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A cross-sectional study comparing the SpO2/FIO2 ratio with PaO2/FIO2 ratio in patients with ARDS

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Abstract
Background: *ARDS is an acute hypoxemic respiratory failure whose early recognition is vital in implementing lung-protective ventilation strategy. PaO2/FiO2 (P/F) ratio is one of the parameters in ARDS diagnosis. This ratio is measured by arterial blood gas sampling. Since, this is an invasive procedure, this ratio can be substituted with Spo2/Fio2(S/F) ratio where SpO2 is measured by pulse oximetry. Therefore, SF ratio may be used as a reliable non-invasive alternative to the PF ratio.*
Aims and Objectives: *Deriving relationship between S/F and P/F ratios in ARDS patients and there by using S/F ratios as surrogate marker for P/F ratio.*
Materials and Methods: *70 patients admitted in ICU of Kempegowda Institute of Medical Sciences and Research Centre, Bengaluru who met the criteria for ARDS, were intubated and receiving mechanical ventilation.*
Results: *Relationship between SF and PF ratio can be described by the regression equation SF =57+0.61 (P/F)[P <0.001]. Based on this equation a PF ratio of 200 corresponds to an SF ratio of 181 [P <0.001]. The SF cut off 181 had 72% sensitivity and 81% specificity for the diagnosis of ARDS.*
Conclusions: *SF ratio is a reliable non-invasive surrogate for PF ratio for ARDS with the advantage of replacing invasive arterial blood sampling by non-invasive and continuously available pulse oximetry.*
Keywords: *ARDS, pulse oximetry, SpO2/FIO2 ratio, PaO2/FIO2 ratio.*

Introduction

Acute respiratory distress syndrome (ARDS) is a clinical syndrome of severe dyspnoea of rapid onset, hypoxemia, diffuse pulmonary infiltrates leading to respiratory failure.[1] Annual incidence of ARDS is estimated to be as high as 60 cases/100,000 populations.[1] Approximately 10% of all ICU admissions involve patients with acute respiratory failure; ~20% of these patients meet the criteria for ARDS. ARDS is a clinical syndrome with mortality as high as 41.1%.[2] Therefore, early recognition is vital in reducing deaths. The diagnostic criteria for ARDS requires PaO2/FiO2 (P/F) ratio, chest radiograph, echocardiography. P/F ratio is measured from arterial blood sampling, an invasive procedure.

Concerns about anemia, excessive blood draws, minimally invasive approaches have led to fewer ABG measurements in critically ill patients leading to inadequate management.

Non-invasive measurement of arterial oxygen saturation by pulse oximetry (SpO2) has been described as a 'fifth vital sign'.[3] In healthy subjects, changes in Pao2 correlate well with changes in Spo2 for oxygen saturation in the range of 80 to 100%[4 &5]. However, studies in critically ill patients, especially ARDS is lacking. Therefore, S/F and P/F ratios has to be recorded and an equation between them has to be derived. Using this equation, P/F can be calculated from S/F noninvasively.

The use of the S/F ratio may better facilitate the screening and rapid identification of patients with ARDS while avoiding the blood use and cost for blood gas determinations.

Utilizing the noninvasive and continuously available S/F ratio may facilitate an earlier diagnosis of ARDS, allowing the application of appropriate therapies such as lung-protective ventilation in the form of low-volume, low-pressure ventilation and conservative fluid management strategies.[1]

Materials and Methods

It is a cross-sectional retrospective study conducted in Department of General Medicine, Kempegowda Institute of Medical Sciences and Research Centre, Bengaluru.

Total 70 subjects were included in the study.

Inclusion Criteria: Patients who were intubated and receiving mechanical ventilation and met the criteria for ARDS.

Table 1: Berlin definition of Acute Respiratory Distress Syndrome

Timing	Within 1 week of a known clinical insult or new or worsening respiratory symptoms
Chest imaging[a]	Bilateral opacities—not fully explained by effusions, lobar/lung collapse, or nodules
Origin of edema	Respiratory failure not fully explained by cardiac failure or fluid overload Need objective assessment (eg, echocardiography) to exclude hydrostatic edema if no risk factor present
Oxygenation[b]	
Mild	200 mm Hg < Pa_{O_2}/FI_{O_2} ≤ 300 mm Hg with PEEP or CPAP ≥5 cm H_2O[c]
Moderate	100 mm Hg < Pa_{O_2}/FI_{O_2} ≤ 200 mm Hg with PEEP ≥5 cm H_2O
Severe	Pa_{O_2}/FI_{O_2} ≤ 100 mm Hg with PEEP ≥5 cm H_2O

Abbreviations: CPAP, continuous positive airway pressure; FI_{O_2}, fraction of inspired oxygen; Pa_{O_2}, partial pressure of arterial oxygen; PEEP, positive end-expiratory pressure.
[a] Chest radiograph or computed tomography scan.
[b] If altitude is higher than 1000 m, the correction factor should be calculated as follows: [Pa_{O_2}/FI_{O_2} × (barometric pressure/760)].
[c] This may be delivered noninvasively in the mild acute respiratory distress syndrome group.

Exclusion Criteria: Patients younger than 18 years of age; pregnancy; increased intracranial pressure, neuromuscular disease impairing spontaneous breathing, sickle cell disease, severe chronic respiratory disease, chronic liver disease (as defined by Child–Pugh class C), measurements with SpO2 value >97% as oxyhemoglobin dissociation curve is flat above these levels.

Inhaled concentrations of oxygen, Spo2, Pao2 was measured and documented. Spo2 was documented at the time of arterial blood gas sampling.

Spo2 was measured after proper positioning and after observing satisfactory waveforms on the monitor; patient positioning was not changed and suctioning was avoided for 10 min prior to the measurement; and no invasive procedures or ventilator changes was done for at least 30 min prior to the measurement.Spo2 was observed for a minimum of 1 min before the value was recorded.

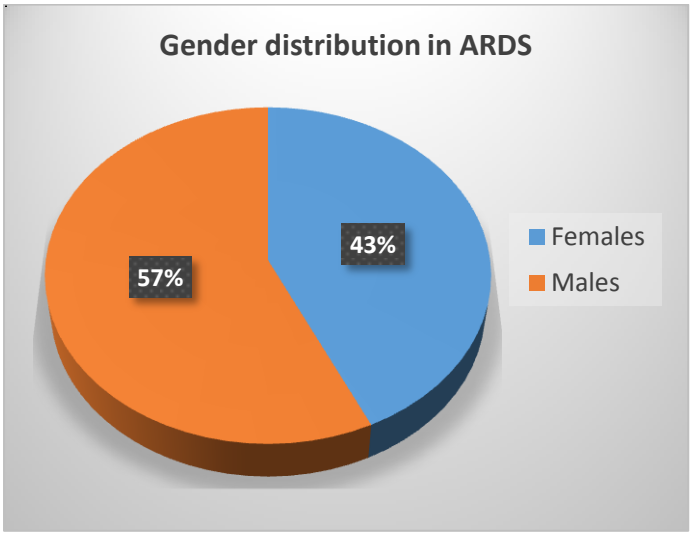
Statistical Analysis

The collected data was entered into Microsoft excel sheet and was analyzed using SPSS version 20.0. A p value of <0.05 was taken as statistically significant. A scatter plot of S/F vs P/F ratios was utilized to determine the linear relationship between the two measurements. Generalized estimating equations was utilized to quantify the best regression line. The equation for this regression line was employed to determine threshold values for S/F ratios that correlate with P/F ratio of 200. Correlation between P/F and S/F ratios is analyzed using Spearman correlation analysis.

Results

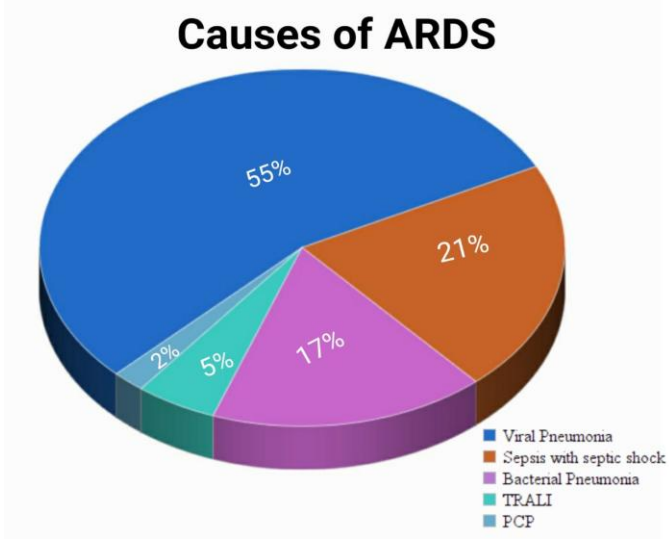
Among the 70 patients recruited in the study, 57% were males and 43% were females. The mean age of the patient was 48 years, the youngest patient being 18 years and the oldest was 58 years.

Figure 1



The most common cause of ARDS in these patients was viral pneumonia followed by severe sepsis with septic shock, bacterial pneumonia, transfusion related acute lung injury (TRALI), Pneumocystis carinii pneumonia (PCP) in descending order of frequency. Dengue virus was leading cause of viral pneumonia related ARDS followed by influenza.

Figure 2:



The linear relationship between the two measurements was derived from scatter plot of S/F vs P/F. The equation for this regression line was employed to determine threshold values for S/F ratios that correlate with P/F ratios of 200. An interaction term was included in the model to assess the effect modification by PEEP on the relationship between the P/F and S/F ratios. Receiver operator characteristic (ROC) curves were plotted to assess the degree of discrimination between S/F and P/F ratios and to adjust the S/F ratio threshold values for ARDS to optimize the sensitivity and specificity.

S/F ratio was predicted from P/F ratio, described by regression equation SF =57+0.61 (P/F). Based on this equation a PF ratio of 200 corresponds to an SF ratio of 181 [P <0.001]. The SF cut off 181 had 72% sensitivity and81% specificity for the diagnosis of ARDS. SF ratio had excellent discrimination ability for ARDS

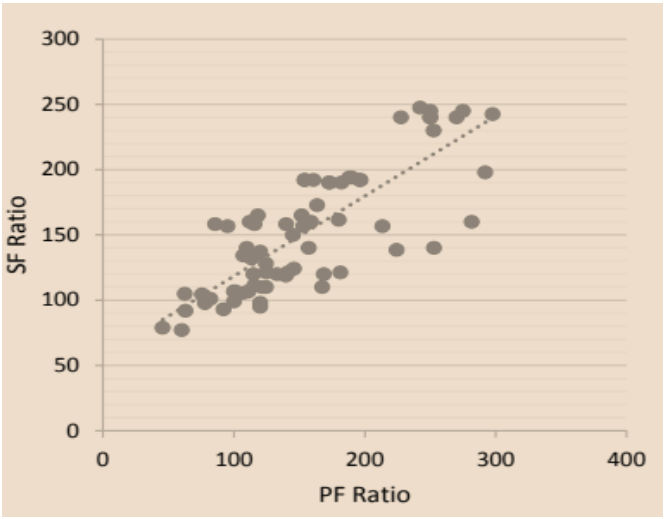


Figure 3: S/F ratio vs P/F ratio scatter plot for the derivation data set. The line represents the best fit linear relationship SF=57+0.61 (P/F) (P<0.001)

Discussion

ARDS is a major contributor of ICU mortality. Deriving P/F ratio from S/F ratio through non-invasive pulse oximetry leads to early recognition of ARDS, opting to lung protective ventilation strategy and frequent arterial blood gas sampling. Using data from patients with ARDS in the present study, we found that S/F ratio correlates well with a simultaneously obtained P/F ratio.

S/F ratio was predicted from P/F ratio, described by regression equation SF =57+0.61 (P/F). Based on this equation a PF ratio of 200 corresponds to an SF ratio of 181 [P <0.001].

Other potential advantages of using S/F ratio is to quantify hypoxemia which is a parameter in many organ failure scoring systems-lung injury scores[6], multi organ dysfunction score[7], sequential organ failure assessment[8], simplified acute physiology score II[9]. S/F ratio threshold can be utilized as a continuously available screening tool to identify which patients should undergo arterial blood gas analysis.

A similar study was conducted by Rice et al.[10] report that a cut-off 235 for SF could predict ARDS with 85% sensitivity and 85% specificity.

In pediatric population, a study by Bilan et al.[11] reported a S/F ratio of 181 corresponded to PF ratio of 200 [P <0.001]. The SF cut-off of 181 had 71% sensitivity and 82% specificity for diagnosis of ARDS.

Limitations

Patients with acute lung injury (ALI) defined as P/F ratio </= 300 were excluded from the study. S/F ratio does not allow the evaluation of acid-base status or Paco2 levels, two other potentially important clinical reasons for performing blood gas analysis.

Conclusion

SF ratio is a reliable non-invasive surrogate for PF ratio for ARDS with the advantage of replacing invasive arterial blood sampling by non-invasive and continuously available pulse oximetry.

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