ORIGINAL ARTICLE

Indian Journal of Anesthesia and Analgesia
Volume 11 Number 3 July - September 2024
DOI: http: //dx.doi.org/10.21088/ijaa.2349.8471.11324.1

Correlation Between Spo_2/Fio_2 (Sf) Ratio to Pao_2/Fio_2, Sao_2/Fio_2 Ratio in Different invasive Modes of Ventilation

K. Harini[1], Akshaya N. Shetti[2], Chandana L[3]

How to cite this article:
K.Harini, Akshaya N. Shetti, Chandana L. Correlation Between Spo2/Fio2 (Sf) Ratio to Pao2/Fio2, Sao2/Fio2 Ratio in Different invasive Modes of Ventilation. Ind J Anesth Analg. 2024; 11(3):121-127.

Abstract

Various invasive and non-invasive techniques are used to understand the oxygenation. This study aimed to assess the correlation between Spo_2/Fio_2 ratio to Pao_2/Fio_2 and Sao_2/Fio_2 in different invasive modes of oxygen supplementation. We hypothesized that the non-invasive index SpO_2/FiO_2 (SF) ratio can be used as a surrogate for to invasive index PaO_2/FiO2 (PF) ratio and SaO_2/FiO_2 ratio in all invasive modes of ventilation.

Methods and methodology: A total of 313 patients admitted to the surgical and medical intensive care unit were enrolled in this retrospective cross-sectional study. Fraction of inspired oxygen (FiO_2) from the monitor, while ABG sampling, Partial pressure of oxygen (PaO_2) and Arterial oxygen saturation (SaO_2) were noted from the ABG, reports in the medical records. The corresponding saturation of peripheral oxygen (SpO_2) was noted from the monitor while ABG sampling. Calculated SF, PF and SaO2/FiO_2 ratios were recorded and correlation between the same was noted in different invasive modes of ventilation.

Results: Pearson's correlation was used to quantify the relationship between the variables. The study showed a positive correlation, r=0.6003 (P< 0.001), between SF and PF ratio and also a positive correlation, r=0.9137 (P<0.001), between SF and SaO2/FiO2 ratio. In addition, the median values of SF ratio (P-value=0) and SaO2/FiO2 ratio (P-value=0) indicated the observed difference is unlikely to be due to chance.

Conclusion: In patients who are on an invasive mode of ventilation, the non-invasive SF can be used as a surrogate for invasive PF and SaO2/FiO2 ratio.

Keywords: ABG; FiO_2 ; Oxygen supplementation; PaO2; Pulse oximetry; SaO2/FiO2 ratio; Spo2/Fio2 ratio.

Author's Affiliation: [1]Junior Resident, [2]HOD, [3]Senior Resident, Department of Anesthesiology and Critical Care, Pravara Institute of Medical Sciences (Deemed to be University), Ahmednagar, 413736, Maharashtra, India.

Corresponding Author: Akshaya N. Shetti, HOD, Department of Anesthesiology and Critical Care, Pravara Institute of Medical Sciences (Deemed to be University), Ahmednagar, 413736, Maharashtra, India.

E-mail: harini1466@gmail.com

Received on: 03.05.2024 **Accepted on:** 27.06.2024

INTRODUCTION

The body regulates oxygen consumption carefully because low oxygen levels can have several immediate consequences on various organs. Due to the critical nature of tissue oxygen consumption in the body, it is essential to be able to monitor current oxygen saturation. SpO^2 represents the peripheral blood oxygen saturation levels and measures the oxygen-carrying capacity of hemoglobin in the blood.[1] Normal oxygen saturation levels are from 94 percent to 100 percent. Low SpO2 levels can result in hypoxemia, which can progress to hypoxia and low oxygen levels in the tissues. A pulse oximeter measures SpO2 levels. It is a non-invasive device placed over a person's finger and can provide a rapid tool to assess oxygenation accurately.

SaO2 is the saturation of oxygen in arterial blood, responsible for carrying oxygenated blood from the lungs to various cells and body organs. The study of arterial blood gas (ABG) yields the SaO2 values. The human cell requires a constant supply of oxygen to function properly.[2] The alveoli in the lungs store the oxygen that is inhaled from the external atmosphere. Low oxygen saturation causes hypoxemia, which in turn causes hypoxia. If left untreated, this might potentially cause irreversible damage to vital organs. A mismatch in oxygen saturation results in respiratory and cardiac deficits. The partial pressure of oxygen (PaO2) measures the pressure at which the oxygen dissolves in your blood. Arterial blood gas is the primary measurement used to assess the partial pressure of oxygen. This allows for the accurate measurement of the arterial blood's partial pressure of carbon dioxide, partial pressure of oxygen, acidity (pH), oxyhemoglobin saturation and bicarbonate content. All of these are useful for the evaluation and treatment of various disease states. The partial pressure of oxygen is decreased through several disease processes. An acute lung injury's (ALI) severity is typically assessed using the ratio of PaO2 to the fraction of inspired oxygen (PaO2/FIO2). Daily changes in the PF ratio demonstrated significant predictive accuracy for abnormal CXRs in ICU patients following MV treatment.[3,4] Although SpO2, SaO2 and PaO2 may differ, they are all reliant upon the oxygen concentration in the bloodstream and have to maintain within the normal range for human cells to remain in a state of homeostasis. One way to quantify how much oxygen a person inhales is to look at the fraction of inspired oxygen (FiO2), which is involved in gas exchange at the alveolar level. It is essential to comprehend oxygen delivery and interpret FiO2 levels to treat hypoxemia patients appropriately. For individuals who are critically sick, use of intrusive mechanical ventilation could be a life-saving measure.[5] The three types of mechanical ventilation that are most frequently utilized are pressure support, synchronized intermittent mandatory ventilation and assist control. By modifying the ventilator settings, a clinician can offer safe and effective invasive mechanical breathing based on the clinical circumstance in addition to the information gathered from the ventilator.

When the respiratory system fails to effectively oxygenate or eliminate carbon dioxide, respiratory failure occurs. It may be caused by lung failure or impairment of the respiratory muscle pump. One of the main causes of acute respiratory distress syndrome is acute severe hypoxemia (ARDS), a severe form of Acute lung injury (ALI). It's a condition where lung injury to the endothelium or epithelium causes inflammation and increased permeability of the pulmonary capillaries. It can also occur concurrently with a cardiac event.[7-9] Both both are conditions that patients with risk factors admitted to the surgical intensive care unit (SICU) have an incidence and mortality of.[10] According to the Berlin criteria, patients on mechanical ventilation, multiorgan failure, pulmonary infiltrates on a chest X-ray, clinical presentation and study of PF ratio are the essential diagnostic standards for ARDS and ALI.[11] The lung injury score is still a commonly used indicator for the severity of the initial lung injury in ARDS, although it offers no additional predictive value for death or the length of mechanical ventilation.[12] acute respiratory distress syndrome (ARDS) is often diagnosed by measuring the partial pressure of arterial oxygen to the fraction of inspired oxygen (PaO2/FiO2) using arterial blood. This can be expensive and may not be feasible in settings with limited resources.

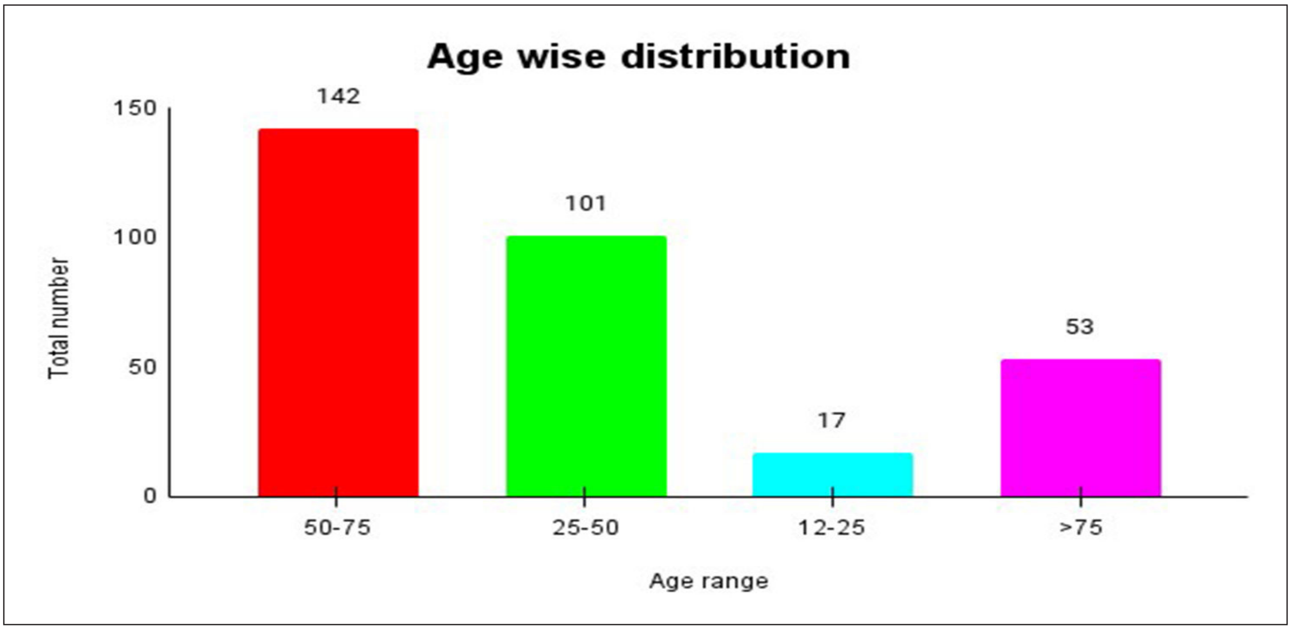
Meanwhile, pulse oximetry is always available, accurate, reasonably priced and non-invasive.[10,13] Research has verified indices based on pulse oximetry for the identification and risk assessment of individuals suffering from acute respiratory distress syndrome (ARDS). The ratio of oxygen saturation from the pulse oximeter to FiO_2 (SpO_2/FiO_2) is one example of such an indicator. If pulse oximetry's limitations are taken into consideration, its application in acute respiratory distress syndrome (ARDS) diagnosis and therapy could lead to a global advancement in clinical practice and research. This could include the formal adoption of the SpO_2/FiO_2 ratio as an alternative to PaO_2/FiO_2 for meeting the diagnostic criterion for hypoxemia in ARDS.[14,16]

METHODOLOGY

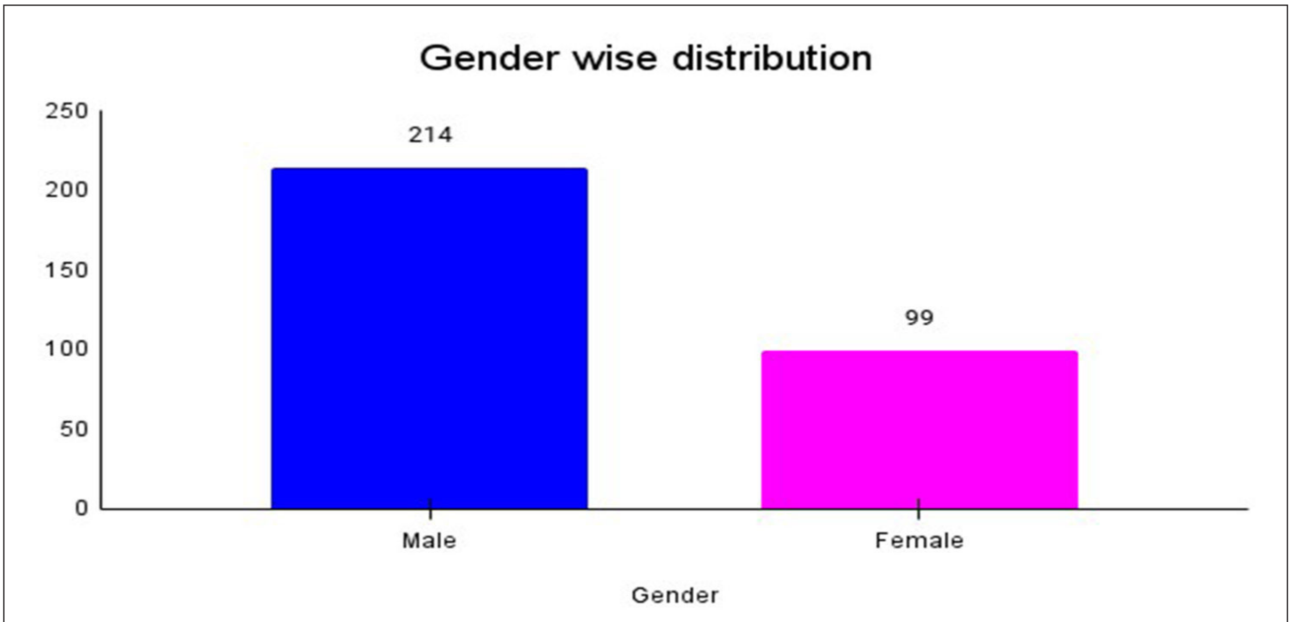
This is a cross-sectional study conducted in the surgical and medical intensive care unit between 1st May, 2023 and 31st December, 2023. All patients admitted in the surgical and medical intensive care unit, except those with satisfying exclusion criteria. Patients in severe shock with cold clammy peripheries, hypothermia (<95°F) and an inconsistent pulse oximetry waveform were excluded. Patient demographics were documented, peripheral oxygen saturation (SpO2) was recorded from the monitor and the ventilator settings were used to measure the fraction of inspired oxygen (FiO2) delivered to the patient while ABG sampling. The partial pressure of oxygen (PaO2) and Arterial oxygen saturation (SaO2) was mentioned in the medical data from the ABG reports collected. The gathered information of SaO2, PaO2, FiO2 and Spo2 are measured simultaneously and documented in the standard proforma. The PF, SF and SaO2/FiO2 ratios were calculated using the documented variables: SpO2, FiO2, PaO2 and SaO2 and analyzed to correlate the relationship.

RESULTS

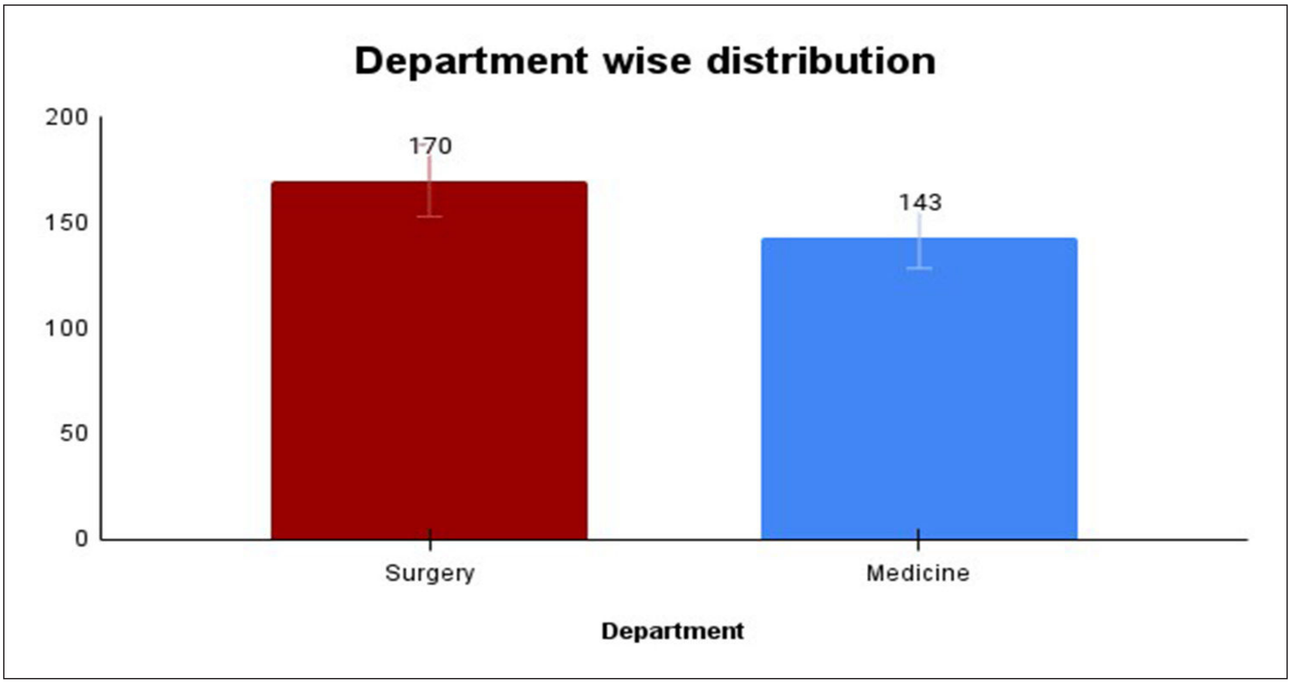
313 sample data points were gathered in total. 99 (31.6%) females and 214 (68.4%) males, most of whom were in the 50–75 age range, participated in the study. (Graph 1,2)



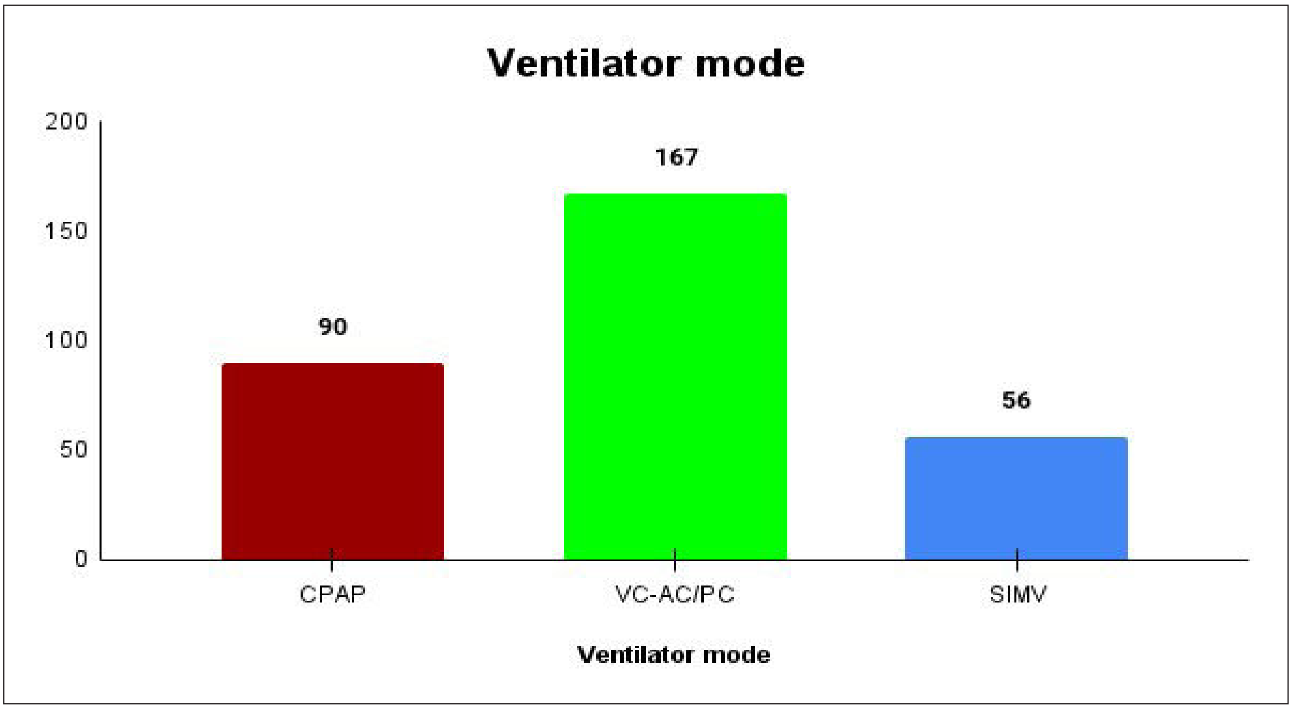
Graph 1: Shows the distribution of the patient based on their age



Graph 2: Shows the distribution of the patient based on their gender



Graph 3: Shows the distribution of the patient based on their departments



Graph 4: Shows the distribution of the patient based on ventilator modes

A total of 170 patients were admitted in the surgical ICU and 143 in the medicine ICU. The readings were collected when 90 patients were on CPAP mode, 167 patients were on Control mode and the rest 56 were on SIMV mode. (Graphs 3 and 4).

A total of 313 sample data were collected. The relationship between the variables was quantified using Pearson's correlation. A favorable association was found in the study, r=0.6003 ($P< 0.001$) (Fig. 1), between SF and PF ratio and also a positive correlation, r=0.9137 ($P<0.001$) (Fig. 2) between SF and SaO_2/FiO_2 ratio. In addition, the median values of SF ratio (P-value=0) and SaO_2/FiO_2 ratio (P-value=0) indicated the observed difference is unlikely to be due to chance.

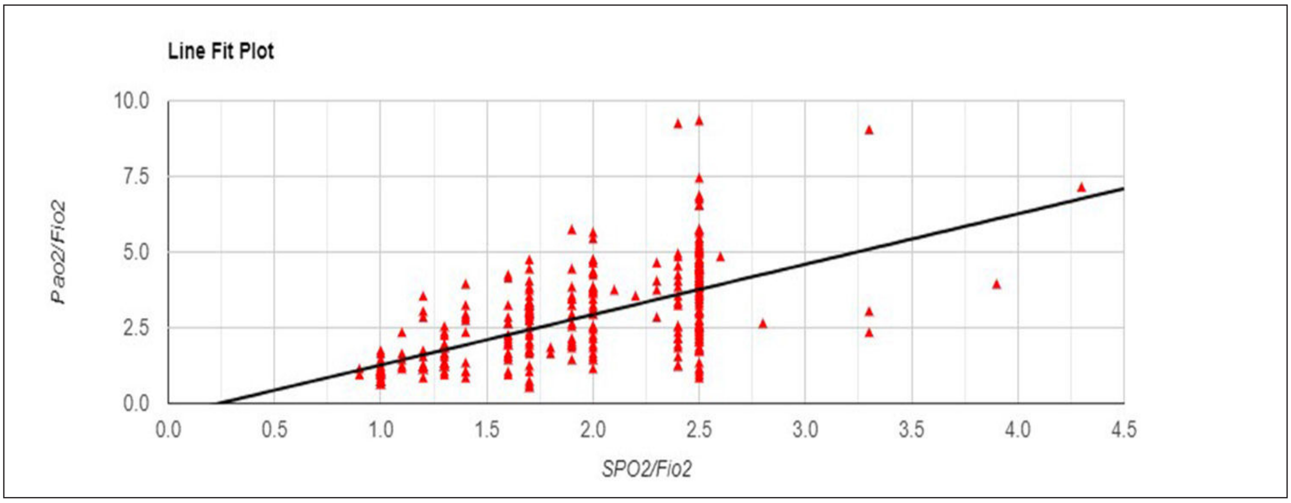


Fig. 1: This displays the SF ratio and PF ratio's correlation coefficient. There was a clear and significant positive linear association found between the PF ratio and SF ratio.The 'r' value was found to be 0.6 and p is < 0.001 which is highly significant.

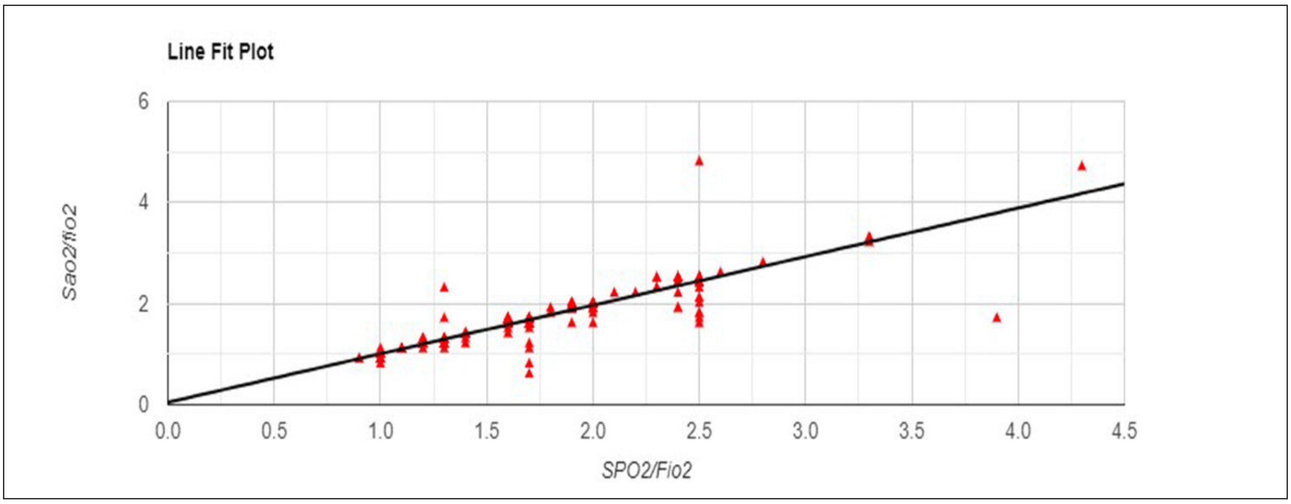


Fig. 2: This displays the SF ratio and SaO2/FiO2 ratio correlation coefficient. There was a significant positive linear correlation. The 'r' value was found to be 0.9 and p is < 0.001 which is highly significant.

DISCUSSION

According to this study, the PF ratio and SF ratio, SaO2/FiO_2 and SF ratio are positively correlated. Moreover, it was concluded that there is no difference in the outcomes when using the PF or SF ratios in any mechanical ventilation technique.[16] SF can therefore be employed as a universal substitute for PF and the SaO_2/FiO_2 ratio. In patients hospitalized in the intensive care unit, the SF ratio is a quick and practical diagnostic tool for identifying and treating acute heart failure (AHRF). This is because pulse oximeters are widely accessible devices for ongoing oxygen saturation monitoring. This avoids the need for arterial blood gas sampling, which is more expensive and invasive. The SF ratio can also be used to substitute for PF and SaO_2/FiO_2 in organ failure scores, such as lung damage scores and sequential organ failure assessment scores,to measure the degree of hypoxia. [15,17] Our results concur with a research project by Sheetal Babu *et al.* To assess the relationship between the SpO_2 /FiO_2 ratio and the PaO_2 /FiO_2 ratio in patients who were admitted to the intensive care unit using various oxygen supplementation techniques and observed a significant positive association between S/F and P/F ratios, concluded that the effective substitute for the intrusive PF ratio is the SF ratio.[18] Comparison studies of the SpO_2/FiO_2 ratio and the PaO_2/FIO_2 ratio were also carried out on patients with ARDS, or acute lung injury which resulted in positive correlation and have been evaluated. [10,19] This is further supported by the idea that individuals experiencing acute respiratory failure shouldn't undergo needless intrusive procedures. There's no denying that pulse oximeters are getting more and more common and that they can offer free monitoring. Consequently, substituting SpO_2 /FiO_2 for PaO_2 /FiO_2 may enable resource-constrained hospitals to identify acute respiratory failure.[20] This narrative review presents the current status of the preclinical and clinical literature on the use of SpO_2 /FiO_2 as a potential surrogate for SaO_2 /FiO_2 and PaO_2 /FiO_2, as well as for use as a diagnostic and prognostic marker. It also gives a general summary of pulse oximetry's limitations.[20]

CONCLUSION

According to this study for invasive PF and SaO_2 /FiO_2 ratio, SF can be utilized as a substitute in patients who are on an invasive mode of ventilation. which uses pulse oximetry in place of arterial blood sampling. Given the challenges associated with arterial blood sampling in patients undergoing critical care, pulse oximetry is a desirable substitute.

REFERENCES

1. Sirohiya P, Vig S, Pandey K, Meena JK, Singh R, Ratre BK, Kumar B, Pandit A, Bhatnagar S. A Correlation Analysis of Peripheral Oxygen Saturation and Arterial Oxygen Saturation Among COVID-19 Patients. Cureus. 2022 Apr 10;14(4):e24005.
2. Wilson-Baig N, McDonnell T, Bentley A. Discrepancy between Sp O2 and Sa O2 in patients with Covid-19 Anesthesia. 2021 Mar;76 Suppl 3(Suppl 3):6-7.
3. Pérez-Padilla JR. La altitudmodifica la relación entre la PaO2/FiO2 y elcortocircuito: impactoen la valoración de la lesiónpulmonaraguda [Altitude, the ratio of PaO2 to fraction of inspired oxygen and shunt: impact on the assessment of acute lung injury]. Arch Bronconeumol. 2004 Oct;40(10):459-62. Spanish.
4. Kwack WG. Evaluation of the Daily Change in PaO 2 /FiO2 Ratio as a Predictor of Abnormal Chest X-rays in Intensive Care Unit Patients Post Mechanical Ventilation Weaning: A Retrospective Cohort Study. Medicina (Kaunas). 2022 Feb 17;58(2):303.
5. Walter JM, Corbridge TC, Singer BD. Invasive Mechanical Ventilation. South Med J. 2018 Dec;111(12):746-753.
6. Singer BD, Corbridge TC. Basic invasive mechanical ventilation. South Med J. 2009 Dec;102(12):1238-45.
7. Catoire P, Tellier E, de la Rivière C, Beauvieux MC, Valdenaire G, Galinski M, Revel P,Combes X, Gil-Jardiné C. Assessment of the SpO 2 / FiO2 ratio as a tool for hypoxemia screening in the emergency department. Am J Emerg Med. 2021 Jun;44:116-120. doi:10.1016/j.ajem.2021.01.092. Epub 2021 Feb 6.
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.
9. Bass CM, Sajed DR, Adedipe AA, West TE. Pulmonary ultrasound and pulse oximetry versus chest radiography and arterial blood gas analysis for the diagnosis of acute respiratory distress syndrome: a pilot study. Crit Care. 2015 Jul 21;19(1):282.
10. Wick KD, Matthay MA, Ware LB. Pulse oximetry for the diagnosis and management of acute respiratory distress syndrome. Lancet Respir Med. 2022 Nov;10(11):1086-1098.
11. 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. 2014Oct;18(10):659-65.
12. Kangelaris KN, Calfee CS, May AK, Zhuo H, Matthay MA, Ware LB. Is there still a role for the lung injury score in the era of the Berlin definition of ARDS? Ann Intensive Care. 2014 Feb 18;4(1):4.
13. Babu S, Abhilash KP, Kandasamy S, Gowri M. Association between SpO_2/FiO_2 Ratio and PaO_2/FiO_2 Ratio in Different Modes of Oxygen Supplementation. Indian J Crit Care Med. 2021 Sep;1005-1001:(9)25.
14. Rice TW, Wheeler AP, Bernard GR, Hayden DL, Schoenfeld DA, Ware LB; National Institutes of Health, National Heart, Lung and Blood Institute ARDS Network. Comparison of the SpO_2/FIO_2 ratio and the PaO_2/FIO_2 ratio in patients with acute lung injury or ARDS. Chest. 2007 Aug;132(2):410-7.
15. Carvalho EB, Leite TRS, Sacramento RFM, Nascimento PRLD, Samary CDS, Rocco PRM, Silva PL. Rationale and limitations of the SpO_2 /FiO_2 as a possible substitute for PaO_2/FiO_2 in different preclinical and clinical scenarios. Rev Bras Ter Intensiva. 2022 Jan-Mar;34(1):185-196.
16. Kumar A, Aggarwal R, Khanna P, Kumar R, Singh AK, Soni KD, Trikha A. Correlation of the SpO_2/FiO_2 (S/F) ratio and the PaO_2/FiO_2 (P/F) ratio in patients with COVID19- pneumonia. Med Intensiva. 2022 Jul;410-408:(7)46.
17. Fleiss N, Polin RA. Sequential organ failure assessment scores to predict outcomes: from

adults to neonates. Curr OpinPediatr. 2023 Apr 1;35(2):218-222.

18. Manthous CA. A practical approach to adult acute respiratory distress syndrome. Indian J Crit Care Med. 2010 Oct;14(4):196-201.

19. Adams JY, Rogers AJ, Schuler A, Marelich GP, Fresco JM, Taylor SL, Riedl AW, Baker JM, Escobar GJ, Liu VX. Association Between Peripheral Blood Oxygen Saturation (SpO_2)/ Fraction of Inspired Oxygen (FiO_2) Ratio Time at Risk and Hospital Mortality in Mechanically Ventilated Patients. Perm J. 2020;24:19.113.

20. Matthay MA, Arabi Y, Arroliga AC, Bernard G, Bersten AD, Brochard LJ, Calfee CS, Combes A, Daniel BM, Ferguson ND, Gong MN, Gotts JE, Herridge MS, Laffey JG, Liu KD, Machado FR, Martin TR, McAuley DF, Mercat A, Moss M, Mularski RA, Pesenti A, Qiu H, Ramakrishnan N, Ranieri VM, Riviello ED, Rubin E, Slutsky AS, Thompson BT, Twagirumugabe T, Ware LB, Wick KD. A New Global Definition of Acute Respiratory Distress Syndrome. Am J Respir Crit Care Med. 2024 Jan 1;209(1):37-47