Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 12s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Comparison of PaO2/FiO2 ratio with SpO2/FiO2 ratio in Respiratory Failure patients

Darshni Srinivasan[1], Koushik Muthu Raja Mathivanan[2*], Dhanasekar Thangaswamy[3]

[1]Assistant Professor, Faculty of Allied Health Sciences, Division of Respiratory Care Technology, Sri Ramachandra Institute of Higher Education and Research

[2]Professor, Department of Respiratory Medicine, Sri Ramachandra Institute of Higher Education and Research

[3]Professor & Hod, Department of Respiratory Medicine, Sri Ramachandra Institute of Higher Education and Research

[1]darshni1999s@gmail.com and [2*]koushikmuthuraja@gmail.com

.Cite this paper as: Darshni Srinivasan, Koushik Muthu Raja Mathivanan, Dhanasekar Thangaswamy, (2025) Comparison of PaO2/FiO2 ratio with SpO2/FiO2 ratio in Respiratory Failure patients. *Journal of Neonatal Surgery*, 14 (12s), 770-774

ABSTRACT

Background: Respiratory failure is marked by inadequate oxygen delivery to tissue or insufficient carbon dioxide removal, commonly categorized into type 1 (hypoxemia) and type 2 (hypercapnia) respiratory failure. The diagnostic criteria for acute lung injury (ALI) and acute respiratory distress syndrome (ARDS) rely on the PaO2/FiO2 (P/F) ratio obtained through arterial blood gas (ABG) analysis to evaluate the severity of hypoxemia. We hypothesized that pulse oximetry saturation SpO2/FiO2 (S/F) ratio could serve as an alternative to the P/F ratio for assessing the oxygenation parameters associated with ALI.

Methods: This periodic observational study included 59 patients with acute respiratory failure. This study aimed to assess the sensitivity and specificity of the S/F ratio as a surrogate for the P/F ratio in diagnosing ALI and ARDS. FiO2, SpO2 and PaO2 levels were recorded at five-minute intervals, and the relationship between S/F and P/F ratios was analyzed using linear regression and receiver operating characteristics (ROC) curves.

Results: There is a significant positive correlation between S/F and P/F ratios, with a linear regression equation of S/F = 183.819 + 0.299 + P/F (r=0.607). For diagnosing cut-off of 272 yielded a sensitivity of 77.3% and specificity of 80%, while for ARDs an S/F cut-off of 247 showed a sensitivity of 69.6% and specificity of 83%. The ROC curve analysis indicated good discrimination abilities for both ARDS (AUC = 0.764) and ALI (AUC=0.786) using the S/F ratio.

Conclusion: S/F ratio provides an alternative for assessing oxygenation and diagnosing ALI and ARDS.

Keywords: *Respiratory failure, S/F ratio, P/F acute lung injury, ARDS*

1. INTRODUCTION

Respiratory failure is characterized by impaired oxygen delivery to tissues or inadequate removal of carbon dioxide from tissues. This is typically defined by an arterial oxygen tension (PaO2) of less than 60 mmHg (Type 1 respiratory failure or hypoxemia), arterial carbon dioxide tension (PaCO2) greater than 45 mmHg (Type 2 respiratory failure or hypercapnia) or both. Otherwise, the primary etiologies of respiratory failure include pump failure leading to inadequate alveolar ventilation and hypercapnia or lung failure resulting in hypoxemia.[1]

Acute respiratory distress syndrome (ARDS) and acute lung injury (ALI) are life threatening conditions that are associated with respiratory failures in severely ill patients[2]. ARDS is characterized by acute hypoxemic respiratory failure from lung inflammation, excluding cardiogenic pulmonary edema as the cause. Since the release of the 2012 Berlin definition of ARDS, various advancements have underscored the necessity for broadening the definition. These include the adoption of high-flow nasal oxygen, increased reliance on pulse oximetry over arterial blood gases (ABG), utilization of ultrasound for chest imaging and the requirement for applicability in setting with limited resources[3]. ALI is defined by acute respiratory insufficiency marked by tachypnea, cyanosis unresponsive to oxygen therapy, reduced lung compliance and diffuse alveolar infiltrates on chest X-ray[4]. ALI and ARDS are defined using a PaO2/FiO2 (P/F) ratio of $\leq$ 300 and $\leq$ 200, respectively[5]. ABG analysis serves as a commonly utilized diagnostic method for respiratory failure, enabling the determination of gas partial pressures in the bloodstream[6].

Concerns regarding anemia, excessive blood draws and a trend towards non-invasive or minimally invasive approaches have led to reduced use of arterial blood gas measurements in critically ill patients. In healthy individuals, changes in PaO2 correlate well with changes in pulse oximetric saturation (SpO2) within the range of 80 to 100%[7]. In intensive care units, comprehensive monitoring systems typically incorporate pulse oximetry as a fundamental component of patients surveillance. Pulse oximeters, non-invasive devices measure oxygen saturation levels by determining the percentage of hemoglobin in arterial blood that is oxygen saturated represented as SpO2[8].

The threshold values for SpO2/FiO2 (S/F) ratios could potentially serve as non-invasive criteria for diagnosing respiratory failures like ALI/ARDS. Implementing the S/F ratio may enhance the efficiency of screening and promptly identifying patients with respiratory failure, thereby circumventing the need for arterial blood gas analysis and reducing associated costs[9]. In the context of non-invasive parameters, the S/F ratio has been identified as a valuable indicator of acute respiratory failure. Several studies have demonstrated a robust correlation between S/F and P/F ratios in patients with ARDS particularly when PF ratios are <300[10]. In this study, our hypothesis posits that the pulse oximetry saturation (SpO2) to fractional inspired oxygen (FiO2) ration (S/F) can serve as a substitute for the arterial partial pressure of oxygen (PaO2) to fractional inspired oxygen (FiO2) ratio in evaluating the severity of hypoxemia. The objective of our research is to assess the sensitivity and specificity of the SpO2/FiO2 ratio as a surrogate for the PaO2/FiO2 ratio in patients experiencing respiratory failure.

2. MATERIALS AND METHODS

This observational study was conducted after the institutional human ethical committee approval (reference number CSP/23/FEB/123/125) at the tertiary care hospital, Chennai, India, over a period of 4 months with a total of 59 acute respiratory failure patients requiring invasive or non-invasive mechanical ventilation recruited. Data collection utilized an observational method where FiO2, SpO2 and PaO2 were monitored in Intensive care unit (ICU), ward and emergency department settings at 5-minute intervals. SpO2 values were recorded from bedside monitors, FiO2 from oxygen flowmeters or mechanical ventilators and PaO2 from ABG analyses. Inclusion criteria encompassed PaO2<80 mmHg, Respiratory failure patients, chest X-ray infiltrates and SpO2 <97%, while exclusion criteria included patient unwillingness to participate. Participants and caregivers were fully informed about the study and informed consent was obtained from all participants prior to data collection.

Statistical Analysis

Statistical analysis was conducted using the statistical package for social sciences (SPSS), version 17.0. A significance level of P<0.005 was used to determine statistical significance. The relationship between SpO2/FiO2 (S/F) and PaO2/FiO2 (P/F) ratios was explored using linear regression analysis. Receiver operating characteristic (ROC) curves were employed to illustrate the sensitivity and specificity of S/F threshold values corresponding to P/F levels of 200 and 300.

3. RESULTS

In this study, a total of 59 adults were enrolled, comprising 52% males and 48% females. Analysis revealed that 51% of the participants met the PF ratio criteria for ARDS, while 49% met the criteria for ALI. We assessed the values of SpO2, PaO2 and FiO2 within a five-minute interval. A significant correlation was observed between the SpO2/FiO2 (SF) ratio and the PaO2/FiO2 (PF) ratio, which is quantified by the linear regression model: SF=183.819 + 0.229 X PF. This linear relationship is further validated by a positive correlation coefficient (r=0.607). Specifically, a PF ratio of 300 corresponds to an SF ratio of 272 while a PF ratio of 200 corresponds to an SF ratio of 247.

Diagnostic accuracy for ALI and ARDS using SF ratios was evaluated. An SF cut-off value of 272 yielded a sensitivity of 77.3% and a specificity of 80% for ALI diagnosis. Conversely, SF cut-off of 247 provided a sensitivity of 69.6% and a specificity of 83% for ARDS diagnosis.

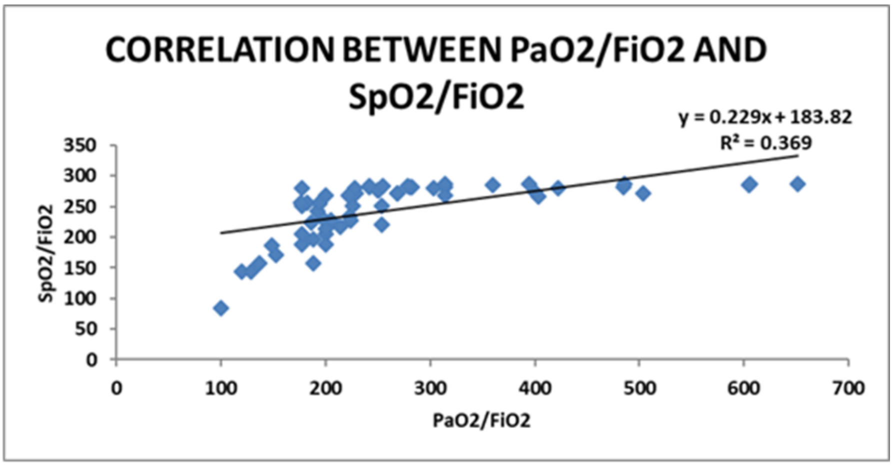

Figure 1. In the scatter plot derived from the dataset, comparing S/F ratio to P/F ratio, the line indicates the most accurate linear relationship: SpO_2/FiO_2= 183.819 +0.229 *PF (P<0.001).

PF ratio 300 corresponds to SF ratio 272 and PF ratio 200 corresponds to 247 SF ratio. There was a 77.3% sensitivity rate and 80% specificity rate for the diagnosis of ALI based on the SF cut-off of 272 and there is a 69.6% sensitivity rate and an 83% specificity rate for ARDS diagnosis when a SF cut-off of 247 is used.

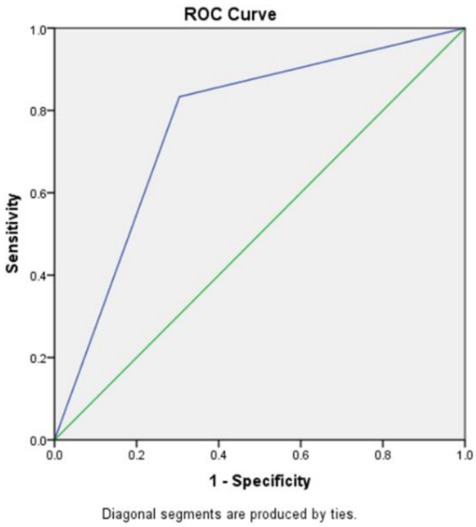

Figure 2. ROC curves for S/F vs P/F ratios of ≤200 (ARDS).

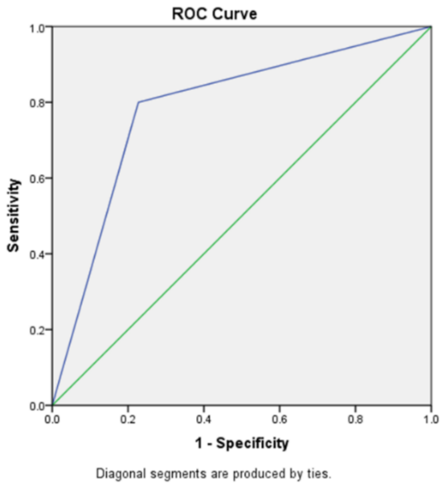

Figure 3. ROC curves for S/F vs P/F ratios of ≤300 (ALI).

SF ratio increases significantly with PF ratio, it's a POSITIVE CORRELATION.

There is a significant relationship between PF ratio and SF ratio with P value <0.001 and R valve 0.607.

The relationship between SF and PF, described by linear regression equation, is

SpO2/FiO2= 183.819 +0.229 *PF.

ROC stands for receiver operating characteristic, and it uses true positive rate and false positive rate to determine the optimal threshold value for a given test. This threshold value can then be used to calculate the sensitivity and specificity of the test, which can then be used to compare the effectiveness of different tests.

Using the ROC curve we found the area under cover for PF ratio <300 and SF ratio cut-off 272 is 78.6% and for PF ratio <200 and SF ratio cut-off 247 is 76.4%. SF ratio had good discrimination ability for ARDS (AUC=0.764) and ALI (AUC=0.786)

4. DISCUSSION

The PaO2/FiO2 (PF) ratio is commonly used to assess the severity of hypoxemic respiratory failure. However, calculating the PF ratio requires the PaO2 value, which is obtained from an Arterial Blood Gas (ABG) sample—a procedure that is invasive and has several limitations, such as the need for proper technique, time constraints for sample analysis, and contraindications for performing the test. Given these challenges, this study investigated the SpO2/FiO2 (SF) ratio as a non-invasive surrogate for the PF ratio, potentially providing a simpler and more accessible method for assessing hypoxemic respiratory failure.

The SF cut-off of 272 was 65 % sensitive and 98 % specificity for the diagnosis of ALI, and the SF cut-off of 247 was 71% sensitive and 82% specific for the diagnosis of ARDS. When the patient meets the inclusion criteria which is previously mentioned, will be taken into the sample population. The variables required for the study are charted within 5 minutes of interval. Then PaO_2/FiO_2 ratio and SPO_2/FiO_2 ratio were calculated.In addition to the advantage of substituting noninvasive pulse oximetry for invasive arterial blood sampling, SF ratio is a reliable noninvasive surrogate for PF ratio when identifying Acute Respiratory Failure.

Our findings were similar to Rice Todd et al study in adults, which states that S/F ratios of 235 and 315 correlate with P/F ratios of 200 and 300, respectively". Using P/F ratios of 200 and 300, threshold values of SF ratio 235 and 315 yielded 85% sensitivity and 85% specificity, respectively, and 91% sensitivity and 56% specificity.In neonates , hemananda et.al found a strong correlation between the invasive and non-invasive ratio . Based on their study SF ratio appears to be a reliable indicator of neonatal respiratory failure severity [12]. Laila et al's study on a pediatric population reported unsatisfactory results [13]. Across different oxygen supplementation modes, babu et.al demonstrated that the noninvasive SF ratio replaces the invasive PF ratio in patients with acute hypoxemic respiratory failure [14].

5. CONCLUSION

According to this study, the SF ratios can be used to assess oxygenation levels and to diagnose acute lung injury or acute respiratory distress syndrome. As an alternative to arterial blood sampling, pulse oximetry is a better option considering complications like anemia and bleeding. This makes them a cost-effective alternative for diagnosis in resource-limited settings. These markers are also easy to use in the intensive care setting. Furthermore, SF ratios can help identify cases of respiratory distress and monitor their progress.

REFERENCES

[1] Lamba TS, Sharara RS, Singh AC, Balaan M. Pathophysiology and Classification of Respiratory Failure. Crit Care Nurs Q. 2016;39(2):85-93. doi:10.1097/CNQ.0000000000000102

[2] Singh G, Gladdy G, Chandy TT, Sen N. Incidence and outcome of acute lung injury and acute respiratory distress syndrome in the surgical intensive care unit. Indian J Crit Care Med. 2014;18(10):659-665. doi:10.4103/0972-5229.142175

[3] Matthay MA, Arabi Y, Arroliga AC, et al. A New Global Definition of Acute Respiratory Distress Syndrome. Am J Respir Crit Care Med. 2024;209(1):37-47. doi:10.1164/rccm.202303-0558WS

[4] Mokrá D. Acute lung injury - from pathophysiology to treatment. Physiol Res. 2020;69(Suppl 3): S353-S366. doi:10.33549/physiolres.934602

[5] Rice TW, Wheeler AP, Bernard GR, et al. Comparison of the SpO2/FIO2 ratio and the PaO2/FIO2 ratio in patients with acute lung injury or ARDS. Chest. 2007;132(2):410-417. doi:10.1378/chest.07-0617

[6] Castro D, Patil SM, Zubair M, Keenaghan M. Arterial Blood Gas. In: StatPearls. Treasure Island (FL): StatPearls Publishing; January 8, 2024.

[7] Merlani P, Garnerin P, Diby M, Ferring M, Ricou B. Quality improvement report: Linking guideline to regular feedback to increase appropriate requests for clinical tests: blood gas analysis in intensive care [published correction appears in BMJ 2001 Oct 27;323(7319):993]. BMJ. 2001;323(7313):620-624. doi:10.1136/bmj.323.7313.620

[8] Bilan N, Dastranji A, Ghalehgolab Behbahani A. Comparison of the spo2/fio2 ratio and the pao2/fio2 ratio in patients with acute lung injury or acute respiratory distress syndrome. J Cardiovasc Thorac Res. 2015;7(1):28-31. doi:10.15171/jcvtr.2014.06

[9] Janipalli VP, Moturi PK. Comparison of SpO2 / FiO2 ratio and PaO2 / FiO2 ratio as diagnostic criteria in patients with ALI and ARDS. J Evid Based Med Healthc 2020;7(44), 2520-2525. DOI: 10.18410/jebmh/2020/521

[10] Wongsrichanalai V. Correlation between the spo2/fio2 ratio and pao2/fio2 ratio in ARDs. Chest. 2019 Apr 1;155(4):98A.

[11] Jusi RL, Limpin E, Bayot R, De Guia T, Ayuyao F. Determination of critical threshold value of SPO2/FiO2 ratio in the diagnosis of acute lung injury.

[12] Muniraman HK, Song AY, Ramanathan R, 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.

[13] Laila D, Yoel C, Hakimi H, Lubis M. Comparison of SpO2/FiO2 and PaO2/FiO2 ratios as markers of acute lung injury. Paediatr Indones. 2017 Jan 1;57(1):30-4.

[14] Babu S, Abhilash KP, Kandasamy S, Gowri M. Association between SpO2/FiO2 Ratio and PaO2/FiO2 Ratio in Different Modes of Oxygen Supplementation. Indian J Crit Care Med. 2021 Sep;25(9):1001-5. doi: 10.5005/jp-journals-10071-23977. PMID: 34963717; PMCID: PMC8664040.

.