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Integrated Pulmonary Index: A New Strategy for Respiratory Patients Evaluation

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Abstract

Purpose: We presented a study of the importance of integrated pulmonary index (IPI) correlated with arterial blood gas analysis in the respiratory management of the patient (surgical or internal medicine) recovering in intensive care unit.

Methods: The IPI incorporated four real-time respiratory measurements; oxygen saturation (SpO_2), the level of carbon dioxide at the end of expiration ($ETCO_2$), respiratory rate (RR), pulse rate (PR). We measured continuosly IPI with repeated arterial blood gas analysis and clinical observations in 100 patients from May/2015 to August/2015 recovered in our intensive care unit. Correlation between measurements was analysed statistically. We analyzed data with SPSS program.

Results: We observed 47 patients in mechanical ventilation support (orotracheal intubation), 8 patients in non invasive ventilation support (NIMV) and 45 patients with venturi mask ventilation. There found to be a correlation between IPI (7.68 ± 1.92) and SpO_2 (96.85 ± 3.58), RR (18.96 ± 7.18). Correlations were identified between SpO_2 of IPI monitor and arterial blood gas Sat measurements, and between $EtCO_2$ (34,27,66) value and arterial blood gas $PaCO_2$ (38.04 ± 8.07) measurements.

Conclusions: IPI correlates arterial blood gas values and provides a single numerical value for early identification of respiratory failure in intensive care. IPI ensures ease of use by displaying multiple parameters on a single screen and being a bed-side, non-invasive method. Even, it might be a potential candidate to be a more dynamic measurement than arterial blood gas.

Keywords

Integrated Pulmonary Index, Endtidal Carbondioxide, Respiratory Failure, Mechanical Ventilation, Intensive Care Unit

Introduction

There are different monitorisation methods for following patients in intensive care units. Monitorisation of respiratory parameters is also important besides monitorisation of hemodynamic parameters [1,2]. Integrated pulmonary index (IPI) algorithm incorporates four real-time respiratory measurements (end-tidal CO_2, respiratory rate, pulse rate and SpO_2) into a single value that represents respiratory profile including these parameters. IPI gives an idea to the clinician to determine the need for additional clinical assessment or intervention by assessing respiratory status of the patient quickly [3].

In our study, consistency of IPI use with clinical findings and correlation of IPI with arterial blood gas were evaluated in patients being treated in intensive care unit under invasive, non-invasive mechanical ventilation or followed in spontaneous ventilation.

Materials and Methods

Fatih Sultan Mehmet Hospital Ethics Committee approved the study (FSM EAH KAEK No: 2015/60) and 100 patients whose families had given consent were enrolled in the study. Patients with nasal packing due to any anatomic reason and/or trauma were excluded. APACHE II score of each patient treated in our intensive care unit was recorded. Besides standard monitorisation, follow-up of respiratory parameters with IPI monitor was initiated. IPI monitorisation was performed by collecting expired air sampling with nasal probe in patients with spontaneous ventilation, with an apparatus placed between endotracheal tube and ventilator circuit in intubated patients and with an apparatus placed between mask and ventilator circuit in non-invasive ventilation. And, SpO_2 and peripheral pulse count was monitorised through peripheral finger probe of IPI monitor. IPI score is between 1 and 10 [3] (Table 1).

In minute 30 following monitorisation practice, arterial blood gas analysis were conducted and IPI, end-tidal CO_2, respiratory rate, peripheral oxygen saturation, peripheral pulse rate, arterial blood gas parameters and patient's clinical status were recorded.

While clinical status of the patient was recorded the following were evaluated as stable:

IMV: In intubated mechanical ventilation

NIV: In noninvasive ventilation

MV: Mask ventilation in spontaneous ventilation

Table 1: IPI score is between 1 and 10

IPI	Patient status
10	Normal
8-9	In normal range
7	Near normal limit - needs attention
5-6	Needs attention ad may require intervention
3-4	Requires intervention
1-2	Requires emergent intervention

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Table 2: Demographic Parameters and Mean Values

	Min-Max	Ort ± SS
Height (cm)	148-180	166.39 ± 7.71
Weight (kg)	45-140	72.27 ± 14.02
BMI	18-46	26.31 ± 4.72
APACHEII	6-43	20.25 ± 6.96
IPI	3-10	7.68 ± 1.92
SPO2 (%)	82-100	96.85 ± 3.58
ETCO2 (mmHg)	19-51	34.2 ± 7.66
RR (per min)	3-37	18.96 ± 7.18
PR (beat/min)	22-150	93.42 ± 20.21
Ph	7.1-7.63	7.41 ± 0.09
PaCO2 (mmHg)	19.3-58	38.04 ± 8.07
PO2 (mmHg)	47.6-263	104.09 ± 31.41
Sat (%)	84.6-99.8	97.88 ± 2.76

Table 3: IPI correlation with SPO_2, $ETCO_2$, RR and PR

	IPI	
	r	p
SPO_2 (%)	0.613	0.001**
$ETCO_2$ (mmHg)	0.167	0.097
RR (per min.)	-0.559	0.001**
PR (beat/min)	-0.090	0.373

*Pearson korelasyon anaylsis; ** p<0.01*

Table 4: Assessment of the IPI according to clinical status

Clinical Status	IPI	
	Mean ± SS	Median
EMV	7.96 ± 1.65	8
MV	7.49 ± 2.11	8
NIV	7.12 ± 2.23	7
p	0.523	

Kruskal Wallis Test

IPI's correlation with $ETCO_2$, SPO_2, respiratory rate (RR), peripheral pulse rate (PR), arterial blood gas parameters (pH, PO_2, PCO_2) and IPI means by clinical status were analysed statistically.

Statistical Analysis

For assessing the data obtained in the study, (IBM SPSS) program was used in statistical analysis. Compliance of parameters with normal distribution was assessed by using Shapiro Wilks test in the analysis of the study data. Besides descriptive statistical methods (Mean, Standard deviation, frequency), Kruskal Wallis test was used in comparisons of quantitative data. For investigating relationships between parameters that were in compliance with normal distribution, Pearson correlation analysis was used. For determining compliance between two methods, Bland Altman test was used. Significance was evaluated on the level of $p < 0.05$.

Results

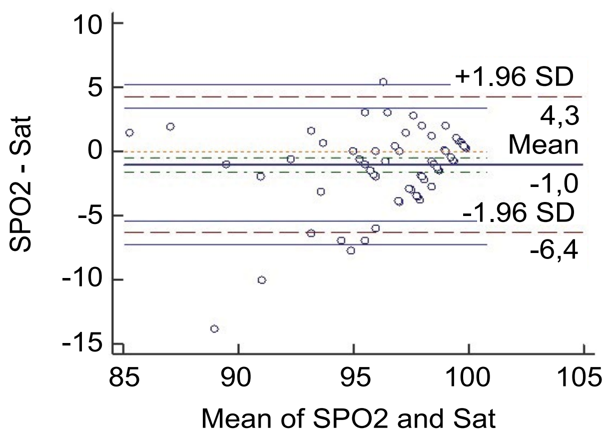
In the study, totally 100 patients were enrolled providing that 50 patients were female and 50 patients were male. Demographic characteristics of patients and mean values of IPI (7.68 ± 1.92), SPO_2, (96.85 ± 3.58), $ETCO_2$ (34,27,66), RR (18.96 ± 7.18), PR (93.42 ± 20.21), blood gas parameters that pH (7.41 ± 0.09), $PaCO_2$ (38.04 ± 8,07), PaO_2 (104.09 ± 31.41) and Sat (97.88 ± 2.76) are shown in Table 2.

While IPI was found to be correlated with SPO_2 and RR, it did not correlate with $ETCO_2$ and PR. (Table 3). Mean IPIs by clinical status are shown in Table 4.

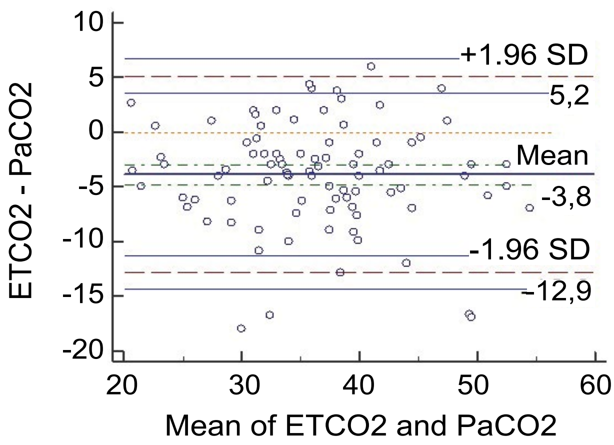
Correlations between IPI monitor SPO_2 and arterial blood gas Sat and between IPI $ETCO_2$ and arterial blood gas $PaCO_2$ were demonstrated (Graph 1 and Graph 2).

Discussion

IPI is a new respiratory index that is specific and more accurate then other single respiratory values. According to Resperato et al. [4] correlation between IPI and blood gas values in intensive care unit was investigated. In this study, 21 patients under the support of mechanical ventilation were enrolled. Respiratory status that reflected in arterial blood gas was found to be correlated with IPI. It was demonstrated that there was a moderately inversely proportional correlation between $PaCO_2$ and IPI while there was a directly proportional correlation between SpO_2 and IPI; these correlations were statistically significant. Thus, they reported that IPI was a potential candidate for evaluating respiratory status for it was a more dynamic, concurrent measurement than arterial blood gas.



Graph 1: Correlation between IPI monitor SPO_2 and arterial blood gas Sat (Bland Altman)



Graph 2: Correlation between IPI $ETCO_2$ and arterial blood gas $PaCO_2$ (Bland Altman)

In the study of Garah et al. [5] it was aimed to study the value of IPI monitorisation during pediatric endoscopic procedures. They randomised patients into 3 groups. Five patients were included in Group 1 which used only propofol, 89 patients were included in Group 2 which used propofol and midazolam, and 15 patients were included in Group 3 which used propofol, midazolam and fentanil. IPI values in Group 2 and Group 3 were found to be significantly higher than the values in Group 1. When compared to 7-12 age groups, IPI values were found to be significantly lower than the values in 4-6 age groups. While IPI was alarming in all apnoea and hypoxia episodes, pulse oxymetry could identify only hypoxia episodes.

In the study of Berkenstadt et al. [6] prospective comparison of respiratory pattern to IPI in patients who underwent colonoscopy in sedation was aimed. In low (1-3), moderate (4-6), high (7-10) IPI groups, there found to be no difference with respect to respiratory rate (RR), SpO_2, pulse rate (PR), but $EtCO_2$ value was found to be higher in high IPI group. These results are similar to our study's results and it was demonstrated that there was a correlation between IPI and SpO_2 and respiratory rate.

Kumar et al. [7] have two different studies of IPI. They followed mean IPI value of 24 obese patients who were under spontaneous ventilation trials. Results of each spontaneous ventilation trial were determined independently by the intensive care team. Records were analysed in order to determine the efficacy of IPI for estimating the results of weaning assessment. Statistical analysis demonstrated that IPI values were higher in successful spontaneous ventilation trials than IPI values in unsuccessful spontaneous ventilation trials. In another study of the same investigators, 43 patients with intubation due to surgical or medical indications and followed in intensive care unit were included in the study. Also in this study, results demonstrated that IPI values were higher in successful spontaneous ventilation trials than IPI values in unsuccessful spontaneous ventilation trials. Sabattani et al. [8] demonstrated that IPI index differed significantly $ETCO_2$ under sedation in 45 patients who went under external cardioversion. It was reported that IPI alone had advantage compared to $ETCO_2$ monitorisation.

Schier et al. [9] in their study stated that IPI was a clinically useful monitorisation. They mentioned that there was a need to conduct further studies in order to determine if IPI was more sensitive to patient factors (tremors in the patient, etc.) than monitors with repeated false alarm which were used commonly in the ward. In our study, we did not experience a problem related to the impact f tremors in IPI monitor. However, in patient whose peripheral temperature was low, we experienced a problem such that the finger probe did not detect data and the data could be obtained after external heating.

In a study conducted by Kuzkov et al. [10] it was aimed to investigate the value of IPI after coronary artery bypass grafting. Twenty-three adult patients who went under elective coronary artery bypass grafting were enrolled in the study. Patients were grouped according to their postoperative IPI values: optimal IPI (IPI > 8, n = 11) and suboptimal (IPI ≤ 8), n = 12). Patients who were smoking were observed to be prone to have low IPI scores after 12 hours of operation. They reported their opinion suggesting that IPI might be a valuable contributor in postoperative monitorisation by facilitating early detection of respiratory problems.

In another study by Kuzkov et al. [11] it was aimed to investigate the role of IPI in the weaning phase after off-pump coronary artery bypass grafting. Seventy-two adults patients were randomised to four groups following elective off-pump coronary artery bypass grafting. Different postoperative ventilation approaches were applied to three groups: CPAP 40 cm H_2O for 40 seconds in Group 1, PEEP 15 cm H_2O for 5 minutes in Group 2 and increased tidal volume for 40 seconds in order to ensure peak pressure be 40 cm H_2O in group 3. When compared to the control group, mechanical ventilation time following off-pump coronary artery bypass grafting was found to be shorter in PEEP 15 cm H_2O manoeuvre group (Group 2). They suggested that IPI could estimate postoperative mechanical ventilation and that it might be a valuable contributor in off-pump monitorisation.

As a result of our study, it was observed that IPI statistically significantly correlated with SPO_2 and RR, and had a clinical compatibility with $ETCO_2$ and PR. In addition, there found to be a correlation between IPI monitor SPO_2 value and arterial blood gas Sat along with IPI monitor ETCO2 value and arterial blood gas $PaCO_2$ measurements. In the light of these results, it may be suggested that IPI monitor which is a continuous and noninvasive measurement method can be opted for arterial blood gas which is an invasive method in monitorising intensive care unit patients.

Conclusion

IPI correlates with arterial blood gas measurements, thus it provides a single numerical value that ensures early detection of respiratory failure in intensive care unit. Features of IPI monitor such as having bedside usage, being a non-invasive method and showing multiple parameters on the same screen makes it easy to use. Even, it may stands for being a more dynamic measurement than arterial blood gas in monitorising patients treated in intensive care units. Particularly, it has been observed that IPI may be an important additional parameter in the monitorisation of critical patients who are in spontaneous ventilation but may require mechanical ventilation and in guiding the physician while making decision about mechanical ventilation indication.

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