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SURVIVAL OF PATIENTS WITH SEVERE ACUTE RESPIRATORY DISTRESS SYNDROME TREATED WITHOUT EXTRACORPOREAL MEMBRANE OXYGENATION

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Abstract

Background—Case series have reported favorable outcomes with extracorporeal membrane oxygenation (ECMO) in patients with severe acute respiratory distress syndrome. However, those patients were generally young, with few comorbid conditions.

Objective—To characterize the clinical features and survival rates of patients with severe acute respiratory distress syndrome who met criteria for ECMO but were managed without it.

Methods—Patients who met the study criteria were identified prospectively. Inclusion criteria for ECMO included severe hypoxemia, uncompensated hypercapnia, or elevated end-inspiratory plateau pressures despite low tidal volume ventilation. Predicted survival rates with ECMO were calculated using the Respiratory ECMO Survival Prediction score.

Results—Of the 46 patients who met the criteria for severe acute respiratory distress syndrome and ECMO consideration, 5 received ECMO and 16 patients had at least 1 contraindication to it. The remaining 25 patients met ECMO criteria but did not receive the treatment. The patients' mean age was 53.5 (SD, 14.3) years; 84% had at least 1 major comorbid condition. The median predicted survival rate with ECMO was 57%. The actual hospital discharge survival rate without ECMO was 56%.

Conclusions—The general medical intensive care patient population with severe acute respiratory distress syndrome is older and sicker than patients reported in prior case series in which patients were treated with ECMO. In this study, the survival rate without ECMO was similar to predicted survival rates with ECMO.

Most patients with acute respiratory distress syndrome (ARDS) require mechanical ventilation to facilitate gas exchange while allowing time for supportive care and healing to occur. However, in some patients, mechanical ventilation cannot maintain gas exchange goals and may cause ventilator-induced lung injury, exacerbating the underlying inciting

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SEE ALSO

For more about ECMO, visit the *Critical Care Nurse* website, www.ccnonline.org, and read the Cochrane Review Summary by Sandoval, “Extracorporeal Membrane Oxygenation for Critically Ill Adults” (December 2016).

injury. In recent years, extracorporeal membrane oxygenation (ECMO) has been used increasingly for the treatment of patients with severe ARDS. This support can allow mechanical ventilation to be modified or removed, lowering the risks of ventilator-induced lung injury and oxygen toxicity. Yet, ECMO itself confers risks, including bleeding, vascular access complications, thrombosis, and infection.¹⁻³

Despite its increasing use, the benefits of ECMO for the treatment of ARDS have not been clearly established. Early randomized controlled trials in 1979 and 1994 did not show benefit with ECMO in ARDS.^{4,5} However, ECMO technology has advanced significantly with improved pumps, oxygenators, and biocompatible circuits since that time.⁶ In a recent controlled clinical trial, patients with ARDS were randomly assigned to either usual care at their local hospitals or transfer to a single, ECMO-capable, high-volume tertiary hospital. Clinical outcomes were better in the patients transferred to the ECMO-capable hospital than in patients who remained at their local hospitals. However, only 75% of the intervention group actually received ECMO at the tertiary hospital.⁷ Moreover, medical care in the control group was not standardized, and fewer patients in the control group received lung-protective ventilation. As a result, it is unclear if ECMO or better care at a high-volume tertiary center was the variable most responsible for the reduction in mortality between the 2 groups.^{6,8}

Adoption of ECMO increased further after researchers reported findings of several uncontrolled case series indicating low mortality rates in patients with ARDS associated with H1N1 influenza who received ECMO.⁹⁻¹² However, a significant limitation of these encouraging case series is that the patients who received ECMO were young (median age, 36 years) and had mostly single-organ disease (median Sequential Organ Failure Assessment score, 9),¹³ in contrast to the typical ARDS population, which is substantially older and has more comorbid conditions.^{14,15} Moreover, in case series of comparably ill patients with H1N1 influenza who were treated without ECMO, similar low mortality rates were reported.^{16,17} Because these were uncontrolled case series, and owing to the young age of patients reported therein, it is not clear whether ECMO actually provided a survival advantage in the setting of severe ARDS.

Because of the lack of strong evidence supporting the use of ECMO in severe ARDS, most patients with severe ARDS at our institution, a high-volume tertiary center, are treated without ECMO. In this prospective cohort study, we report the demographic and clinical features and clinical outcomes of patients with severe ARDS who were treated without ECMO despite meeting previously published criteria for receiving it.⁶

Methods

This prospective, observational study was conducted at a single tertiary academic center. This study was approved by the institutional review board at Johns Hopkins University. We screened for eligible patients each day by reviewing electronic medical records of patients admitted to the medical intensive care unit from February 2014 to June 2015. Patients were identified on the basis of the Berlin definition of severe ARDS.¹⁸ Patients with severe ARDS were included in our cohort if they met 1 of the following criteria for ECMO consideration,

which were modified from Brodie and Bacchetta⁶: (1) ratio of Pao₂ to fraction of inspired oxygen (Fio₂) was less than 100 mm Hg despite levels of positive end-expiratory pressure of at least 10 cm H₂O for at least 6 hours; (2) uncompensated hypercapnia with acidemia (Pco₂ > 50 mm Hg with arterial pH < 7.15 or venous pH < 7.12); or (3) end-inspiratory plateau pressure greater than 35 cm H₂O with either tidal volume no greater than 6 mL/kg predicted body weight or with arterial pH less than 7.15.^{6,18} Eligibility criteria were confirmed by 2 of the physician investigators. Time of enrollment was defined as the time and date when criteria for severe ARDS and ECMO eligibility first were met. We additionally noted whether a contraindication to ECMO was present, such as inability to receive anticoagulation (eg, because of intracranial hemorrhage, major internal or gastrointestinal bleeding requiring red blood cell transfusion within 7 days); high pressure ventilation (plateau pressure > 30 cm H₂O) for longer than 7 days; high Fio₂ (ie, Fio₂ > 0.80) requirements for longer than 7 days; or any condition that would limit the likelihood of overall benefit from ECMO (eg, severe neurologic dysfunction, diffuse anoxic brain injury, end-stage lung disease and not a transplant candidate, untreatable metastatic cancer).⁶

For patients who met the study's inclusion criteria, we recorded the following data from inclusion until time of discharge: ventilator settings, laboratory results, length of stay, vital status at hospital discharge, and use of adjunct therapies such as prone positioning and neuromuscular blockade. Comorbid conditions were defined as the presence of 1 or more of the following chronic medical conditions in the past year:

- Chronic lung disease (eg, use of home oxygen, chronic hypercapnia [Paco₂ 50 mm Hg] severe pulmonary hypertension [mean positive airway pressure 40 mm Hg or New York Heart Association class IV symptoms], chronic ventilator dependence);
- Chronic liver disease (ie, biopsy-proven cirrhosis, portal hypertension, hepatic failure based on Child-Pugh score 10);
- Chronic renal disease requiring dialysis;
- Vasculitis;
- Sickle cell disease;
- malignant neoplasia (eg, leukemia, lymphoma, known metastatic cancer, or currently receiving cancer treatment);
- AIDS;
- Receiving immunosuppressive therapy (eg, treatment in the past year with agents such as azathioprine, mycophenolate, tacrolimus, sirolimus, cyclophosphamide, or corticosteroids [15 mg of prednisone daily or equivalent for 20 days]); or
- Other conditions, such as Parkinson disease.

Severity of illness was assessed by using Acute Physiology and Chronic Health Evaluation (APACHE) II and Sequential Organ Failure Assessment scores.

We calculated the Respiratory ECMO Survival Prediction (RESP) score¹⁹ for each patient to estimate the probability of survival while receiving ECMO had ECMO been used. The RESP score is a validated model for predicting hospital survival for respiratory failure based on patient and treatment variables before ECMO is initiated.¹⁹

Descriptive statistics are reported as frequency (percentage) for categorical variables and mean (standard deviation) or median (interquartile range [IQR]) for continuous variables. Statistical analyses were conducted by using Stata, version 14 (StataCorp).

Results

At the end of the 16-month screening period, 46 patients met criteria for severe ARDS and ECMO consideration. Of these 46 patients, 5 (11%) actually received rescue ECMO. These patients were younger, more hypoxemic, and had fewer comorbid conditions than the remaining 41 patients who did not receive ECMO (Table 1). The hospital discharge survival rate of these 5 patients who received ECMO was 20%.

Of the 41 patients treated without ECMO, the mean age was 52.6 (SD, 16.0) years, 19 patients (46%) were female, and 37 patients (90%) had at least 1 comorbidity. At day 1 of admission to the intensive care unit, the mean APACHE II score was 28.3 (SD, 7.5), and the mean Sequential Organ Failure Assessment score was 12.6 (SD, 4.0) (Table 2). Of the 41 patients, 16 patients had at least 1 contraindication to ECMO, which included an inability to receive anticoagulation (7 patients) or a nonrecoverable comorbidity (9 patients: 3 had anoxic brain injury, 2 had metastatic cancer, and 4 had end-stage lung disease and were not transplant candidates). No patient had a contraindication due to receiving ventilatory support for longer than 7 days. Of this group with contraindications to ECMO, the survival rate at time of hospital discharge was 25%.

The remaining 25 patients met criteria for ECMO but did not receive it (see Figure). The mean age of these 25 patients was 53.5 (SD, 14.3) years, 56% were female, and 84% had at least 1 major comorbidity. The most common comorbidities were chronic liver disease and chronic lung disease (Table 3). In most of these patients, ARDS developed in association with pneumonia (64%). The mean APACHE II score was 28.9 (SD, 7.4) and the mean Sequential Organ Failure Assessment score was 13.2 (SD, 3.6) on the first day of admission to the intensive care unit. The median lowest Pao₂/Fio₂ ratio for this group was 66 (IQR, 58-93) mm Hg, with a concomitant median Fio₂ of 0.90 (IQR, 70%-100%) and positive end-expiratory pressure of 14 (IQR, 12-18) cm H₂O. Most patients (64%) met criteria for ECMO consideration because of isolated severe hypoxemia rather than uncompensated hypercapnia (16%) or excessive inspiratory pressures (0%). Five patients (20%) met more than 1 criterion, having severe hypoxemia combined with either hypercapnia or excessive pressures. Most received lung protective ventilation with a mean lowest tidal volume per kilogram of predicted body weight of 5.3 (SD, 0.8). Two patients who received tidal volumes greater than 6 mL/kg of predicted body weight had isolated uncompensated hypercapnia rather than severe hypoxemia. Approximately one-half of patients (48%) received neuromuscular blockade, and 3 (12%) were placed in the prone position. The median length of stay in the intensive care unit was 13 (IQR, 9.5-26) days, and median

hospital stay was 21 (IQR, 13-35) days (Table 4). On the day that the patient met the criteria for severe ARDS and at least 1 criterion for ECMO, the median RESP score was 1 (IQR, -2 to 2), which corresponds to a predicted survival rate while receiving ECMO of 57%.¹⁹ Our group of 25 patients who met ECMO eligibility criteria but did not receive ECMO had an actual survival rate of 56% at the time of hospital discharge.

Discussion

Many institutions have developed ECMO programs for use in the treatment of severe ARDS despite the lack of high-level evidence supporting the assumption that the benefits of ECMO outweigh the risks. With this prospective observational cohort study, we sought to characterize the features and outcomes of patients with severe ARDS who might have received ECMO at other institutions but did not receive ECMO at our hospital. To our knowledge, no other prospective studies have been done to assess the outcomes of patients with ARDS who met criteria to receive ECMO but did not receive it.

Our data support several key conclusions. First, the unselected population arriving in our tertiary medical intensive care unit with severe ARDS is older and has more comorbidities and higher illness severity scores than did the patients reported in prior case series describing low mortality rates with the use of ECMO for H1N1 influenza-related severe ARDS.⁹⁻¹² Patients in these case series were relatively young, lacked substantial comorbid conditions, and potentially would have survived without ECMO. In other case series evaluating outcomes in critically ill patients with H1N1 influenza, researchers reported comparably low mortality rates when ECMO was not used.^{16,17} In contrast, very few of our patients with severe ARDS were young and had isolated respiratory failure. A strength of our study is that all critically ill patients with ARDS severe enough to meet the criteria for ECMO consideration were included prospectively. As a result, our cohort was substantially older, with more organ failures, and was most likely more representative of a general population with severe ARDS (Table 5).

Second, although the overall survival rate in the cohort without ECMO in our study was 44%, which compares unfavorably with published series of ECMO in severe ARDS, more than one-third of our patients with severe ARDS would have been considered ineligible for ECMO owing to a contraindication such as an inability to receive anticoagulation or a condition that severely limited the likelihood of benefit from ECMO (eg, metastatic cancer, anoxic brain injury). This is a key finding, suggesting that many patients with severe ARDS may not even be eligible for ECMO support. Notably, these possibly ineligible patients had a hospital survival rate of only 25%, which was substantially lower than the survival rate of patients without contraindications to ECMO. This low survival rate is not surprising, because the conditions that make patients ineligible for ECMO, such as cerebral hemorrhage, life-threatening bleeding, and end-stage lung disease, frequently portend poor prognoses regardless of the treatment strategy. Indeed, in a recent retrospective analysis of patients with interstitial lung disease treated with ECMO for acute respiratory failure, authors reported a 7% survival rate in those who did not qualify for lung transplant.²⁰

Finally, among the patients who would have been eligible but did not receive ECMO, we report a survival rate of 56%. This study was not a randomized trial; therefore, we cannot directly compare this survival rate with the survival rate obtained in patients receiving ECMO. However, to compensate for this limitation, we calculated the RESP score for each patient at the time they met the criteria for ECMO consideration to estimate the predicted survival for our patients had they received ECMO. Based on the RESP score, predicted survival for our cohort receiving ECMO was 57%, indicating that the outcomes without ECMO are similar to the outcomes predicted for patients who received ECMO. Moreover, the survival rate of 56% determined in this study is similar to the survival rate reported in multiple clinical studies and the Extracorporeal Life Support Organization database (Table 5). Although caution should be applied to any conclusions drawn from this observational series, we suggest, on the basis of the data, that the survival rate of patients with severe ARDS treated without ECMO may be similar to the survival rate of patients with severe ARDS who receive ECMO.

Our institution is a high-volume center for treatment of ARDS and use of ECMO. In the calendar year 2016, more than 60 patients were treated with ECMO. However, we use ECMO primarily for patients after cardiotomy or who are experiencing cardiogenic shock. In our medical intensive care unit, patients with severe ARDS are typically treated with lung protective ventilation, antibiotics for infections, conservative fluid management, adjuncts such as neuromuscular blockade and prone positioning, and supportive care strategies. Fewer than half of the patients with severe ARDS in the present study were treated with neuromuscular blockade, and less than 10% were treated with prone positioning, perhaps because the implementation of these interventions took time after their use was supported by findings in landmark publications.^{21,22} Our implementation rates of these adjunct therapies are similar to implementation rates across the world in 2016, as identified in the Large Observational Study to Understand the Global Impact of Severe Acute Respiratory Failure (LUNG-SAFE) study.¹⁵ Furthermore, had these proven therapies been used more widely, it is possible that our outcomes without ECMO would have been even better.

This study has several limitations. Although data were collected prospectively to capture all patients who met the criteria for ECMO consideration, this is an observational study of only 46 patients. As such, no attempt was made to randomly assign patients to receive ECMO or usual care. Most other ECMO case series and case-control series are from the H1N1 influenza population; thus, it is difficult to draw comparisons to our study. In addition, the RESP score was developed on the basis of patients who received ECMO, even though only pre-ECMO variables were included in the model. This score has not been validated for patients who did not receive ECMO, although it does appear to be a relevant instrument for predicting survival in patients receiving ECMO for severe acute respiratory failure.

Finally, 5 patients in our sample did receive ECMO. These patients were substantially younger, but they had more severely impaired gas exchange (mean P_{aO_2}/F_{iO_2} ratio, 52.6 mm Hg; P_{CO_2} , 102.2 mm Hg), worse respiratory mechanics (median plateau pressure, 44 [IQR, 41-46] cm H_2O ; mean tidal volume, 3.76 [SD, 0.70] mL/kg predicted body weight), and adjunctive therapies. The mortality rate for the patients receiving ECMO was 80%, which is higher than mortality rates reported for prior ECMO series (see Table 5). In all 5 patients,

ECMO was offered as a late salvage therapy by the clinical team caring for them. Three of the patients who received ECMO had received mechanical ventilatory support for at least 7 days, which could have been considered a contraindication to ECMO.⁶ The high mortality rate of these patients further emphasizes the need to identify the appropriate patient population for ECMO.

Conclusions

The general patient population with severe ARDS in this study was older and had more comorbid conditions than the patient populations in many of the case reports of favorable outcomes of severe ARDS treated with ECMO. The reports of low mortality rates in those case series could be attributable to the patients' young age and lack of comorbid conditions rather than to the use of ECMO. Almost all of our institution's patients with severe ARDS were treated medically, even if they were eligible for ECMO. Their actual survival rate without ECMO was similar to their predicted survival rates with ECMO. A new randomized controlled trial evaluating ECMO versus conventional management for severe ARDS is currently enrolling patients ([ClinicalTrials.gov](https://clinicaltrials.gov/ct2/show/study/NCT01470703) identifier: [NCT01470703](https://clinicaltrials.gov/ct2/show/study/NCT01470703)). However, until reduced mortality with ECMO is demonstrated in patients with acute respiratory failure in future randomized controlled trials, we suggest, on the basis of our results, that it is reasonable to treat patients with severe ARDS with usual best-care clinical practices without ECMO.

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Figure.

Flowchart of patients who met criteria for severe acute respiratory distress syndrome (ARDS) and extracorporeal membrane oxygenation (ECMO).

Table 1

Demographics, clinical features, and outcomes of the 5 patients receiving ECMO

Characteristic	Patients receiving ECMO
Age, mean (SD), y	29 (7)
APACHE II score, mean (SD)	21.6 (2.3)
SOFA score, mean (SD)	12.6 (3.2)
RESP score, median (IQR)	0 (–1 to 1)
Pneumonia, No. (%) of patients	4 (80)
Lowest Pao ₂ /FIO ₂ , median (IQR)	49 (41-50)
Highest FIO ₂ , mean (SD)	100 (0)
Highest PEEP, median (IQR), cm H ₂ O	18 (16-20)
Highest Pplat, median (IQR), cm H ₂ O	44 (41-46)
Highest Pco ₂ , mean (SD), mm Hg	102.2 (29.3)
Lowest pH, mean (SD)	7.15 (0.10)
Lowest tidal volume, mL/kg PBW	3.76 (0.70)
Mechanical ventilation before ECMO, mean (SD), d	6.4 (2.9)
Adjunct therapies, No. (%) of patients	5 (100)
Neuromuscular blockade	4 (80)
Prone positioning	3 (60)
ICU length of stay, median (IQR), d	8 (5-10)
Hospital length of stay, median (IQR), d	30 (16-33)
Mortality, No. (%) of patients	4 (80)

Abbreviations: APACHE, Acute Physiology and Chronic Health Evaluation; ECMO, extracorporeal membrane oxygenation; FIO₂, fraction of inspired oxygen; ICU, intensive care unit; IQR, interquartile range; PEEP, positive end-expiratory pressure; Pplat, plateau pressure; PBW, predicted body weight; RESP, Respiratory Extracorporeal Membrane Oxygenation Survival Prediction; SOFA, Sequential Organ Failure Assessment.

Table 2

Demographics and clinical features of patients in the intensive care unit who met the criteria for severe ARDS and ECMO consideration

Characteristic	All patients ^a (n = 41)	Eligible for ECMO (n = 25)	Contraindication to ECMO (n = 16)
Age, mean (SD), y	52.6 (16.0)	53.5 (14.3)	51.2 (18.9)
Female sex, No. (%) of patients	19 (46)	14 (56)	5 (31.2)
APACHE II score, mean (SD)	28.3 (7.5)	28.9 (7.4)	27.4 (7.3)
SOFA score, mean (SD)	12.6 (4.0)	13.2 (3.6)	11.6 (4.6)
RESP score, median (IQR)	0 (-2 to 2)	1 (-2 to 2)	-1 (-4 to 2)
Pneumonia, No. (%) of patients	24 (59)	16 (64)	8 (50)
Lowest Pao ₂ /Fio ₂ , median (IQR)	61 (51-91)	66 (58-93)	67.5 (49.5-75)
Highest Fio ₂ , mean (SD)	90 (70-100)	90 (70-100)	95 (70-100)
Highest PEEP, median (IQR), cm H ₂ O	14 (11-16)	14 (12-18)	12 (10.5-16)
Highest Pplat, median (IQR), cm H ₂ O	33 (30-36)	32 (30-36)	34.5 (30.5-36.5)
Highest Pco ₂ , mean (SD), mm Hg	67.5 (22.5)	61 (20)	70.5 (24.5)
Lowest pH, mean (SD)	7.16 (0.11)	7.16 (0.12)	7.16 (0.10)
Lowest tidal volume, mL/kg PBW	5.41 (0.72)	5.32 (0.77)	5.56 (0.62)

Abbreviations: APACHE, Acute Physiology and Chronic Health Evaluation; ARDS, acute respiratory distress syndrome; ECMO, extracorporeal membrane oxygenation; Fio₂, fraction of inspired oxygen; ICU, intensive care unit; IQR, interquartile range; PEEP, positive end-expiratory pressure; Pplat, plateau pressure; PBW, predicted body weight; RESP, Respiratory Extracorporeal Membrane Oxygenation Survival Prediction; SOFA, Sequential Organ Failure Assessment.

^aIncludes all patients meeting criteria for severe ARDS and at least 1 criterion for ECMO consideration, subdivided into patients with a contraindication to ECMO and patients who were eligible for ECMO but did not receive it. Specific demographics of the 5 patients who received ECMO are reported in Table 1.

Table 3

Comorbid conditions of patients in the intensive care unit meeting the criteria for severe acute respiratory distress syndrome (ARDS) and consideration for extracorporeal membrane oxygenation (ECMO)

Characteristic	No. (%) of patients		
	All patients ^a (n = 41)	Eligible for ECMO (n =25)	Contraindication to ECMO (n = 16)
None	4 (10)	4 (16)	0 (0)
Chronic liver disease ^b	17 (41)	12 (48)	5 (31)
Chronic lung disease ^c	12 (29)	6 (24)	6 (38)
Chronic dialysis	3 (7)	2 (8)	1 (6)
Malignant neoplasia ^d	3 (7)	1 (4)	2 (12)
AIDS	4 (10)	4 (16)	0 (0)
Immunosuppression ^e	5 (12)	4 (16)	1 (6)
Sickle cell disease	2 (5)	1 (4)	1 (6)
Vasculitis	1 (2)	1 (4)	0 (0)
Other ^f	1 (2)	0 (0)	1 (6)

^aIncludes all patients meeting criteria for severe ARDS and at least 1 criterion for ECMO consideration, subdivided into patients with a contraindication to ECMO and patients who were eligible for ECMO but did not receive it. Specific demographics of the 5 patients who received ECMO are reported in Table 1.

^bBiopsy-proven cirrhosis, portal hypertension, hepatic failure based on Child-Pugh score 10.

^cUse of home oxygen, chronic hypercapnia PaCO₂ 50 mm Hg, severe pulmonary hypertension (mean pulmonary artery pressure 40 mm Hg or New York Heart Association class IV symptoms), chronic ventilator dependence.

^dLeukemia, lymphoma, solid tumor currently receiving cancer treatment, or known metastatic cancer.

^eTreatment in the past year with immunosuppressive agents such as azathioprine, mycophenolate, tacrolimus, sirolimus, cyclophosphamide, or corticosteroids (15 mg of prednisone daily or equivalent for at least 20 days).

^fParkinson disease.

Clinical course and survival rates at time of hospital discharge of patients in the intensive care unit meeting criteria for severe ARDS and ECMO consideration

Table 4

Characteristic	All patients ^a (n = 41)	Eligible for ECMO (n = 25)	Contraindication to ECMO (n = 16)
Adjunct therapies, No. (%) of patients	17 (41)	12 (48)	5 (31)
Neuromuscular blockade	17 (41)	12 (48)	5 (31)
Prone positioning	4 (10)	3 (12)	1 (6)
ICU length of stay, median (IQR), d	17.5 (7.5-27)	13 (9.5-26)	20 (6-33)
Hospital length of stay, median (IQR), d	21 (13-35)	21 (13-35)	22 (14.5-43)
Survival, No. (%) of patients	18 (44)	14 (56)	4 (25)

Abbreviations: ARDS, acute respiratory distress syndrome; ECMO, extracorporeal membrane oxygenation; IQR, interquartile range.

^aIncludes all patients meeting criteria for severe ARDS and at least 1 criterion for ECMO consideration, subdivided into patients with a contraindication to ECMO and patients who were eligible for ECMO but did not receive it. Specific demographics of the 5 patients who received ECMO are reported in Table 1.

Table 5
Comparison of demographics and mortality from severe ARDS in previously published case series

Reference	N	ECMO received, %	H1N1 influenza	Age, mean, y	SOFA score	APACHE II score	Pao ₂ /FIO ₂	Mortality, %
Davies et al ⁹ ; Australia, New Zealand	68	100	Yes	36	NR	NR	56	23
Patroniti et al ¹⁰ ; Italy	49	100	Yes	39	7	NR	63	29
Noah et al ¹¹ ; United Kingdom	80	86.3	Yes	34	9	NR	55	28
Pham et al ¹² ; France	123	100	Yes	42	9.5	NR	59	36
Kumar et al ¹⁷ ; Canada	168	4.2	Yes	32	6.8	19.7	147	17.3
Miller et al ¹⁶ ; Utah	47	0	Yes	34	7	25	61	27
Peek et al ⁷ ; CESAR intervention group	90	75	No	39.9	NR	19.7	75.9	37
Peek et al ⁷ ; CESAR, control group	90	0	No	40.4	NR	19.9	75	45
Schmidt et al ¹⁹ ; ELSO database	2355	100	No	41	NR	NR	NR	43
Johns Hopkins ^a	25	0	No	53.5	13.2	28.9	66	44

Abbreviations: APACHE, Acute Physiology and Chronic Health Evaluation; ARDS, acute respiratory distress syndrome; CESAR, conventional ventilatory support vs extracorporeal membrane oxygenation for severe adult respiratory failure; ELSO, Extracorporeal Life Support Organization; ECMO, extracorporeal membrane oxygenation; FIO₂, fraction of inspired oxygen; NR, not reported; SOFA, Sequential Organ Failure Assessment.

^aData reported here include the 25 patients who were eligible for ECMO but did not receive it, that is, patients with severe ARDS who met at least 1 ECMO criterion and did not have a contraindication to ECMO.