EDITORIAL

Revisiting ARDS Classification: Are We There Yet?

Shivangi Mishra

Keywords: Acute respiratory distress syndrome, COVID-19, COVID-19 ARDS, Mean airway pressure, Oxygenation index.
Indian Journal of Critical Care Medicine (2024): 10.5005/jp-journals-10071-24820

Department of Critical Care Medicine, Manipal Hospital Whitefield, Bengaluru, Karnataka, India

Corresponding Author: Shivangi Mishra, Department of Critical Care Medicine, Manipal Hospital Whitefield, Bengaluru, Karnataka, India, Phone: +91 9999873965, e-mail: shivangivatsa@gmail.com

How to cite this article: Mishra S. Revisiting ARDS Classification: Are We There Yet? Indian J Crit Care Med 2024;28(10):899–900.

Source of support: Nil

Conflict of interest: None

Acute respiratory distress syndrome (ARDS) was initially described by Ashbaug et al. in 1967.[1] After that the definition of ARDS underwent various changes till the Berlin definition came into the picture in 2012.[2] The limitations of the Berlin definition soon started surfacing, like the use of noninvasive oximetry device-based oxygenation criteria and the application of the Berlin definition in resource-limited settings where the availability of invasive lines was difficult. These problems led to the surfacing of various modifications of the Berlin definition.[3] However, even after 50 years, predicting outcomes in ARDS patients remains difficult. Despite phenotypic identification in ARDS, the mortality remains high. Furthermore, management strategies for ARDS are mainly supportive therapies including lung-protective ventilation, the use of positive end-expiratory pressure (PEEP), recruitment maneuvers and prone ventilation. One of the significant reasons for the relative scarcity of effective treatment strategies for ARDS is the lack of uncomplicated, easily applicable, and accurate methods for severity classification.

The PaO_2/FiO_2 (P/F ratio) and SpO_2/FiO_2 (S/F ratio) are validated indices for risk classification of ARDS. However, P/F ratio or S/F ratio-based severity classification does not take into consideration changes in PEEP, airway pressure, mechanical ventilation, and other lung-protective strategies. Patients can have the same P/F ratio for different PaO_2 and FiO_2 values with different mechanical ventilation settings or levels of oxygen support. The COVID-19 ARDS phenotypes, as described by Gattinoni et al. are composed of an early L-phenotype with low elastance requiring low PEEP, later followed by an H-phenotype characterized by high elastance requiring high PEEP. However, a patient can have a similar P/F ratio in both conditions without considering PEEP while severity classification.[4]

The oxygenation index (OI) is a vital tool used more commonly in neonatal and pediatric intensive care units. It serves as a comprehensive index for assessing the severity of hypoxic respiratory failure and guiding management strategies. Its significance lies in its ability to incorporate airway pressure, fraction of inspired oxygen (FiO_2), and arterial oxygenation, making it an indispensable tool in these critical care settings.[5]

Oxygenation index is calculated using the following formula:

$$OI = MAP \times FiO_2 \times 100/PaO_2$$

where

- FiO_2: Fraction of inspired oxygen.
- MAP: Mean airway pressure.
- PaO_2: Partial pressure of arterial oxygen.

A cutoff of 15 or less signifies mild ARDS, 16 and 25 show moderate ARDS, 26 and 40 show severe ARDS, and a cutoff of more than 40 shows very severe ARDS. An OI of > 40 has been used to initiate advanced therapies like inhaled nitric oxide and extracorporeal membrane oxygenation (ECMO) in infants with ARDS and pulmonary hypertension.[6]

Clinical Significance of the OI

The major advantage of the OI is its ability to assess the level of ventilator support required to maintain adequate oxygenation. Various other indices have been developed, adding airway pressure measurements and oxygenation-related parameters like $PaO_2/FiO_2 \times$ PEEP ratio(P/FP ratio). Oxygen saturation index (OSI) replaces PaO_2 with oxygen saturation (SpO_2) in OI. It is calculated as $OSI = MAP \times FiO_2 \times 100/SpO_2$. It has the added advantage of the lack of an invasive line to monitor oxygenation and allows for continuous monitoring of oxygenation status, making it much easier to estimate bedside. Oxygen saturation index is a validated tool for pediatric critically ill patients to assess ARDS severity. Oxygenation index, OSI, and PaO_2/FiO_2 ratio correlate well in non-COVID patients. Wu et al. showed that OI and OSI correlated. They found that OI increased by 1.4 times with an increase in OSI. ($p < 0.001$). Oxygen saturation index was found to have highest area under receiver operating characteristic curve (AUROC) compared with OI and other indices like P/F ratio, S/F ratio and Berlin definition with a $p < 0.001$ for predicting 28-day mortality. For 90-day mortality as well OSI was found to have highest AUROC compared with other indices. They further used these indices to classify ARDS as mild, moderate, and severe. Mild ARDS is defined as OI <15.91 or OSI <14.69. Moderate ARDS is defined as OI between 15.91 and 28.78 or OSI between 14.69 and 23.08 and severe ARDS defined as OI >28.78 or OSI >23.08. Survival analysis has also shown a significant difference in both 28-day and 90-day mortality between different categories of ARDS identified by OI and OSI ($p < 0.001$).[7] Desprez et al. showed OI and OSI were strongly correlated ($\rho = 0.862$; $p < 0.001$). Oxygen saturation index was independently associated with hospital mortality (OR per 5-point increase in OSI, 1.228 (95% CI, 1.056–1.429); $p = 0.008$).[8]

Vadi S et al. initially performed a retrospective analysis in 203 COVID-19 ARDS patients. They compared the ability to predict mortality between OI, OSI, PaO_2/FiO_2 ratio, and $PaO_2/FiO_2 \times$ PEEP ratio(P/FP ratio). They concluded that OI and OSI can significantly predict mortality. They also found that OI, OSI, and PaO_2/FiO_2 ratio correlated well in COVID ARDS patients. They identified a cutoff of OI of >13.5 and OSI of >10.4 for mortality prediction.[9]

A secondary analysis of the OXIVA-CARDS study was done in the current study.[10] In the secondary analysis, multiple logistic regression assessed the effect of Pmean, S/F ratio, OI, and P/FP ratio on mortality. Reclassification of the risk severity of ARDS was attempted with the incorporation of PPEP levels in P/F ratio. Though they found moderate agreement between the two scales, only 2.7% were reclassified to a more severe category, while 31.3% moved to a milder category. Acute respiratory distress syndrome patients with a lower P/FP ratio were found to have higher mortality ($p < 0.05$). However, it can be agreed upon that a higher MAP is expected for a patient with a poor P/F ratio. Multiple factors can contribute to a higher MAP and, thus, higher OI and OSI, like tidal volume, PEEP, inspiratory time, flow rate, and peak inspiratory pressure. At the same time, with an increase in the severity of ARDS, the use of lung-protective strategies like neuromuscular relaxants, ventilator changes, and prone ventilation are used. The effect of these strategies on the parameters is yet to be measured.[11] The current study and the previous study by the same investigators emphasize that the currently used classification of ARDS might be underestimating or not correctly estimating the severity of the condition, which might lead to inadequate treatment of the patients.

Nevertheless, the significance of mean airway pressure-based parameters with respect to hypoinflammatory, hyperinflammatory, focal, and non-focal phenotypes of ARDS is yet to be answered. With the difference in phenotypes between COVID-19 and non-COVID ARDS, the results of this study cannot be generalized to non-COVID ARDS. Further studies with similar indices and confounding variables in consideration like ventilator strategies, lung compliance sti, stiffness, and inflammatory phenotype in non-COVID ARDS patients, will address the generalizability of these oxygenation indices.

Limitations of the OI and Oxygen Saturation Index

Despite its clinical utility, the OI has limitations. Since it incorporates MAP, it is influenced by the type of ventilatory strategy being used. For instance, high-frequency oscillatory ventilation (HFOV) results in higher MAP values, which can artificially inflate the OI without necessarily reflecting a worse oxygenation status. Careful interpretation is essential, particularly in patients with unconventional ventilation modes. OI also needs an indwelling catheter and can only be monitored intermittently, a problem answered by OSI.[6] Though OSI might not be able to correctly predict the severity of in the presence of conditions affecting peripheral perfusion like peripheral vascular diseases and high ionotropic support.

Future Directions

The future of oxygenation monitoring and risk assessment for ARDS patients is moving toward more sophisticated and noninvasive technologies. Innovations like pulse oximetry variability provide real-time continuous data regarding oxygenation status. However, the application of these oxygenation and airway pressure-related parameters in the management of different phenotypes of ARDS remains unknown. Oxygenation index and OSI are robust and practical tools, particularly in settings where these newer technologies are not yet fully integrated. Also, developing a more composite index including parameters regarding oxygenation, airway pressure, effect of ventilator strategies and phenotype of ARDS might answer the question of clearly predicting the outcome of ARDS.[12]

As critical care evolves, the OI will likely serve as a cornerstone in assessing respiratory failure in ARDS.

Orcid

Shivangi Mishra https://orcid.org/0000-0003-4960-2400

References

1. Ashbaugh DG, Bigelow DB, Petty TL, Levine BE. Acute respiratory distress in adults. Lancet 1967;2(7511):319–323. DOI: 10.1016/s0140-6736(67)90168-7.
2. The ARDS Definition Task Force*. Acute Respiratory Distress Syndrome: The Berlin Definition. JAMA 2012;307(23):2526–2533. DOI: 10.1001/jama.2012.5669.
3. Riviello ED, Kiviri W, Twagirumugabe T, Mueller A, Banner-Goodspeed VM, Officer L, et al. Hospital incidence and outcomes of the acute respiratory distress syndrome using the Kigali modification of the Berlin definition. Am J Respir Crit Care Med 2016;193:52–59. DOI: 10.1164/rccm.201503-0584OC.
4. Gattinoni L, Chiumello D, Caironi P, Busana M, Romitti F, Brazzi L, et al. COVID-19 pneumonia: Different respiratory treatments for different phenotypes? Intensive Care Med 2020;46(6):1099-1102. DOI: 10.1007/s00134-020-06033-2.
5. Pediatric Acute Lung Injury Consensus Conference Group. Pediatric acute respiratory distress syndrome: Consensus recommendations from the Pediatric Acute Lung Injury Consensus Conference. Pediatr Crit Care Med 2015;16(5):428–439. DOI: 10.1097/PCC.0000000000000350.
6. Muniraman HK, Song AY, Ramanathan R, Fletcher KL, Kibe R, Ding L, et al. Evaluation of oxygen saturation index compared with oxygenation index in neonates with hypoxemic respiratory failure. JAMA Netw Open 2019;2(3):e191179. DOI: 10.1001/jamanetworkopen.2019.1179.
7. Wu S-H, Kor C-T, Chi S-H, Li C-Y. Categorizing acute respiratory distress syndrome with different severities by oxygen saturation index. Diagnostics 2024;14(1):37. DOI: 10.3390/diagnostics14010037.
8. DesPrez K, McNeil JB, Wang C, Bastarache JA, Shaver CM, Ware LB. Oxygenation saturation index predicts clinical outcomes in ARDS. Chest 2017;152(6):1151–1158. DOI: 10.1016/j.chest.2017.08.002.
9. Vadi S, Suthar D, Sanwalka N. Correlation and prognostic significance of oxygenation indices in invasively ventilated adults (OXIVA-CARDS) with COVID-19-associated ARDS: A retrospective study. Indian J Crit Care Med 2023;27(11):801–805. DOI: 10.5005/jp-journals-10071-24560.
10. Vadi SMR, Sanwalka N, Suthar D. Oxygenation Index, Oxygen saturation index vs PaO_2/FiO_2 *PEEP: A secondary analysis of OXIVA-CARDS Study. Indian J Crit Care Med 2024;28(10):917–922.
11. Palanidurai S, Phua J, Chan YH, Mukhopadhyay A. Is it time to revisit the PaO_2/FiO_2 ratio to define the severity of oxygenation in ARDS? Ann Intensive Care 2021;11(1):138. DOI: 10.1186/s13613-021-00927-0.
12. Siuba M, Panitchote A, Krishnan S, Duggal A. 1172: Oxygenation index predicts need for prone positioning or ECMO in ARDS. Critical Care Medicine 2019;47(1):563. DOI: 10.1097/01.ccm.0000551917.13369.79.