Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

axillary IABP. One patient had a prior Impella device (Abiomed) in place before undergoing axillary IABP placement, and 1 patient directly received an axillary IABP.

Of 9 patients, the mean duration of mechanical support via transaxillary IABP was 14 days, with 7 of 9 patients receiving support for more than 7 days, 3 patients receiving more than 20 days of mechanical support, and 1 patient receiving support for 43 days. Two of 9 patients were successfully bridged to heart transplant. Three patients were bridged to LVAD. Two patients were bridged to recovery, with 1 patient discharged home and the other discharged to rehab. One patient was converted to hospice care and their IABP was explanted. One patient died on venoarterial extracorporeal membrane oxygenation.

Six of 9 patients were able to ambulate with physical therapy while receiving mechanical circulatory support via transaxillary IABP. One patient was able to sit with physical therapy assistance. One patient refused physical therapy and remained bedbound, and the remaining patient walked on extracorporeal membrane oxygenation.

One patient developed a left axillary artery thrombosis requiring operative thromboendarterectomy. The IABP in 2 patients became malpositioned. One patient required replacement for balloon rupture and the other patient developed left subclavian artery stenosis after the balloon migrated into the subclavian artery. One patient developed a left axillary artery dissection during placement of his IABP, requiring axillary artery stent placement in the catheterization laboratory.

Our data indicated that mechanical circulatory support achieved via transaxillary IABP, as opposed to hindering physical rehabilitation in the ICU, can be compatible with a post-recovery reconditioning regimen. Seventy-eight percent of our patients who received transaxillary IABP, with a duration of support exceeding 7 days, ambulated with physical therapy or were able to sit up in a chair. This represents a meaningful advance from the limitation imposed by femoral IABPs.

Conflict of Interest

None.

References

1 Estep JD, Cordero-Reyes AM, Bhimaraj A, et al. Percutaneous placement of an intra-aortic balloon pump in the left axillary/subclavian position provides safe, ambulatory long-term support as bridge to heart transplantation. JACC Heart Fail 2013;1:382–8.

Aneel Deshmukh, MD*
Edward McGough, MD*
Mustafa M. Ahmed, MD†
*Department of Anesthesiology, University of Florida College of Medicine, Gainesville, FL
†Department of Internal Medicine, Division of Cardiovascular Medicine, University of Florida College of Medicine, Gainesville, FL

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Use of ECMO in Patients With Coronavirus Disease 2019: Does the Evidence Suffice?

To the Editor:

CORONAVIRUS DISEASE 2019 (COVID-19) is a contagious infection precipitated by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2. It is a novel virus of which transmissability, incidence and mortality rates have made it a global emergency. While the clinical manifestations of the virus may vary in severity, it is widely known that the cardiorespiratory system is the principle infection point of the virus, with acute respiratory distress syndrome (ARDS) and shock being possibilities.[1]

Although severe and critically ill patients account for 15-26% of patients, there are currently no targeted COVID-19 therapeutics.[2] At present, supportive care forms the core of disease management, with emphasis on oxygen delivery in the early stage of the disease.[3] In March 2020, the World Health Organization (WHO) published interim guidelines recommending the use of extracorporeal membrane oxygenation (ECMO) in ARDS patients unresponsive to mainstream therapies, in order to maintain cardiorespiratory function.[4]

In this letter, we present a systematic review of the literature to summarize the evidence behind using ECMO in COVID-19 patients, in accordance to the "Preferred Reporting Items for Systematic Reviews and Meta-Analysis: (PRISMA) Guidelines. We have performed a comprehensive electronic literature search using key words “COVID-19,” “SARS-CoV2,” “Coronavirus,” “ECMO,” “Extracorporeal membrane oxygenation,” “VA-ECMO,” “VV-ECMO,” “Outcomes,” “Respiratory support,” and “circulatory support,” either as MeSH terms or in the combined key word formats.

Our results showed a total of 102 articles that were collected from the database search and through snowballing. A total of 25 articles were selected to be included, after exclusion of duplication and subsequent screening (Fig 1). A summary of each of the chosen studies was conducted as shown in Table 1. After combining the data from the studies, 3,428 patients were diagnosed with COVID-19 overall, 612 patients were diagnosed with ARDS, and 479 were placed on ECMO, with VV-ECMO being the most commonly used type.

Commonly used as a form of rescue therapy, ECMO was delivered to COVID-19 patients with induced ARDS and other complications demanding urgent care.[5-8] After data collation from the selected articles, an overall mortality rate of 19.83% was estimated. Nevertheless, the actual mortality rate may have been higher as some papers did not account for deaths of patients put on ECMO. The estimated figure, however, supported the claim that the use of ECMO does not exacerbate patient outcomes for COVID-19 patients in critical condition.

Few studies reported high mortality rates for patients with COVID-19. In this review, a total of three studies found a 100% mortality in patients with ARDS placed on ECMO. Yang et al. published similar findings ,with mortality rate of 83.33% (an overall total of 15 deaths).[9-12] Additionally, a

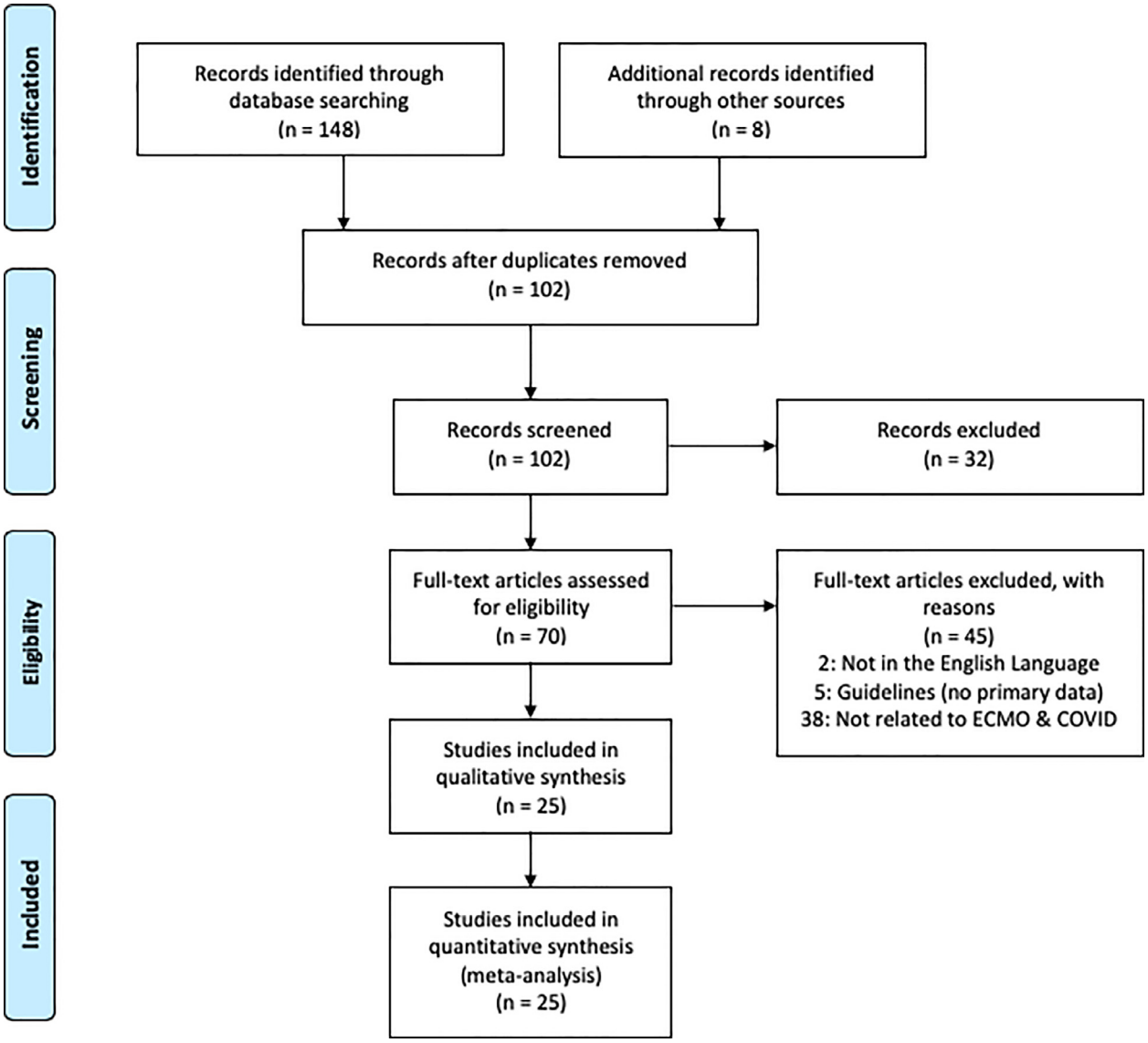

Fig 1. PRISMA chart of the literature search.

study by Guan et al. reported that 5 patients receiving ECMO all faced the same composite primary endpoint (admission to the ICU, mechanical ventilation or death).[13] However, with a number of deaths attributed to septic shock and multiple organ failure, the connection of VA-ECMO support and mortality outcomes could not be ascertained. Another consideration is whether the patients under observations experienced multiple organ failure while on ECMO, this is because ECMO is not advised in multiple organ failure (as highlighted in ELSO guidelines).[14]

Other reports showed conflicting data, with Li et al. depicting an ambivalent 50% mortality rate.[15] Meanwhile, 75% of deaths occurred in patients older than age 75 with comorbidities. Marullo et al. had similar findings, with a marginal difference between the number of patients who weaned off ECMO (60) and the number of deaths after ECMO (57) and an elevated risk in patients older than 60 with comorbities.[16]

In a separate research study by Loforte et al., 75% weaning rate was reported; however,one- third of weaned patients died after subsequent VV-ECMO removal.[17] Also, the remaining patient of the four had severe gastrointestinal bleeding while on ECMO, a severe complication linked to ECMO.[18] Thus, with a final mortality rate of 50%, with 2 out of 4 patients eventually dying, these results were also inconclusive in terms of the benefit of ECMO in COVID-19.

Despite results in these studies being less-than- optimistic, several considerations should be noted. First, the small sample in the majority of these articles offered no reliable conclusions. Second, the patient's disease severity at the time of ECMO initiation was often not addressed; therefore, ECMO administration may have been delayed to an extent that its effect on patients was questionnable.

Even though the postive results of some studies did not suffice as concrete evidence for ECMO use in COVID-19, they may be useful to determine whether specific patient characteristics are more compatible with ECMO use. Such findings have been reported by 2 case series and six case reports and 2 case series, which all found positive

Table 1
Summary of Included Articles.

Author	Country	Study Type	Cohort Size (No. of Patients on ECMO)	ARDS	Time and Type of ECMO (VV or VA)	Overall Mortality (%)
Barrasa et al.[5]	Spain	Retrospective	48 (1)	48	N/A	6 (15)
Bemtgen et al.[20]	Germany	Case report	1 (1)	1	VA-ECMO and then switched to VV-ECMO	N/A
Chen et al.[24]	China	Retrospective	99 (3)	17	N/A	11 (11)
Firstenberg et al.[21]	USA	Case report	1 (1)	1	VV-ECMO (introduced on seventh day)	N/A
Guan et al.[13]	China	Cross-sectional	1,099 (5)	37	N/A	14 (1.4)
Hartman et al.[22]	USA	Case report	1 (1)	N/A	VV-ECMO Started ECMO on hospital day 4	N/A
Huang et al.[6]	China	Cross-sectional	41 (2)	12	N/A	6 (14.6)
Jacobs et al.[31]	USA	Cross-sectional	32 (32)	N/A	VV-ECMO used in 78.1% of cases	10 (31.3)
Li et al.[15]	China	Case series	16 (8)	N/A	7 on VV-ECMO 1 on VA-ECMO	N/A
Loforte et al.[17]	Italy	Observational	59 (4)	59	VV-ECMO used in all patients	1 (25)
Marullo et al.[16]	Europe	Retrospective	333 (333)	N/A	VV-ECMO used in 93.7% of cases	57 (17.1)
Nakamura et al.[23]	Japan	Case report	1 (1)	1	VV-ECMO introduced on hospital day 2	N/A
Ruan et al.[9]	China	Retrospective	150 (7)	62	N/A	68 (48.3)
Shen et al.[25]	China	Case series	5 (1)	5	N/A	N/A
Sultan et al.[29]	USA	Case series	10 (10)	10	VV ECMO Median time from first symptom to ECMO: 11 days 7 and 10 days in total on ECMO	1 (10)
Takeda[30]	Japan	Letter to the Editor	26 (26)	N/A	N/A	N/A
Tang et al.[7]	China	Retrospective case-control	179 (10)	73	N/A	21 (28.3)
Taniguchi et al.[26]	Japan	Case report	1 (1)	1	VV-ECMO (introduced on sixth day, day 2 after intubation) 6 days on ECMO in total	N/A
Wang et al.[2]	China	Case series	138 (4)	22	N/A	6 (4.3)
Wu et al.[10]	China	Retrospective	201 (1)	84	N/A	44 (22.9)
Yang et al.[11]	China	Retrospective	710 (6)	35	N/A	32 (4.5)
Zangrillo et al.[8]	Italy	Case series	73 (5)	73	N/A	17 (23.3)
Zeng et al.[28]	China	Case series	12 (12)	12	1.3 mean days on ECMO	5 (41.6)
Zhan et al.[27]	China	Case report	1 (1)	N/A	VV-ECMO 5 days on ECMO	N/A
Zhou et al.[12]	China	Retrospective	191 (3)	59	N/A	54 (28.3)

Abbreviations: ARDS (Acute Respiratory Distress Syndrome) , VA-ECMO (Veno-arterial Extracorporeal Membrane Oxygenation), VV-ECMO (Veno-venous Extracorporeal Membrane Oxygenation).

endpoints for patients on ECMO (weaned off ECMO or discharged from the hospital).[19-27]

The included literature postulated that if given earlier, ECMO may improve patient outcomes. Both Zhan et al. and Taniguchi et al. favored early ECMO provision to improve recovery chances of their patients via protection of their organ oxygen supply and prevention of lung injury through mechanical damage (ventilators).[26-27] Firstenberg et al. reported similar findings, with emphasis on the impact of decision-making for ECMO initiation on patient discharge; the timing between reaching the threshold for indication and the decision to begin therapy were found to be of utmost importance[21] Additionally, the role of ECMO in stabilizing oxygenation and supporting the lung have been deemed essential by Taniguchi et al. to improve outcomes.[26] In patients with deteriorating lung function, determining and treating its cause are imperative. In this respect, aggravated oxygenation may be attributed to to worsening ARDS by COVID-19 pneumonia. In cases with stronger inflammatory results than pulmonary congestion, ECMO was initiated to assist the patient's recovery.[28-30] The ELSO guidelines outlined the principal contraindications for the use of ECMO, which have been summarized in Table 2.

The authors searched other literature and found that these results were comparable with regard to the use of ECMO. A systematic review and meta-analysis, including studies such as the CESAR[31] and EOLIA[32] trials among othe, posited that the use of VV-ECMO in acute severe respiratory failure was linked to a 60-day reduced mortality (RR 0.73, 95% CI 0.58-0.92) in comparison to conventional mechanical ventilation.[33] Despite many clinicians against the results in the CESAR study, the EOLIA study still did not reveal any significant difference in overall mortality. Furthermore, an estimate of

Table 2
Absolute Contraindications for ECMO in COVID-19 Patients With Cardiopulmonary Failure.

1. Advanced age	2. Clinical frailty scale category ≥3
3. Severe multiple organ failure (renal failure is not an exclusion criterion)	4. Severe acute neurological injury
5. Significant underlying comorbidities	6. Mechanical ventilation >10 days
7. Uncontrolled bleeding	8. Contraindications to anticoagulation
9. Inability to accept blood products	10. Ongoing CPR

Abbreviations: CPR, cardiopulmonary resuscitation; ECMO, extracorporeal membrane oxygenation.
Adapted from ELSO.[17]

40%-predicted survival to discharge on VA has been reported by ELSO,[34] compared with 58% on VV[35]; yet since no comparison has been made to conventional care, the survival advantage of VV is still to be determined.[36,37]

Supported by several guidelines,the use of VV-ECMO in COVID-19 ARDS,[4,14,38,39] VV-ECMO has proven useful in offering respiratory support, particularly in severe respiratory failure. Hence, with acute respiratory failure and occasionally acute respiratory failure as distinctive features of SARS-COV-2 pneumonia,VV-ECMO use has been on the increase.

Meanwhile, 22% of COVID-19 patients experienced cardiovascular complications, such as heart failure, myocarditis and a hypercoagulability. The evidence in favor of VA-ECMO use for both respiratory and hemodynamic support is well-founded, with VA-ECMO recommended in an array of scanarios, such as myocarditis, acute myocardial infarction, decompensated cardiac failure, or even cardiogenic shock as complications of cardiac injury. This presents an opportunity for additonal use VA-ECMO in COVID-19 patients.[40]

Through compilation of the published findings, the authors devised the systematic plan portayed in Figure 2. Decisions about patient suitability for ECMO should be done in a timely manner to avoid overuse of ventilators and associated complications. For futher risk minimization, patient referrals to specialized tertiary centers are suggested for those in need of ECMO in order to ensure proper care provision and compliance to standardized ECMO guidelines.

Furthermore, risk of thrombotic and hemorrhagic complications can increase due to disruption in coagulation pathways. This may be because of the use of anticoagulants when delivering ECMO and concurrent systemic inflammation. Hence, additional attention must be provided to coagulability levels in patients during ECMO.[41]

Apart from present guidelines, other tools have been produced for the purpose of decision-making around VV-ECMO use to optimize outcomes. Such prediction tool scores include PRESERVE (AUC 0.75, 95% CI 0.57-to-0.92, $p = 0.01$) and RESP scores (AUC 0.81, 95% CI 0.67-to-0.95, $p = 0.035$).[42] Scores like the survival after veno-arterial-ECMO (SAVE) can help to discern patients best suited for VA-ECMO in order to maximize allocation of resources,[43] They also have been salient in forecasting survival outcomes for patients with ARDS using VV-ECMO, but they do not come without limitation. With COVID-19 manifastations being very multifactorial, prediction tool scores often do not consider individual pathophysiologies; for example cytokine storms.

In conclusion, these authors recommend ECMO use in COVID-19 but with caution and in compliance with current guidelines. While evidence advocating ECMO use in COVID-19 is not substantial, ongoing studies may provide new insight in ECMO use in COVID-19 patients in critical cases. To ensure optimal patient care, a case-by-case approach should be implement, with risk-benefit analysis conducted for each patient.

Limitations

Due to the scarcity of data in this area, particularly for use of VA-ECMO, the suitability of ECMO use for COVID-19 is still to be determined. A plausible reason for this is that the prevalence of ARDS (utilizing VV-ECMO) among COVID-19 patients is higher with respect to those with shock (for which VA-ECMO is suggested).

As several studies did not report patient outcomes, we were unable to acertain the true extent to which ECMO affected patient health. The gaps in our outcomes data prevented us from performing a high-quality meta-analysis, as effect sizes could not be estimated for some studies. Therefore, the overall mortality rate that we reported, which included studies without reported outcomes, may be subject to change.

As the characteristics of the study participants in this review were not always mentioned, we were unable to make any assumptions on how ECMO may reduce mortality in particular patient groups. Since demographic factors and presence of comorbidities have shown to have an influence COVID-19 prognoses, these variables should be taken into consideration as potential determinants of patients' outcomes, along with initiation of ECMO as salvage therapy.

Treatment in COVID-19 patients is often complex with ECMO as one of many therapy elements involved in primary treatment. For this reason, the extent to which ECMO use has contributed to patient recovery is still to be determined.

There is no single gold standard to decide initiation of ECMO use, resulting in inconsistent data. In studies with patients receiving ECMO at a more advanced stage, baseline risk of mortality would be elevated. Additionally, hospitals with low numbers of ECMO machines may have prioritized critical patients, due to their greater need of salvage therapy, which could have been reflected in the reported mortality rates (selection bias).

Although collation of data has produced an overall mortality rate, treatment variations, such as treatment technique and time of ECMO initiation, are not being considered. This stems from the fact that diversity of guidelines and degree of compliance to guidelines may have resulted in variable patient outcomes, which cannot be distilled into quantifiable data.

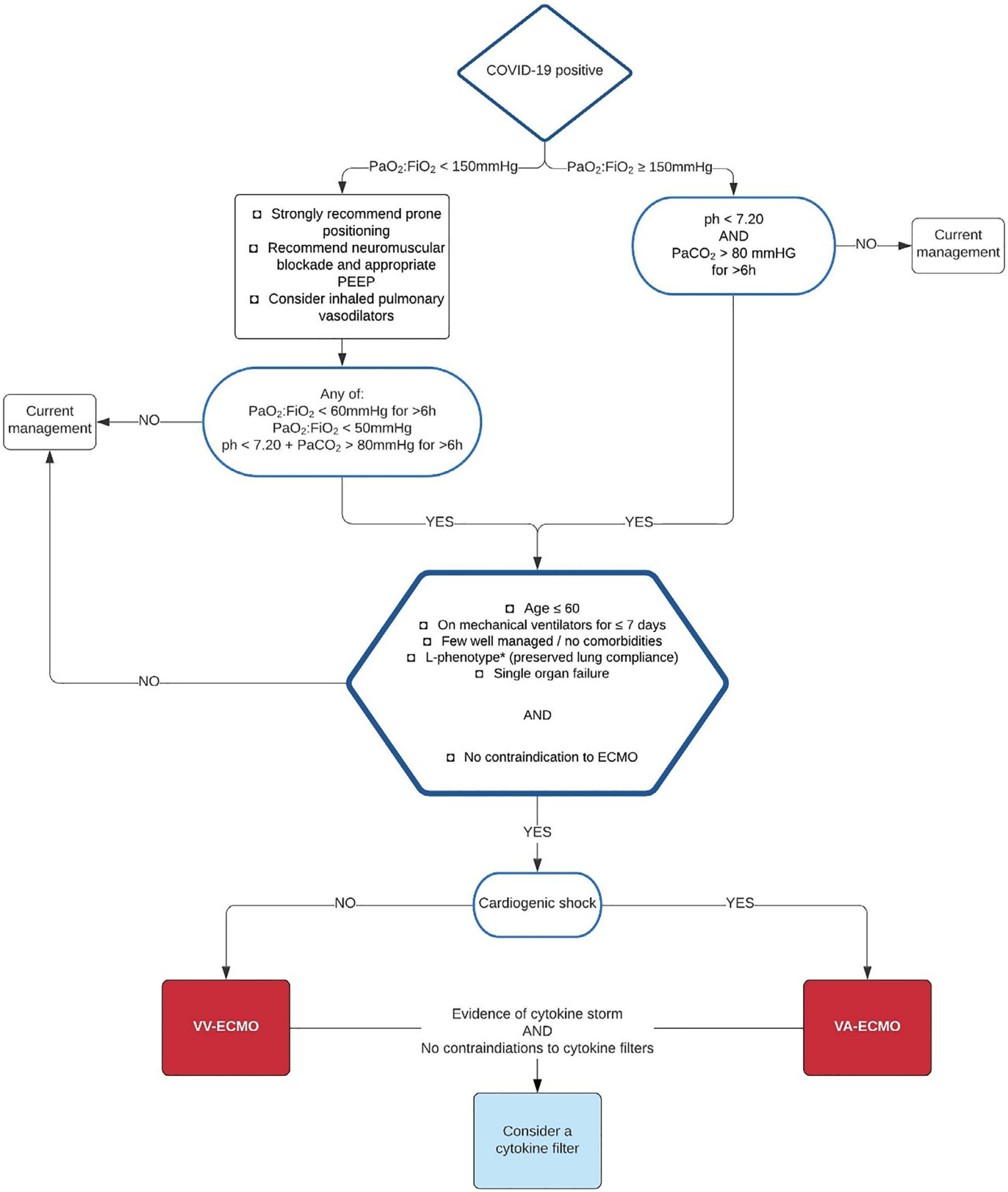

Fig 2. Algorithm for decision-making regarding ECMO provision in COVID-19 patients. Abbreviations: EMCO, extracorporeal membrane oxygenation; Pao_2:Fio_2, ratio of partial pressure of oxygen in arterial blood to the fractional concentration of oxygen in inspired air; $PaCo_2$, partial pressure of carbon dioxide in arterial blood; PEEP, positive end-expiratory pressure. *L-phenotype has been associated with preserved lung compliance and shown to have favorable outcomes with ECMO.[29] Adapted from the Extracorporeal Life Support Organization (ELSO).[14]

Conflict of Interest

None.

References

1 Singhal T. A review of coronavirus disease-2019 (COVID-19). Indian J Pediatr 2020;87:281–6.
2 Wang D, Hu B, Hu C, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus−infected pneumonia in Wuhan, China. JAMA 2020;323:1061–9.
3 Cascella M, Rajnik M, Cuomo A, et al. Features, evaluation and treatment coronavirus (COVID-19). StatPearls 2020.
4 World Health Organization. Clinical management of severe acute respiratory infection (SARI) when COVID-19 disease is suspected: Interim guidance. Available at: https://apps.who.int/iris/rest/bitstreams/1272156/retrieveAccessed 27 May, .
5 Barrasa H, Rello J, Tejada S, et al. SARS-CoV-2 in Spanish intensive care units: Early experience with 15-day survival in Vitoria [E-pub ahead of print]. Anaesth Crit Care Pain Med. 2020. https://doi.org/10.1016/j.accpm.2020.04.001; Accessed August 4.
6 Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 2020;395:497–506.
7 Tang X, Du R, Wang R, et al. Comparison of hospitalized patients with ARDS caused by COVID-19 and H1N1. Chest 2020;158:195–205.
8 Zangrillo A, Beretta L, Scandroglio AM, et al. Characteristics, treatment, outcomes and cause of death of invasively ventilated patients with COVID-19 ARDS in Milan, Italy [E-pub ahead of print]. Crit Care Resusc [Accessed 1st June 2020]
9 Ruan Q, Yang K, Wang W, et al. Clinical predictors of mortality due to COVID-19 based on an analysis of data of 150 patients from Wuhan, China. Intensive Care Med 2020;46:846–8.
10 Wu C, Chen X, Cai Y, et al. Risk factors associated with acute respiratory distress syndrome and death in patients with coronavirus disease 2019 pneumonia in Wuhan, China. JAMA Intern Med 2020;180:1–11.
11 Yang X, Yu Y, Xu J, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: A single-centered, retrospective, observational study. Lancet Respir Med 2020;8:475–81.
12 Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: A retrospective cohort study. Lancet 2020;395:1054–62.
13 Guan W, Ni Z, Hu Y, et al. Clinical characteristics of coronavirus disease 2019 in China. N Engl J Med 2020;382:1708–20.
14 Extracorporeal Life Support Organization. COVID-19 interim guidelines. Available at: https://www.elso.org/Portals/0/Files/pdf/ELSO%20covid%20guidelines%20final.pdf Accessed May 25 .
15 Li X, Guo Z, Li B, et al. Extracorporeal membrane oxygenation for coronavirus disease 2019 in Shanghai, China. ASAIO J 2020;66:475–81.
16 Marullo AG, Cavarretta E, Biondi-Zoccai G, et al. Extracorporeal membrane oxygenation for critically ill patients with coronavirus-associated disease 2019: An updated perspective of the European experience [E-pub ahead of print]. Minerva Cardioangiol. 2020. https://doi.org/10.23736/S0026-4725.20.05328-1; Accessed August 4.
17 Loforte A, Dal Checco E, Gliozzi G, et al. Veno-venous extracorporeal membrane oxygenation support in COVID-19 respiratory distress syndrome. ASAIO J 2020;66:734–8.
18 Aubron C, DePuydt J, Belon F, et al. Predictive factors of bleeding events in adults undergoing extracorporeal membrane oxygenation. Ann Intensive Care 2016;6:1–10.
19 Steinberg E, Balakrishna A, Habboushe J, et al. Calculated decisions: COVID-19 calculators during extreme resource-limited situations. Emerg Med Pract 2020;22(suppl 4);CD1-5.
20 Bemtgen X, Krüger K, Supady A, et al. First successful treatment of coronavirus disease 2019 induced refractory cardiogenic plus vasoplegic shock by combination of percutaneous ventricular assist device and extracorporeal membrane oxygenation: A case report. ASAIO J 2020;66:607–9.
21 Firstenberg MS, Stahel PF, Hanna J, et al. Successful COVID-19 rescue therapy by extra-corporeal membrane oxygenation (ECMO) for respiratory failure: A case report. Patient Saf Surg 2020;14:20.
22 Hartman M, Hernandez R, Patel K, et al. COVID-19 respiratory failure: Targeting inflammation on VV-ECMO support. ASAIO J 2020;66:603–6.
23 Nakamura K, Hikone M, Shimizu H, et al. A sporadic COVID-19 pneumonia treated with extracorporeal membrane oxygenation in Tokyo, Japan: A case report. J Infect Chemother 2020;26:756–61.
24 Chen N, Zhou M, Dong X, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: A descriptive study. Lancet 2020;395:507–13.
25 Shen C, Wang Z, Zhao F, et al. Treatment of 5 critically ill patients with COVID-19 with convalescent plasma. JAMA 2020;323:1582–9.
26 Taniguchi H, Ogawa F, Honzawa H, et al. Veno-venous extracorporeal membrane oxygenation for severe pneumonia: COVID-19 case in Japan. Acute Med Surg 2020;7;e509.
27 Zhan W, Li M, Xu M, et al. Successful treatment of COVID-19 using extracorporeal membrane oxygenation, a case report. Eur Rev Med Pharmacol Sci 2020;24:3385–9.
28 Zeng Y, Cai Z, Xianyu Y, et al. Prognosis when using extracorporeal membrane oxygenation (ECMO) for critically ill COVID-19 patients in China: a retrospective case series. Critical Care 2020;24:1–48.
29 Sultan I, Habertheuer A, Usman AA, et al. The role of extracorporeal life support for patients with COVID-19: Preliminary results from a statewide experience. J Card Surg 2020;35:1410–3.
30 Takeda S. Nationwide system to centralize decisions around extracorporeal membranous oxygenation use for severe COVID−19 pneumonia in Japan. Acute Med Surg 2020;7:e510.
31 Jacobs J, Stammers A, St.Louis J, et al. Extracorporeal membrane oxygenation in the treatment of severe pulmonary and cardiac compromise in COVID-19: Experience with 32 patients. ASAIO J 2020;66:722–30.
32 Peek GJ, Mugford M, Tiruvoipati R, et al. Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR): A multicentre randomised controlled trial. Lancet 2009;374:1351–63.
33 Combes A, Hajage D, Capellier G, et al. Extracorporeal membrane oxygenation for severe acute respiratory distress syndrome. N Engl J Med 2018;378:1965–75.
34 Munshi L, Walkey A, Goligher E, et al. Venovenous extracorporeal membrane oxygenation for acute respiratory distress syndrome: A systematic review and meta-analysis. Lancet Respir Med 2019;7:163–72.
35 Extracorporeal Life Support Organization (ELSO). Guidelines for adult cardiac failure. Available at: https://www.elso.org/Portals/0/IGD/Archive/FileManager/e76ef78eabcusersshyerdocumentselsoguidelinesforadultcardiacfailure1.3.pdf Accessed May 25 .
36 Extracorporeal Life Support Organization (ELSO). Guidelines for adult respiratory failure. Available at: https://www.elso.org/Portals/0/ELSO%20Guidelines %20For%20Adult%20Respiratory%20Failure%201_4.pdf Accessed May 25 .
37 Cheng R, Hachamovitch R, Kittleson M, et al. Complications of extracorporeal membrane oxygenation for treatment of cardiogenic shock and cardiac arrest: A meta-analysis of 1,866 adult patients. Ann Thorac Surg 2014;97:610–6.
38 Pavlushkov E, Berman M, Valchanov K. Cannulation techniques for extracorporeal life support. Ann Transl Med 2017;5:70.
39 Alhazzani W, Møller M, Arabi Y, et al. Surviving sepsis campaign: Guidelines on the management of critically ill adults with coronavirus disease 2019 (COVID-19). Crit Care Med 2020;48:e440–69.
40 Wilson KC, Chotirmall SH, Bai C, et al. COVID−19: Interim guidance on management pending empirical evidence. From an American Thoracic Society−led International Task Force. Available at: https://www.thoracic.org/covid/covid-19-guidance.pdf Accessed May 25 .
41 Chow J, Alhussaini A, Calvillo-Argüelles O, et al. Cardiovascular collapse in COVID-19 infection: The role of veno-arterial extracorporeal membrane oxygenation (VA-ECMO). CJC Open 2020;2:273–7.
42 Kowalewski M, Fina D, Słomka A, et al. COVID-19 and ECMO: The interplay between coagulation and inflammation—A narrative review. Crit Care 2020;24:205.

43 Klinzing S, Wenger U, Steiger P, et al. External validation of scores proposed for estimation of survival probability of patients with severe adult respiratory distress syndrome undergoing extracorporeal membrane oxygenation therapy: A retrospective study. Crit Care 2015;19:142.

Samiha Alom, MPH[*,†]
Ana Alina Haiduc, BSc[*]
Naomi Melamed, BSc[*]
Ariana Axiaq[‡]
Amer Harky, MBChB, MRCS, MSc[§,‖,¶]
[*]*St. George's, University of London, Cranmer Terrace, UK*
[†]*School of Public Health, Imperial College London, South Kensington, UK*
[‡]*School of Medicine, Queen's University Belfast, Belfast, UK*
[§]*Department of Cardiothoracic Surgery, Liverpool Heart and Chest Hospital, Liverpool, UK*
[‖]*Department of Integrative Biology, Faculty of Life Sciences, University of Liverpool, Liverpool, UK*
[¶]*Liverpool Centre for Cardiovascular Science, University of Liverpool and Liverpool Heart and Chest Hospital, Liverpool, UK*

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Testing the Asymptomatic Pre-Surgical Population for Severe Acute Respiratory Syndrome Coronavirus 2

To the Editor:

IN RESPONSE to the coronavirus disease 2019 (COVID-19) pandemic, healthcare facilities deferred all but emergency surgeries for ≥12 weeks to minimize/reduce risk to patients and healthcare workers.[1-6] However, by April 2020, increased mortality for delaying necessary cardiac and thoracic procedures prompted multidisciplinary teams to determine how to restart surgical cases safely, balancing the urgent needs of patients, the reported increased morbidity and mortality of COVID-19–positive patients undergoing surgical procedures,[2,3,7,8] and the risk of spreading COVID-19 infection among healthcare workers.[4,6,7,9-11]

Donning of personal protective equipment (PPE) by healthcare workers and screening of patients for COVID-19 infection are necessary for the success of surgery during the pandemic.[10,12] Screening includes a questionnaire regarding signs and symptoms of COVID-19, exposure to an infected person, and severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) reverse transcriptase polymerase chain reaction (PCR) testing with or without thoracic computed tomography (CT).[4,5,10-15] Whereas screening should be universal, PCR testing and CT imaging may not be available or, in low-prevalence areas, may not be necessary.[10,12] Furthermore, universal PCR testing for healthcare workers has not been advocated, except for those with signs, symptoms, and/or exposure.[16]

Herein, the results of preoperative screening and PCR SARS-CoV-2 testing (cobas 6800 System; Roche Diagnostics, Basel, Switzerland [approved by the US Food and Drug Administration on March 2020]) at our institution during the time of the restart and ramping up of surgical cases are reported.

After approval by the Lifespan Medical Systems Institutional Review Board, 14 weeks of SARS-CoV-2 PCR testing data were collected beginning at the restart of elective surgical cases in April 2020. For comparison, data also included non-surgical patients with suspicion of infection. All patients underwent a nasopharyngeal SARS-CoV-2 PCR test (Cobas 6800 System), with the surgical group being tested within 72 hours of their procedure. Forehead temperatures were assessed, and all patients reviewed and answered a questionnaire regarding possible COVID-19 exposure and related symptoms for the 10 days before the test.[15] Patients who were afebrile and without symptoms of COVID-19 or exposure were considered asymptomatic.

After the initial 11 weeks, the medical center policy changed, and outpatient surgical patients were screened with a questionnaire and temperature recording. If asymptomatic, afebrile, and without record of exposure to a COVID-19–positive or suspected patient for 10 days before surgery, then PCR testing was not performed. This 10-day period is in line with the likelihood of developing a COVID-19 infection syndrome after exposure and/or the unlikely recovery of replicant SARS-CoV-2 virus 10 days after presenting with symptoms of COVID-19.[10,15,17-20]

Healthcare workers were not tested routinely. Policy relied on personal monitoring and reporting of symptoms, signs, and/or fever, all of which are in line with Centers for Disease Control and Prevention recommendations.[14] Healthcare workers donned PPE during aerosol-generating procedures (eg, intubation).[12]

Although the actual perioperative care of surgical patients is not described, the general practice care was in line with the principle of enhanced recovery to facilitate extubation, ambulation, pulmonary care, and discharge.[9]

Surgical follow-up included phone calls for outpatients and chart review for inpatients. Reports of infection syndromes among healthcare workers were recorded. Patients and healthcare workers were not tested or retested unless they became symptomatic. The data were analyzed with the Fisher exact test and the Cochran-Armitage test to assess trends of positive tests over time.

A total of 36,939 patients were tested over 14 weeks, and 29,655 presented with symptoms and/or suspicion of COVID-19 infection, of whom 2,081 (7.0%) tested positive (Table 1). The percent who tested positive significantly declined from the first to the last week (15.4% *v* 3.3%; $p < 0.001$), between weeks 3 and 4 (14.1% *v* 10.9%; $p < 0.01$), and between weeks 7 and 8 (9.0% *v* 4.4% $p < 0.0001$) (Fig. 1 and 2).

Furthermore, 7,284 consecutive asymptomatic patients were tested before surgery during the 14-week period, of whom 30 (0.4%) tested positive for SARS-CoV-2 (see Table 1). From the first week to the last week, there was a significant decline in the percent of positive tests (2.8% *v* ≤0.5%; $p < 0.001$) (see Fig. 1 and 2). In the final 6 weeks, the percent of positive tests ranged between 0.0% and 0.4%. Of the 30 positive patients, all were verified as asymptomatic at the time of screening before surgery and all resided in densely populated areas in the state where the prevalence of infection was higher.[15] Among these patients, there had been no report of an infection syndrome.