Comparison of the $\text{Spo}_2/\text{Fio}_2$ Ratio and the $\text{Pao}_2/\text{Fio}_2$ Ratio in Patients With Acute Lung Injury or Acute Respiratory Distress Syndrome

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**Introduction**

Acute lung injury (ALI) and acute respiratory distress syndrome (ARDS) are grave syndromes associated with high mortality and morbidity.

It is estimated that 30% to 60% of all patients admitted to pediatric intensive care unit (PICU) require mechanical ventilation, and of these patients up to 25% suffer ALI and 5% to 10% have ARDS.

With the implementation of lung-protective ventilation strategies, overall morbidity and mortality have improved significantly for both adult and children with ALI and ARDS.

Based on American European Consensus Conference (AECC) in 1994, diagnostic criteria for ALI and ARDS require acute onset of disease, chest radiograph demonstrating bilateral pulmonary infiltrates, lack of significant left ventricular dysfunction and $\text{Pao}_2/\text{Fio}_2$ (PF) ratio ≤300 for ALI or ≤200 for ARDS.

Recent criteria require invasive arterial sampling. The pulse oximetric saturation $\text{Spo}_2/\text{Fio}_2$ (SF) ratio may be a reliable non-invasive alternative to the PF ratio.

**Methods**

In this cross-sectional study, we enrolled 70 patients with ALI or ARDS who were admitted in Tabriz children's hospital pediatric intensive care unit (PICU).

$\text{Spo}_2$, $\text{Fio}_2$, $\text{Pao}_2$, charted within 5 minutes of each other and calculated SF and PF were recorded to determine the relationship between SF and PF ratio. SF values were examined as a substitute of PF ratio for diagnosis ARDS and ALI.

**Results**

The relationship between SF and PF ratio was described by the following regression equation: $\text{SF}=57+0.61 \text{PF}$ (P<0.001).

SF ratios of 181 and 235 corresponded of PF ratio 300 and 200. The SF cutoff of 235 had 57% sensitivity and 100% specificity for diagnosis of ALI. The SF cutoff of 181 had 71% sensitivity and 82% specificity for diagnosis of ARDS.

**Conclusion**

SF ratio is a reliable noninvasive surrogate for PF ratio to identify children with ALI or ARDS with the advantage of replacing invasive arterial blood sampling by non-invasive pulse oximetry.
It is presumed that the more available and less invasive SF ratio measurement can replace PF ratio measurement in the diagnosis of ALI and ARDS.

Materials and methods
In this cross-sectional study 70 children with ARDS or ALI who were admitted in Tabriz children’s hospital PICU, Iran between 2012 and 2013 were enrolled. In patients with ARDS or ALI who were intubated and under mechanical ventilation with same Fio2; Pao2 was measured with arterial blood sampling and Spo2 was measured with pulse oximetry and charted within 5 min. SF and PF ratio were then calculated.

Inclusion criteria were children with ARDS or ALI and acute onset of disease and chest radiograph demonstrating bilateral pulmonary infiltrates, consistent with pulmonary edema.

Exclusion criteria were children with pulmonary edema due to heart failure and congenital heart disease and anatomic anomalies of lung or air ways and hypotension and weak pulses.

Statistical analysis
Statistical analyses were performed using the Statistical Package for Social Sciences, version 17.0 (SPSS, Chicago, Illinois). Quantitative data were presented as mean ± standard deviation (SD), while qualitative data were demonstrated as frequency and percent (%). The categorical parameters were compared by χ2 tests, and the continuous variables were compared by independent t test. A P <0.05 was considered statistically significant.

Relationship between SF and PF, described by linear regression equation. ROC curves were plotted to determine the sensitivity and specificity of the SF threshold values correlating with PF of 200 (ARDS) and 300 (ALI).

Results
Of 70 children enrolled in this study, 38 patients were female (54.3%) and 32 patients were male (45.7%). Mean age of study population was 32± 5 months (minimum 2 and maximum 144 months).

A total of 70 data pairs 56 (80%) met the PF ratio criteria for ARDS and 14 (20%) met the PF criteria for ALI. The median time difference between charted values of Spo2 and Pao2 pairs was 5 minutes.

Table 1 demonstrates baseline findings of the patients enrolled in the study.

| Parameter | Max-Min | Mean±SD |
|-----------|---------|---------|
| Pao2/ Fio2 | 298-46 | 155±61 |
| Spo2/Fio2 | 248-77 | 152±47 |
| Spo2 | 99-71 | 94±4 |
| Fio2 | 100-40 | 67±18 |
| Pao2 | 176-41 | 96±25 |
| Age | 144-2 | 32±5 |

Figure 1. S/F ratio vs P/F ratio scatter plot for the derivation data set. The line represents the best fit linear relationship SF=57+0.61PF (P<0.001).

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

Discussion
ALI and ARDS are major contributors to morbidity and mortality for patients admitted to PICU.15 The routine use of pulse oximetry and capnography have led to less frequent arterial blood gas sampling. In most PICUs, pulse oximetry is readily available and is being used routinely for continuous monitoring of oxygenation status.16-18
oximetry circumvents the harms and costs of arterial blood sampling. Using SF ratio for diagnosing ALI and ARDS leads to identification of undiagnosed cases of aforementioned syndromes. SF ratio may be useful in many organ failure scores, such as lung injury scores, multi organ dysfunction score, sequential organ failure assessment, as an alternative to PF ratio to estimate the degree of hypoxemia. In this study we enrolled 70 patients with ALI or ARDS. Pao₂ and Spo₂ were measured with the same Fio₂ and SF and PF ratio were calculated. The relationship between SF and PF ratio was described with the following equation: SF=57+0.61 PF. SF ratio threshold values for ALI was 235 and for ARDS was 181 corresponding to PF ratio 300 and 200. A similar study was conducted by Khemani et al. on pediatric population. They report that a cut-off of 201 for SF could predict PF for ARDS with 84% sensitivity and 78% specificity and a cut-off of 263 for SF could predict ALI with 93% sensitivity and 43% specificity. However, they didn’t have age limitation. Also the time interval between pulse oximetry and arterial blood sampling was 15 minutes which is longer that our study. They did not examine the relationship between SF and PF ratio with sex and gender.

In adult patients, Rice et al. report that a cut-off 235 for SF could predict ARDS with 85% sensitivity and 85% specificity and cut-off of 315 for SF could predict ALI with 91% sensitivity and 56% specificity. In this study, we examined the relationship between age and gender with PF and SF ratio. We measured Pao₂ and Spo₂ in maximum 5 minutes apart. The SF ratio thresholds determined in this study were based on the PF ratio which is proposed by the AECC. There are limitations to this study. First, ABG and pulse oximetry measurements were not simultaneous. Given that changes in Spo₂ and Pao₂ can take place quickly, this could affect our results. In addition we did not control for PH, hemoglobin, Paco₂, body temperature, ventilator set up. These factors also could influence the relationship between Spo₂ and Pao₂.

Figure 3. ROC curves for S/F vs. P/F ratios of ≤ 200 (ARDS) and S/F vs. P/F ratios of ≤ 300 (ALI) for the derivation data set.

**Ethical issues**

The study was approved by the local Ethics Committee.

**Competing interests**

Authors declare no conflict of interests in this study.

**Conclusion**

According to this study SF ratio is a reliable non invasive and readily available marker for PF ratio for the diagnosis of children with ALI or ARDS which replaces arterial blood sampling by pulse oximetry. Considering complications of arterial blood sampling such as anemia, and bleeding in critical care patients, pulse oximetry is a desirable replacement for arterial blood sampling.

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