ECMO for COVID-19 in Pediatric Patients

Evolving Strategy

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No disclosures

Objectives

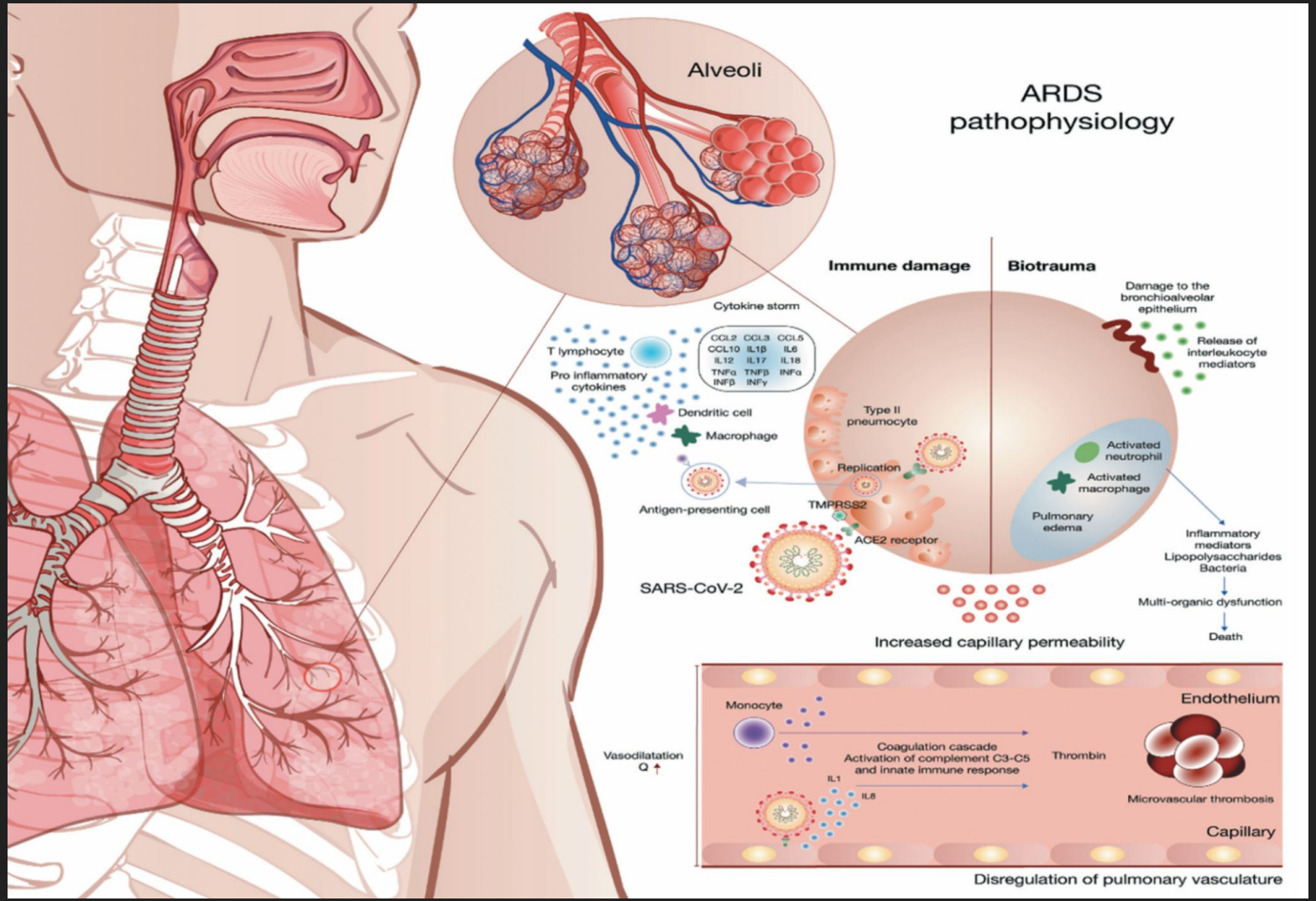
By the end of this talk, the learner will:

1. Understand the pathophysiology of COVID-19 associated lung and heart disease, and how this compares to other viral cardiopulmonary disease.
2. Know the benefits and risks of an awake ECMO, early extubation, and aggressive rehabilitation strategy for severe ARDS.
3. Describe how right ventricular support can be beneficial in patients on ECMO with severe lung disease.

Pathophysiology of COVID-19

COVID-19 ARDS

- Risk factors for severe disease
  - Male sex, obesity, increased age
- Direct viral cellular damage and hyperinflammation
- Lung injury
  - Diffuse Alveolar Damage
  - Imbalance of coagulation and fibrinolysis
  - Late fibrosis
- Severe hypoxemia with compliance variably affected
  - Often strong response to prone positioning
- Comparison to other cases of infectious ARDS



Montenegro, Francisco, et al. Expert Review of Respiratory Medicine. 2021.

Right Ventricular Failure

- High rate of severe ARDS in COVID-19
  - Risk of RV dysfunction and failure
- RV function can be difficult to assess
- Studies show associated with mortality
  - Meta-analysis of ARDS patients - RV dysfunction associated with mortality (OR = 1.68 [1.21-2.32])
  - Echo evidence of RV dysfunction in 120 COVID-19 patients independently associated with mortality.

Dong, Daoran, et al. Heart & Lung. 2021.
Li, Yuman, et al. Cardiovascular Imaging. 2020.

Vasodilatory and Cardiogenic Shock

- Direct viral toxicity, inflammatory cascade, thrombosis, endothelial injury
  - Cardiac dysfunction
  - Arrhythmia
  - Acute coronary syndrome
  - Vasodilatory shock
  - Right heart strain due to ARDS
- VA ECMO support in severe illness

Hajjar, Ludhmila Abrahão, et al. Annals of intensive care. 2021.
Adeghate, Ernest A., Nabil Eid, and Jaipaul Singh. Heart Failure Reviews. 2021.

Early Literature on ECMO for COVID-19

Extracorporeal membrane oxygenation support in COVID-19: an international cohort study of the Extracorporeal Life Support Organization registry

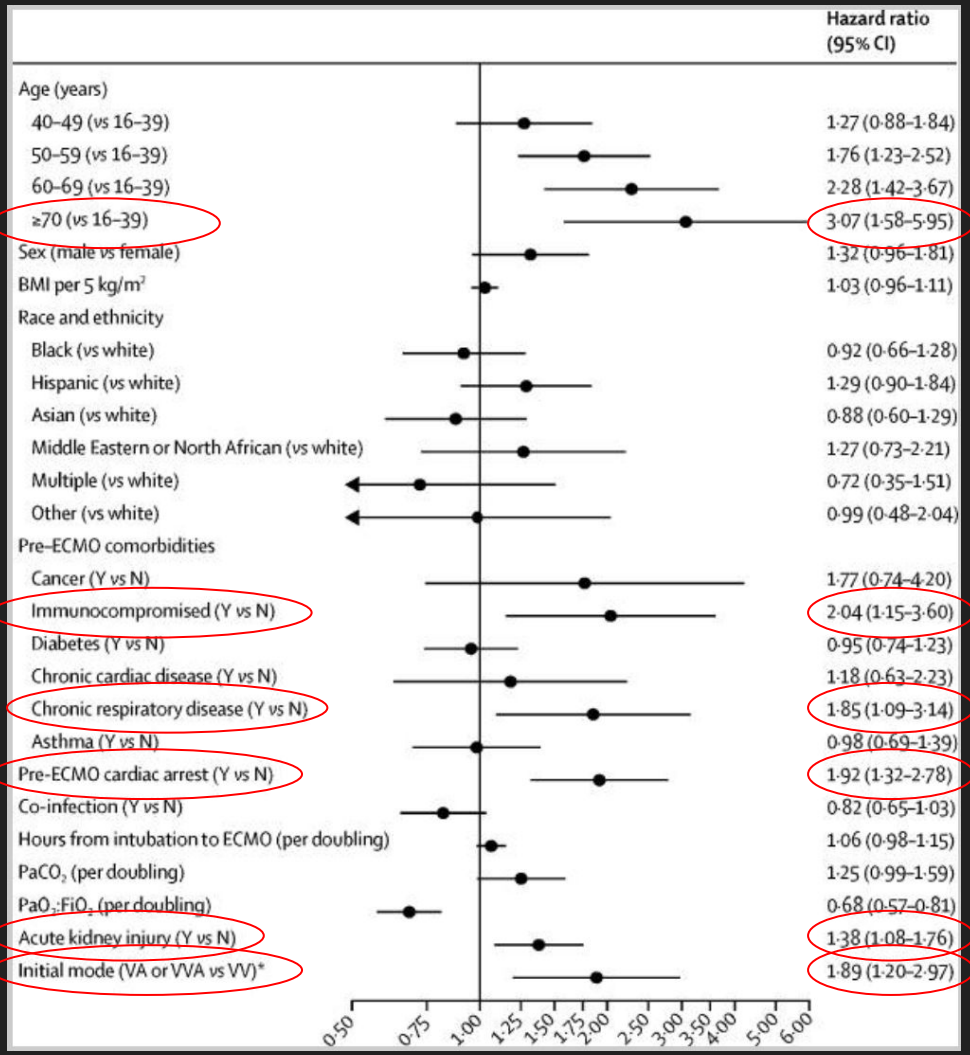
Ryan P Barbaro, Graeme MacLaren*, Philip S Boonstra, Theodore J Iwashyna, Arthur S Slutsky, Eddy Fan, Robert H Bartlett, Joseph E Tonna, Robert Hyslop, Jeffrey J Fanning, Peter T Rycus, Steve J Hyer, Marc M Anders, Cara L Agerstrand, Katarzyna Hryniewicz, Rodrigo Diaz, Roberto Lorusso†, Alain Combes†, Daniel Brodie†, for the Extracorporeal Life Support Organization‡*

Summary

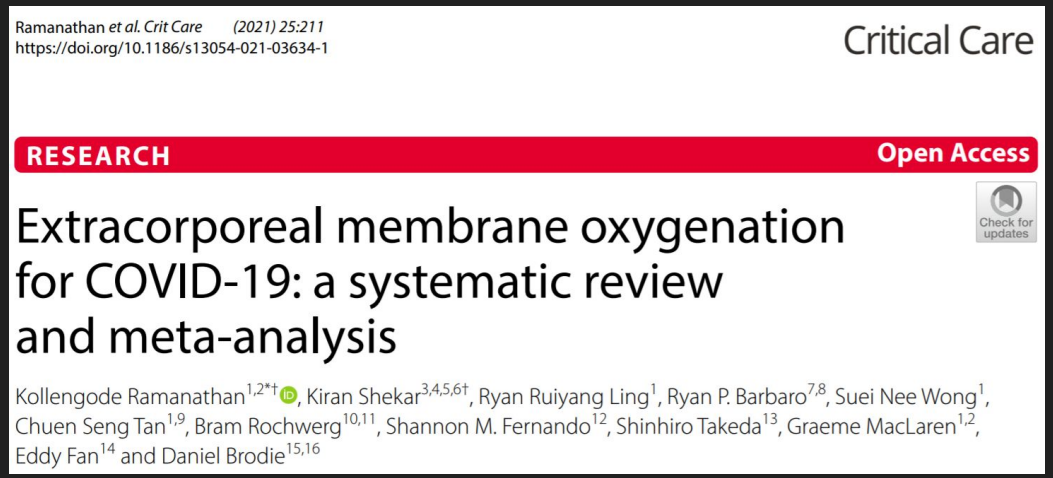
Background Multiple major health organisations recommend the use of extracorporeal membrane oxygenation

Lancet 2020; 396: 1071–78

- ELSO data - ECMO for COVID-19 16y and older Jan-May 2020
- Primary outcome - in hospital mortality in a time-to-event analysis assessed at 90d after ECMO start
- 1035 pts, median 49y and BMI 31
  - 79% ARDS, 29% AKI, 5% heart failure
  - **Median time intubation to ECMO 4 days**
  - 94% VV ECMO
- In-hospital mortality 90d after the initiation of ECMO - **37·4%** (95% CI 34·4–40·4)



Barbaro, Ryan P., et al. The Lancet. 2020.



Ramanathan *et al. Crit Care* (2021) 25:211
https://doi.org/10.1186/s13054-021-03634-1

Critical Care

RESEARCH Open Access

Extracorporeal membrane oxygenation for COVID-19: a systematic review and meta-analysis

Kollengode Ramanathan[1,2*†], Kiran Shekar[3,4,5,6†], Ryan Ruiyang Ling[1], Ryan P. Barbaro[7,8], Suei Nee Wong[1], Chuen Seng Tan[1,9], Bram Rochwerg[10,11], Shannon M. Fernando[12], Shinhiro Takeda[13], Graeme MacLaren[1,2], Eddy Fan[14] and Daniel Brodie[15,16]

- Systematic review and meta-analysis of studies examining ECMO in adults with COVID-19 ARDS Dec 2019-Jan 2021
- Primary outcome - in hospital mortality
- 22 observational studies - 1896 patients
  - VV ECMO - 98.6%
- Pooled in-hospital mortality - 37.1% (32.3–42.0%, high certainty)
  - Mean duration of MV prior to ECMO - 4.4 days
  - **Increasing age (p=0.01), shorter ECMO duration (p=0.001), and lower BMI (p=0.04) associated with mortality**
  - SOFA score, time from MV to ECMO not associated with mortality

Changing outcomes as COVID-19 pandemic progressed

Extracorporeal membrane oxygenation for COVID-19: evolving outcomes from the international Extracorporeal Life Support Organization Registry

Ryan P Barbaro, Graeme MacLaren*, Philip S Boonstra, Alain Combes, Cara Agerstrand, Gail Annich, Rodrigo Diaz, Eddy Fan, Katarzyna Hryniewicz, Roberto Lorusso, Matthew L Paden, Christine M Stead, Justyna Swol, Theodore J Iwashyna†, Arthur S Slutsky†, Daniel Brodie†, for the Extracorporeal Life Support Organization*

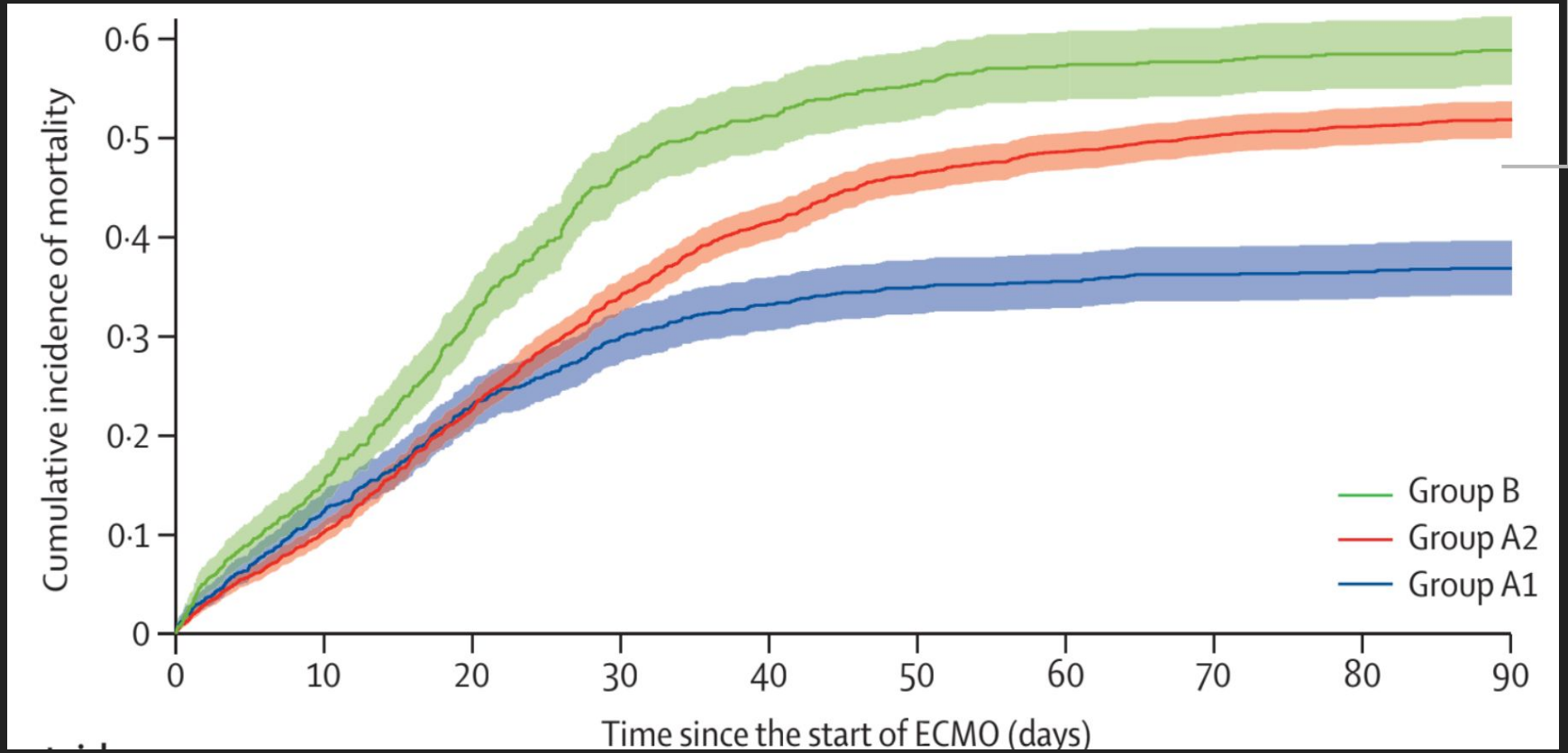
Lancet 2021; 398: 1230–38

Published Online September 29, 2021

Summary

Background Over the course of the COVID-19 pandemic, the care of patients with COVID-19 has changed and the use of extracorporeal membrane oxygenation (ECMO) has increased. We aimed to examine patient selection, treatments, outcomes, and ECMO centre characteristics over the course of the pandemic to date.

- ELSO Registry Study comparing 3 groups of COVID-19 ECMO patients:
  - A1 - Early ECMO (before May 1, 2020) at early-adopting centers
  - A2 - Late ECMO (after May 1, 2020) at early-adopting centers
  - B - Late ECMO (after May 1, 2020) at late-adopting centers
- 4800 patients throughout 2020
- Primary outcome - in-hospital mortality


Cumulative incidence of mortality
0·6
0·5
0·4
0·3
0·2
0·1
0
0
10
20
30
40
50
60
70
80
90
Time since the start of ECMO (days)
Group B
Group A2
Group A1
After 5/1/20

Results

- Relative to group A2:
  - A1 - lower adjusted relative risk of 90d in-hospital mortality (HR 0·82 [0·70−0·96])
  - B - higher adjusted relative risk of 90d in-hospital mortality (HR 1·42 [1·17−1·73])
- Comparing late vs early pandemic ECMO:
  - Longer ECMO duration (14.1 vs 20.0 days)
  - Lower proportion of patients discharged to home or rehab facility
- Patient characteristics
  - Similar risk factors
  - Late group
    - higher rate of non-invasive ventilation prior to intubation
    - More dexamethasone use
    - Late adopting centers had lower pre-pandemic ECMO volume

Changing Approach to ECMO for COVID-19

We needed to reconsider our approach

- COVID-19 ARDS - high rate of severe disease
- High risk of right ventricular failure
- Long recovery time
- High risk of complications

Research Letter

FREE

August 11, 2020

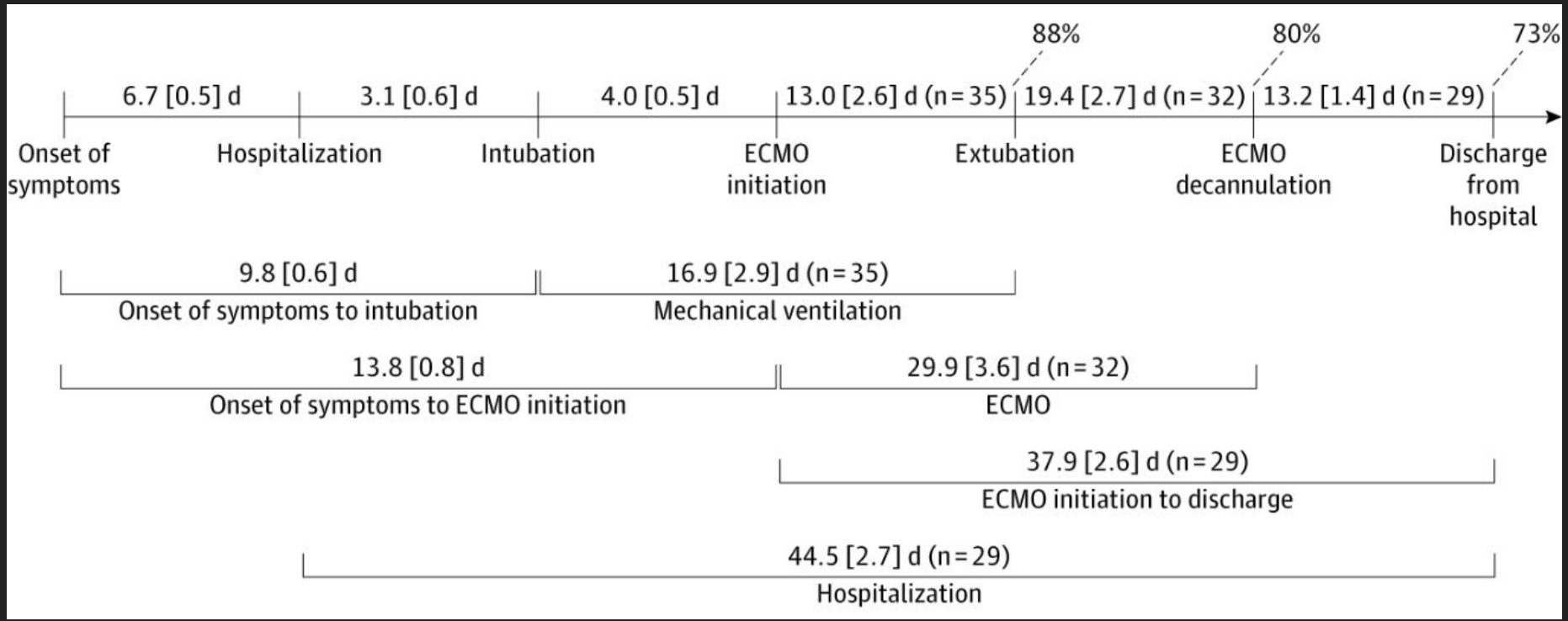
Extracorporeal Membrane Oxygenation for Patients With COVID-19 in Severe Respiratory Failure

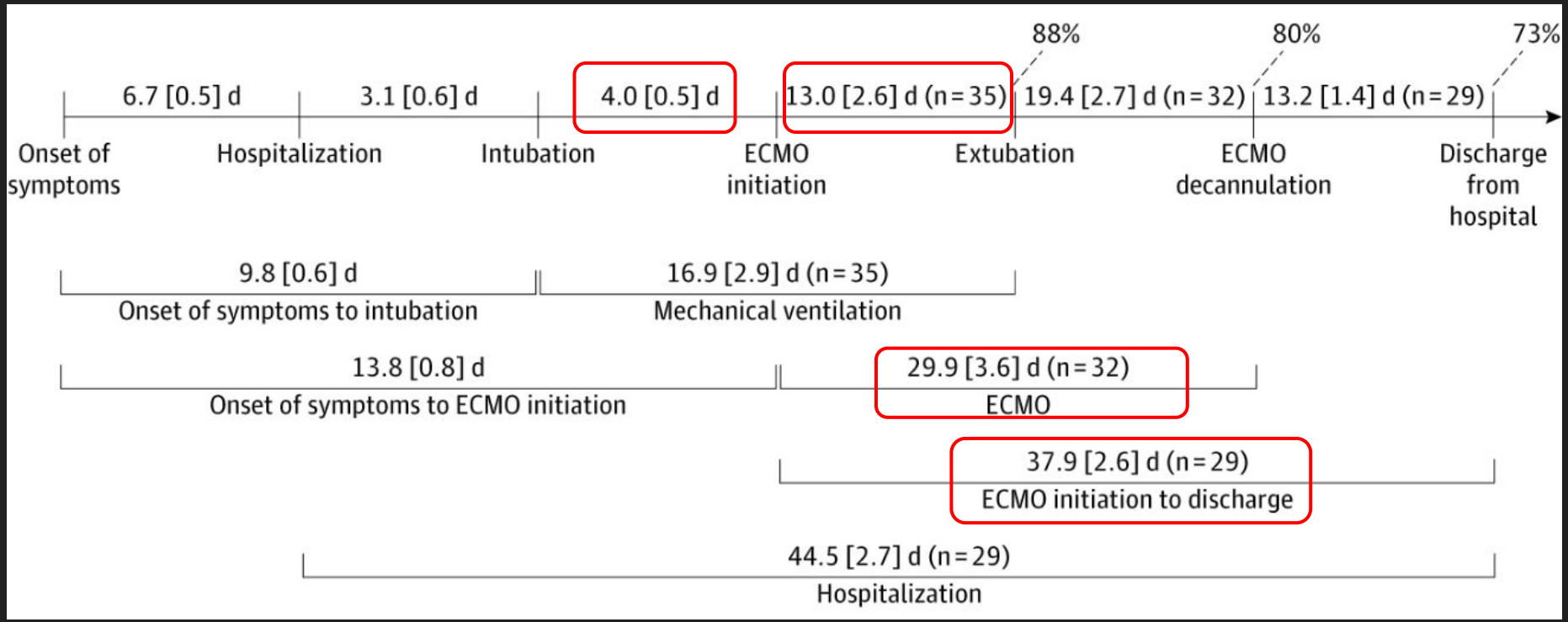
Asif K. Mustafa, MD, PhD[1,2]; Philip J. Alexander, MD[1,2]; Devang J. Joshi, MD[1,2]; et al

» Author Affiliations | Article Information

JAMA Surg. 2020;155(10):990-992. doi:10.1001/jamasurg.2020.3950

- 40 consecutive COVID-19 patients on ECMO for respiratory failure
- Dual lumen right atrium to pulmonary artery catheter for oxygenation and RV support
- Emphasis on rehab and early extubation


88%
80%
73%
6.7 [0.5] d
3.1 [0.6] d
4.0 [0.5] d
13.0 [2.6] d (n = 35)
19.4 [2.7] d (n = 32)
13.2 [1.4] d (n = 29)
Onset of symptoms
Hospitalization
Intubation
ECMO initiation
Extubation
ECMO decannulation
Discharge from hospital
9.8 [0.6] d
Onset of symptoms to intubation
16.9 [2.9] d (n = 35)
Mechanical ventilation
13.8 [0.8] d
Onset of symptoms to ECMO initiation
29.9 [3.6] d (n = 32)
ECMO
37.9 [2.6] d (n = 29)
ECMO initiation to discharge
44.5 [2.7] d (n = 29)
Hospitalization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37.9 [2.6] d (n = 29)
ECMO initiation to discharge
44.5 [2.7] d (n = 29)
Hospitalization

Discussion

- Direct RA-PA cannula:
  - Improved oxygenation
  - Less recirculation
  - RV support
  - Improved mobility (compared to femoral)
  - Improved rehab tolerance
- Extubation - decreased exposure to positive pressure ventilation
- Rehabilitation
  - Redistributed weight off lungs
  - Improved recovery
- Extended ECMO runs

Outcomes of Extubated COVID and Non-COVID Patients Receiving Awake Venovenous Extracorporeal Membrane Oxygenation

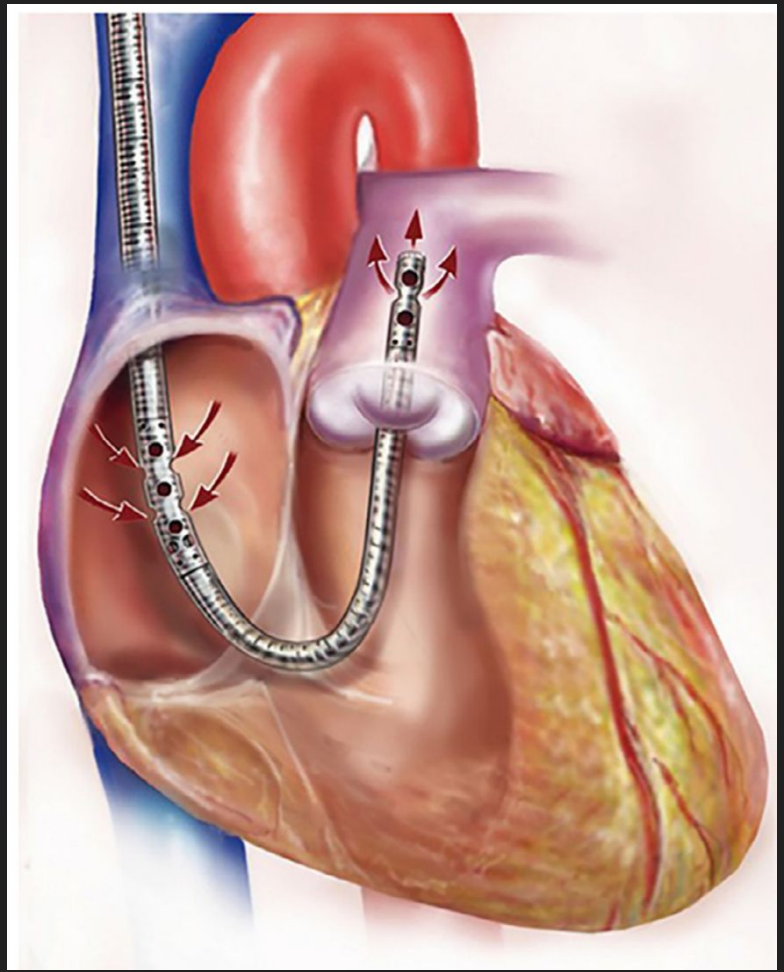
Payal K. Gurnani,*† Lauren A. Michalak,‡ Deborah Tabachnick,‡ Michael Kotwas,‡ and Antone J. Tatooles‡

- 62 consecutive ARDS patients receiving awake VV and VP ECMO
- Survival to discharge - 85%
  - Same between COVID-19 and non-COVID-19 ARDS
  - 79% discharged home or to acute rehab facility
- Median ECMO duration 33 days
- Median time to extubation after cannulation - 6 days

Extracorporeal membrane oxygenation with right ventricular support in COVID-19 patients with severe acute respiratory distress syndrome

Antone J. Tatooles, MD, Asif K. Mustafa, MD, PhD, Devang J. Joshi, MD, and Pat S. Pappas, MD

- 150 Patients supported for COVID-19 ARDS with RA-PA cannulation onto ECMO
  - Average ECMO run 48 days
- 67% survival to discharge
- 3% required long term rehab



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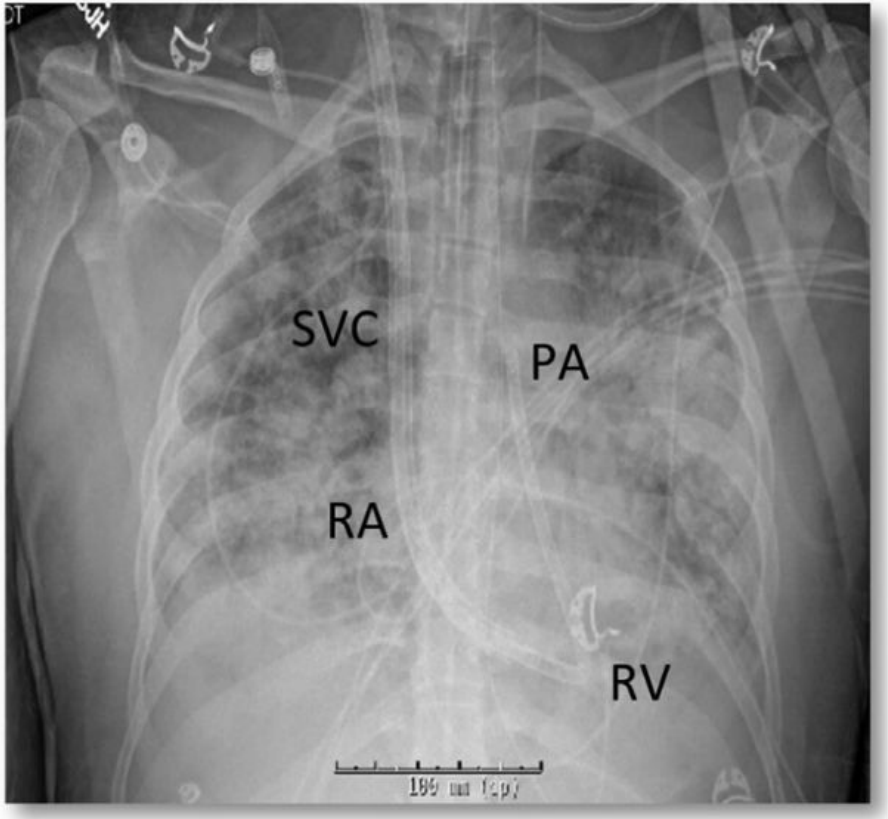
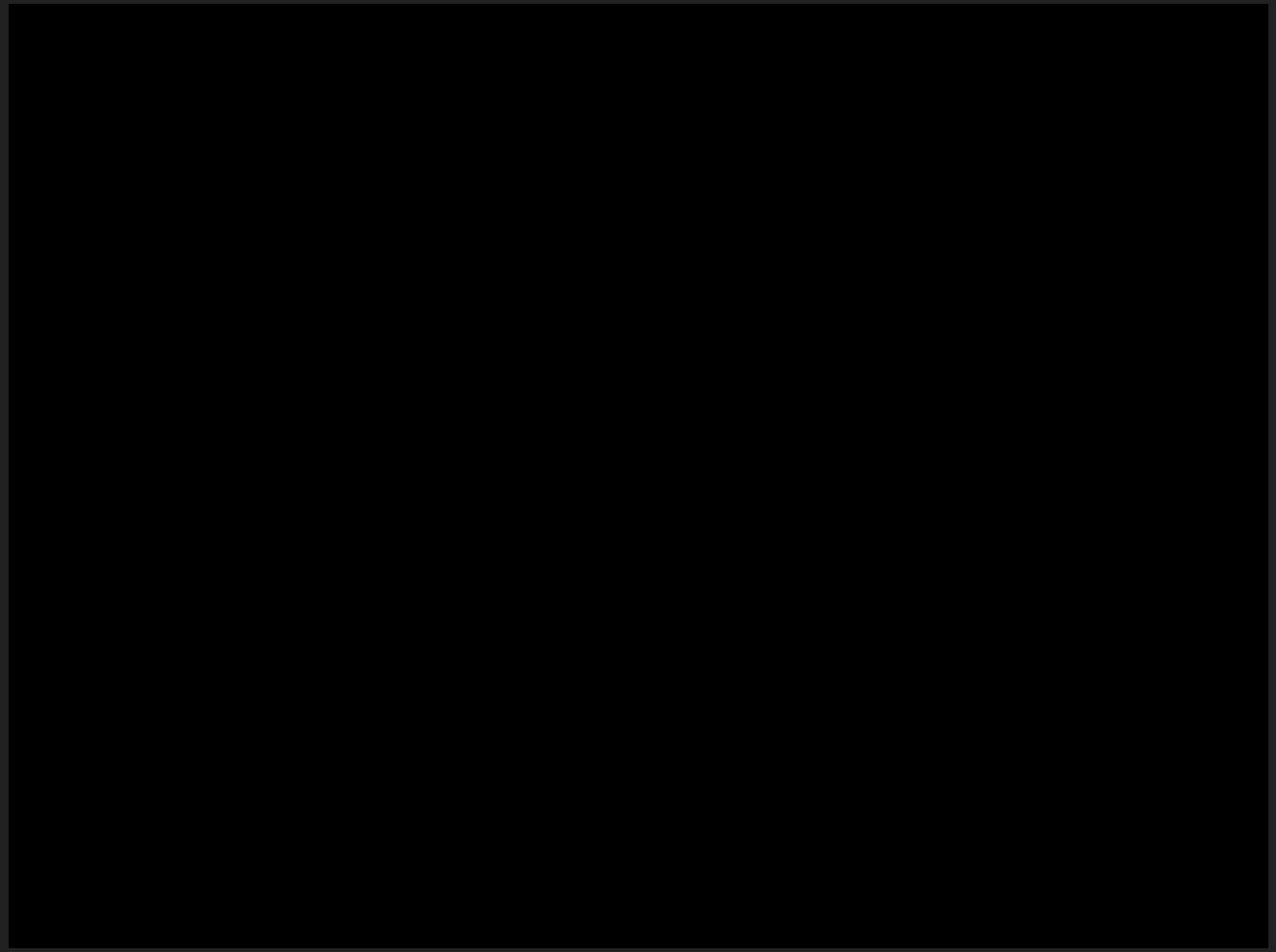

SVC
PA
RA
RV



Association for Academic Surgery

Extracorporeal Membrane Oxygenation with Right Ventricular Assist Device for COVID-19 ARDS

Michael T. Cain, MD,[a] Nathan J. Smith, MD,[a] Mark Barash, DO,[b] Pippa Simpson, PhD,[c] Lucian A. Durham III, MD, PhD,[a] Hemanckur Makker, MD,[d] Christopher Roberts, MD, PhD,[d] Octavio Falcucci, MD,[d] Dong Wang, PhD, MS,[e] Rebekah Walker, PhD,[e,f] Gulrayz Ahmed, MD,[g] Sherry-Ann Brown, MD, PhD,[h] Rahul S. Nanchal, MD,[b] and David L. Joyce, MD, MBA,[a,]*

Comparative Propensity Matched Outcomes in Severe COVID-19 Respiratory Failure—Extracorporeal Membrane Oxygenation or Maximum Ventilation Alone

Asif K. Mustafa, MD, PhD,†✉ Devang J. Joshi, MD,*† Philip J. Alexander, MD,*† Deborah R. Tabachnick, MD,*† Chadrick A. Cross, MD,*† Eias E. Jweied, MD, PhD,*† Nitesh S. Mody, DO,‡ Marc H. Huh, MD,‡ Subia Fasih, MD,§ Pat S. Pappas, MD,*† and Antone J. Tatooles, MD*†✉*

Possible Reasons for Improved Outcomes

- Cessation of mechanical ventilation
- Weaning of sedation
- Aggressive rehab and mobility
- RV support

Children’s Colorado Awake ECMO Experience

CHCO Experience

- 4 patients - all teenagers with varying comorbidities
  - Obesity common
- Different cannulation strategies
  - VA and VVA
  - VV ECMO
  - VP ECMO
    - Protek Duo via the IJ
    - Protek Duo RD perventricular cannulation

Contents lists available at ScienceDirect

Journal of Cardiothoracic and Vascular Anesthesia

journal homepage: www.jcvaonline.com

Case Report

Transapical ProtekDuo Rapid Deployment Cannula as Temporary Left Ventricular Assist Device in a Jehovah's Witness Patient

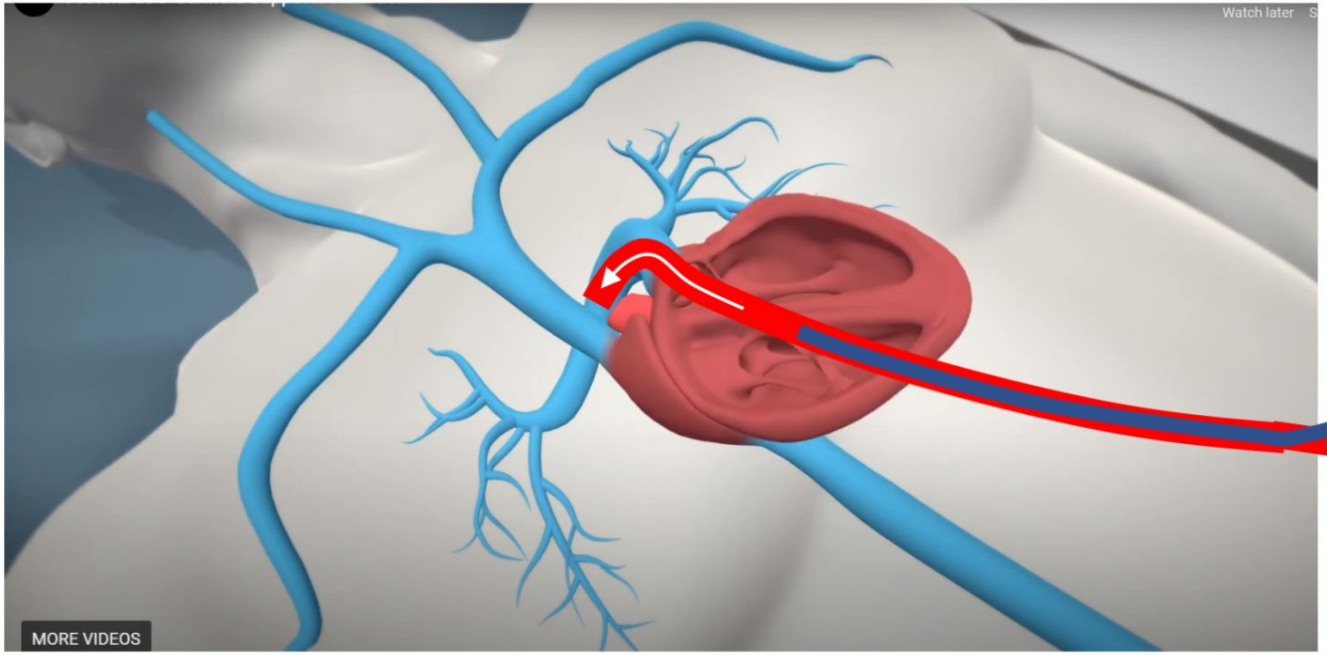
Kiran Belani, MD[*,1], Christina E. Saikus, MD, PhD[†], Jacob N. Schroder, MD[‡], Rebecca Y. Klinger, MD, MS[§]

[*]*Beth Israel Deaconess Medical Center, Department of Anesthesia, Critical Care, and Pain Medicine, Boston, MA*

[†]*Cleveland Clinic, Heart and Vascular Institute, Thoracic and Cardiovascular Surgery, Cleveland, OH*

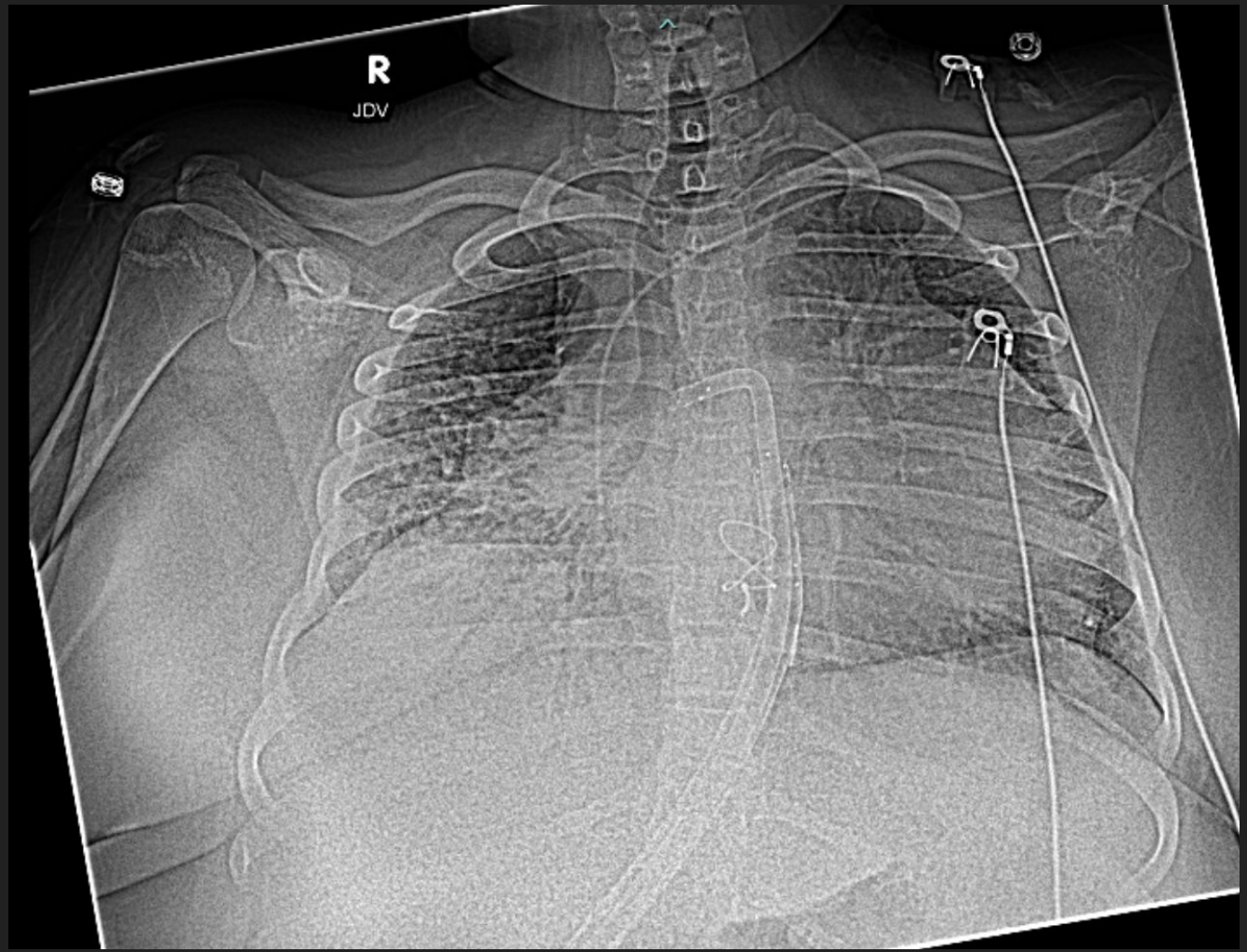
[‡]*Duke University Medical Center, Department of Surgery, Division of Cardiovascular and Thoracic Surgery, Durham, NC*

[§]*Duke University Medical Center, Department of Anesthesiology, Division of Cardiothoracic Anesthesiology, Durham, NC*



To ECMO circuit

From ECMO circuit


R
JDV

Results

- Extended ECMO runs
  - 1-5 months
- All patients extubated
- Good rehab participation
- Results
  - 3/4 survived to discharge
  - All discharged home (one had stay on rehab floor)

Difficulties and Setbacks

- Long ECMO runs with ups and downs
  - Compassion fatigue
- Infection
- Dyspnea and air hunger
- Cannula and cannulation issues
  - Best cannulation strategy in children
  - Cannula malposition
  - Cannula fracture
- Other issues
  - Effusions
  - Arrhythmias

Conclusions

COVID-19 causes a high rate of severe ARDS, even in children.

ECMO can be used successfully in these patients.

RV support, early extubation, and aggressive rehab with ambulation can lead to good outcomes.

Novel cannulation strategies should be considered in children due to their varying size.

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Questions?

And Thank You!