

Welcome to the 12th Annual MAVES

3 May 2020



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ECMO in COVID-19

Mohammed Nabeel MD

- No Disclosures

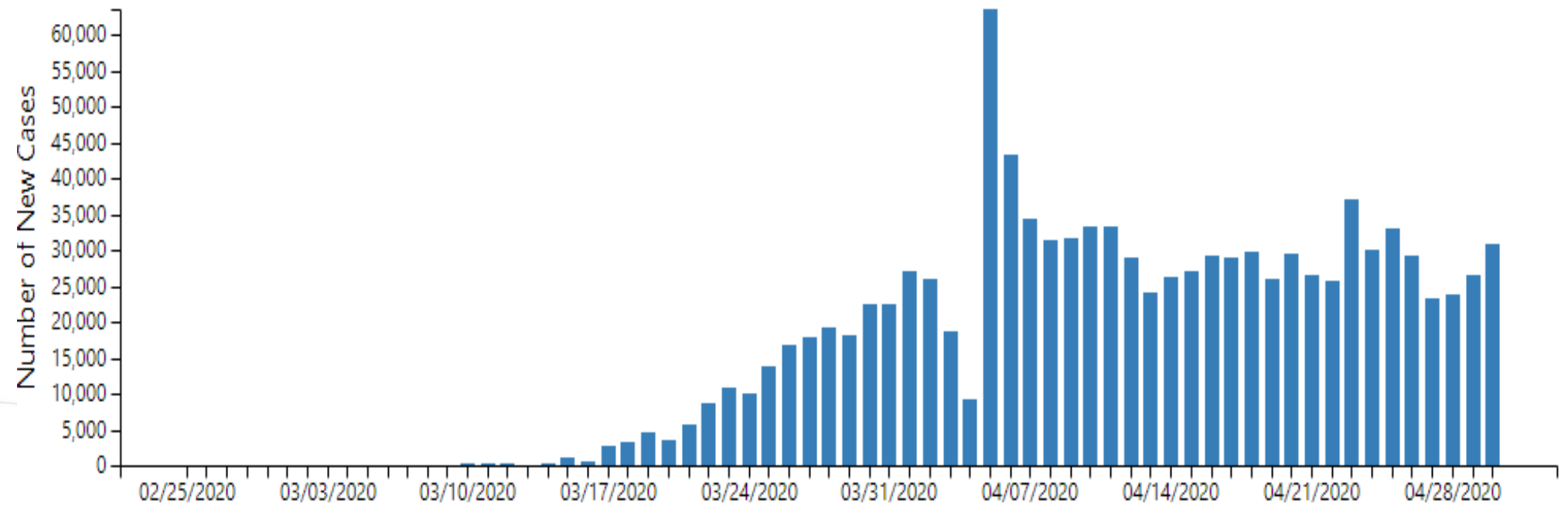
Last updated on May 1, 2020

TOTAL CASES
1,062,446
30,787 New Cases*

TOTAL DEATHS
62,406
2,349 New Deaths*

*Compared to yesterday's data

[About the Data](#)



<https://www.cdc.gov/coronavirus/2019-ncov/cases-updates>

Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel Coronavirus–Infected Pneumonia in Wuhan, China

Table 4. Complications and Treatments of Patients Infected With 2019-nCoV

| | No. (%) | | | P Value ^a |
|------------------------|-----------------|--------------|-------------------|----------------------|
| | Total (N = 138) | ICU (n = 36) | Non-ICU (n = 102) | |
| Complications | | | | |
| Shock | 12 (8.7) | 11 (30.6) | 1 (1.0) | <.001 |
| Acute cardiac injury | 10 (7.2) | 8 (22.2) | 2 (2.0) | <.001 |
| Arrhythmia | 23 (16.7) | 16 (44.4) | 7 (6.9) | <.001 |
| ARDS | 27 (19.6) | 22 (61.1) | 5 (4.9) | <.001 |
| AKI | 5 (3.6) | 3 (8.3) | 2 (2.0) | .11 |
| Treatment | | | | |
| Antiviral therapy | 124 (89.9) | 34 (94.4) | 90 (88.2) | .36 |
| Glucocorticoid therapy | 62 (44.9) | 26 (72.2) | 36 (35.3) | <.001 |
| CKRT | 2 (1.45) | 2 (5.56) | 0 | >.99 |
| Oxygen inhalation | 106 (76.81) | 4 (11.11) | 102 (100) | <.001 |
| NIV | 15 (10.9) | 15 (41.7) | 0 | <.001 |
| IMV | 17 (12.32) | 17 (47.22) | 0 | <.001 |
| ECMO | 4 (2.9) | 4 (11.1) | 0 | .004 |

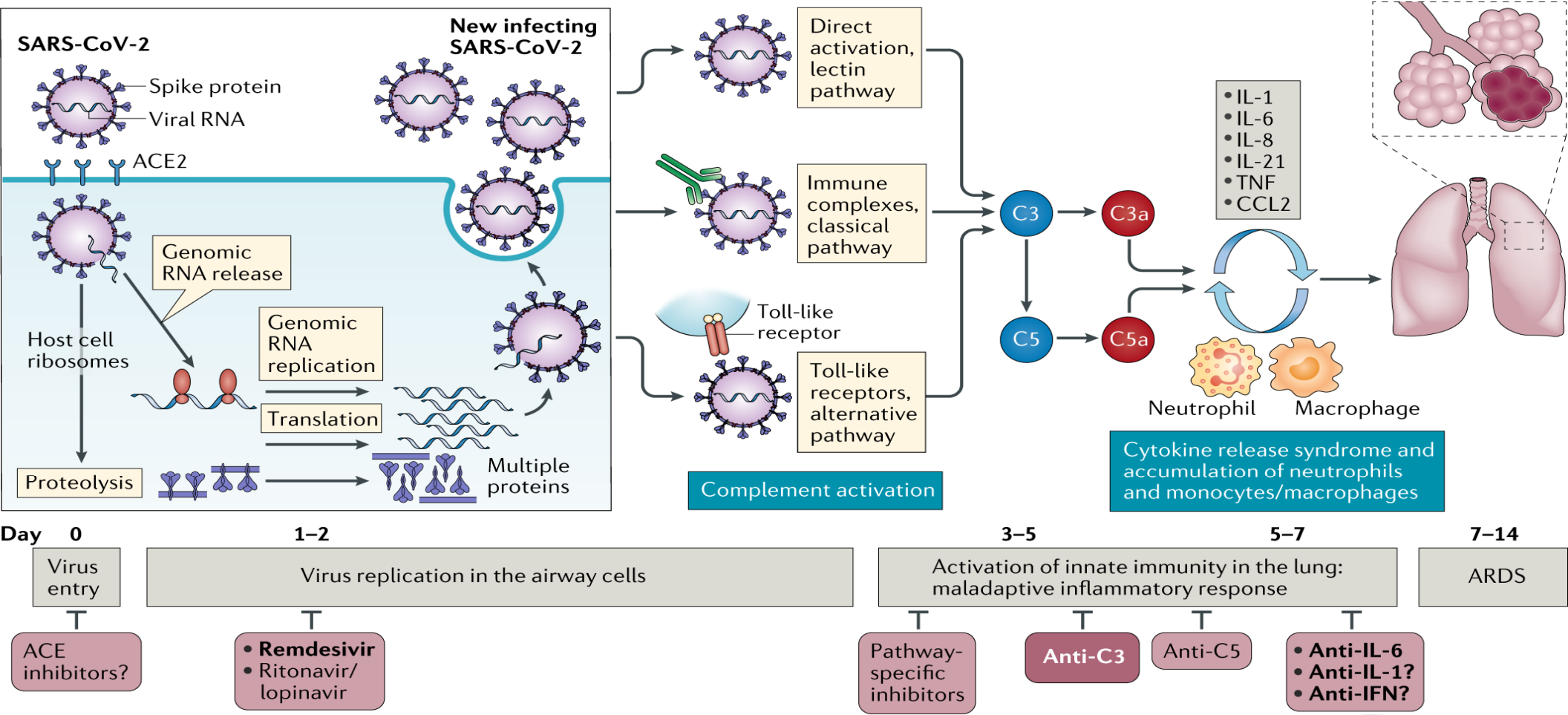
March 13, 2020

Risk Factors Associated With Acute Respiratory Distress Syndrome and Death in Patients With Coronavirus Disease 2019 Pneumonia in Wuhan, China

Chaomin Wu, MD^{1,2,3}; Xiaoyan Chen, MD³; Yanping Cai, MD²; et al
[» Author Affiliations](#) | [Article Information](#)
JAMA Intern Med. Published online March 13, 2020. doi:10.1001/jamainternmed.2020.0994

Table 1. Demographic Characteristics of Patients With Coronavirus Disease 2019 Pneumonia

| Study population | No. (%) |
|---|------------------|
| No. of patients | 201 |
| Age, median (IQR), y | 51 (43-60) |
| ≥65 | 40 (19.9) |
| <65 | 161 (80.1) |
| Highest patient temperature, median (IQR), °C | 38.8 (38.3-39.0) |
| ≥39 (high fever) | 77 (38.3) |
| <39 | 93 (46.3) |
| Gender | |
| Male | 128 (63.7) |
| Female | 73 (36.3) |
| Clinical outcomes | |
| ARDS | 84 (41.8) |
| ICU admission | 53 (26.4) |
| Death | 44 (21.9) |



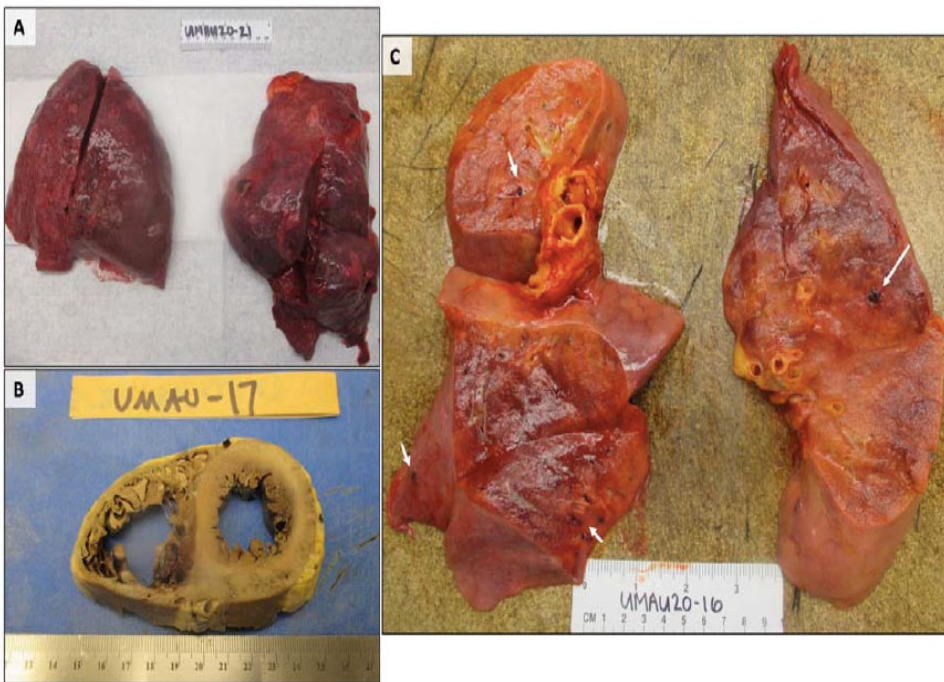


FIGURE 1: Gross Findings of the Lungs and Heart. A) Lungs with bilateral pulmonary edema and patches of dark hemorrhage, and B) A heart showing extreme right ventricular dilatation, with straightening of the interventricular septum. C) Cut sections of lung showing thrombi present within peripheral small vessels (white arrows).

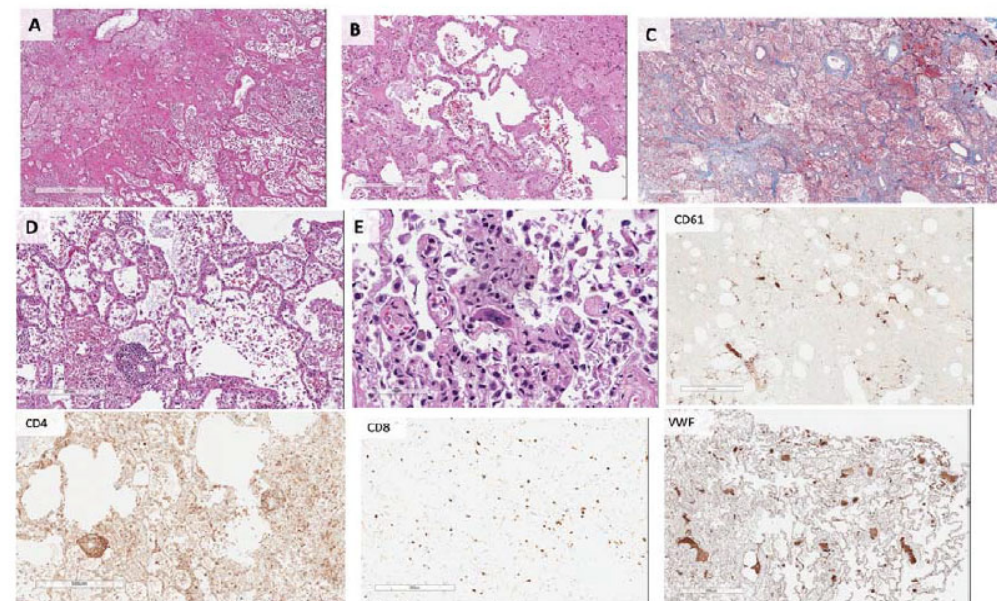


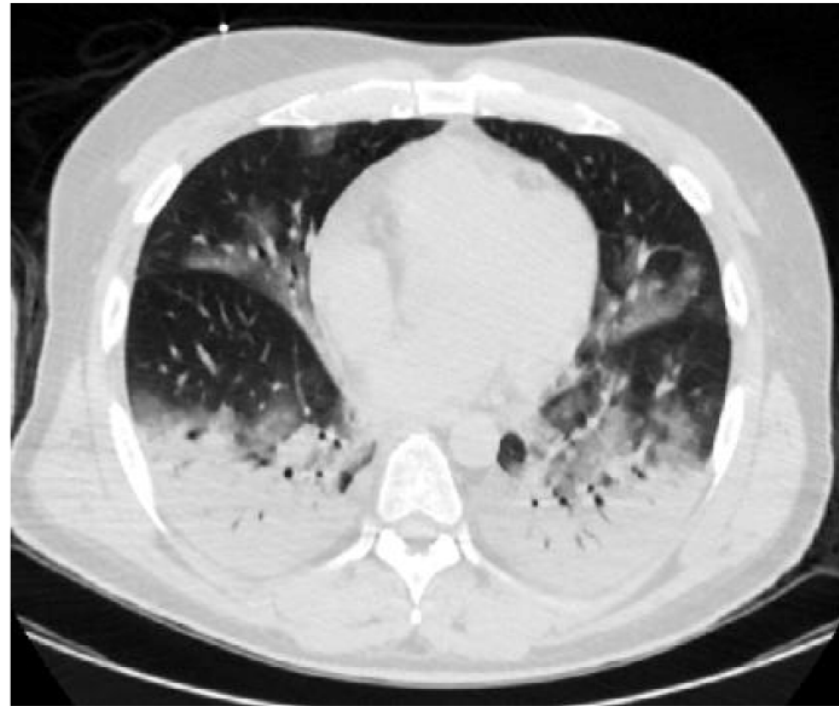
FIGURE 2: Pulmonary Microscopic Findings. All patients demonstrated extensive diffuse alveolar damage. A) Hyaline membranes and hemorrhage (H&E), with B) Fibrin thrombi present within distended small vessels and capillaries, and C) Extensive extracellular fibrin deposition highlighted in blue by Masson-Trichrome stain. D) Perivascular aggregations of lymphocytes, which were positive for CD4 immunostain, with only scattered CD8 positive cells present. E) Numerous megakaryocytes were present within the small vessels and alveolar capillaries, highlighted by CD61 and Von Willebrand Factor immunostains.

COVID ARDS

Type 1



Type 2



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

Giles J Peek*¹, Felicity Clemens², Diana Elbourne², Richard Firmin¹, Pollyanna Hardy^{2,3}, Clare Hibbert⁵, Hilliary Killer¹, Miranda Mugford⁴, Mariamma Thalanany⁴, Ravin Tiruvoipati¹, Ann Truesdale² and Andrew Wilson⁶

November 4, 2009

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

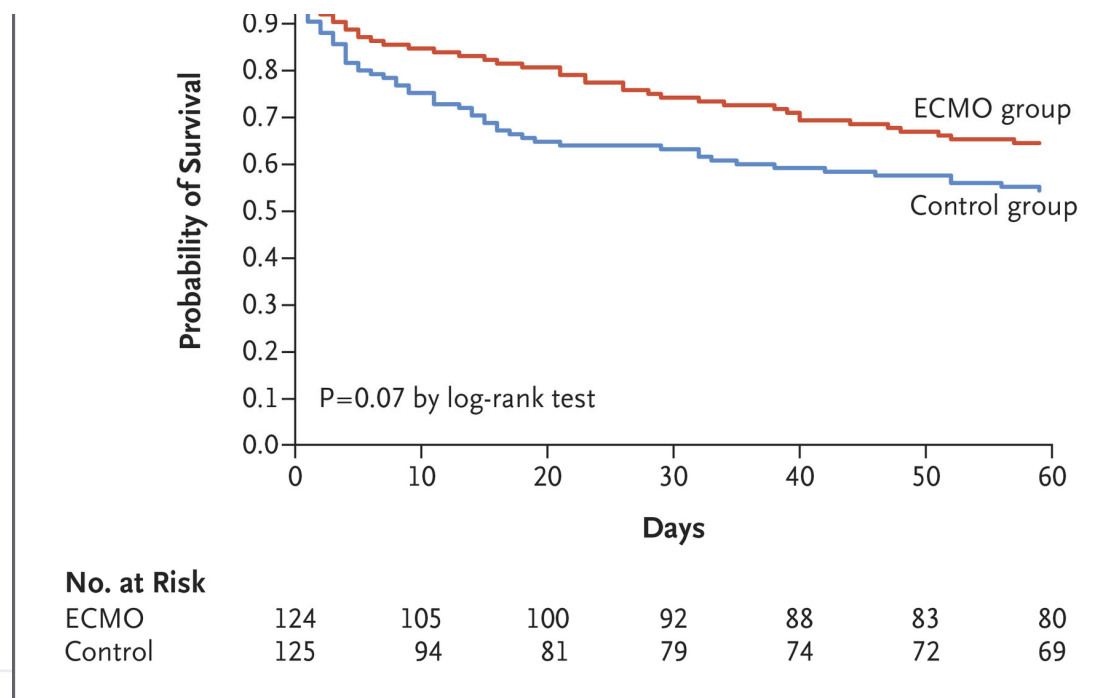
The Australia and New Zealand Extracorporeal Membrane Oxygenation (ANZ ECMO) Influenza Investigators*

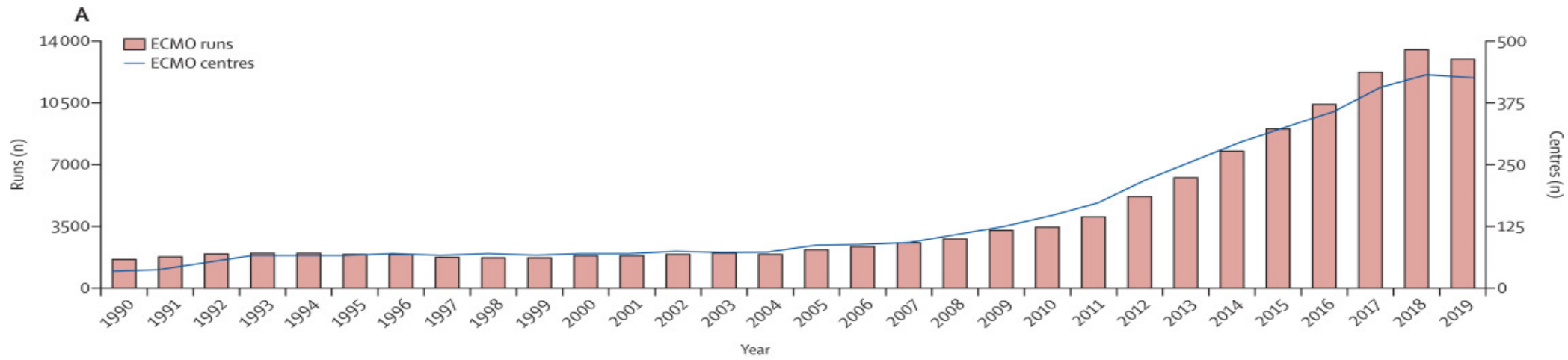
» [Author Affiliations](#) | [Article Information](#)

JAMA. 2009;302(17):1888-1895. doi:10.1001/jama.2009.1535

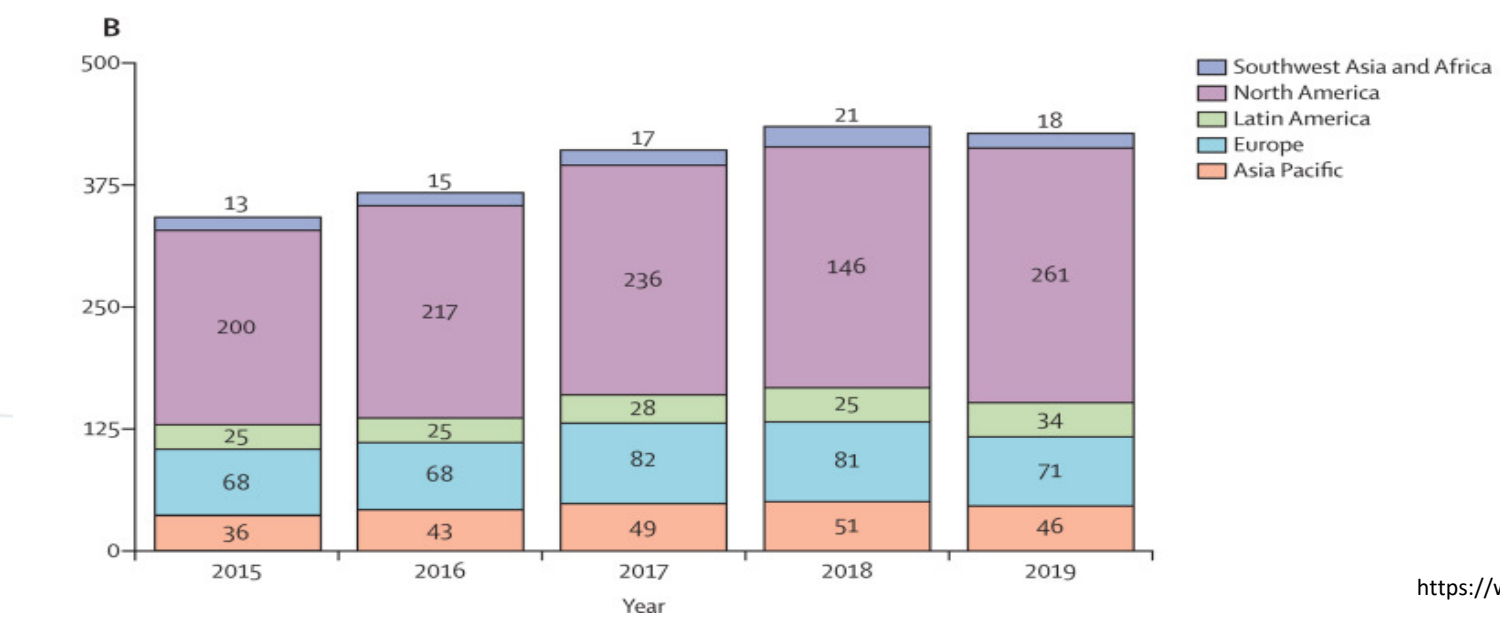
Extracorporeal Membrane Oxygenation for Severe Acute Respiratory Distress Syndrome

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., et al., for the EOLIA Trial Group, REVA, and ECMONet*





| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|
| Number of centres | 83 | 86 | 115 | 98 | 112 | 111 | 115 | 112 | 112 | 112 | 115 | 115 | 119 | 117 | 118 | 130 | 131 | 135 | 150 | 164 | 183 | 205 | 246 | 278 | 314 | 342 | 368 | 412 | 435 | 430 |
| Number of runs | 1664 | 1775 | 1868 | 1933 | 1743 | 1910 | 1720 | 1880 | 1722 | 1876 | 1862 | 1855 | 1908 | 1974 | 1925 | 2184 | 2346 | 2565 | 2803 | 3262 | 3445 | 4040 | 5150 | 6199 | 7718 | 8950 | 10334 | 12130 | 13394 | 12850 |



Planning and provision of ECMO services for severe ARDS during the COVID-19 pandemic and other outbreaks of emerging infectious diseases



Kollengode Ramanathan, David Antognini, Alain Combes, Matthew Paden, Bishoy Zakhary, Mark Ogino, Graeme MacLaren, Daniel Brodie*, Kiran Shekar*



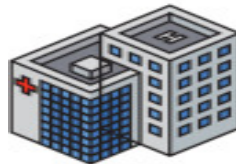
Manifest of all team members
Allocation of roles and team training
PPE and PAPR drills
Staff support for wellbeing

Equipment



Record of equipment and tracking of its movements
Central coordination of equipment and supplies
Awareness of local resources and minimisation of waste
Avoidance of hoarding supplies

Facilities



Clustering of infected patients
Strict infection control procedures
Protocols for patient transport
Waste disposal protocols

Systems



Communication and coordination
Referrals, retrievals, and reporting
Contingency plans and resource allocation
Quality assurance and research

Ramanathan K, Antognini D, Combes A, et al. *Lancet Respir Med.* May 2020. doi:10.1016/S2213-2600(20)30121-1

Total Overall Tested
21,135

Total Positives
4,658

Total Recovered
666

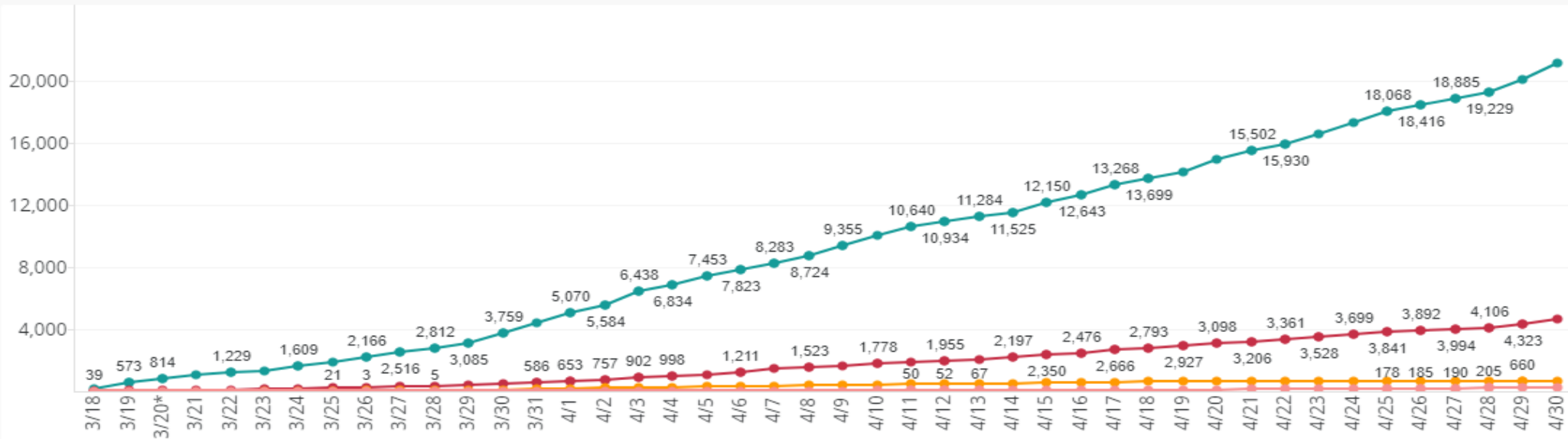
Total Deaths
231

Overall Tested

Positives

Recovered

Deaths



3/18 - 4/30

3/7 4/30

Due to the rapidly evolving nature of this public health crisis, DC is updating this dashboard daily between 8 am - 10 am based on the most recently available data.
*There is no data for "people tested overall" result for 3/20, an averaged number (adjacent days) has been inserted for graphing purposes until the data can be corrected.



Capacity

- Total Beds: 900+
- ICU beds : 85+ (March 2020)
- Repurposed CC units
 - PACU
 - Surge Ares
 - CC capacity : 100+
- ECMO Capacity ~ 15
 - CentriMag
 - RVAD
- Flex ICU Capabilities
- Medstar Network -7 Hospitals



- Who
- When
- How long
- Outcome



ECMO Triage

| | | |
|--|--|--|
| ICU Staffing capabilities <50% | ICU Staffing capabilities 50-75% | ICU Staffing capabilities >75% |
| Equipment availability <50% | Equipment availability 50-75% | Equipment availability >75% |
| Intensive care units' beds' situation <50% | Intensive care units' beds' situation 50-75% | Intensive care units' beds' situation >75% |

Partially available for in-house patients only and NO transfers accepted

The above contraindications apply but with **age more than 60 years old**

No ECMO service

Please consider

- ECMO is labor-intensive and can utilize the ICU staff used for two mechanical ventilated patients
- The family should consent that this is a time-limited intervention, and it is up to the medical team to stop / withdrawal ECMO
- Palliative care medicine/ethics should be consulted on all ECMO patients

Indications for VV ECMO:

Severe acute respiratory distress syndrome that fails traditional management of ARDS (Low tidal volume, optimum PEEP, prone positioning, inhaled epoprostenol) as evident by:

- P/F ratio of less than 50 for 3 hours
- P/F ratio of less than 80 for 6 hours
- pH < 7.25 with PCO₂ >60 for 6 hours

Indications for VA ECMO:

Cardiogenic shock as indicated by any dose of vasopressors or inotropes and documents acute decline in LV function by echocardiogram and pulmonary artery catheter



Contraindications for all forms of ECMO:

- Advanced directives, do not resuscitate order or power of attorney declining ECMO
 - Poor underlying functional status
 - Ongoing cardiac arrest
 - Severe acute brain injury or possible anoxic brain injury
 - Active malignancy associated with unfavorable outcome
 - Contraindication to systemic anticoagulation or unacceptance for blood transfusion (e.g., Jehovah witness)
 - Difficult vascular access (infected site, peripheral vascular disease)
 - Irreversible forms of RV failure without an exit strategy
 - Irreversible organ failure including multi-organ system failure, kidney, or liver failure
 - A non-survivable condition or multi-organ system failure (MOSF) as evident by SAP II > 90
 - Previous mechanical ventilation with high peak air-way pressure or high FiO₂ for more than seven days
 - Presence of additional severe chronic/end-stage organ failures (cirrhosis, acute hepatic failure, severe pulmonary disease)
-

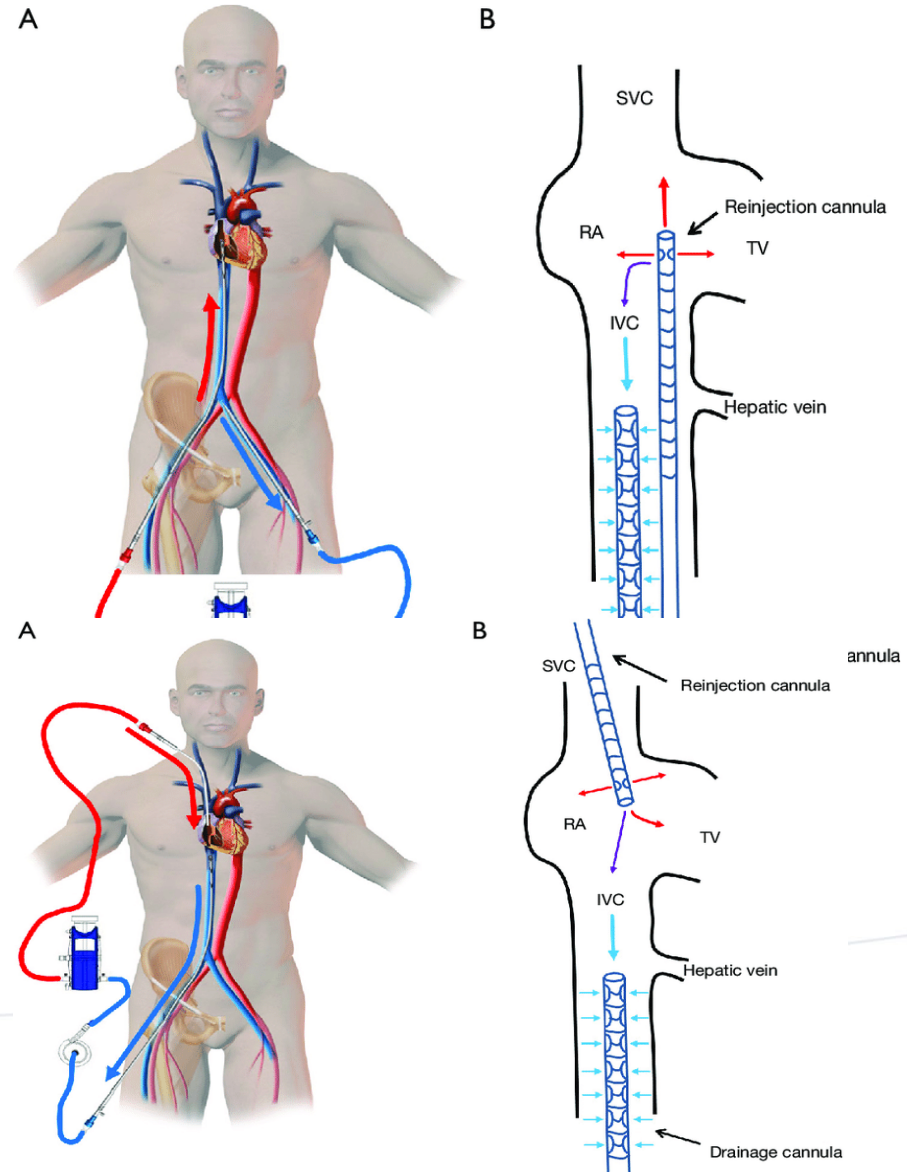
Cases 3/18– 4/24

- Total No. of COVID on ECMO : 14
- VV- 13
- VA -1
- Decannulation: 5
- Death : 4
- Discharged home : 1

| | Deceased ON ECMO (N=2) | Survived to Decannulation (N=4) | Continuing therapy (N=7) |
|---------------------------------------|---------------------------|------------------------------------|-----------------------------|
| Median Age (YO) | 52 (40-64) | 43 (40-46) | 37 (32-51) |
| Male Sex | 0 | 2 (50) | 7 (100) |
| Race | | | |
| White | 0 | 0 | 0 |
| Hispanic | 1 (50) | 3 (75) | 5 (71.4) |
| Black | 1 (50) | 1 (25) | 2 (28.6) |
| Risk Factors | | | |
| Diabetes | 1 (50) | 0 | 2 (28.6) |
| Hypertension | 2 (100) | 0 | 2 (28.6) |
| Asthma | 1 (50) | 1 (25) | 1 (14.2) |
| BMI >30 | 1 (50) | 2 (50) | 6 (85.7) |
| Renal Replacement | 2 (100) | 3 (75%) | 1 (14.2) |
| ECMO | | | |
| Mechanical ventilation to ECMO (days) | 2.1 (1.4.-2.8) | 2.5 (0.9-4.05) | 4.1 (0.25-10.5) |
| Duration of ECMO (days) | 9.2 (7.8-10.6) | 9.7 (2.8-12.1) | 9.8 (1.0 – 14.1) |

Cannulation

- Location- ICU Bedside
- Infection control – PPE , Personnel
- Optimize hemodynamics
- Site: Fem-Fem , Fem-IJ
- Drainage : 25Fr
- Return: 21 Fr
- Risk of recirculation



Ventilator Management

- Mode - Provider Discretion
- APRV preferred
- Low TV/RV < 4-6cc/kg/IBW
- Goal Driving Pressure $\Delta P = V_T / C_{RS} < 14$.
- Prone
 - Proning Protocol
 - Proning Team
- Weaning



Anticoagulation

- Heparin . Anti Xa 0.3-0.5
- Argatroban
- Low AT 3
- DIC
- High Clot burden
- Bleeding Episodes
- Multiple Oxygenator changes
- VTE prevalence



Management


- High sedation requirements
- AKI – CRRT
- COVID Management
 - Abx- Azth. Superinfections
 - Anti-Inflammatory- Hydroxychloroquine , Tocilizumab
 - Anti Viral
 - Convalescent Plasma
- Complications- PTX, GI Bleed
- Labs – LDH , IL 6 , Inflammatory markers.
- Ethical Challenges

Future Directions

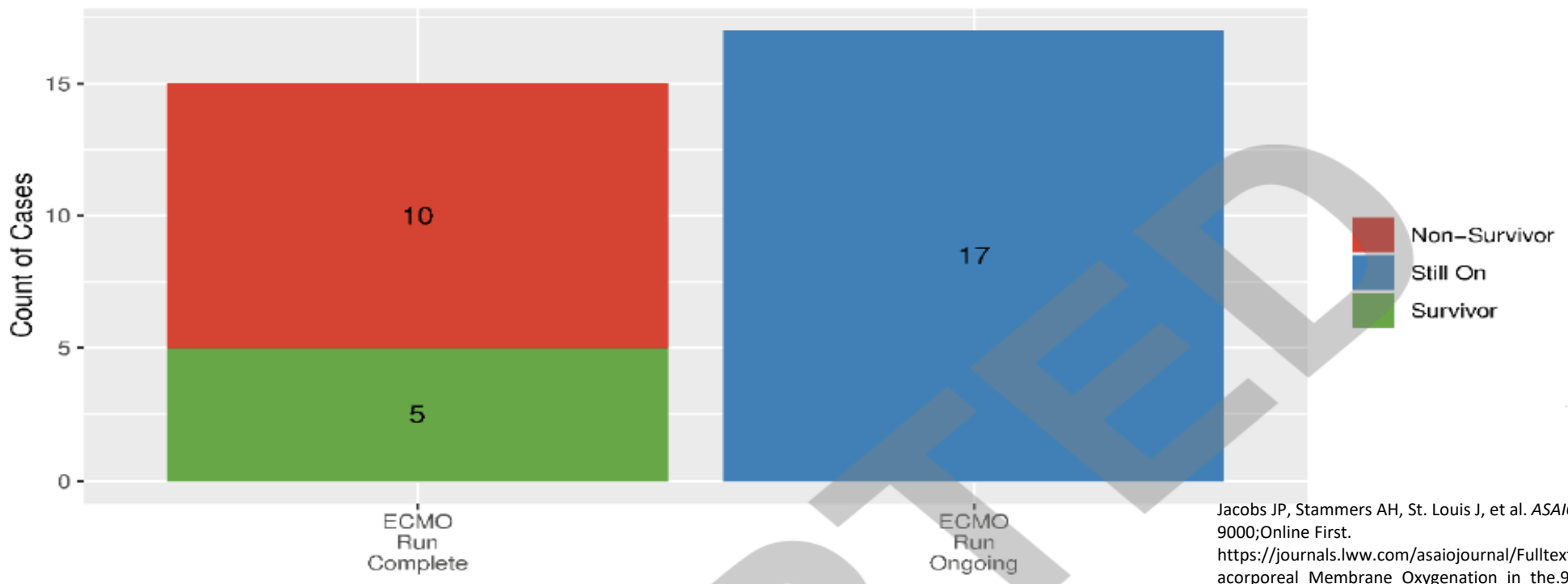
- Post Decannulation Care
 - Placement
 - Management
 - Trach/Peg
 - Long term AC
 - Post Intensive Care Syndrome
- Outcomes
 - PTSD/ Cognitive Dysfunction
 - CC Myopathy
 - Long term Survival

Extracorporeal Membrane Oxygenation in the Treatment of Severe Pulmonary and Cardiac Compromise in COVID-19

Experience with 32 patients

Jacobs, Jeffrey P. MD^{a,b}; Stammers, Alfred H. MSA, PBMS, CCP Emeritus^a; St. Louis, James MD^c; Hayanga, J.W. Awori MD^b; Firstenberg, Michael S MD FAIM FACC^d; Mongero, Linda B. , BS, CCP Emeritus^a; Tesdahl, Eric A. PhD^a; Rajagopal, Keshava MD, PhD^d; Cheema, Faisal H. MD^{e,f}; Coley, Tom CCP Emeritus^a; Badhwar, Vinay MD^b; Sestokas, Anthony K. PhD^a; Slepian, Marvin J. MD^g [Author Information](#) 

Status of 32 COVID-19 ECMO Patients at Time of Publication



Jacobs JP, Stammers AH, St. Louis J, et al. *ASAIO J.* 9000; Online First. https://journals.lww.com/asaiojournal/Fulltext/9000/Extracorporeal_Membrane_Oxygenation_in_the.98533.aspx.

ELSO

Extracorporeal Life Support Organization

COVID-19 Interim Guidelines

A consensus document from an international group of interdisciplinary
ECMO providers



Conventional Capacity

System is running within capacity, judicious ECMO case selection

Capacity exists
Judicious patient selection
Offer V-V, V-A ECMO in selected COVID-19 patients based on usual criteria
Offer ECMO for non COVID-19 indications
ECPR only in expert centres

Contingency Capacity Tier 1

System is running within expanded capacity: triage to maximize ECMO capacity to outcome

Expanded capacity
Triage to maximise resource:benefit ratio
V-V, V-A ECMO in younger COVID-19 patients with single organ failure
Judicious ECMO use for non COVID-19 indications
ECPR not offered

Contingency Capacity Tier 2

Expanded capacity close to saturation, restrictive ECMO selection criteria

Capacity Saturated
Restrictive ECMO criteria for all indications
Prioritise non COVID-19 indications with better chance of survival
V-V ECMO in younger, single organ failure COVID-19 patients
V-A ECMO and ECPR not offered

Crisis Capacity

System is overwhelmed, ECMO may no longer be appropriate, concentrate resources to usual care

Capacity overwhelmed
ECMO not feasible in both COVID-19 and non- COVID-19 patients
Triage ICU admissions
Consider ceasing all futile care to create capacity in the system

ELSO Registry COVID -19

COVID-19 Cases on ECMO in the ELSO Registry

COVID-19
Suspected or Confirmed

660

COVID-19
Confirmed Cases

652

COVID-19
Discharged Alive

77/166 (46%)

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

COVID-19 ECMO counts by ELSO Chapter

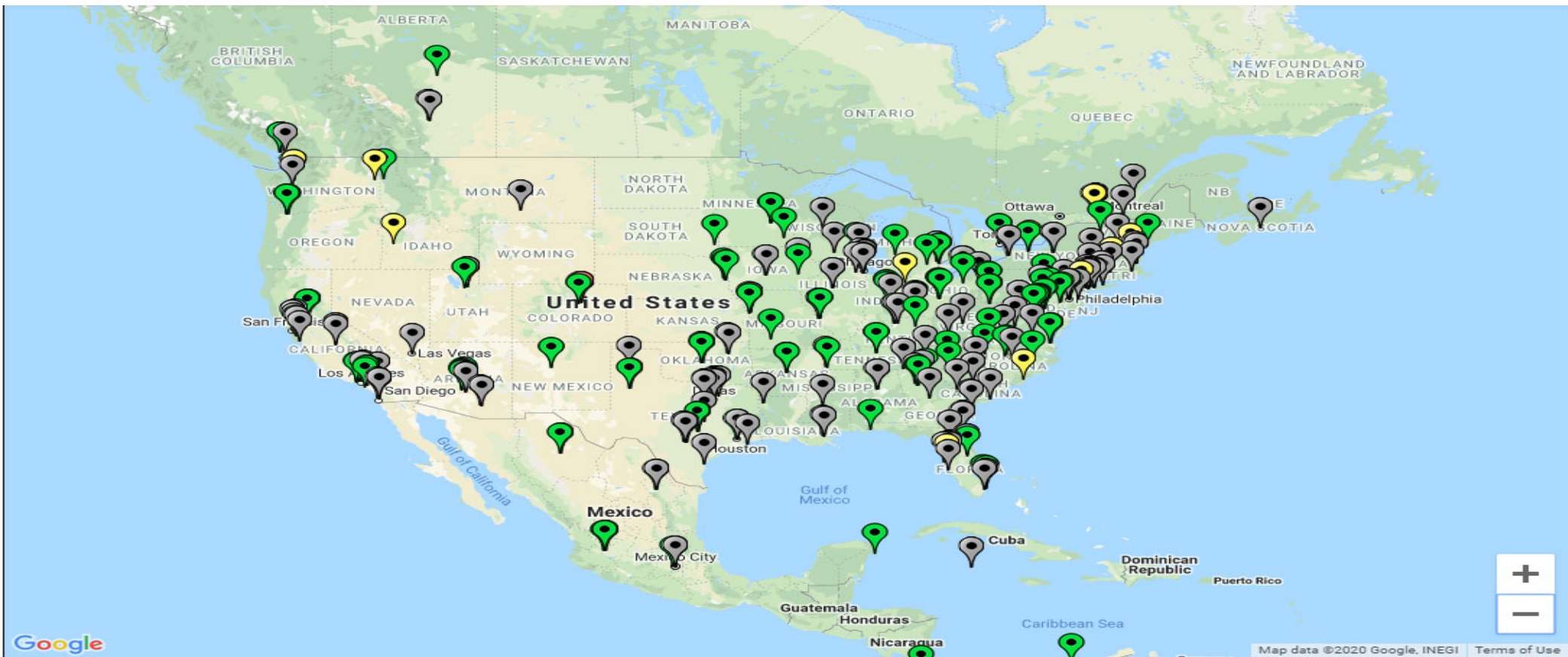
| | Total (n) | Still on ECMO | Completed ECMO | Discharged alive/dead | Transferred out on ECMO |
|---------------|-----------|---------------|----------------|-----------------------|-------------------------|
| All ELSO | 660 | 334 | 326 | 202 | 3 |
| North America | 443 | 236 | 207 | 131 | 2 |
| Europe | 168 | 77 | 60 | 60 | 1 |
| Asia Pacific | 23 | 7 | 16 | 7 | 0 |
| Latin America | 16 | 8 | 8 | 3 | 0 |
| SWAAC | 10 | 6 | 4 | 1 | 0 |

* not reporting cases where n < 5

Reports counts of ECMO-supported suspected or confirmed COVID-19 cases by ELSO Chapter (provided the chapter has at least 5 cases reported)

COVID-19 ECMO Statistics, for all cases including those still on ECMO

| | Statistics | Counts (n) | Range | |
|--|-----------------------------|------------|-----------------|-----------------|
| | | | 25th Percentile | 75th Percentile |
| cases | | 660 | | |
| Age, years (median) | 49 | 660 | 40 | 57 |
| Male | 485 (73%) | 660 | | |
| Weight, kg (median) | 95 | 570 | 80 | 109 |
| Intubation to ECMO, hours (median) | 92 | 660 | 35 | 145 |
| ECMO Support Type | | | | |
| Respiratory | 635 (96%) | 660 | | |
| Cardiac | 19 (2%) | 660 | | |
| ECPR | 6 (0%) | 660 | | |
| ECMO Mode | | | | |
| VV | 608 (92%) | 660 | | |
| VA | 23 (3%) | 660 | | |
| VVA | 3 (0%) | 660 | | |
| Conversion | 25 (3%) | 660 | | |
| Positive end expiratory pressure (median) | 15 cm H₂O | 480 | 12 | 18 |
| PF ratio (median) | 73 | 475 | 60 | 99 |



ECMO Availability Center Map

-  - ECMO capacity available
-  - Limited ECMO capacity
-  - ECMO not available
-  - No status information

- **Provide Best ICU Practice Care.**
- **ECMO – Works !! Use Wisely !**
- **Team Game. Time Game .**
- **Rapidly Evolving Disease Process.**
- **Learn on the go.**
- **Collaborative Effort.**
- **Share Data & Experiences**



RESOURCES

- ELSO
- EuroELSO
- Perfusion SCCM
- NIH Covid Guidance
- Emcrit



Thank you

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