Understanding Ventilation Strategies for ECMO Patients at a Community Hospital

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Understanding Ventilation Strategies for ECMO Patients at a Community Hospital

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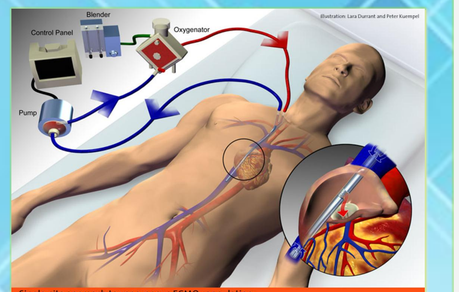
Introduction

Extracorporeal Membrane Oxygenation (commonly abbreviated to ECMO) is a modified form of cardiopulmonary bypass utilized in patients with severe yet reversible respiratory and/or cardiac failure (1). The extracorporeal circuit is used to directly oxygenate and remove carbon dioxide from the patient's blood (2). This type of therapy is used as temporary support for heart and lung function leading to organ recovery or replacement.



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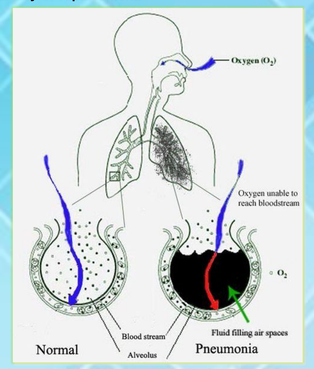


http://upload.wikimedia.org/wikipedia/commons/ffb/New_Pneumonia_cartoon.jpg

In order to maintain the patient's lung mechanics and inflation during extracorporeal membrane oxygenation it is necessary to incorporate one of the various forms of mechanical ventilation strategies. HFPV is a nonconventional form of ventilation which is utilized when PCMV and ECMO parameters are maximized and gas exchange remains inadequate, the patient has maintained secretions after frequent bronchoscopies, and the patients lung hypo inflation is marked be a compliance of less than or equal to 12cm H2O. HFPV has been shown to work as both an effective ventilator and a powerful mucokinetic.

Methods

- **42 patients were cannulated with ECMO at Lehigh Valley Health Network (LVHN) since January of 2013. All patients' data was analyzed and a comprehensive ECMO database was created. All of these patients were also placed on mechanical ventilation during their treatment with ECMO. 21 of these 42 patients were treated with high frequency percussive ventilation (HFPV) and various aspects of their data were analyzed to better understand the efficacy of the VDR ventilator. Patient age, etiology, reason for use of HFPV ventilation strategy, RESP score (pulmonary score developed by The Australian and New Zealand Intensive Care Research Centre), and current status of patient were all taken into consideration. By comparing these various pieces of data the effectiveness of the HFPV strategy was determined.**
- **HFPV is a nonconventional form of ventilation which is utilized when PCMV and ECMO parameters are maximized and gas exchange remains inadequate, the patient has maintained secretions after frequent bronchoscopies, and the patients lung hypo inflation is marked be a compliance of less than or equal to 12cm H2O. HFPV has been shown to work as both an effective ventilator and a powerful mucokinetic. By keeping the patients lungs operational during ECMO management, the patient is more quickly weaned off of ECMO due to maintained lung compliance, elasticity, and ventilation. To further understand the effectiveness and uses of HFPV employed by the VDR ventilator, the data of 40 patients who were placed on ECMO in combination with either high frequency percussive ventilation or pressure control mandatory ventilation was analyzed.**

REFERENCES

1. **Mannino, F., Anas, N., & Cleary, M. (n.d.). Extracorporeal Membrane Oxygenation (ECMO) for the. . Retrieved July 15, 2014, from http://www.calthoracic.org/sites/default/files/ecmopp.pdf**
2. **Columbia University College of Physicians and Surgeons. (2011). Extracorporeal Membrane Oxygenation for ARDS in adults. The New England Journal of Medicine, 365, 1905-1914.**

Results

- **Data analysis and compilation of all ECMO patients who received High Frequency Percussive Ventilation by VDR prior to ECMO cannulation.**

Patient ID Numbers	Etiology	Primary Reason For Being Put On VDR	Age Of Patient	Total Respiratory Score	Status
1884990	H1N1/ARDS	Gas Exchange	47	1	alive
1135678	Staph Pneumonia	Gas Exchange	32	-3	expired
1952461	H1N1	Gas Exchange	51	4	alive
1416314	Aspiration	Gas Exchange	31	4	alive

- **Data analysis and compilation of all ECMO patients who received High Frequency Percussive Ventilation by VDR during ECMO management.**

Patient ID Number	Etiology	Primary Reason For Being Put On VDR	Age Of Patient	Total Respiratory Score	Status
792610	Pulmonary Embolism	Secretions (Used As Mucokinetic)	46	4	alive
1823618	Aspiration	Secretions (Used As Mucokinetic)	51	4	alive
1920871	H1N1	Air Leak/Pneumonia	25	4	alive
1786205	MRSA Pneumonia	Secretions (Used As Mucokinetic)	59	4	alive
1951444	Unknown	Secretions (Used As Mucokinetic)	39	1	alive
1955049	H1N1	Secretions (Used As Mucokinetic)	44	7	alive
1954753	H1N1	Secretions (Used As Mucokinetic)	47	4	alive
1955399	H1N1	Gas Exchange	62	1	expired
58012	Pneumonia	Secretions (Used As Mucokinetic)	66	-4	withdrawal
363686	Aspiration	Secretions (Used As Mucokinetic)	32	5	alive
948061	Pneumonia	Secretions (Used As Mucokinetic)	45	1	expired
473436	Pneumothorax	Lung Recruitment	33	-4	N/A
1544181	Aspiration Pneumonitis	Secretions (Used As Mucokinetic)	53	2	alive

- **Data analysis and compilation of all ECMO patients who received High Frequency Percussive Ventilation by VDR prior to and during ECMO management.**

Patient ID Number	Etiology	Age Of Patient	Total Respiratory Score	Status
1213954	DKA, Aspirated, Pulmonary Embolism	28	3	alive
1949522	H1N1	61	-1	alive
1259060	Aspiration Pneumonitis	74	1	expired
264715	Aspiration	83	3	expired

- **Comparisons and calculations of survival rates of all ECMO Patients and ECMO patients with VDR**

	Number Of Patients	Average Age	Average Respiratory Score	Survival Rate
Pre-ECMO	4	40.25	1.5	75%
During ECMO	13	46.3	2.23	75%
Both Pre & During	4	61.5	1.5	50%

	Number Of Patients	Average Age	Average Respiratory Score	Survival Rate
VDR	21	48.04	1.95	70%
No VDR	21	53.26	1.48	66.7%

- **The average survival rate recorded in the ELSO database (Extracorporeal Life Support Organization) is 57%. Since the initiation of the ECMO program at the Lehigh Valley Health Network (LVHN) 42 patients have undergone ECMO management and 28 of the 42 patients survived (68.3% survival). One of the patients is currently undergoing ECMO management and therefore this patient's status was not factored into the survival rate. Of the various ventilation strategies used in combination with ECMO management, HFPV administered by VDR was used on 21 patients at some point during their management, prior to cannulation, during ECMO management, or both. Of the 21 total HFPV administered by VDR patients, 20 of them have been decannulated (taken off of ECMO) and 14 of them survived, giving these patients a survival rate of 70%. The average age of these HFPV administered by VDR patients was recorded at 48.04 years and included 11 female patients and 10 male patients. The most common etiologies of these HFPV administered by VDR ECMO patients included H1N1 (7), Pneumonia (4), and Aspiration (6).**

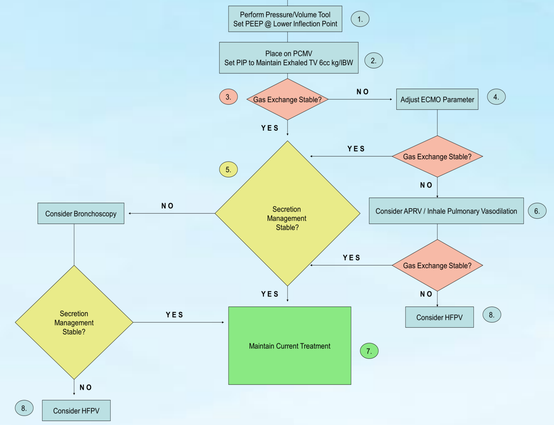
Discussion

Since January of 2013 Lehigh Valley Health network has utilized ECMO management on a total of 42 patients with Acute Respiratory Distress Syndrome (ARDS). Lehigh Valley Health network has maintained a survival rate of over 68.3%, which markedly higher than the national average recorded by the ELSO database of 57%. By utilizing various ventilatory strategies (VDR), patients who were not being oxygenated properly using PCMV or were otherwise unstable were more successfully managed. By studying the success rate of High Frequency Percussive Ventilation and the VDR ventilator we hoped to show that not only is this mode of ventilation capable of maintaining lung mechanics during ECMO management, but that it could have improved patient outcomes for patients with whom PCMV is not sufficient.

Of the 42 ECMO patients, HFPV with VDR was utilized on a total of 21 patients. These patients were ventilated using HFPV with VDR for various reasons including gas exchange, air leaks, lung recruitment, and sustained secretions. The ECMO patients with whom HFPV was utilized ended up with a survival rate of over 70%. The patients who were ventilated using conventional ventilation (PCMV) had a slightly lower survival rate of 66.7% resulting with an overall survival rate of 68.3%. Looking at this data it is clear that HFPV is not only a legitimate ventilation strategy, but can have extremely positive outcomes on patients who were not responding well to conventional ventilation or were put on HFPV due to other factors (see tables 1-3). We believe that among other factors, LVHN's utilization of HFPV and the VDR ventilator contribute greatly to the much higher than average survival rates of our ECMO patients.

ECMO Ventilatory Management Algorithm

This algorithm was designed to help the physicians better take care of patients after ECMO cannulation. For physicians or nurses who are unfamiliar with the ECMO system, this algorithm gives them step by step instructions on how to properly maintain sufficient oxygenation, circulation and lung mechanics. Due to the complexity of some of the instructions, nodes were added alongside the text boxes which help the user locate the included explanations.



ECMO Ventilatory Management Algorithm

Node 1: Post ECMO cannulation a pressure volume tool (P/V) assessment should be performed to determine the lower and upper inflections. The PEEP should be set to 2 cm H2O above the lower inflection point or higher if there is evidence of premature expiratory limb deflation. The P/V tool should be performed every 12 hours or until spontaneous breathing is noted.
Node 2: PCMV mode will be utilized and the PIP will be set above the peep to target an exhale tidal volume of 6cc/kg/IBW.
Node 3: Stable gas exchange is defined as SpO2≥88%/PaO2≥60 torr, and PaCO2/ETCO2≤50 torr
Node 4: If gas exchange is not adequate the ECMO FIO2 and/or sweep should be increased prior to any ventilator adjustments. Root cause assessments should be performed to determine the etiologies of inadequate gas exchange. Ventilator recruitment maneuvers may be attempted by placing the patient on 30cm/H2O PEEP for 30 seconds. Ventilator FIO2 should always be 10-20% less than set on ECMO FIO2.
Node 5: If The reason for inadequate gas exchange is retained secretions, consider bronchoscopy and/or mucokinetic therapy via IPV or manual chest percussion. If secretions are voluminous and/or inspissation occurs, consider 24-48 hours of ventilation via HFPV.
Node 6: If gas exchange is inadequate secondary to poor lung compliance or hypoventilation consider APRV maintaining a Phighs≤32cm/H2O and Thigh≥5 seconds or extend inspiratory time and inverse ratio PCMV.
Node 8: Consider HFPV ventilation when the following clinical situations are evident:
-ECMO parameters are maximized and gas exchange remains inadequate
-Frequent bronchoscopies and evidence of retained secretions
-Lung hypoinflation marked by a compliance of ≤12cm/H2O
Attempt to maintain the VDR PIP/PEEP parameters as low as possible, maintaining a minimum driving pressure ≥15cm/H2O.