Evaluation of the RESP Score and Demographic Information in order to Predict Survival of ECMO Patients at a Community Hospital

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Abstract:

Rationale: Extracorporeal membrane oxygenation (ECMO) has been shown to increase survival rates for patients with acute respiratory failure. Yet, this extreme measure has been commonly used only in large university or government based hospitals. Lehigh Valley Health Network began using ECMO in 2013 and has seen great success. By using the Respiratory Extracorporeal Membrane Oxygenation Survival Prediction (RESP) score, clinicians can better target patients who will benefit from ECMO as well as patients who need more resources and attention.

Objectives: To show that ECMO at a community hospital is possible and has excellent survival rates.

Methods: Out of the 42 Venovenous ECMO patients, 28 patients (68.3%) were discharged alive from the hospital and one is still currently on ECMO. By using the RESP score, the survival of patients with certain characteristics prior to initiation of ECMO was calculated and analyzed. Attention was focused on patients who were diagnosed with H1N1, were administered a paralytic, those who developed a cardiac arrest before ECMO, and those who were placed on a high frequency percussive ventilator (VDR) for rescue therapy.

Conclusions: Lehigh Valley Health Network, a community scholastic hospital, was seen to have a higher survival percentage than the Extracorporeal Life Support Organization (ELSO) database. Our hypothesis for this success lies in three factors: 24 hour attending physician supervision, a fully trained clinical staff in ECMO management, and the availability of various rescue modes of ventilation.

Background: Extracorporeal Membrane Oxygenation (ECMO) is the use of mechanical devices to temporarily support heart or lung function during cardiopulmonary failure, leading to organ recovery or replacement.[1] It is used to directly oxygenate and remove carbon dioxide from the blood.[2] Venovenous (VV) ECMO is commonly used in patients with acute respiratory distress syndrome (ARDS) in which blood is withdrawn from and returned through the venous system. The patient's blood is oxygenated and carbon dioxide is excreted via a membrane outside the body. ECMO is initiated in patients with ARDS when positive-pressure ventilation cannot maintain adequate gas exchange to support life.[2] The Australian and New Zealand Intensive Care Research Centre developed a method using pre-ECMO variables of 2,355 patients from the Extracorporeal Life Support Organizations (ELSO) international registry. It assesses 12 variables focusing on age, immunocompromised status, duration of mechanical ventilation before ECMO, diagnosis, central nervous system dysfunction, acute associated nonpulmonary infection, neuromuscular blockade agents, nitric oxide administration, bicarbonate infusion, cardiac arrest, $PaCO_2$, and peak inspiratory pressure to determine a final score predicting survival for patients receiving ECMO for respiratory failure.[3] The score can range anywhere from -22 to 15. The lower the score, the sicker the patient was before ECMO and the lower chance of survival is assumed. Lehigh Valley Health Network (LVHN) has recently instituted the use of VV ECMO for ARDS patients and has had great outcomes. The Network's survival percentage of 68.3% is higher than the average calculated by the ELSO database. By calculating the RESP score for all patients on VV ECMO at LVHN, a survival rate for patients within each score range at LVHN has been developed. These numbers are higher than the statistics seen in the ELSO database previously calculated. We believe these numbers and our successes to be the result of our 24 hour attending physician supervision, the arsenal of rescue modes of ventilation, and a fully trained clinical staff in ECMO management. Age, gender, BMI, and other patient demographic information were also collected and analyzed during this study.

Methods: LVHN had 42 VV ECMO patients starting from January of 2013. One of the 42 patients is currently on ECMO. That patient's demographics and pre-ECMO data is included but the status post ECMO is not included in any percentages. All patient data was analyzed for demographic information and the pre-ECMO variables instituted by the RESP score. A database was then created in Microsoft Access collecting the patient's age, BMI, date of birth, hospital admittance date, ICU admittance date, ECMO start and end date, the patient's discharge status, and all medical consults during their hospital stay. The database also included blood culture results, blood transfusion information, and respiratory data including mode of ventilation, rescue therapy used, and if the patient required a tracheostomy. The RESP score was then calculated for each patient based on the 12 parameters (Table 1). The survival rates were then analyzed for overall score, age, gender, and BMI. The patients were then subcategorized into groups focusing on those who were diagnosed with H1N1 influenza, were administered a paralytic, those who were not administered a paralytic, those who developed a cardiac arrest, and those who were placed on high frequency percussive ventilation (VDR). In these groups, the average RESP score was calculated as well as the survival percentage in order to show a connection and highlight the importance of the RESP score.

Table 1: The RESP Score at ECMO Initiation[3]

Parameter	Score
Age, yr	
18 to 49	0
50 to 59	-2
≥ 60	-3
Immunocompromised status	-2
Mechanical Ventilation prior to initiation of ECMO	
< 48 hours	3
48 hours to 7 days	1
> 7 days	0
Acute Respiratory Diagnosis Group	
Viral Pneumonia	3
Bacterial Pneumonia	3
Asthma	11
Trauma and burn	3
Aspiration Pneumonitis	5
Other Acute Respiratory Diagnoses	1
Nonrespiratory and chronic respiratory diagnoses	0
Central Nervous System Dysfunction	-7
Acute Associated (nonpulmonary) infection	-3
Neuromuscular Blockade Agents before ECMO	1
Nitric Oxide used before ECMO	-1
Bicarbonate infusion before ECMO	-2
Cardiac Arrest before ECMO	-2
$PaCO_2$, mmHg	
< 75	0
≥ 75	-1
Peak Inspiratory Pressure, cm H2O	
< 42	0
≥ 42	-1
Total Score	-22 to 15

Definition of abbreviations: ECMO= Extracorporeal Membrane Oxygenation; RESP= Respiratory ECMO Survival Prediction.

Results: Since the initiation of ECMO at our academic community hospital, 42 patients have undergone VV ECMO and a total of 28 patients have survived (68.3%). One patient is currently on ECMO so the status post ECMO is not included in this study. The average survival for patients receiving ECMO in the ELSO database is 57%. Information was obtained for all patients and the Microsoft Access database is now available for all physicians and therapists to use. Most patients who were placed on ECMO management developed ARDS secondary to pneumonia. The most common etiologies of pneumonia

were legionella, H1N1, aspiration, or another bacterium or virus. One patient received ECMO because of necrotizing fasciitis and another because of MRSA pneumonia. The average RESP score calculated for patients at LVHN was 1.74. Based on the RESP score parameters pre-ECMO, 81% of the patients were administered a paralytic, 19% of the patients developed a cardiac arrest before ECMO cannulation, 23.8% of the patients were tested to have an acute nonpulmonary infection involving another bacterial, viral, parasitic, or fungal infection, 28.6% of the patients were diagnosed with H1N1, 57.1% of the patients received Flolan, an inhaled pulmonary vasodilator, Nitric Oxide, or a combination of the two, and 50% of patients were administered a bicarbonate infusion. Only 6 patients were considered immunocompromised because of either being on chemotherapy, being HIV+, or recently undergoing a renal transplant. It was also shown that 54.8% of the patients either pre-ECMO or during ECMO received high frequency percussive ventilation (VDR).

Table 2: Pre-ECMO Parameters

	All Patients (n=42)	Alive (n=28)	Expired (n=13)
Acute Respiratory Failure Diagnoses			
Bacterial or Viral Pneumonia	27	19	8
Aspiration Pneumonitis	10	7	3
Other Acute Respiratory Diagnoses***	4	2	1
Other	1	0	1
Immunocompromised***	6	3	2
Acute Associated Nonpulmonary Infection***	10	3	6
Central Nervous System	0	0	0
Neuromuscular Blockage Agents before ECMO***	34	25	9
Nitric Oxide Infusion before ECMO *	24	17	7
Bicarbonate Infusion before ECMO***	21	11	9
Cardiac Arrest before ECMO	8	3	5
PaCO$_2$, mmHg			
< 75***	37	25	11
≥ 75	5	3	2
Peak Inspiratory Pressure, cmH$_2$O **			
< 42***	39	26	12
≥ 42	3	2	1
* Flolan also included			
** Patient Info Missing (1 patient)			
***One patient is still on ECMO so the status is unavailable			

Age, gender, and BMI did have a small impact in survival percentages. The average age and BMI was 50.7 and 32.7 respectively. We found that patients under 60 years of age (n=31) had a 76.7% chance of survival compared to those 60 years of age and above (n=11) who had a 54.5% chance of survival. Males (n=19) had a higher survival percentage of 79% compared to female's (n=23) 59% (Table 4). BMI seemed to have a slightly less effect on survival. Patients with a BMI of less than 30 had a 68.4% chance of survival compared to those of a BMI greater than 30 with a 66.7% chance. However, for the morbid obese patients with BMI greater than 40 (n=6), the survival rate dropped to 33% (Table 5). The average RESP score and average age for patients were all very similar regardless of BMI.

Table 3: Demographic Characteristics of Critically Ill Patients on ECMO

	No. of Patients (%)
Age, mean in years	50.7
18-49	19 (45.2)
50-59	12 (30)
60+	11 (27.5)
Females	23 (54.8)
Males	19 (45.2)
Overall Avg RESP Score	1.74
Overall Avg BMI	32.7

Definition of abbreviations: RESP=Respiratory ECMO Survival Prediction; BMI= body mass index

Table 4: Gender Survival Percentages with Demographic Information

Gender	Total #	% Survival	Avg RESP Score	Avg Age	Avg BMI
Females	23*	59%	1.48	49.4	33.3
Males	19	79%	1.89	52.2	31.2

*One Patient still on ECMO so status is unavailable

Table 5: BMI Survival Percentages with Demographic Information

BMI	Total #	% Survival	Avg RESP Score	Avg Age
< 30	19	68.40%	1.68	48
30-40	15	80%	1.93	52.2
> 40*	7	33%	1.29	54.1
obesity(>30)*	22	66.7%	1.95	52.8

*One Patient still on ECMO so status is unavailable
One Patient's BMI is unknown

The development of a cardiac arrest before ECMO cannulation had a very negative effect on a patient's chance of survival. Of the 8 patients who had a cardiac arrest, only 3 survived (37.5%). Four patients were male and 4 were female. Three of the males expired while 2 of the females died. The

average BMI was higher in males (36.5 vs. 27.8). The patients who died had a greatly lower average RESP score of 0 while the patients who lived had an average RESP score of 4.3.

Out of the 42 VV ECMO patients, 34 of them were administered a paralytic and they had a 72.7% chance of survival. Of the 8 patients not administered a paralytic, only 4 survived (50%). These patients received a paralytic either because they were receiving high frequency percussive ventilation or in order to maintain ventilator synchrony. It was seen that patients who did not receive a paralytic were at a higher risk for cardiac arrest. Out of the 8 non-paralyzed patients, 5 developed a cardiac arrest. They only had a 20% chance of survival.

High frequency percussive ventilation (VDR) was used in patients as a rescue mode of ventilation. It was either initiated pre-ECMO or during ECMO. Of the 42 patients, 46% used the VDR at some point (n=21) and had a 70% survival. The patients who used it pre-ECMO (n=9) had a 66.7% survival. The 14 patients that were only on VDR during ECMO had a 75% chance of survival. The patients who were never on a VDR had a 66.7% survival. There were 12 females on VDR and 9 males. The females had a 72.7% chance of survival while the males had a 62.5%. The patients on the VDR who had a BMI under 30 had a survival percentage of 85.7% while those above 30 BMI had only a 58.3% chance. There were 11 females and 10 males not on a VDR. The females had a 45.5% chance of survival while the males had a 90% chance. The males did have a higher RESP score (2.4 vs. 0.64). However, the males were older (55.2 vs. 51.5). The patients not on a VDR who had a BMI greater than 30 had a survival percentage of 75% while patients under 30 BMI had a 58.3% chance. These obese patients also were older in age (57.9 vs 50.2) (Table 6).

Table 6: Survival Percentages and Demographic Information for Patients on a VDR

	Total #	% Survival	Avg RESP Score	Avg Age	Avg BMI
VDR	21	70%	1.95	48	34.35
Female*	12	72.70%	2.25	47.5	36.7
Male	9	62.50%	1.56	48.8	31.3
< 30 BMI	7	85.70%	2.14	44.3	-
> 30 BMI*	12	58.30%	1.86	49.9	-
No VDR	21	66.70%	1.33	53.3	31.06
Female	11	45.50%	0.64	51.5	31
Male	10	90%	2.4	55.2	31.1
< 30 BMI	12	58.30%	1.33	50.2	-
> 30 BMI	8	75%	1.5	57.9	-

Definition of abbreviations: VDR= ventilator that provides high frequency percussive ventilation
*One Patient is still on ECMO so status is unknown

The patients who developed bacterial pneumonia stemming from the H1N1 influenza (n=12) had a high survival rate of 83.3%. There were 5 males and 7 males with an 80% and 85.7% survival respectively. Males and females had similar average BMI's and the males were slightly older (54 vs. 48).

Discussion: Lehigh Valley Health Network is a community academic hospital who believes to be one of the first hospitals of its kind to institute ECMO. Before ECMO initiation at LVHN, we would transfer our severe ARDS patients to Hershey Medical. Now, we can support these patients and provide them with

the best care possible. In the past 18 months, 42 patients have been on Venovenous ECMO in the ICU and most have responded well. One patient is currently still on ECMO and the status of that patient is not included in any survival percentages. We have had a 68.3% survival rate which is above the ELSO database survival rate of 57%.[3] Our patients have been evaluated by the RESP score in order to find out how the score relates to our patients and their survival. We sought to assess why our results are better and how we can demonstrate and convince other community hospitals that ECMO is a feasible and lifesaving option.

By calculating the RESP scores, we created five risk classes that demonstrated hospital survival percentages as seen in the RESP score article (3). We separated them by scores of greater or equal to 6, scores from 3 to 5, -1 to 2, -5 to -2, and less than or equal to -6. Hospital survival for each class was determined and compared to the ELSO database survivals. LVHN had a higher survival percentage in the greater than 6 and 3 to 5 categories, had a slightly lower survival percentage for the -1 to 2 category, and had the same percentage as the article for the -5 to -2 category. LVHN did not have any patients with a RESP score of less than or equal to -6. For patients with a score of 6 or greater we had a 100% survival rate, and patients with a score of 3 to 5 had a 93% survival (Tables 7).

Table 7. Survival by Risk Class at LVHN and in the RESP Article[3]

RESP Score	% Patients at LVHN	LVHN Survival %		% Patients in RESP Article	RESP Article Survival %
≥ 6	4.8%	100%		7%	92%
3 to 5	38.1%	94%		24%	76%
-1 to 2	47.6%	50%		44%	57%
-5 to 2	9.5%	33%		19%	33%
≤ -6	0%	N/A		6%	18%

As seen in our study, the RESP score did hold true: the lower the score, the lower the chance of survival. Looking closer at the data, older age, the development of a cardiac arrest pre-ECMO, and the non-administering of a paralytic were associated with poor outcomes in patients. Gender did seem to play a role as seen by males having a 20% higher chance of survival even though their average RESP score and average age were fairly similar. Many patients who were not administered a paralytic then developed a cardiac arrest (71.4%) thus decreasing their chance of survival. Only 1 of the 5 patients who were not paralyzed and developed a cardiac arrest survived (20%). The survival percentage of all patients who developed a cardiac arrest before ECMO was 37.5%.

A wide variety of rescue modes of ventilation were available for utilization including high frequency percussive ventilation (VDR), APRV (airway pressure release ventilation), and the administration of Nitric Oxide or Flolan. We believe the high availability of these modes is what led to our high patient survival rate. Nitric Oxide was administered to patients along with the VDR. The use of the VDR as a rescue mode was instituted when conventional mechanical ventilation was not mobilizing secretions. Patients who were placed on the VDR as a rescue mode of ventilation had a 70% chance survival. It had a slightly higher survival rate of 75% in patients who were only on it during ECMO. For patients with a BMI of less than 30 and placed on the VDR, survival was 85.7% compared to those with a

BMI below 30 not on a VDR, 58.3%. Patients with a BMI above 30 had a higher survival percentage not on the VDR (75% vs. 58.3%).

Two other reasons LVHN believes to have a higher survival rate than the ELSO database is due to their 24 hour attending physician supervision and a fully trained staff in ECMO management. This decreases miscommunication and errors thus leading to higher survival rates. With the properly trained staff, attending supervision, and a wide availability of rescue modes of ventilation, ECMO management should be feasible at many community hospitals around the country.

Study Strengths and Limitations: A major limitation of this study was due to the small population of Venovenous ECMO patients. With its recent institution at Lehigh Valley Health Network, only 42 patients have undergone this life saving measure. Even though we have great statistics so far, much is to be learned and verified.

Two patients did not have complete data. One patient's BMI could not be found due to his short stay in the hospital and another patient's peak inspiratory pressure was not recorded. One patient is currently on ECMO and is not included in any survival percentages. The RESP scores were calculated prospectively which might have accounted for slight errors from patient to patient due to different charting by nurses and therapists.

An ECMO database for Lehigh Valley Health Network was created for future data and analysis. The first informative research study on VV ECMO patients at LVHN was performed showing great success for a community hospital. We hope to continue receiving patients and improving our care. We hope our data and knowledge will influence other community hospitals to begin to initiate ECMO management.

References

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