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Validity of Spo2 in Measuring of Oxygenation Index

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Abstract

Background

Pulse-oximetry (Spo_2) widely uses as a help tools for therapeutic interventions in the pediatric intensive care units (PICU). The aim of this study was to evaluate the validity of Spo2 in measuring of oxygenation index (OI) in children.

Materials and Methods

In a descriptive analytical study, 100 patients who were admitted to PICU Tabriz Children's Hospital were studied. Oxygenation index measured by using two methods, including SpO_2 which obtained from Spo_2 and partial pressure of oxygen in arterial blood (PaO_2) which obtained from Arterial Blood Gases analysis.

Results

Based on findings, there was a linear correlation between SpO_2 and PaO_2, and also about OI which measured with Spo_2 and PaO_2. Based on Receiver Operating Curve (ROC), sensitivity and specificity of OI with considering PaO_2 as denominator and in values less or more than 0.145, were 100%, and 76.9%, respectively; and with considering SpO_2 as denominator and in values less or more than 0.145, were 98.6%, and 67.7%, respectively.

Conclusion

This study indicates that SpO_2 instead of pao_2 for measuring OI can be useful.

Key Words: Arterial Blood Gases, Pulse-oximetry, Oxygenation Index.

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1- INTRODUCTION

Partial pressure of oxygen in arterial blood named as PaO_2, and percentage of oxygen saturation attached to haemoglobin (Hb) named as SaO_2, and when this value is measured with Pulse-Oximeter, called as SpO_2 (1, 2).

The most common technical problems in blood sampling from radial artery for arterial blood gas (ABG) analysis are vasospasm, venous blood sampling instead of arterial blood, and some rare vascular complications like: radial artery aneurysm, hand ischemia, and hematoma which cause compartment syndrome. Therefore, it is important to use an alternative non-invasive method in patients who have indications to check ABG serially(3).

In the other hand, measuring of SpO_2 and predicting PaO_2 is very important and useful. Studies demonstrated that continuously monitoring with Pulse-Oximeter, reduces the risk of hypoxia(3, 4). A single SpO_2 about 90.0% shows adequate oxygenation during mechanical ventilation(5, 6). Arterial blood sampling is not a proper method for evaluating SaO_2, because is invasive and we cannot use it continuously, but Pulse-oximeter can shows oxygen saturation continuously and non-invasively. In turn these devices have some errors and in various conditions may show the oxygen saturation up or down falsely. Carbon monoxide poisoning, methemoglobinemia, nail polish, surrounding light, severe hypotension, and clubbing are some conditions which may cause incorrect interpretation of Pulse-oximeter (7).

Some studies showed that anemia reduces the accuracy of pulse-oximeter, but it is not proved in other studies(8, 9). Also acidosis and alkalosis may affect the pulse-oximetry and SpO_2(10). One study proposed that SpO_2 not able to indicate the accurate amount of PaO_2 in severely ill patients and for ensuring arterial oxygen saturation, it is better to be more than 94.0%(11). As well, it is obvious that in patients with sepsis or ill patients who are admitted to Intensive Care Unit (ICU) with hypotension, SpO_2 is not an accurate marker of PaO_2(12).

In general, oxygenation index (OI) is a variable which is calculated in the ICU to measure the fraction of inspired oxygen (Fio_2) and its usage within the body. A lower oxygenation index is better. As the oxygenation of a patients improves, they will be able to achieve a higher PaO_2 at a lower FiO_2 which results in decreased OI (1, 2).

Although, pulse-oximeters are useful tools for patients' oxygenation in both operating room and ICU, but the role of them in quick decision and action for treatment of certain clinical conditions is still unknown. So we decided to evaluate the validity of pulse-oximetry in measuring of oxygenation index in patients who were admitted to PICU.

2- MATERIALS AND METHODS

In a descriptive-analytical study from October 2014 to October 2015, 100 patients who were admitted to PICU underwent study. Inclusion criteria were all patients aged 2 months to 15 years old who admitted to PICU and they were under mechanical ventilation.

Exclusion criteria were patients who were in severe acidosis because of low cardiac output and hypotension; patients with contraindications for arterial sampling, cases that pulse-oximetry is not accurate like: hypotension, skin burn, nail polish, clubbing, or physical barrier in the location of the pulse-oximeter probe, and also the lack of patients parental consent.

Study protocol approved by Regional Ethics Committee of Tabriz University of Medical Sciences-Iran, with ID code of TBZMED.REC.1394.99. All parents were informed about study and after taking

informed consent form, were enrolled in the study. Patients at the beginning of study were matched in terms of demographic characteristics. When blood samplings were done for ABG analyses, pulse-oximetry with the same devices were done for patients and the blood oxygen saturation recorded. Blood sampling were done for all patients by an expert member of the nursing staff of PICU, and after blood sampling (0.5cc), samples were transferred to the main laboratory of Children Hospital and ABG analysis were done. All ABG interpretation was done by single paediatric pulmonologist. Pulse oximeter probe attached to the finger with best waves (thumb) and blood sampling was done from opposite hand and all variables were recorded at the same time.
Software SPSS version 16 was used for statistical analysis. Pearson's correlation coefficient (r) used for analysis of linear correlation of SpO_2 and SaO_2. Also SpO_2/Fio_2 (SF) and PaO_2/FiO_2 was determined and linear regression test used for comparing these two findings and ROC curve for determining sensitivity and specificity of these ratios. All cases with $P \leq 0.05$ were considered as statistically significant.

3- RESULTS

Amongst all 100 patients, 62 (62.0%) were male and 38 (38.0%) female. Mean age was 14.72 ± 14.11 with range of 2 months to 6 years old. Mean of oxygenation index based on PaO_2 was 0.049 ± 0.041 (ranged 0.009-0.107) and based on SpO_2 was 0.047 ± 0.044 (ranged 0.026-0.111). Mean of mean airway pressure (MAP) in patients was 8.88 ± 1.41. Linear regression test results and Pearson correlation coefficient (r) of studied variables were according to (**Table.1**).

Figure.1 shows the linear correlation between spo2/fio2 (SF) and pao2/fio2 (PF) in patients. Based on ROC curve, the SF use in comparing with PF, in values less or more than 200, the sensitivity and specificity were 98.1%, and 73.9% respectively. Also, in values less or more than 300, the sensitivity and specificity were 96.7%, and 43.9% respectively. In other words,using SPO_2 associated with acceptable sensivity and specifity.

Figures 2 and 3, show ROC curve for OI calculation with PaO_2 and SpO_2 respectively.

Based on ROC curve, sensitivity and specificity of OI with considering PaO_2 as denominator and in values less or more than 0.145 were 100%, and 76.9%, respectively (**Figure.2**), and with considering SpO_2 as denominator and in values less or more than 0.145, were 98.6%, and 67.7% respectively (**Figure.3**).

Table 1: Linear regression test results and Pearson correlation coefficient (r) of studied variables

Item / Variables	Mean ± SD	r	P- value
PaO_2 & SpO_2	PaO_2: 113.62±46.09 SpO_2: 94.98±40.08	0.485	0.1
OI (PaO_2) & OI (SpO_2)	OI (PaO_2): 0.047±0.031 OI (SpO_2): 0.047±0.016	0.719	0. 2
PaO_2/FiO_2 (PF) & SPO_2/FiO_2 (SF)	PF: 245.27±1.26 SF: 201.06±4.51	0.628	0. 21

SD= Standard deviation; r= Pearson correlation coefficient; OI= oxygenation index; PF= PaO_2/FiO_2; SF= SPO_2/FiO_2.

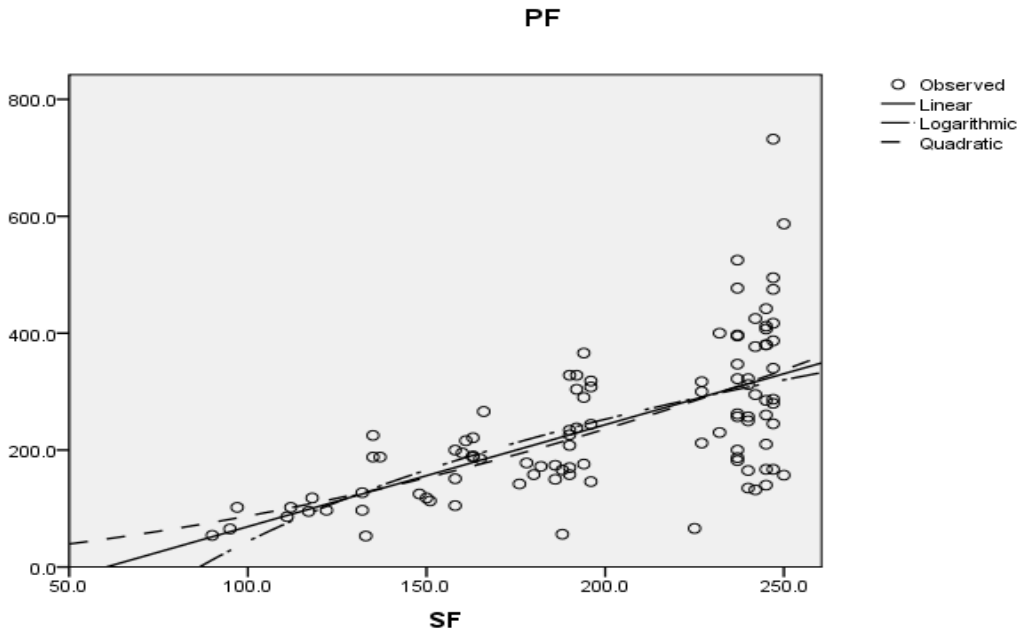

Fig.1: Linear correlation between SF and PF.

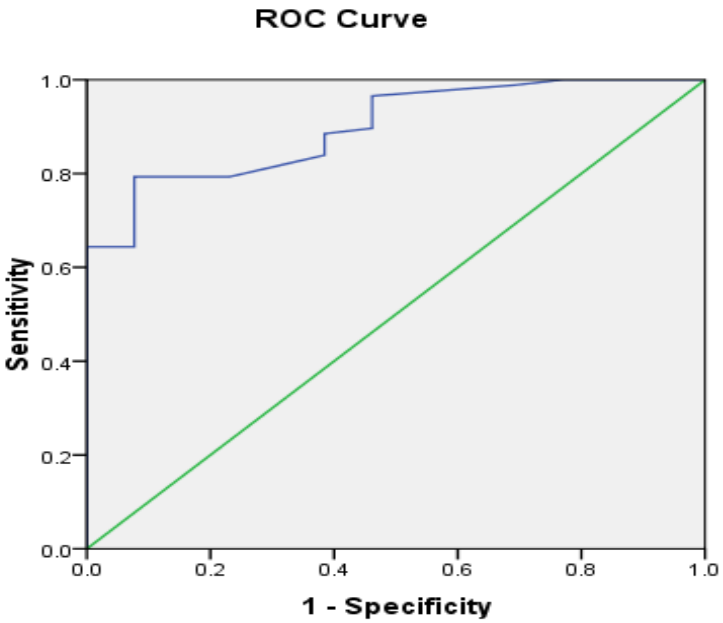

Fig 2: ROC curve of OI based on PaO_2.

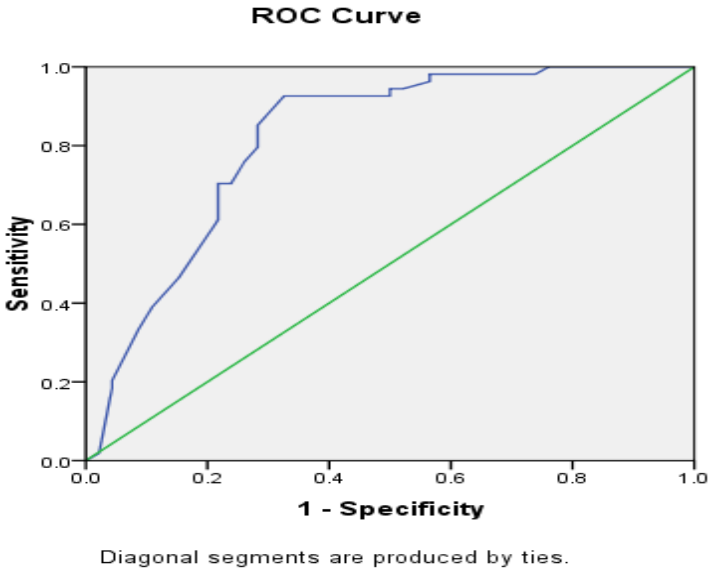

Fig 3: ROC curve of OI based on SpO_2.

4- DISCUSSION

Pulse oximetry is now available in most Pediatric Intensive Care Unit and routine use of it has led to reduce Arterial Blood Gas (ABG) measurements. Pulse oximetry prevents arterial blood sampling and cost for ABG analysis (8).

In this study we included 100 patients who were admitted to PICU. Pao2 and Spo2 measured with the same Fio2 and computed SF and PF ratio. Our study indicated the linear correlation between spo2/fio2 (SF) and pao2/fio2 (PF) in patients. In study of Mahoori and colleagues which was conducted in Cardiac Surgery Intensive Care Unit (CSICU), Spo_2 and Pao_2 were compared. This study showed that there is a linear correlation between these two values (1).

This correlation is also present in our study. In Jenic and colleagues study, researchers stated that pulse-oximeter is one of useful devices with advanced technology in providing health of preterm infants (13). Also in our study, most of patients were under mechanical ventilation and their conditions were almost like anesthesia, as well based on our findings although there are some limitation and errors in using pulse-oximeter, but it is useful and ideal device. Some studies stated that continuous using of pulse-oximeter can reduce the probable of hypoxia in patients; however these studies also showed that arterial oxygen saturation calculated by pulse-oximeter is lower than real one (3, 4).

In contrast, study of Seguin and colleagues showed that in conditions with saturation more than 90.0% pulse-oximeter have great accuracy(5). Our study proved the linear correlation between SpO_2 and PaO_2 and so our findings indicate that pulse-oximetry is an efficient and convenient method for evaluating arterial oxygen saturation similar to ABG analysis.

Previous studies showed that pulse-oximeters in conditions like carbon monoxide poisoning, methemoglobinemia, nail polish, and, severe hypotension may have some errors which may cause to incorrect interpretation (6, 7). Acidemia, alkalemia, Hb level, and hypotension were

the major cause of false pulse-oximetry in our study too. Study by Lyer and colleagues showed that acidosis and alkalosis may affect the results of pulse-oximetry in evaluating arterial oxygen saturation(14). Our study showed that arterial oxygen saturation in patients with acidosis decreases significantly in comparison with alkalosis.

Study by Perkins and colleagues in general ICU on 51 patients showed that Spo_2 measured by pulse-oximetry is higher than real PaO_2 levels (15). In our study there was no significant difference in PaO_2 between two groups.

Study by Wilson and colleagues showed that SpO_2 is not an accurate marker of PaO_2 in patients with sepsis or ill patients who admitted to ICU (12). Study by Fouzas and colleagues stated that pulse-oximeter as a non-invasive device for measuring oxygen saturation is very useful and helpful tool, even though there are some errors because of some condition like perfusion abnormality, skin pigmentation, nail polish, heart arrhythmias, and non-calibrated probe (16).

Findings of our study also approved the usefulness of pulse-oximeter and its accuracy in evaluating oxygen saturation. Study by Solevåg and colleagues showed that pulse-oximetry in neonates under mechanical ventilation is reliable and could ensure the results of ABG analysis (17). Our study demonstrates a linear correlation between SpO_2 and PaO_2 and confirms this study.

4- Limitations of the study

This study has some limitations. In our study we could not assess the relationship between anemia and oxygenation index (OI). Therefore, in another sudy, OI with considering PaO_2 and OI with considering SpO_2 shoud be calculated in two groups of patients (patients with anemia and those without anemia).

5. CONCLUSION

Confirmation of linear correlation between arterial blood PaO_2 and SpO_2, for measuring OI, we suggest using Spo_2 in children (as a non-invasive method) instead of Pao_2 (as an invasive procedure) in oxygenation index calculation seems reasonable. We can use PaO_2 and SpO_2 variables interchangeably in OI formula.

6- CONFLICT OF INTEREST: None.

7- ACKNOWLEDGMENTS

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