 hours of admission

Indications for ECMO after Trauma

Use of extracorporeal membrane oxygenation in severe traumatic lung injury with respiratory failure☆,☆☆,★

Shih-Chi Wu, MD, Msc [a,b,*], William Tzu-Liang Chen, MD [b,c], Hui-Han Lin, MD [d], Chih-Yuan Fu, MD [e], Yu-Chun Wang, MD [a,b], Hung-Chieh Lo, MD [a,b], Han-Tsung Cheng, MD [a], Chia-Wei Tzeng, MD [a]

American Journal of Emergency Medicine 33 (2015) 658–662

2.1. Inclusion criteria for ECMO in severe traumatic lung injury

Patients with traumatic lung injury who received conventional management initially were considered candidates for ECMO when they met one of the following criteria:

1. Arterial Pao_2/fraction of inspired oxygen (1.0) less than 60 and PEEP greater than 10 cm H_2O for 2 hours in spite of optimized mechanical ventilation strategy and conservative treatment.
2. Irreversible CO_2 retention with unstable hemodynamics.
3. The initial arterial blood gas Pao_2/fraction of inspired oxygen (1.0) less than 60, where the pulmonary condition and hemodynamics rapidly deteriorated despite vigorous mechanical ventilation strategy.

Indications for ECMO – UMMC/STC

- University of Maryland Medical Center/R Adams Cowley Shock Trauma Center (UMMC/STC)
  - ***Inclusion criteria*** (Non Trauma/Non Transplant)
    - Murray Score ≥ 3
    - Hypercapnia with pH < 7.25 or inability to ventilate with Pplat ≤ 30 cm H20
    - On ventilator ≤ 10 days
    - ≤ 75 years old
    - Reversible etiology of ARDS
    - Bedside physician discretion

Indications for ECMO – UMMC/STC

- ***Exclusion criteria (Relative)***
  - > 75 years of age
  - > 10 days on the ventilator
  - Requiring home O_2 therapy for severe lung disease
  - Severe neurological insult
  - Terminal disease with low 1 year survival rate
  - Jehovah's witness
  - Bedside physician clinical discretion

Indications for ECMO – UMMC/STC

- Trauma
  - Guidelines for consideration/initiation of VV ECMO
    - ***Inclusion criteria***
      - Any patient post traumatic pneumonectomy
      - PaO_2 < 100 mmHG with $Fi0_2$ ≥ 80%, and Pplat ≥ 30 cm H_20 or P1 ≥ 30 cm H_20 ***or*** Hypercapnia (CO2>60) with pH <7.25, or inability to adequately ventilate with Pplat ≤ 30 **and**
      - On ventilator ≤ 7 days
      - < 70 years of age
      - Patient with a reversal form of ARDS – (infectious, trauma, post-operative)
      - Bedside physician clinical discretion

Indications for ECMO – UMMC/STC

- Trauma
  - Guidelines for consideration/initiation of VV ECMO
    - ***Exclusion criteria***
      - Same as non trauma
      - Underlying cirrhosis (Child class C or MELD≥ 30)
      - Abdominal compartment syndrome
      - Bedside physician clinical discretion
  - ***The use of VA ECMO following injury for patients without a direct cardiac injury is discouraged***

- Conclusion:
  - Earlier is probably better
  - No absolutes
    - Severe hypoxia or hypercarbia not responding to maximal therapy
  - VA ECMO after trauma is not recommended