Oxygenation Index as a Predictor of Survivability in Pediatric Acute Hypoxic Respiratory Failure

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Introduction

Mortality for severe respiratory failure in the PICU remains high. Consensus among pediatric intensivists as to optimal criteria to predict outcome or implement rescue therapies such as extracorporeal life support (ECMO) are lacking. Historically, the Oxygenation Index (OI = (MAP x FiO2)/paO2) has been used to identify potential candidates for initiation of ECMO, with an OI >40 often quoted as an eligibility criteria. As understanding of the harmful effects of mechanical ventilation has increased and efforts to limit inspiratory pressure and oxygen therapy have occurred, consideration that past criteria may not represent current day has occurred. Some recent data has shown that mortality risk increases significantly at lower levels of OI.

Objectives

This study aims to expound upon previously reported data on increased mortality risk with lower levels of OI than historically used for ECMO candidacy. Additionally, it examines the utility of the electronic medical record (EMR) in providing serial calculations of the OI. Validation of the EMR as a tool for calculating respiratory severity score measurements, such as serial and maximum OIs, and the associated mortality risks would be of great value to clinicians. Identification of specific levels of OI may allow creation of critical alert algorithms for escalation of respiratory support and potentially, entry criteria for ECMO in the current era.

Methods

Single-center retrospective review of electronic medical record (EMR) data for patients age 0-20 years who were mechanically ventilated for >24 hours in the pediatric intensive care unit (PICU) from Dec 2011 to Mar 2014. OI variables were obtained to calculate serial, average and maximum OIs. Length of mechanical ventilation, hospital stay and outcome were assessed. Continuous variables were compared with Wilcoxon signed rank test. Receiver operating curve (ROC) analysis was used in determining discriminant ability. Logistic regression conducted to determine odds ratio for risk of death with increasing OI. Patients with known intra-cardiac shunts or cyanotic heart disease were excluded.

Results

Serial OIs were calculated on 65 patients from EMR data. Within this group, 59 patients (91%) survived hospitalization and were discharged, while 6 expired (9%). Distribution of maximum OIs were found to be non-normally distributed. The median maximum OI was 10 for all patients, 17 for non-survivors (NS) versus 8 for survivors (S) (p=0.14 via Wilcoxon rank-sum). Interquartile range of maximum OI was 13 for all patients, 12 for S group and 53 for NS group.

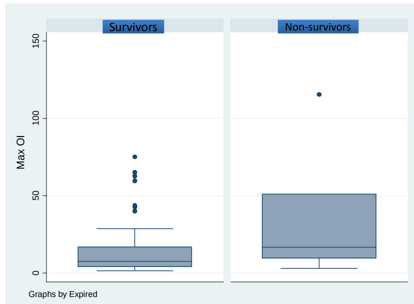

Figure 1: Box Plots of Maximum Oxygenation Index in Survivors (S) & Non-survivors (NS) groups which demonstrate a higher median maximum OI as well as increased dispersion from the mean for the NS cohort.

The serial OIs for the duration of mechanical ventilation for each patient were averaged and compared, which again demonstrated non-normal distribution. The medians of the individual mean OI values were closer in proximity for the S and NS groups than the median of the maximal individual OI values, at 4 and 6, respectively (p=.48). The interquartile range for average OI was 7 for all patients, 7 for S, and 20 for NS.

Maximum OI	Survivors (S)	Non-survivors (NS)	All
Median	7.57	16.69	9.62
Standard Error	2.21	15.86	2.58
Average OI	**Survivors (S)**	**Non-survivors (NS)**	**All**
Median	4.45	6.19	4.78
Standard Error	0.98	7.81	1.06

Table 1: Median Maximum & Median Mean OIs and Outcome

No statistically significant differences were observed between S and NS groups with regard to age, length of mechanical ventilation, or length of hospital stay (LOS).

Results

65 patients were analyzed and divided into quartiles according to their maximum OI (table 1). Analysis within each quartile indicated that mortality was unchanged (6-7%) until maximum OI >17. With OI >17, mortality increased to 18%.

Max OI Cut Points	< 4	4-10	10-17	> 17
Number of Patients	16	17	15	17
Percent of Patients	25%	26%	23%	26%
Mortality	1	1	1	3
Mortality within Category	6%	6%	7%	18%

Table 2: Maximum OI determined quartiles and cut points for risk of death.

Logistic regression was used to obtain odds ratios for risk of death per one-percent increase in both maximum and average OIs by determining the exponential function of the regression coefficient. After adjusting for age and length of hospitalization, an odds ratio of 2.1 was determined for odds of death with each one-percent increase in maximum OI (p=0.08) over the course of hospitalization, with 95% confidence interval of 0.89 – 5.03. Average OI also resulted in an odds ratio of 2.1, thus increasing the odds of death for each one-percent increase in average OI (p=0.14) over the length of hospitalization, with 95% confidence interval 0.77 – 5.48.

Receiver operating curve (ROC) analysis of maximum and average OI demonstrated an advantage of maximum OI over mean OI in discriminatory ability. The area under curve (AUC) for maximum OI was 0.68, while mean OI AUC was 0.58.

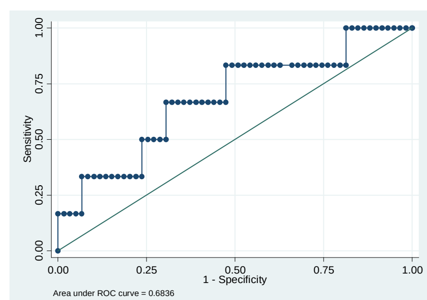

Figure 2: Receiver Operating Characteristic Analysis of Maximum Oxygenation Index versus Risk of Death with Area Under Curve of .68, indicative of increased discriminatory performance.

Discussion

Quantifying the predictive capability of the OI and identifying a threshold value for escalation of therapy will help guide discussion regarding appropriate time of rescue intervention. In addition, use of lower OI's for entry criteria into clinical studies of pediatric respiratory failure may also be warranted. This threshold OI finding warrants further investigation with larger data sets from multiple centers.

Additionally, utilizing the EMR as a research tool has the capacity to improve participation in clinical research or quality improvement projects while allowing a reduction in personnel. In our study, review of the patient EMR had limited capability in calculating OI. While unit-based personnel were not aware of study specifics and no attempt was made to remind personnel to record variables needed for the OI into the EMR, only 44% of patients had the necessary data recorded within the specified timeframe to calculate OI. The frequency of the P_aO_2 being recorded in the EMR within the four-hour time limit associated with MAP and FiO_2 was the greatest limiting factor in expanding the data set.

Conclusion

We found nearly three-fold increase odds of mortality with each increasing point in maximum OI, and an OI threshold of 17 that triples the risk of death. Historically, entry criteria for rescue therapies such as ECMO generally included significantly higher OI values. Given the significant increase in mortality at a value much lower than previously suggested, this study supports the lower thresholds of OI for defining respiratory disease severity as outlined in the newly established PARDS definition.

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