VV-ECMO Should Be Considered a First-line Treatment for Severe ARDS

Pro VV-ECMO:

Karsten J. Roberts, MSc, RRT, RRT-ACCS

Hospital of the University of Pennsylvania

Philadelphia, PA

Conflicts of Interest

I have no real or perceived conflicts of interest that relate to this presentation.

Objectives

1. Review venous-venous ECMO
2. Summarize current literature supporting VV-ECMO

Non-Ventilatory Strategies for ARDS management

Pooled Mortality in "conventional treatment" is 48% in observational studies, 37% in RCTs

- Neuromuscular blockades
- Inhaled Nitric oxide
- Prone positioning
- IV Phenylephrine, Avoidance of Systemic Vasodilators
- Other considerations:
  - Conservative Fluid management
  - Corticosteroids
  - Nutritional Supplementation

Rozencwajg et al 2016*/Schmidt et al 2019*

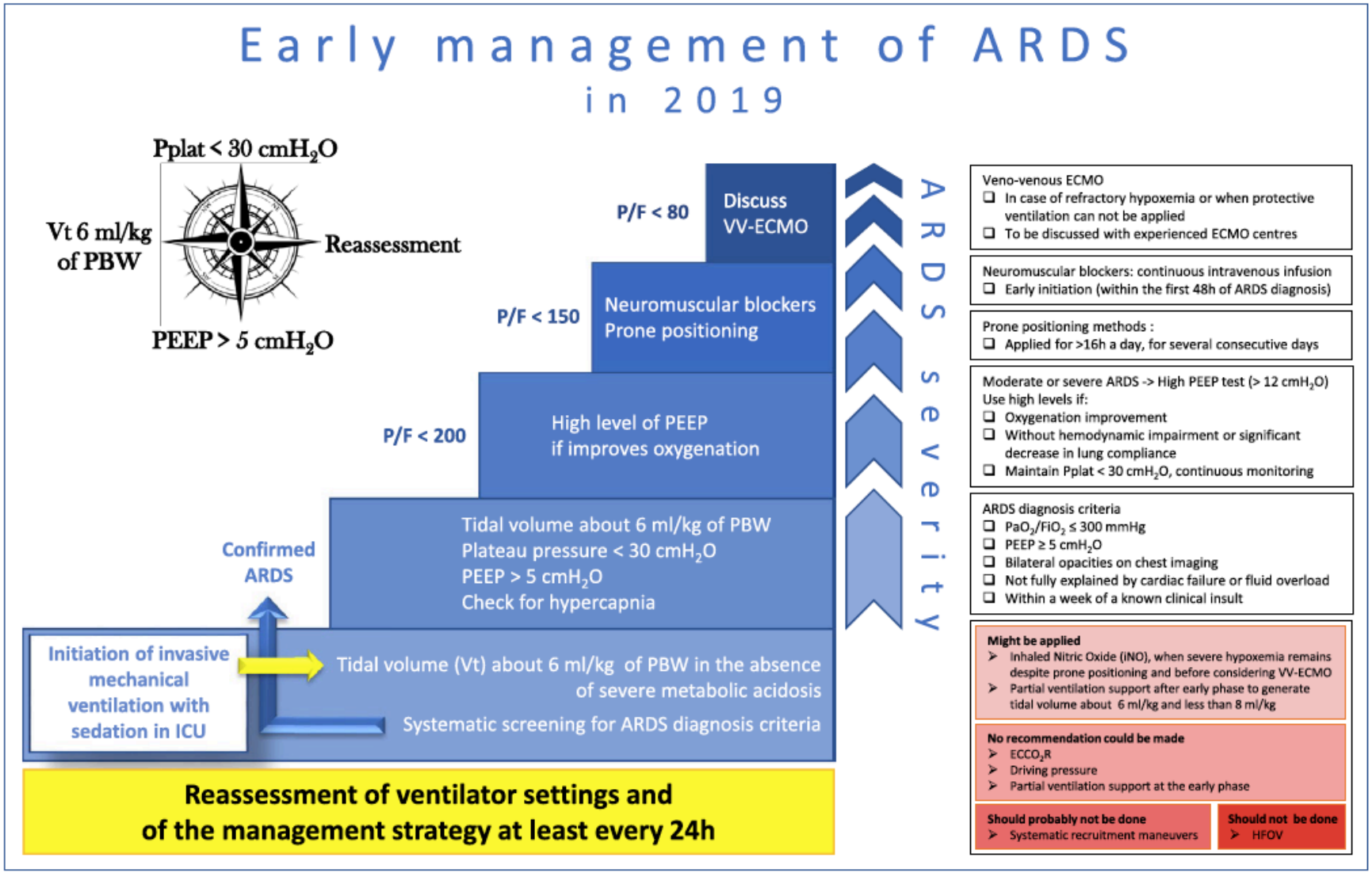
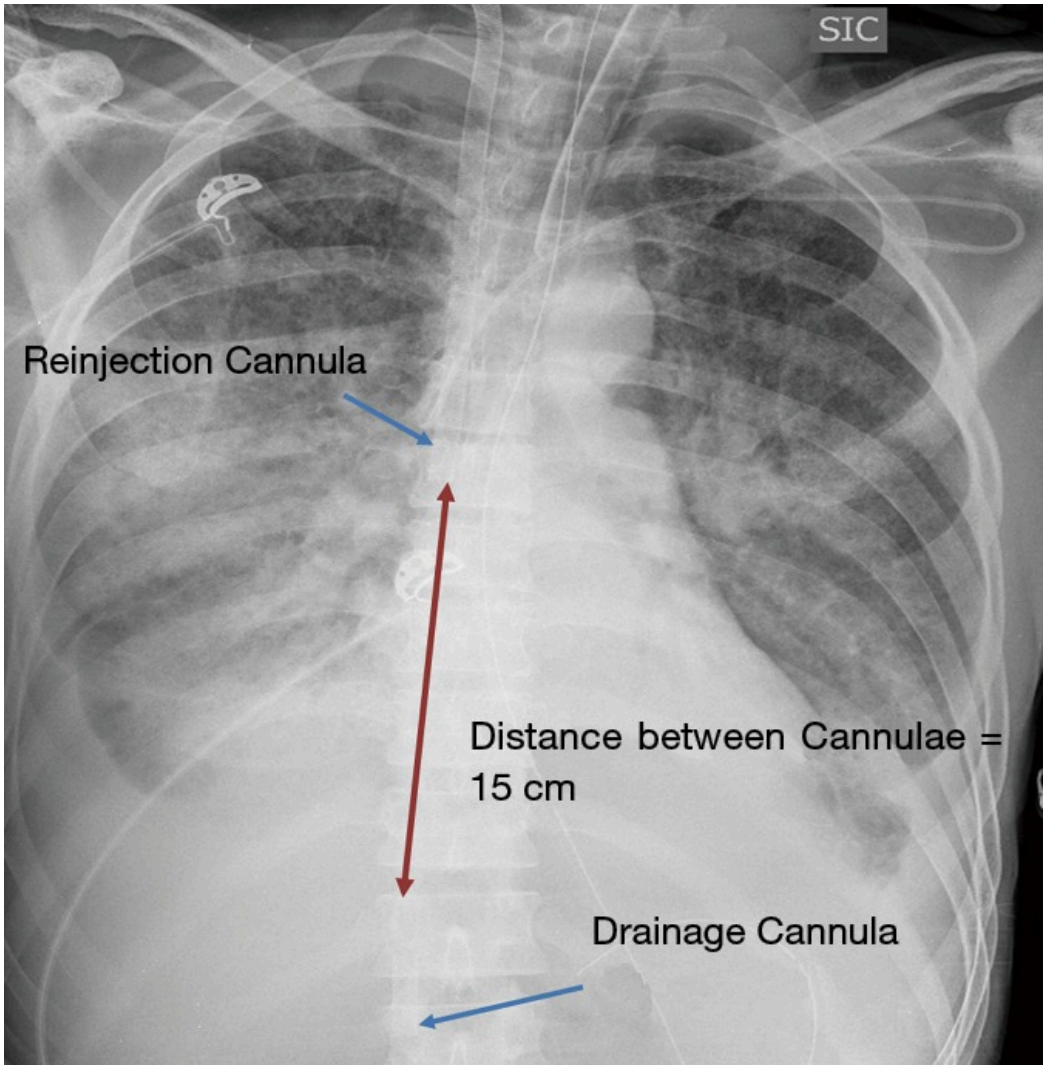


Fig. 1 Therapeutic algorithm regarding early ARDS management (EXPERT OPINION)

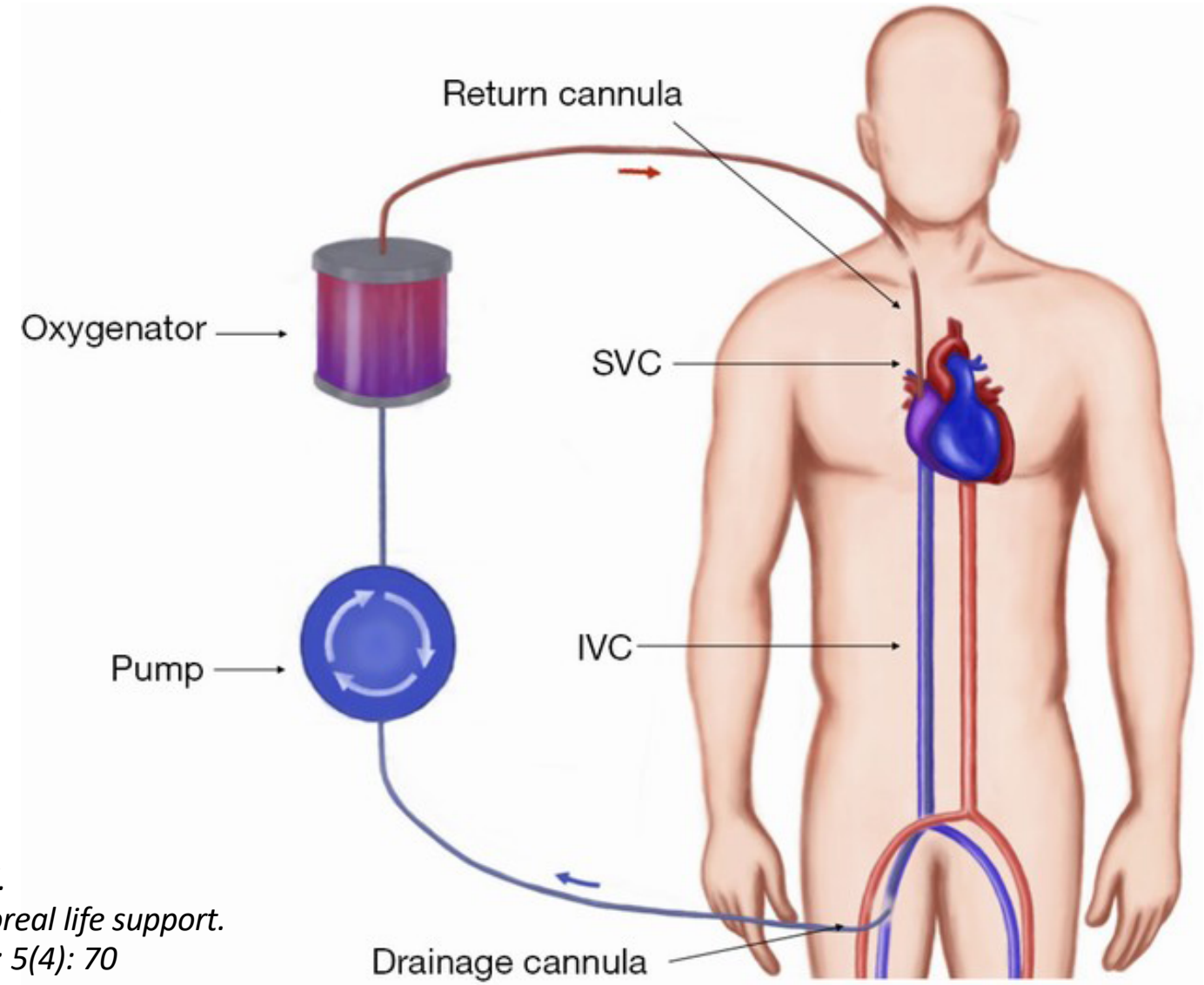
VV-ECMO

Venous Venous
No cardiac support
Cannulation from venous back to venous
Pulmonary blood flow maintained
Not used with RV failure
Lower PaO_2 achieved (avoid O_2 toxicity)
Runs in series with the heart and lungs

Makdisi G & Wang I. Journal of Thoracic Disease. 2015, 7(7): E166-E176



Veno-Venous ECMO



Pavlushkov E, Berman M, Valchanov K.
Cannulation techniques for extracorporeal life support.
Annuls of Transitional Medicine. 2017; 5(4): 70

Patient Population

Indications

- ARDS
- Bronchopulmonary aspiration
- Bacterial, viral or atypical pneumonia
- interstitial pneumonitis
- OI > 40, Murray Score 3 - 4

Contra-indications

- Advanced, irreversible disease
- uncontrolled sepsis
- non-pulmonary multi-organ failure
- irreversible neurological injury
- terminal illness

"Patients with chronic respiratory failure or ventilator-dependent respiratory failure who are not eligible to be bridged to lung transplantation should not be considered as candidates for VV-ECMO." --Banfi, et al. Journal of Thoracic Disease, 2016

Indications

Oxygen index = Mean airway pressure x FiO2/PaO2

Example: MAP (22) x FiO2 (100%)/PaO2 (55) = OI (40)

OI < 5 = Normal

OI > 10 = Hypoxemia

OI > 20 = Severe hypoxemia

OI > 40 = Consider ECMO

Indications

Murray Score: severity of lung injury, patient selection

Example: Consolidation in 3 lung quadrants (3)

PaO2/FiO2 ratio < 100 (4)

PEEP = 10 cmH2O (2)

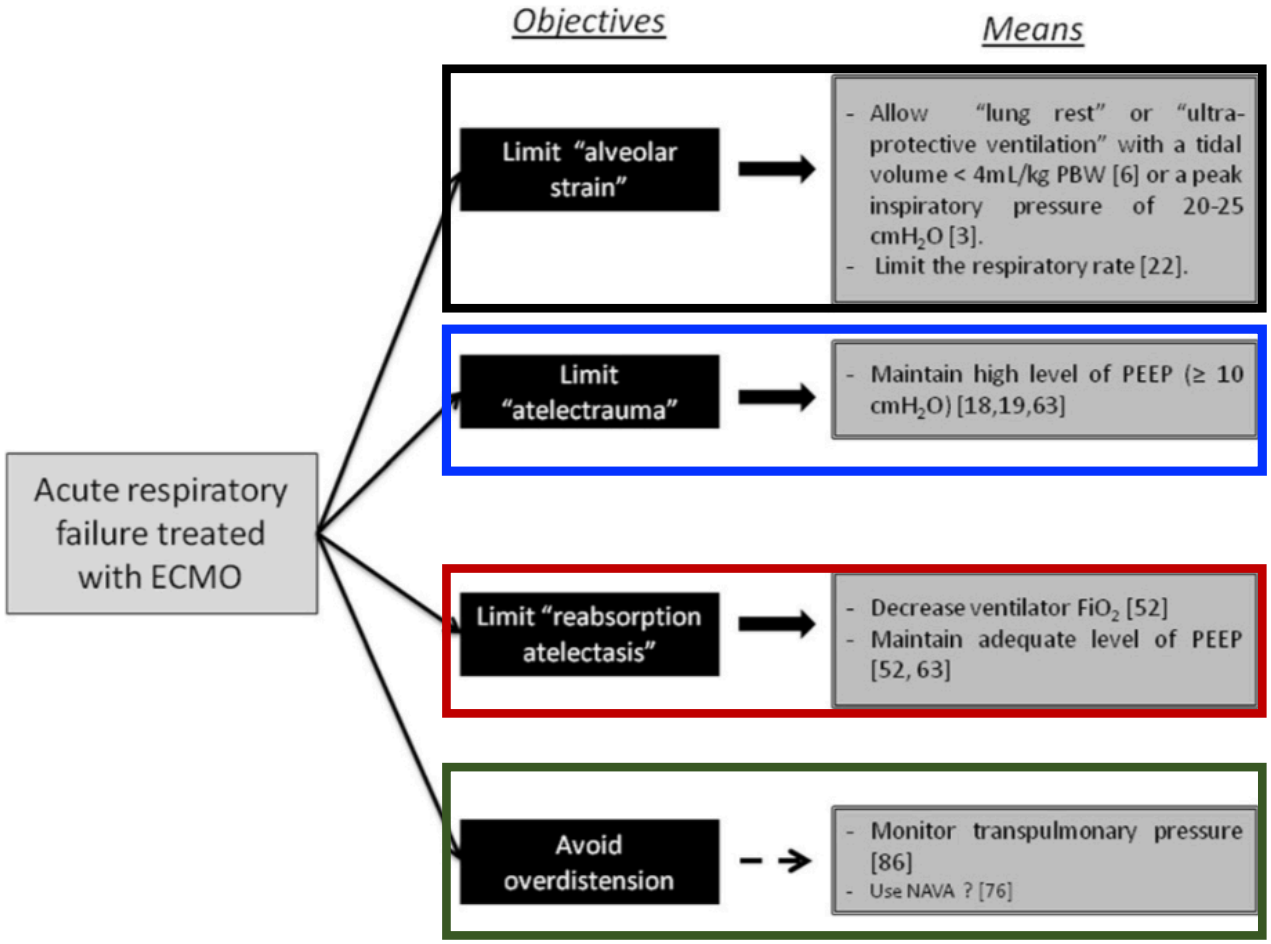
Lung Compliance = 15 mL/cmH2O (4)

Murray Score = 3.3

Patients with severe ARDS and a Murray score of 3 – 4 should be considered.

Benefits

- Survival reported between 53 – 63%
- Lung protection
- mechanical ventilation equals inflammation & potential lung injury



Mass General, 2009; CESAR Trial, 2009; Schmidt et al, 2014

jamanetwork.com

Extracorporeal Membrane Oxygenation for Nonneonatal Acute Respiratory Failure: The Massachusetts General Hospital Experience From 1990 to 2008 | Critical Care Medicine | JAMA Surgery

Deepika Nehra, MD; Allan M. Goldstein, MD; Daniel P. Doody, MD; et al

- Survival benefit in “carefully selected patients with non-neonatal respiratory failure.”
- Overall survival 53%
- Highest survival in patients with viral or bacterial pneumonia
- Risk of mortality increased with:
  1. Older age, multiple organ failure,
  2. prolonged ventilation prior to ECMO initiation
  3. long ECMO runs are associated with decreased survival.

BMC Health Services Research

BioMed Central

Study protocol

Open Access

CESAR: conventional ventilatory support vs extracorporeal membrane oxygenation for severe adult respiratory failure

Giles J Peek*[1], Felicity Clemens[2], Diana Elbourne[2], Richard Firmin[1], Pollyanna Hardy[2,3], Clare Hibbert[5], Hilliary Killer[1], Miranda Mugford[4], Mariamma Thalanany[4], Ravin Tiruvoipati[1], Ann Truesdale[2] and Andrew Wilson[6]

- 180 patients randomized to ECMO or conventional ventilation
- 63% of patients survived without severe disability (6 months)
- ICU LOS (median days): 24 vs. 13
- Hospital LOS (median days): 35 vs. 17

Conclusion: Recommend transferring adult patients with severe but potentially reversible respiratory failure….to a center where ECMO-based management is available.

Intensive Care Medicine
October 2013, Volume 39, Issue 10, pp 1704–1713 | Cite as

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

- 140 patients (Three French ICUs)
- Ninety-five percent of patients received VV-ECMO
- Median time, intubation to ECMO cannulation of 5 days
- Bacterial pneumonia was the main cause of ARDS (45%)
- Survival rates:
  - Sixty-four percent at ICU discharge
  - Sixty percent at 6-months

Predicting Survival after Extracorporeal Membrane Oxygenation for Severe Acute Respiratory Failure. The Respiratory Extracorporeal Membrane Oxygenation Survival Prediction (RESP) Score

Matthieu Schmidt [1,2], Michael Bailey [1,3], Jayne Sheldrake [3], Carol Hodgson [1,3], Cecile Aubron [1], Peter T. Rycus [4], Carlos Scheinkestel [3], D. Jamie Cooper [1,3], Daniel Brodie [4,5], Vincent Pellegrino [1,3], Alain Combes [2], and Show All...
+ Author Affiliations
https://doi.org/10.1164/rccm.201311-2023OC **PubMed:** 24693864

- 2355 patients extracted from the international ELSO registry
- ECMO initiated after a median of 57 hours of MV
- 49% of patients receiving neuromuscular blocker agents
- 20% inhaled nitric oxide and 10% HFOV
- Fifty-seven per cent of patients were alive at hospital discharge
- Median of 170 hours on ECMO.

American Journal of Respiratory and Critical Care Medicine, 2014

Abrams *et al. Critical Care* 2014, **18**:R38
http://ccforum.com/content/18/1/R38

RESEARCH Open Access

Early mobilization of patients receiving extracorporeal membrane oxygenation: a retrospective cohort study

- Retrospective cohort, 100 patients on ECMO that participated in PT
- Secondary outcomes:
  1. Duration of ECMO 14.3days+/-10.9
  2. 23 patients liberated from mechanical ventilation
  3. 14 bridge to recovery patients survived to discharge
  4. 9 bridge to transplant patients survived to discharge
  5. 57% of survivors discharged to home.

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 MAY 24, 2018 VOL. 378 NO. 21

Extracorporeal Membrane Oxygenation for Severe Acute Respiratory Distress Syndrome

- 249 patients randomized
- ECMO versus MV with prone position and NMBA
- Inclusion criteria P_aO_2/F_iO_2 ratio 50 – 80 mmHg
- 60-day mortality, 35% versus 46% died (P=0.09)
- No significant difference in outcomes

Combes et al, 2018

EOLIA Trial

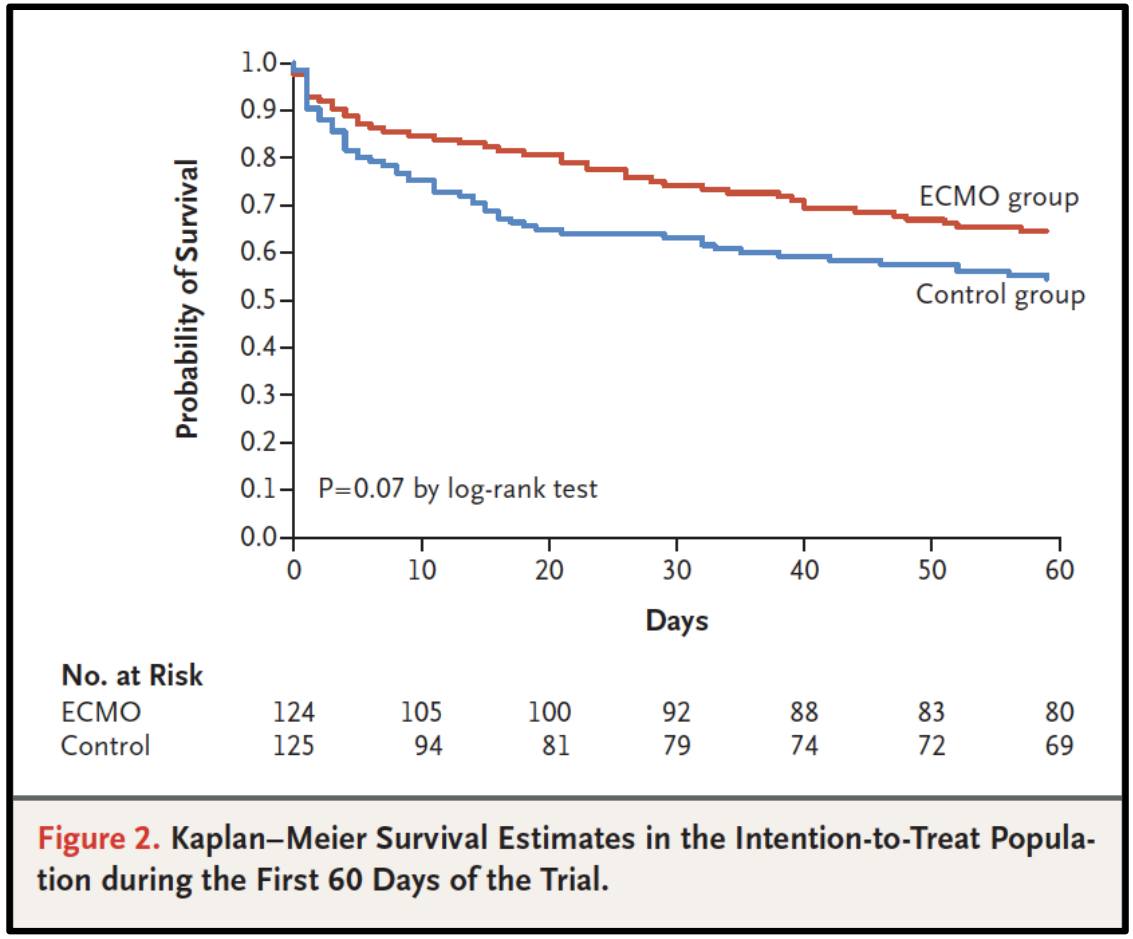


Figure 2. Kaplan–Meier Survival Estimates in the Intention-to-Treat Population during the First 60 Days of the Trial.

ORIGINAL ARTICLE

Mechanical Ventilation Management during Extracorporeal Membrane Oxygenation for Acute Respiratory Distress Syndrome

An International Multicenter Prospective Cohort

- 350 patients, 23 ICUs
- Prone position and NMBA
- VT (6.46 vs 3.76 ml/kg), P_{PLAT} (32 vs.24 cmH2O), ΔP (20 vs.14 cm H2O)
- Six-month survival 61%

Schmidt et al. Am J Respir Crit Care Med 2019;200(8) pp 1002–1012

Table 4. Predictors of 6-Month Mortality of Patients with Severe ARDS Rescued by ECMO

Variable	OR (95% CI)	*P* Value
Pre-ECMO		
Age, per additional year	1.03 (1.02–1.05)	<0.001
Immunocompromised condition	3.85 (2.11–7.17)	<0.001
Extrapulmonary sepsis	2.32 (1.18–4.56)	0.014
Delay from intubation to the initiation of ECMO, for each day	1.08 (1.03–1.14)	0.004
pH, for 0.01 unit	0.98 (0.96–0.99)	0.004
Pre- and early post-ECMO		
Age, per additional year	1.03 (1.01–1.05)	<0.001
Immunocompromised condition	3.81 (2.10–7.02)	<0.001
Extrapulmonary sepsis	2.61 (1.30–5.30)	0.007
Delay from intubation to the initiation of ECMO, for each day	1.11 (1.05–1.18)	<0.001
Lactate in the first 2 d on ECMO, for 1 mmol/L	1.15 (1.01–1.33)	0.043
Fluid balance in the first 2 d on ECMO, for 1 L	1.28 (1.11–1.50)	0.001

Schmidt et al. Am J Respir Crit Care Med 2019;200(8) pp 1002–1012

Goals of Care

- Move, quickly toward recovery AND prevent further damage
- Improve oxygenation
- Improve lung mechanics
- Supportive Care
- Timing
    - potentially reversible causes
    - within 7 days of onset
    - no significant comorbidities
    - < 65 years old
    - no contraindications for anticoagulation

Raoof et al. Severe Hypoxemic Respiratory Failure. Chest. 2010; 137(6):1437-1448

"VV-ECMO is the treatment of choice for patients with respiratory failure refractory to optimal mechanical ventilation and conventional medical treatments."

-- Banfi et al. 2016.

COVID-19 Cases on ECMO in the ELSO Registry

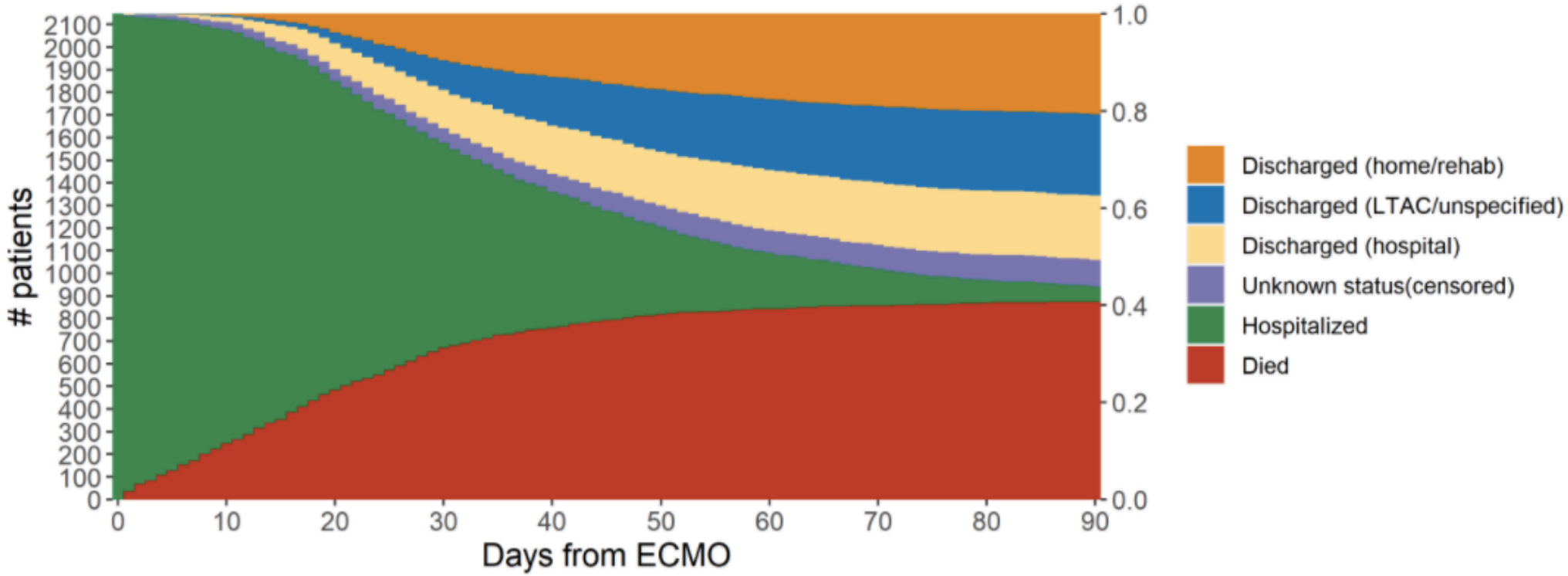
Total COVID-19 Cases	COVID-19 Suspected or Confirmed	COVID-19 Confirmed Cases
	2904	2895

Total counts of COVID-19 confirmed patients and count of COVID-19 suspected but not confirmed by testing.

Patients who initiated ECMO at least 90 days ago	COVID-19 Confirmed	COVID-19 In-hospital Mortality
	2147	42%

https://www.elso.org/Registry/FullCOVID19RegistryDashboard; Accessed 20 October 2020

Outcomes



https://www.elso.org/Registry/FullCOVID19RegistryDashboard; Accessed 20 October 2020

Should VV ECMO be used as the first-line in the treatment of ARDS?

Thank you!

Karsten J. Roberts, MSc, RRT, RRT-ACCS

Karsten.Roberts@pennmedicine.upenn.edu

Should VV ECMO be used as the first-line in the treatment of ARDS?

Pro Ventilation First:

Maria Madden, MS, RRT-ACCS

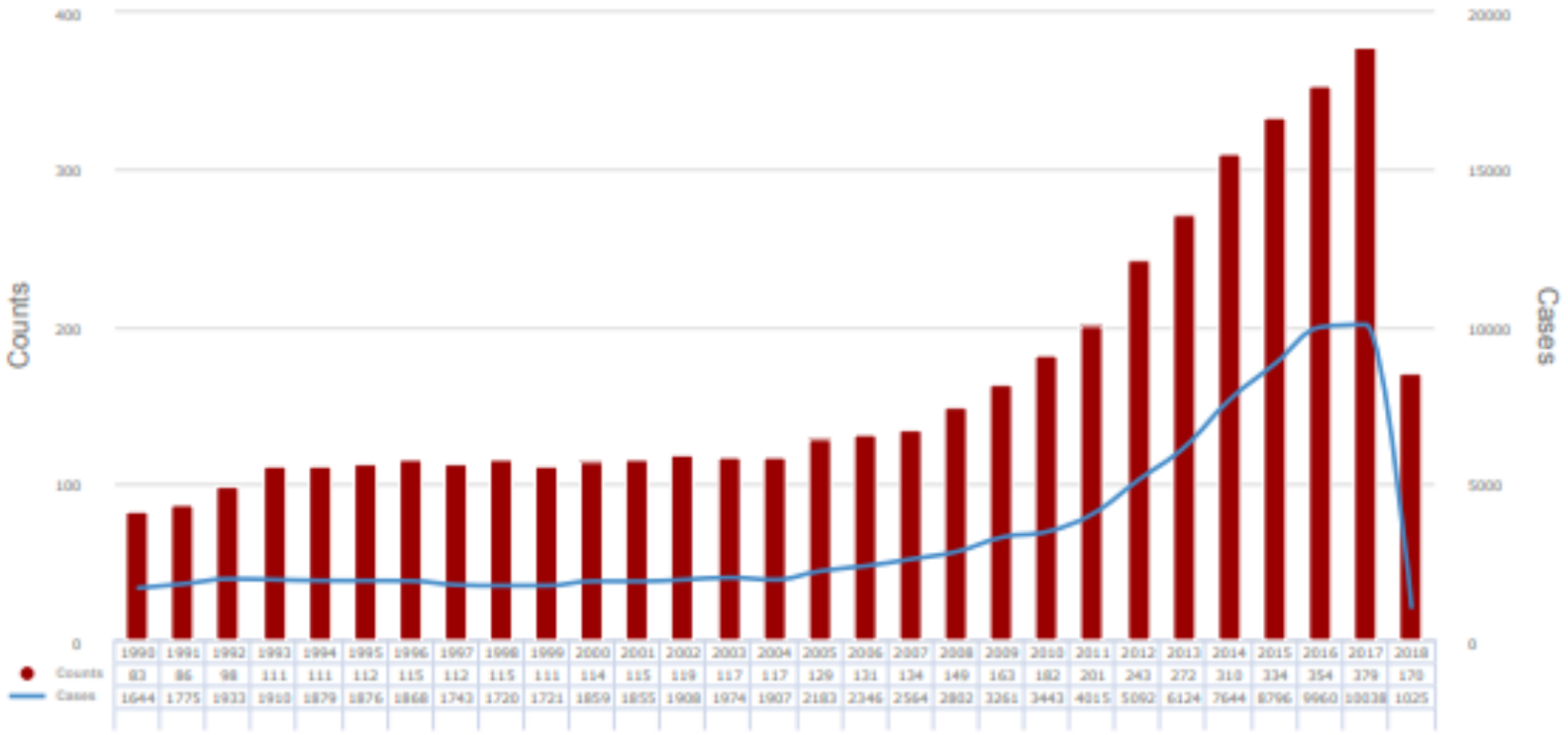
Clinical Educator

VERO-Biotech

Disclosures

- Lectured for Intensive Care On-line Network (ICON) and Draeger sponsored symposia and workshops
- Employed by VERO-Biotech
- Consultant for ICON
- ***None of the funding organizations or sponsors had any role in the design and conduct of any of the studies presented; the collection, management, analysis, or interpretation of the data presented; or preparation, review, or approval of this lecture and the data presented.***

VV-ECMO Should
NOT
Be Considered
a First Line Treatment for Severe ARDS



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Counts	83	86	98	111	111	112	115	112	115	111	114	115	119	117	117	129	131	134	149	163	182	201	243	272	310	334	354	379	170
Cases	1644	1775	1933	1910	1879	1876	1868	1743	1720	1721	1859	1855	1908	1974	1907	2183	2346	2564	2802	3261	3443	4015	5092	6124	7644	8796	9960	10038	1025

(c) 2018 Extracorporeal Life Support Organization

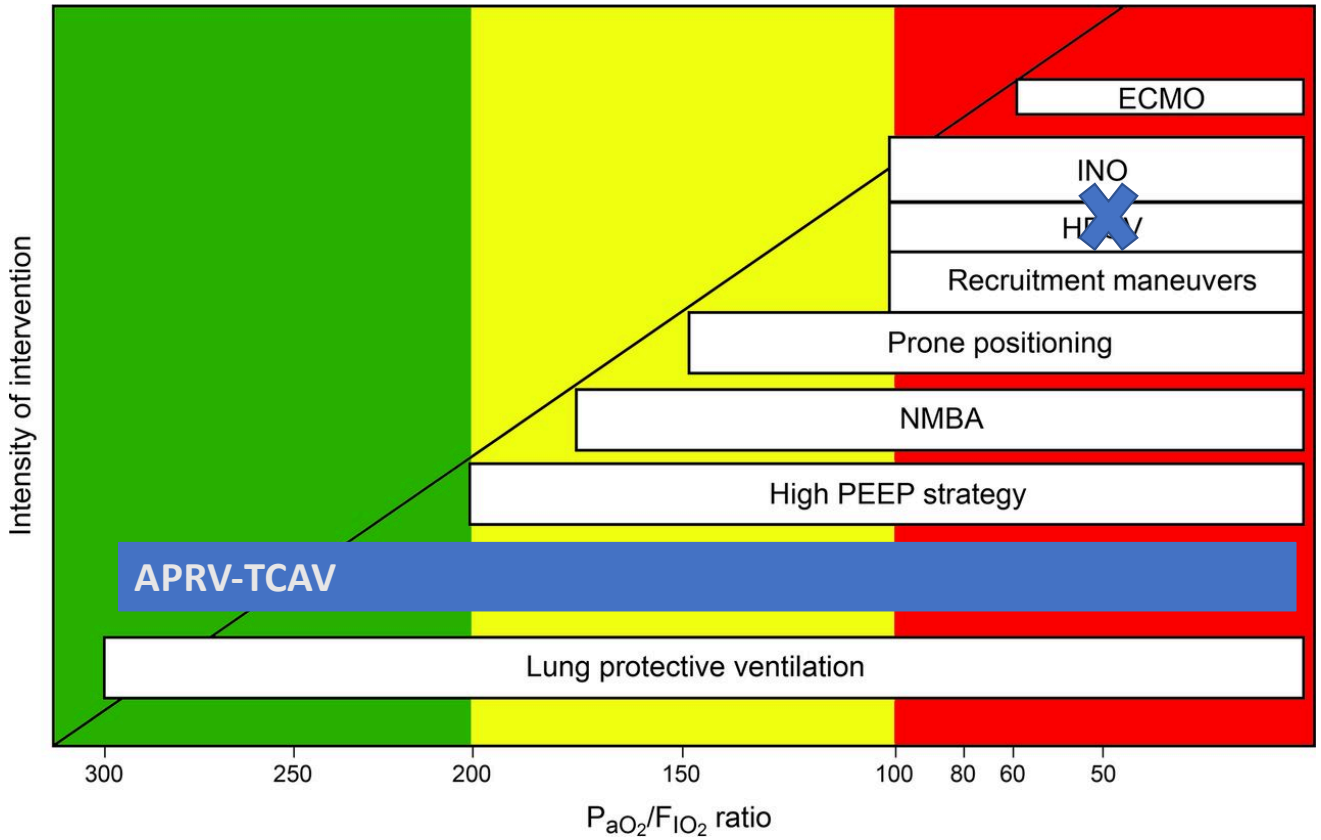
WHY DO PATIENTS NEED VV-ECMO

- Bridge to Lung Transplantation
- Trauma - Emergency pneumonectomy
- ARDS - ?

IES FOR ARDS


KEEP
CALM
I'M A
RESPIRATORY
THERAPIST

Rescue therapy in increasing hypoxemia severity.



Francesco Alessandri et al. Respir Care 2018;63:92-101

(c) 2012 by Daedalus Enterprises, Inc.

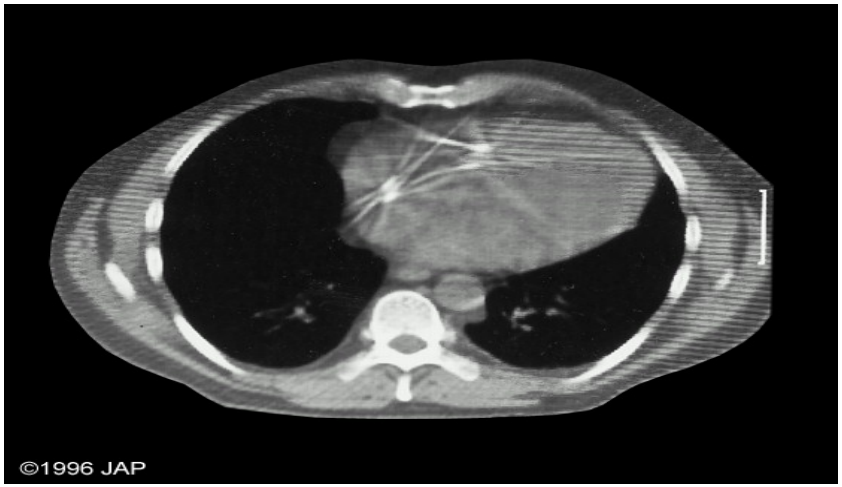
Problems with Mechanical Ventilation

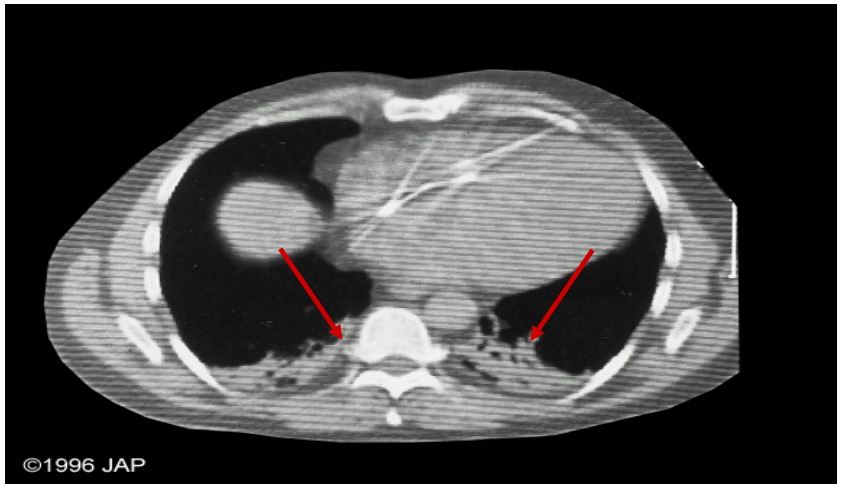
Need for Mechanical Ventilation

- Potential for Ventilator Associated Lung Injury (VALI)
  - Gajic, et al. Crit Care Med 2004
    - 24% of patients who did not have acute lung injury (ALI) from the outset and ventilated for >48 hrs developed ALI
    - 60-80% of those with ALI go on to develop ARDS
- Ventilator Associated Pneumonia (VAP)
- Patient–ventilator asynchrony
  - Increased patient discomfort
  - Increased sedation
  - Increased length of stay and cost

Effects of Elimination of Spontaneous Breathing

V/Q distribution and correlation to atelectasis in anesthetized paralyzed humans





Tokics, L. et al.
J Appl Physiol ,1996

Copyright ©1996 American Physiological Society

Mobility Interventions to Improve Outcomes in Patients Undergoing Prolonged Mechanical Ventilation: A Review of the Literature

JiYeon Choi, MN, RN [PhD Candidate],
University of Pittsburgh School of Nursing, Pittsburgh, PA

Frederick J. Tasota, MSN, RN [Clinical Nurse Specialist], and
University of Pittsburgh Medical Center Presbyterian Hospital, Pittsburgh, PA tasotafj@upmc.edu

Leslie A. Hoffman, PhD, RN, FAAN [Professor and Chair]
Department of Acute/Tertiary Care University of Pittsburgh School of Nursing, Pittsburgh, PA
lhof@pitt.edu

Patients who require prolonged mechanical ventilation (PMV) experience high rates of mortality and morbidity and decreased quality of life, which often necessitates substantial assistance from family caregivers (Chelluri et al., 2003; Combes et al., 2003; Gracey, Naessens, Krishan, & Marsh, 1992; Spicher & White, 1987). Over 50% of 1-year PMV survivors require assistance in basic activities in daily life (Chelluri et al., 2004). For this reason, there is growing interest in ways to improve long-term physical and psychosocial outcomes directly linked with overall quality of life in this population (Carson, 2006; Morris, 2007).

Society of Critical Care Medicine
The Intensive Care Professionals

The Importance of Early Rehabilitation and Mobility in the ICU

2013 - 4 August - Managing Post-Intensive Care Syndrome in the ICU

Ann Parker, MD; Dale M. Needham, FCA, MD, PhD

J Intensive Care Med. 2020 Jan;35(1):55-62. doi: 10.1177/0885066617728486. Epub 2017 Aug 29.

Mobilization of Mechanically Ventilated Patients in Switzerland

Alberto Sibilla [1], Peter Nydahl [2], Nicola Greco [1], Giuseppe Mungo [1], Natalie Ott [1], Ines Unger [1], Spencer Rezek [1], Sarah Gemperle [3], Dale M Needham [4], Sapna R Kudchadkar [5]

SINGLE-CENTER QUALITY IMPROVEMENT REPORT

The Effects of Early Mobilization on Patients Requiring Extended Mechanical Ventilation Across Multiple ICUs

Escalon, Miguel X. MD, MPH; Lichtenstein, Ann H. DO; Posner, Elliot PT, MBA; Spielman, Lisa PhD; Delgado, Andrew MS; Kolakowsky-Hayner, Stephanie A. PhD **Author Information**

Critical Care Explorations: June 2020 - Volume 2 - Issue 6 - p e0119
doi: 10.1097/CCE.0000000000000119

ARDS SURVIVAL RATE

JAMA | Review

Acute Respiratory Distress Syndrome
Advances in Diagnosis and Treatment

Eddy Fan, MD, PhD; Daniel Brodie, MD; Arthur S. Slutsky, MD

February 2018

IMPORTANCE Acute respiratory distress syndrome (ARDS) is a life-threatening form of respiratory failure that affects approximately 200 000 patients each year in the United States, resulting in nearly 75 000 deaths annually. Globally, ARDS accounts for 10% of intensive care unit admissions, representing more than 3 million patients with ARDS annually.

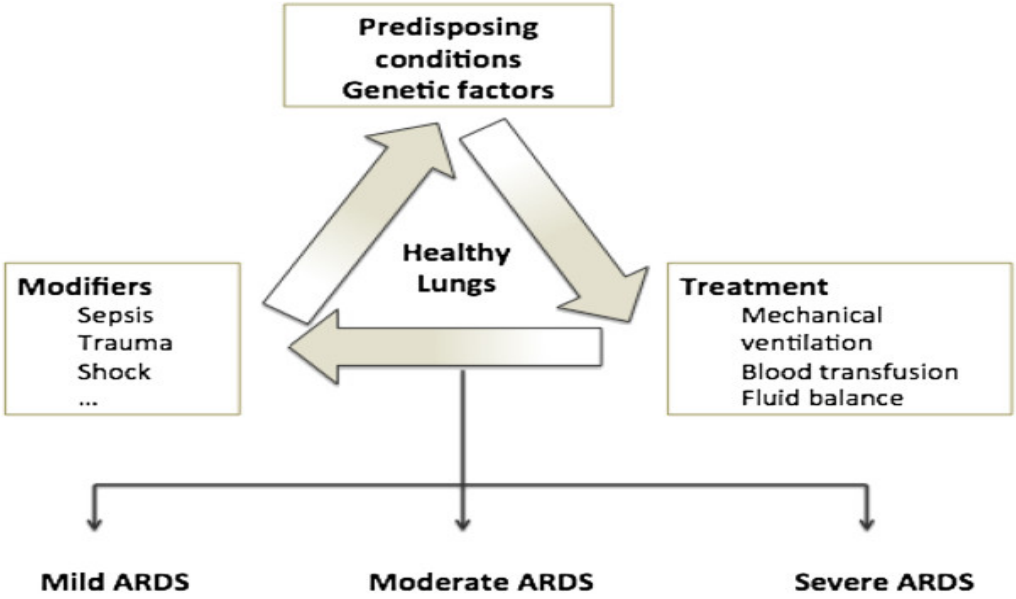
ARDS affects approximately 3 million patients annually, accounting for 10% of intensive care unit (ICU) admissions, and 24% of patients receiving mechanical ventilation in the ICU.

Mortality from ARDS remains high, ranging from **35% to 46%**

Ann Intensive Care. 2013; 3: 11.
Published online 2013 Apr 24. doi: 10.1186/2110-5820-3-11
PMCID: PMC3639084

Acute respiratory distress syndrome: prevention and early recognition

Candelaria de Haro,[✉1] Ignacio Martin-Loeches,[1] Eva Torrents,[1] and Antonio Artigas[1]



Crit Care Resusc. 2016 Sep;18(3):174-80.

The impact of an education program and written guideline on adherence to low tidal volume ventilation.

Nota C[1], Santamaria JD[2], Reid D[2], Tobin AE[2].

Author information

The mean tidal volume for the cohort was 7.4 mL/kg (SD, 1.3 mL/kg) PBW, and 760 patients (26.9%) received an average tidal volume during mandatory ventilation of ≤6.5 mL/kg PBW.

Improved compliance with lower tidal volumes for initial ventilation setting- using a Computerized Clinical Decision Support System.

Sidharth Bagga, Dalton E. Paluzzi, Christine Y. Chen, Jeffrey M. Riggio, Manjula Nagaraja, Paul E. Marik and Michael Baram

Respiratory Care December 2013, respcare.02223; DOI: https://doi.org/10.4187/respcare.02223

The initial set tidal volumes ranged from 6.26 to 13.45 cc/kg IBW with a mean of 8.92 cc/kg.

SPECIAL ARTICLE

Driving Pressure and Survival in the Acute Respiratory Distress Syndrome

Marcelo B.P. Amato, M.D., Maureen O. Meade, M.D., Arthur S. Slutsky, M.D., Laurent Brochard, M.D., Eduardo L.V. Costa, M.D., David A. Schoenfeld, Ph.D., Thomas E. Stewart, M.D., Matthias Briel, M.D., Daniel Talmor, M.D., M.P.H., Alain Mercat, M.D., Jean-Christophe M. Richard, M.D., Carlos R.R. Carvalho, M.D., et al.

Curr Opin Anaesthesiol. 2013 Apr;26(2):126-33. doi: 10.1097/ACO.0b013e32835e1242.

Intraoperative ventilatory strategies to prevent postoperative pulmonary complications: a meta-analysis.

Hemmes SN[1], Serpa Neto A, Schultz MJ.

.

8 Articles – 1669 patients

Decrease in lung injury, pulmonary infection, and atelectasis by using high PEEP with or without recruitment maneuvers.

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JUNE 6, 2013 VOL. 368 NO. 23

Prone Positioning in Severe Acute Respiratory Distress Syndrome

Claude Guérin, M.D., Ph.D., Jean Reignier, M.D., Ph.D., Jean-Christophe Richard, M.D., Ph.D., Pascal Beuret, M.D., Arnaud Gacouin, M.D., Thierry Boulain, M.D., Emmanuelle Mercier, M.D., Michel Badet, M.D., Alain Mercat, M.D., Ph.D., Olivier Baudin, M.D., Marc Clavel, M.D., Delphine Chatellier, M.D., Samir Jaber, M.D., Ph.D., Sylvène Rosselli, M.D., Jordi Mancebo, M.D., Ph.D., Michel Sirodot, M.D., Gilles Hilbert, M.D., Ph.D., Christian Bengler, M.D., Jack Richecoeur, M.D., Marc Gainnier, M.D., Ph.D., Frédérique Bayle, M.D., Gael Bourdin, M.D., Véronique Leray, M.D., Raphaele Girard, M.D., Loredana Baboi, Ph.D., and Louis Ayzac, M.D., for the PROSEVA Study Group*

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JUNE 6, 2013 VOL. 368 NO. 23

Prone Positioning in Severe Acute Respiratory Distress Syndrome

Claude Guérin, M.D., Ph.D., Jean Reignier, M.D., Ph.D., Jean-Christophe Richard, M.D., Ph.D., Pascal Beuret, M.D., Arnaud Gacouin, M.D., Thierry Boulain, M.D., Emmanuelle Mercier, M.D., Michel Badet, M.D., Alain Mercat, M.D., Ph.D., Olivier Baudin, M.D., Marc Clavel, M.D., Delphine Chatellier, M.D., Samir Jaber, M.D., Ph.D., Sylvène Rosselli, M.D., Jordi Mancebo, M.D., Ph.D., Michel Sirodot, M.D., Gilles Hilbert, M.D., Ph.D., Christian Bengler, M.D., Jack Richecoeur, M.D., Marc Gainnier, M.D., Ph.D., Frédérique Bayle, M.D., Gael Bourdin, M.D., Véronique Leray, M.D., Raphaele Girard, M.D., Loredana Baboi, Ph.D., and Louis Ayzac, M.D., for the PROSEVA Study Group*

ORIGINAL ARTICLE

Early application of airway pressure release ventilation may reduce mortality in high-risk trauma patients: A systematic review of observational trauma ARDS literature

Penny L. Andrews, RN, BSN, Joseph R. Shiber, MD, Ewa Jaruga-Killeen, PhD, Shreyas Roy, MD, CM, Benjamin Sadowitz, MD, Robert V. O'Toole, Louis A. Gatto, PhD, Gary F. Nieman, BA, Thomas Scalea, MD, *and* **Nader M. Habashi, MD,** *Baltimore, Maryland*

BACKGROUND: Adult respiratory distress syndrome is often refractory to treatment and develops after entering the health care system. This suggests an opportunity to prevent this syndrome before it develops. The objective of this study was to demonstrate that early application of airway pressure release ventilation in high-risk trauma patients reduces hospital mortality as compared with similarly injured patients on conventional ventilation.

METHODS: Systematic review of observational data in patients who received conventional ventilation in other trauma centers were compared with patients treated with early airway pressure release ventilation in our trauma center. Relevant studies were identified in a PubMed and MEDLINE search from 1995 to 2012 and included prospective and retrospective observational and cohort studies enrolling 100 or more adult trauma patients with reported adult respiratory distress syndrome incidence and mortality data.

RESULTS: Early airway pressure release ventilation as compared with the other trauma centers represented lower mean adult respiratory distress syndrome incidence (14.0% vs. 1.3%) and in-hospital mortality (14.1% vs. 3.9%).

CONCLUSION: These data suggest that early airway pressure release ventilation may prevent progression of acute lung injury in high-risk trauma patients, reducing trauma-related adult respiratory distress syndrome mortality. (*J Trauma Acute Care Surg.* 2013;75: 635–641.
Copyright © 2013 by Lippincott Williams & Wilkins)

LEVEL OF EVIDENCE: Systematic review, level IV.

KEY WORDS: Airway pressure release ventilation; APRV; ARDS; adult respiratory distress syndrome; ALI.

Lung Protection

EAST 2012 PLENARY PAPER

Early stabilizing alveolar ventilation prevents acute respiratory distress syndrome: A novel timing-based ventilatory intervention to avert lung injury

Shreyas Roy, MD, CM, Benjamin Sadowitz, MD, Penny Andrews, RN, Louis A. Gatto, PhD, William Marx, DO, Lin Ge, PhD, Guirong Wang, PhD, Xin Lin, PhD, David A. Dean, PhD, Michael Kuhn, BA, Auyon Ghosh, BSc, Joshua Satalin, BA, Kathy Snyder, BA, Yoram Vodovotz, PhD, Gary Nieman, BA, *and* **Nader Habashi, MD,** *Syracuse, New York*

J Trauma Acute Care Surg.
2012 Vol. 73 No. 2

THE USE OF AIRWAY PRESSURE RELEASE VENTILATION (APRV) PREVENTS THE NEED FOR EXTRACORPOREAL MEMBRANE OXYGENATION (ECMO) IN A TRAUMA PATIENT

UNIVERSITY of MARYLAND MEDICAL CENTER

Dolly, Kate[1]; Madden, Maria[1]; Andrews, Penny [1]; Habashi, Nader[1]

R ADAMS COWLEY SHOCK TRAUMA CENTER
UNIVERSITY OF MARYLAND

Data Table

TIME	MODE	SETTINGS	pH	$PaCO_2$	PaO_2	SPO_2	HCO_3	BE	P/F RATIO
0430	PRVC	FiO_2 100% RR 22 VT470 mL PEEP 14 PIP 50 cmH_2O	7.09	61	72	88%	17	-13.3	72
0730	APRV	FiO_2 97% P High 36 cmH_2O P Low 0 cmH_2O T High 2.0 sec T Low 0.65 sec	7.36	29	216	100%	16	-7.8	223
1600	APRV	FiO_2 47% P High 35 cmH_2O P Low 0 cmH_2O T High 5.0 sec T Low 0.75 sec	7.42	25	141	98%	16	-6.0	300

Journal of Critical Care

Volume 34, August 2016, Pages 154-159

Outcomes/Predictions

Characteristics and outcomes of patients treated with airway pressure release ventilation for acute respiratory distress syndrome: A retrospective observational study ☆

Jolene Lim MBBS (Hon) [a, 1], Edward Litton MB, ChB, MSs, FCICM [b, c], Hayley Robinson BMedSci (Hon), MBBS (Hon) [d], Mike Das Gupta [e, 2]

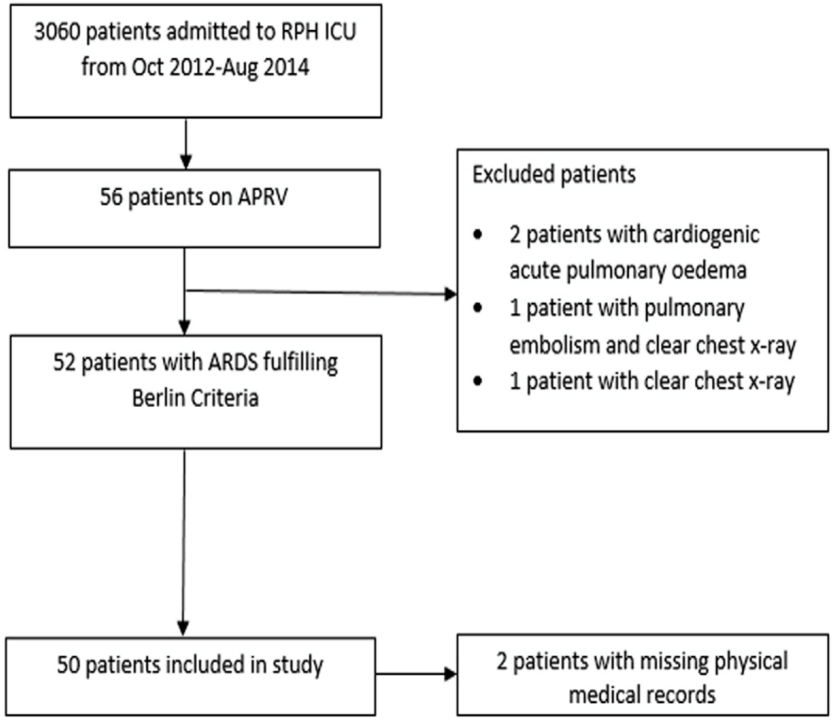


Fig. 1. Flow chart of the patients included in the study.

Table 2
Ventilatory parameters on initiation of APRV and 12 h post-APRV initiation. Statistics presented as median and interquartile range (IQR) unless otherwise stated.

Ventilatory parameter	
On initiation of APRV	*N = 50*
P_{high} (cmH_2O)	30 (26–30)
Peak airway pressure (cmH_2O)	32 (29–35)
Mean airway pressure (cmH_2O)	25 (24–26)
Set pressure (cmH_2O)	30 (26–30)
Tidal volume (ml)	500.0 (400.0–600.0)
12 h post initiation of APRV	*N = 35*
P_{high} (cmH_2O)	28 (24–30)
Peak airway pressure (cmH_2O)	32 (28–35)
Mean airway pressure (cmH_2O)	25 (24–26)
Set pressure (cmH_2O)	28 (24–30)
Tidal volume (ml)	500.0 (400.0–650.0)

ORIGINAL

Early application of airway pressure release ventilation may reduce the duration of mechanical ventilation in acute respiratory distress syndrome

Yongfang Zhou, Xiaodong Jin, Yinxia Lv, Peng Wang, Yunqing Yang, Guopeng Liang, Bo Wang and Yan Kang*

- 138 patients with ARDS who received mechanical ventilation for <48 h
- Patients were randomly assigned to receive APRV (n = 71) or LTV (n = 67).

Day 3 of enrollment	APRV	LTV
P/F RATIO	280	180
PaCO2	40.8	42.3
PaO2	116.2	84.8

Intensive Care Med (2017) 43:1648–1659
DOI 10.1007/s00134-017-4912-z

Airway Pressure Release Ventilation in Adult Patients With Acute Hypoxemic Respiratory Failure: A Systematic Review and Meta-Analysis

Jolene Lim, MBBS (Hon), MSc (Dist)[1]; Edward Litton, MBChB, FCICM, MSc, PhD[1,2]

Conclusions: In adult patients requiring mechanical ventilation for acute hypoxic respiratory failure, airway pressure release ventilation is associated with a mortality benefit and improved oxygenation when compared with conventional ventilation strategies. Given the limited number of patients enrolled in the available studies, larger multicenter studies are required to validate these findings. (*Crit Care Med* 2019; XX:00–00)

Crit Care Med 2019

Study protocol

Open Access

CESAR: conventional ventilatory support vs extracorporeal membrane oxygenation for severe adult respiratory failure

Giles J Peek*[1], Felicity Clemens[2], Diana Elbourne[2], Richard Firmin[1], Pollyanna Hardy[2,3], Clare Hibbert[5], Hilliary Killer[1], Miranda Mugford[4], Mariamma Thalanany[4], Ravin Tiruvoipati[1], Ann Truesdale[2] and Andrew Wilson[6]

- Mortality rate at 6 months: 63% in ECMO vs. 47% in conventional ventilation group
- Ninety patients were randomized to consideration of ECMO and 90 to continued conventional treatment
- 24% (n = 22) of patients randomized to ECMO never received this treatment
  - 82% survival rate On MV

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

- From the group of 194 mechanically ventilated patients with confirmed 2009 influenza A(H1N1) or influenza A not subtyped (not all of whom had ARDS), patients treated with ECMO (n = 61) were compared with those without (n = 133).
- The patients who were treated with ECMO had longer duration of mechanical ventilation 18 [9-27] vs 8 [4-14] days
- ICU stay (22 [13-32] vs 12 [7-18] days;

JAMA. 2009;302(17):1888-1895

ECMO STUDIES

- **The PRESERVE Study**
  - 64% survival rate at discharge = 36% Mortality Rate
- **The RESP Score**
  - 57% survival rate at discharge = 43% Mortality Rate

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 MAY 24, 2018 VOL. 378 NO. 21

Extracorporeal Membrane Oxygenation for Severe Acute Respiratory Distress Syndrome

Among patients with very severe ARDS, 60-day mortality was not significantly lower with ECMO than with a strategy of conventional mechanical ventilation that included ECMO as rescue therapy.

ECLS Registry Report

International Summary

July, 2020

Report data through 2019

Extracorporeal Life Support Organization
2800 Plymouth Road
Building 300, Room 303
Ann Arbor, MI 48109

Overall Outcomes

	Total Runs	Survived ECLS		Survived to DC or Transfer	
Neonatal					
Pulmonary	32,634	28,627	87%	23,860	73%
Cardiac	8,993	6,216	69%	3,899	43%
ECPR	2,080	1,463	70%	883	42%
Pediatric					
Pulmonary	10,549	7,636	72%	6,347	60%
Cardiac	12,836	9,271	72%	6,854	53%
ECPR	5,086	3,032	59%	2,159	42%
Adult					
Pulmonary	25,631	17,832	69%	15,471	60%
Cardiac	27,004	16,117	59%	11,891	44%
ECPR	8,558	3,582	41%	2,549	29%
Total	133,371	93,776	70%	73,913	55%

60%

COMPLICATIONS

ORIGINAL ARTICLES

A meta-analysis of complications and mortality of extracorporeal membrane oxygenation

Alberto Zangrillo, Giovanni Landoni, Giuseppe Biondi-Zoccai, Massimiliano Greco, Teresa Greco, Giacomo Frati, Nicolò Patroniti, Massimo Antonelli, Antonio Pesenti and Federico Pappalardo

- 52% renal failure requiring continuous venovenous hemofiltration
- 33% bacterial pneumonia
- 33 % bleeding
- 29% oxygenator dysfunction requiring replacement
- sepsis (26%), 18% hemolysis
- 16% liver dysfunction
- 10% leg ischemia
- central nervous system complications (8%), gastrointestinal bleeding

Table 2. Adverse Events Associated with ECMO in Adults with Respiratory Failure.*

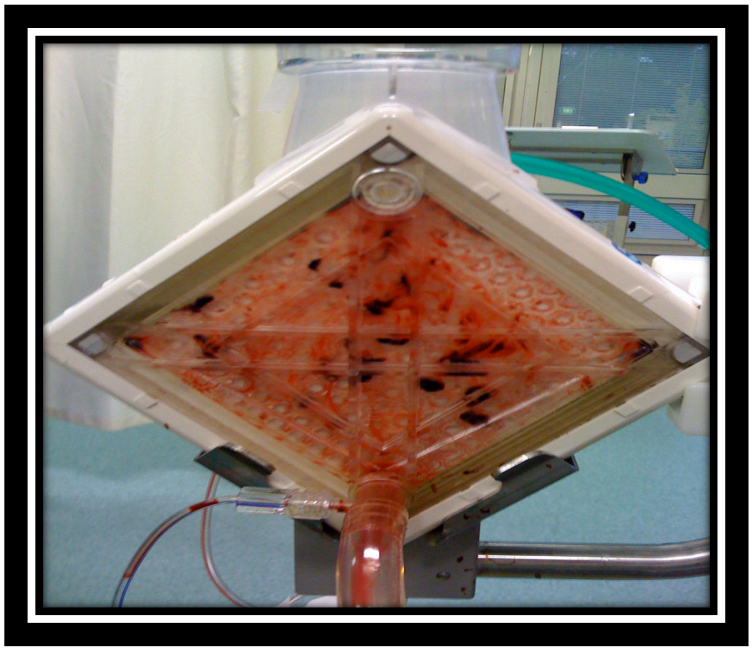
Event	Rate %
Directly related to the ECMO circuit	
Oxygenator failure	17.5
Blood clots	
Oxygenator	12.2
Other circuit	17.8
Cannula-related problems	8.4
Other mechanical complications	7.9
Not directly related to the ECMO circuit†	
Bleeding	
Surgical-site bleeding	19.0
Cannulation-site bleeding	17.1
Pulmonary hemorrhage	8.1
Gastrointestinal hemorrhage	5.1
Intracranial hemorrhage	3.8
Hemolysis	6.9
Disseminated intravascular coagulation	3.7
Culture-confirmed infection at any site (related or unrelated to ECMO)‡	21.3

Extracorporeal Life Support Organization. Registry report: international summary. Ann Arbor: ELSO; July 2012


Thrombosis
Bleeding

MECHANICAL COMPLICATIONS

- Air in circuit
- Clots in circuit
- Cannula problems
- Tubing rupture
- Motor failure



Ann Intensive Care. 2017 Dec;7(1):51.

OTHER COMPLICATIONS

- Bridge to nowhere
- Long-term complications
- Financial cost and resource utilization
- Prolonged ICU Lengths of Stay

REST SETTINGS?

During ECMO, ventilator settings are gradually reduced to allow lung rest, i.e. peak inspiratory pressure 20 cm H_2O, end expiratory pressure 10 cm H_2O, rate 10 breaths per minute and FIO_2 30%. Anticoagulation is

Eur Respir J 2012; 40: 1531–1537
DOI: 10.1183/09031936.00189911
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Diagnosis-related deterioration of lung function after extracorporeal membrane oxygenation

Marjolein Spoel*,+, Roxanne Laas*,+, Saskia J. Gischler*, Wim J.C. Hop#, Dick Tibboel*, Johan C. de Jongste[¶] and Hanneke Ijsselstijn*

Protecting the Lung

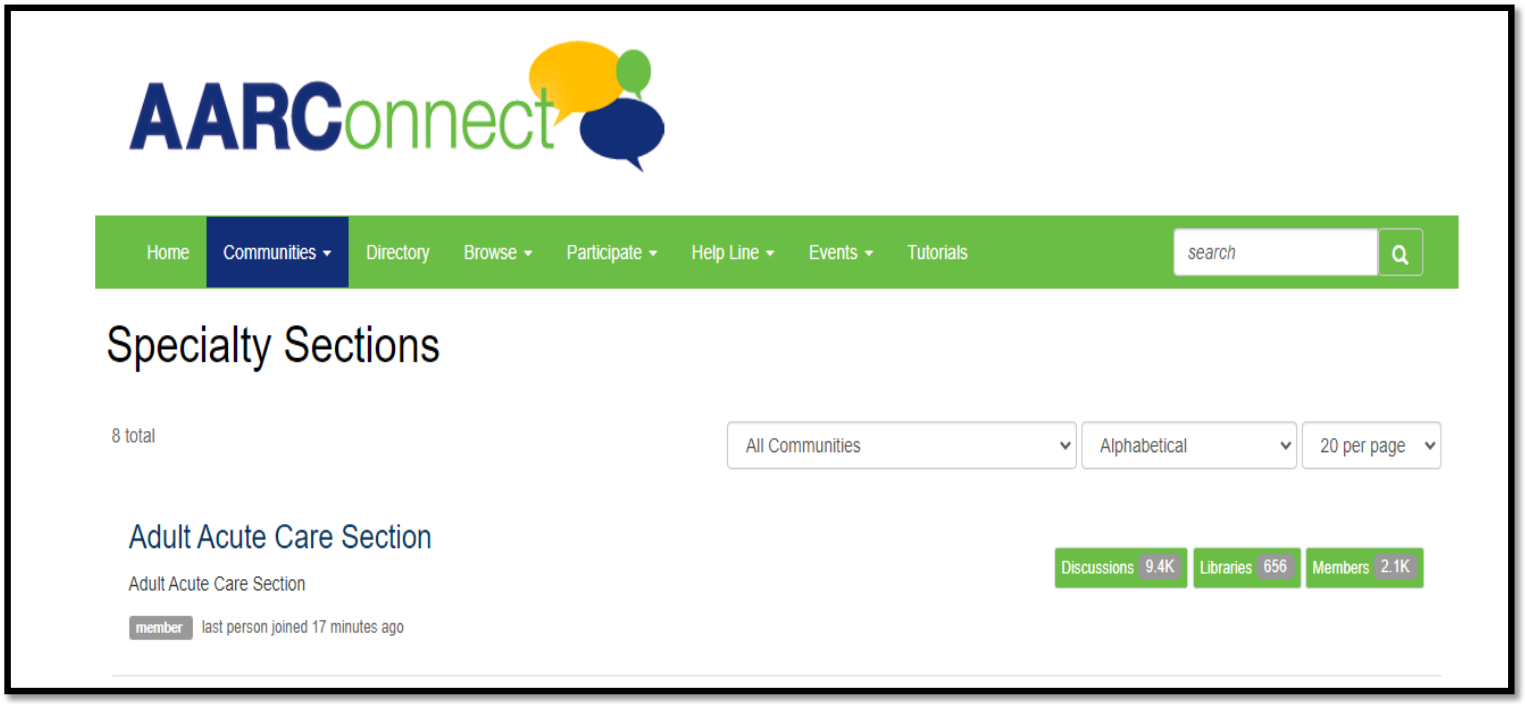
"ARDS is no longer a syndrome that must be treated, but is a syndrome that should be prevented."

Villar And Slutsky
Is acute ARDS an iatrogenic disease? Crit Care , 2010; 14: 120

"The importance of early lung recruitment and stabilization cannot be stressed enough, for this will affect all aspects of ventilatory physiology; therefore, we must use an "open lung" approach in all mechanically ventilated patients."

Lachman
Open up the lung and keep the lung open
Intensive Care Med (1992) 18:319-321

AARC Connect



Should VV ECMO be used as the first-line in the treatment of ARDS?

Thank You!

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