EDITORIAL

Noninvasive Oxygenation Indices: New Tools for Resource-limited Settings?

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Keywords: Acute respiratory distress syndrome, Arterial oxygen partial pressure to fractional inspired oxygen ratio, Coronavirus disease-2019, Oxygen index, Oxygen saturation index.

Indian Journal of Critical Care Medicine (2023): 10.5005/jp-journals-10071-24583

The coronavirus disease-2019 (COVID-19) pandemic has had a profound impact on global public health, overwhelming healthcare systems, and leading to an urgent need for research to understand the complexities of the disease.

Hypoxemia is the most common indication for hospitalization of COVID-19 patients. Conventional oxygen therapy may not be sufficient among moderately and severely ill COVID-19 patients.[1]

One of the critical challenges faced by healthcare providers in the management of these patients was hypoxia caused by acute respiratory distress syndrome (ARDS), which was the hallmark of severe respiratory involvement in these patients.

The severity and progression of ARDS are most commonly assessed by serial measurement of the ratio of arterial oxygen partial pressure (PaO_2) to fractional inspired oxygen (FiO_2)—often referred to as the PaO_2/FiO_2 (P/F) ratio. According to the Kigali modification, ARDS was defined without the need for positive end-expiratory pressure (PEEP), with the presence of bilateral opacities at chest radiograph or lung ultrasound, and hypoxia was defined with a cutoff of SpO_2/FIO_2 (S/F) ratio less than or equal to 315.[2]

However, in the context of the COVID-19 pandemic, questions have arisen regarding the utility of oxygen saturation indices (OSIs), particularly in pediatric patients. In pediatrics, the S/F ratio, derived from peripheral oxygen saturation (SpO_2), has gained attention as a noninvasive alternative for assessing oxygenation due to difficulties in obtaining arterial blood samples due to size and vascular access considerations.

However, it is important to recognize that lung mechanics in ARDS patients is influenced by various factors, including the degree of alveolar collapse, changes in lung compliance, and the distribution of ventilation. These variables can significantly impact the effectiveness of oxygenation strategies and patient outcomes.

This is where the oxygen index (OI) and the OSI offer a significant advantage. By factoring in mean airway pressure (MAP) along with oxygenation parameters, they provide a more comprehensive assessment of lung mechanics and oxygen delivery. Mean airway pressure accounts for PEEP and peak inspiratory pressure (PIP), making it a reflection of the pressure required to maintain alveolar recruitment and adequate oxygenation.

In this issue of the journal, *Indian Journal of Critical Care Medicine*, Vadi et al. present the OXIVA-CARDS study.[3] They studied the correlation and prognostic significance of oxygenation indices in 203 adults invasively ventilated adults with COVID-19-associated ARDS. A total of 1,557 measurements were collected over 21 days.

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How to cite this article: Jagiasi BG. Noninvasive Oxygenation Indices: New Tools for Resource-limited Settings? Indian J Crit Care Med 2023;27(11):784–785.

Source of support: Nil

Conflict of interest: None

On the first day of ventilation, 79.3% had a P/F ratio less than 200, 13.8% had a P/F ratio between 200 and 300, and 6.9% had a P/F ratio greater than 300.

The 36.5% survivors exhibited significantly higher P/F ratios compared to nonsurvivors ($p < 0.05$). Additionally, OSI and OI values were notably lower in survivors compared to nonsurvivors. A strong linear relationship was observed between the P/F ratio and the OSI, the P/F ratio and the OI, and between OSI and OI. Based on day 1 readings, a higher OSI and OI were identified as significant predictors of mortality. In contrast, a higher P/F ratio was predictive of survival.

On day 1 patients with OSI above 10.4 and OI above 13.5 faced a substantially higher risk of mortality. Patients with a P/F ratio below 160 also had an elevated risk of mortality.

In a single-center retrospective review of the 1,833 mechanically ventilated pediatric population, Khemani et al.,[4] evaluated (A) the Berlin definition of ARDS in children using PF; (B) the effect of substituting SF ratio; (C) differences between patients with and without arterial blood gases; and (D) the ability of SpO_2 and PaO_2 indices to discriminate ICU mortality. The authors found that the Berlin criteria for ARDS, based on the P/F ratio, identified less than half of the children with ARDS, particularly favoring those with cardiovascular issues. In contrast, parameters such as the S/F ratio and the OSI were equally effective in discriminating ICU mortality, doubling the number of children available for risk assessment. These findings suggest that SF and OSI should be considered for inclusion in severity of illness scoring systems and the development of a pediatric-specific definition for ARDS.[4]

The first study of its kind by Pisani et al.,[5] which was a prospective observational study in patients admitted to a mixed medical–surgical intensive care unit and had divided patients into four groups as per S/F and PEEP. In a comprehensive analysis of 456 patients with moderate to severe ARDS, a substantial and linear relationship ($p < 0.001$, $R_2 = 0.676$) was identified between S/F and P/F, expressed as $S/F = 42.6 + 1.0 \times P/F$. Notably, risk stratification conducted at the initial ARDS diagnosis yielded groups with comparable in-hospital mortality rates. However, when risk stratification was revisited 24 hours later, it revealed distinct groups with progressively increasing mortality rates. It is important to note that the association between group assignment at 24 hours and patient outcomes was influenced by multiple factors, including Acute Physiology and Chronic Health Evaluation (APACHE IV) scores, arterial pH, plasma lactate levels, and the administration of vasopressor therapy. These findings underscore the potential practicality of employing S/F and PEEP for risk stratification, particularly in resource-constrained healthcare settings, despite the contrasting outcomes observed after the 24-hour mark.[5]

In a prospective cohort study by DesPrez K et al.,[6] OSI was used to predict clinical outcomes in ARDS to find a noninvasive surrogate for the OI, which requires arterial blood gas measurements and may better reflect ARDS severity than traditional measures. They introduced the oxygenation saturation index OSI, calculated using pulse oximetry data, and found that it was strongly correlated with OI. Also, OSI was independently associated with higher hospital mortality and fewer ventilator-free days (VFDs) in ARDS patients. The area under the receiver-operating characteristic curve [area under the curve (AUC)] for mortality prediction was highest for the Acute Physiology and Chronic Health Evaluation II scores, but OSI showed promise, especially in patients under 40 years of age. This study suggests that OSI is a reliable noninvasive tool to assess ARDS.[6]

Chen WL et al., evaluated the association between OSI and the outcome of ARDS patients, and assess the predictive performance of OSI for ARDS patients' mortality in 101 adults. They found that OSI was significantly associated with increased mortality among ARDS patients, had good predictive performance for (AUC of 0.656), comparable to the oxygenation index (OI). Additionally, OSI outperformed traditional parameters like P/F and S/F ratios in predicting mortality. Patients with an OSI above 12 had a significantly higher risk of death. This suggests that OSI could be a valuable noninvasive tool for assessing the severity and prognosis of ARDS, providing a potential alternative to more invasive arterial blood gas measurements. However, further research in larger and more diverse patient populations is needed to validate these findings.[7]

Certainly, the inclusion of MAP in both the OI and the OSI is a crucial distinction that sets them apart from the P/F Ratio and makes them valuable tools in the assessment of oxygenation in COVID-19 ARDS. This emphasis on considering MAP acknowledges the importance of a more comprehensive evaluation of lung mechanics, which goes beyond the sole reliance on the P/F ratio.

This is where the OI and the OSI offer a significant advantage. By factoring in MAP along with oxygenation parameters, they provide a more comprehensive assessment of lung mechanics and oxygen delivery. Furthermore, MAP accounts for PEEP and PIP, making it a reflection of the pressure required to maintain alveolar recruitment and adequate oxygenation.

In conclusion, while the P/F ratio remains an important parameter for classifying ARDS and assessing oxygenation, the OI, and OSI provide a more nuanced view by incorporating MAP into their calculations. This approach acknowledges the multifaceted nature of lung mechanics in COVID-19 ARDS, offering a potential advantage in optimizing ventilator settings and ultimately improving patient care and outcomes. Further research into the utility of these indices and their correlation with mortality and long-term recovery is warranted to validate their clinical significance fully.

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