Evaluation of oxygen reserve index vs. Peripheral oxygen saturation for the prediction of hypoxemia in morbidly obese patients: a prospective observational study.

Dr. Rachna Verma[1], Dr. Vishal Jainth[2], Dr. Deepak Shukla[3], Dr. Chaitra Srinivas[4], Dr. Shahanwaz Azam[5], Dr. Aneesha Vangapandu*[6]

Assistant Professor[1], Department of Anesthesiology, G.S.V.M. Medical College, Kanpur, Uttar Pradesh, India.

Assistant Professor[2*], Department of Anesthesiology, Rama Medical College Hospital & Research Centre, Hapur, Uttar Pradesh, India.

Anesthesiologist & Critical Care Specialist[3], Department of Anesthesia, Indian Naval Hospital Kalyani, VIZAG, Andhra Pradesh, India.

Senior Resident[4], Critical Care Unit, Fortis Chunningham, Bangalore, India.

Assistant Professor[5], Department of Surgery, Varun Arjun Medical College & Rohilkhand Hospital, Shahjahanpur, Uttar Pradesh, India.

Assistant Professor[*], Department of Anesthesiology, NRI Institute of Medical Sciences, Sanghivalasa, India.

ABSTRACT

BACKGROUND: Intraoperative anesthetic monitoring techniques have also been developed in parallel with the development of surgical instruments over the years. Blood pressure, heart rate, and blood oxygen saturation level are routinely monitored during intraoperative anesthesia.

AIM AND OBJECTIVE: To study the oxygen reserve index vs. peripheral oxygen saturation for the prediction of hypoxemia in morbidly obese patients.

MATERIAL AND METHODS: This was a prospective observational study conducted in the Department of Anaesthesia at a tertiary care hospital. Total 100 patients were included in this study, in which 50 were morbidly obese (BMI>40 Kg/m^2) and 50 were non obese (19<BMI<25 kg/m^2) undergoing an elective surgery requiring tracheal intubation. Oxygen reserve index sensor were placed and baseline values were recorded. The patients received preoxygenation until 90% of their end tidal expiratory oxygen concentration was attained.The breathing circuit was not attached to the tracheal tube until the SpO2 dropped to 95% during the induction of anaesthesia and tracheal intubation.Chi-square, t-test, and Mann Whitney U test were used for the study.

RESULTS: The total number of patients included in this study was one hundred, out of which fifty were non obese (19<BMI<25 Kg/m^2) and fifty were morbidly obese (BMI > 40Kg/m^2). Out of which 38 were males and 62 were females and their age ages ranged from 19 to 72 years. The oxygen reserve index alert period was longer than the SpO2 alert period in both groups because the alert began before the SpO2 level reached 97%. The oxygen reserve index alert period was found to be 31 seconds for patients who were morbidly obese and 92 seconds for people with a normal body mass index. In contrast, the SpO2 alert period was found to be 13 seconds and 32 seconds for these patients.

CONCLUSION: Consequently, in morbidly obese patients, oxygen reserve index can act as an early warning system for detecting sudden hypoxia before saturation starts to decline.

KEYWORDS: Oxygen reserve index, SpO_2 , Hypoxia, Morbidly obese patients, anesthesia.

INTRODUCTION

Hypoxemia in the perioperative period is a very important factor to be considered, as it greatly affects the prognosis of the patient. As a result of severe hypoxemia, cellular hypoxia, decrease in ATP production, cell death due to apoptosis and organ dysfunction occur. If hypoxemia is prolonged, it causes a decrease in cognitive functions.

Intraoperative anesthetic monitoring techniques have also been developed in parallel with the development of surgical instruments over the years. Blood pressure, heart rate, and blood oxygen saturation level are routinely monitored during intraoperative anesthesia. Pulse oximetry; it is a painless, cost-effective and most common objective monitoring method that easily measures the oxygen saturation in the arterial blood by non-invasive method by recording the light absorptions of different hemoglobins in the arteries with arterial pulsation [1].

Obesity is a chronic complex disease with a significant increasing rate globally. According to World Health Organization (WHO), 1 in 8 people were defined as obese in 2022 [2]. Obesity related respiratory changes include increased work of breathing and decreased chest wall compliance [3].An additional decrease becomes remarkable in morbidly obese patients regarding the Total Lung Capacity, Vital Capacity, Forced Expiratory Volume in 1 s (FEV1) and Forced Vital Capacity (FVC) [4].

Pulse oximetry is a standart of anesthesia for perioperative monitoring. Due to the principles of Hb oxygen dissociation curve, peripheral oxygen saturation has an approximate sensitivity and specificity of 90% for the detection of hypoxemia [5].

Oxygen Reserve Index (ORi®) (Masimo Corp., Irvine, CA, USA) is a novel continuous and noninvasive parameter that serves as a relative indicator of the PaO2. Regression analyzes report a correlation between ORi® and PaO2, especially at PaO2≤240 mmHg (r2 =0.536), and ORi®>0.24 indicates PaO2≥100mmHg [6–8]. ORi® ranges from 0 to 1 as PaO2 increases from 80 mmHg to 200 mmHg [9]. On the other hand, a key limitation of SpO2 is its inability to reflect values above 100%, even when PaO2 surpasses 100 mmHg. The patient's oxygen status can be evaluated more precisely when used in conjunction with SpO2 to prevent hypoxemia [10].

While the ORi® cannot show us the actual, direct PaO2 value, it can warn of impending PaO2 decline even without a change in SpO2. In particular, ORi® monitoring may be useful in patients at risk for insufficient preoxygenation, such as difficult mask ventilation [11], aspirated hypoxemic patients [12], rapid sequence induction [13], obese patients [14], intubations in intensive care unit [15], intubation of hypoxic patients requiring noninvasive ventilation [16].

However, there are limited studies on this, therefore we aimed to evaluate the Oxygen reserve index vs. peripheral oxygen saturation for the prediction of hypoxemia in morbidly obese patients.

MATERIAL AND METHODS

Study Design: This was a prospective observational study conducted at a tertiary care hospital, for a period of 12 months i.e, from August 2023 to August 2024.

Study Area and Study population: The total sample size was 100 in which 50 patients were morbidly obese (BMI >40kg/m^2) and other 50 patients were non obese (19<BMI<25 kg/m^2). Written informed consent was obtained from the patients.

Inclusion criteria: Patients aged 18-80 years and Scheduled for an elective surgical procedure which require tracheal intubation and general anesthesia. were included in this study.

Exclusion criteria: Patients with a history of pregnancy, Cardiac disease, difficulty in intubation, anaemia were excluded from the study.

Data Measurement: For measurements of patient's heart rate, Blood pressure, the standard monitors were established.

Other than this, the Oxygen reserve index and SpO_2 were measured simultaneously at a one second interval with a pulse oximeter which has applied to the finger and connected to a Masimo Root with Radical-7 pulse oximeter [17]. The data were downloaded from the monitor.

Pulse oximeter uses spectrophotometry as its operatingprinciple to determine oxyhemoglobin in peripheral arterial blood. The two wavelengths of light originating from oxygenated and deoxygenated hemoglobin in the blood are compared to each other.

Data Collection

- Continuous monitoring of ORI using Masimo Radical-7 Pulse CO-Oximeter.
- SpO2 monitored using a conventional pulse oximeter.
- Hypoxemia defined as SpO2 ≤ 90%.

Procedure

- Baseline readings recorded after induction of anesthesia.
- ORI and SpO2 monitored continuously throughout surgery and into the recovery period.
- Time interval between the first decline in ORI and corresponding SpO2 desaturation recorded.

Statistical Analysis: Statistical significance assessed using the Chi-square test or t-test ($p < 0.05$ considered significant).
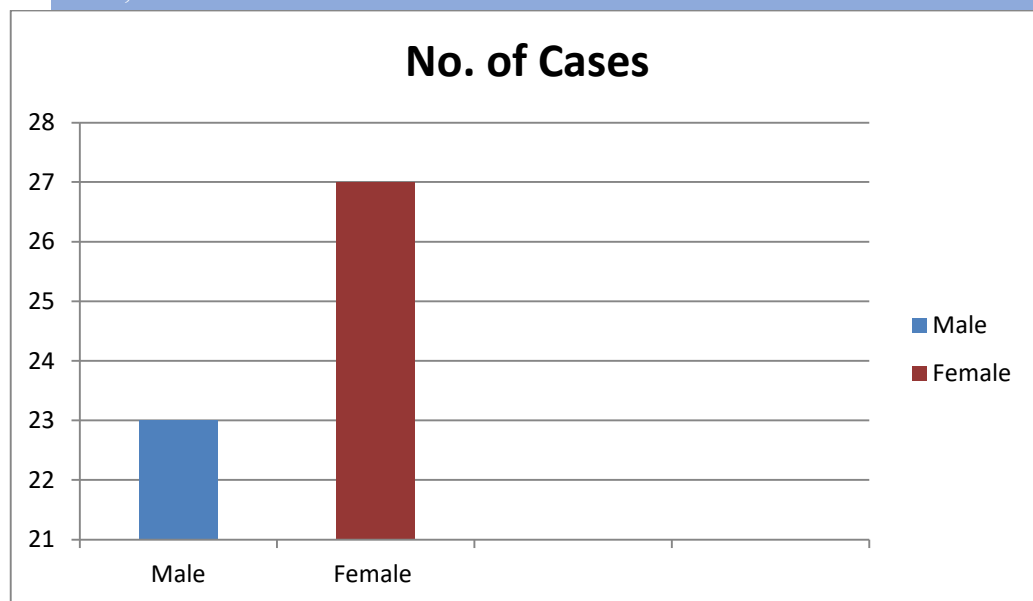
RESULTS

The total number of patients included in this study was one hundred, out of which fifty were non obese ($19<BMI<25$ Kg/m^2) and fifty were morbidly obese ($BMI > 40Kg/m^2$). Out of which 38 were males and 62 were females and their age ages ranged from 19 to 72 years.

Table 1 shows the difference in mean age, weight, BMI as well as gender. The age differences between non-obese and morbidly obese patients were not significant, based on the p values derived from the statistical tests. Not a single subject exhibited desaturation when their SpO2 level dropped below 95%. There was a statistically significant difference can be seen between non obese and morbidly obese patients. It was also observed that there were more morbidly obese patients in females than males. There is a clear difference can be seen in BMI between morbidly obese and obese patients.

Table 1: Characteristics of Patients

VARIABLES	BMI (19<BMI<25Kg/m^2)	BMI>40Kg/m^2
Age(min-max)	19-72	24-69
Gender Male Female	23 27	6 44
Weight	45-86	73-112
BMI	18-25	41-53

Graph No. 1: Graphical representation of genderwise distribution of the cases

Table 2 shows the averages of the oxygen reserve index, SpO2 alert, and tolerable apnea of non-obese and morbidly obese cases.

The oxygen reserve index alert period was longer than the SpO2 alert period in both groups because the alert began before the SpO2 level reached 97%. The oxygen reserve index alert period was found to be 31 seconds for patients who were morbidly obese and 92 seconds for people with a normal body mass index. In contrast, the SpO2 alert period was found to be 13 seconds and 32 seconds for these patients.

Table 2: Mean time difference between Non-obese and morbidly obese cases.

Time taken	Non obese (n=50)	Morbidly obese (n=50)
Tolerable apnea time mean	380	189
Oxygen reserve index warning time mean	92s	31s
SpO2 time mean	32s	13s

DISCUSSION

Obesity may aggravate the morbid condition in patients by causing anatomical, functional and systemic changes. Therefore, morbidly obese patients are considered to be at high risk for anesthesia. Compared to pulse oximetry, the oxygen reserve index in both groups gave an earlier indication of severe oxygen desaturation, according to our study.

In our prospective observational study, we evaluate the oxygen reserve index and SpO2 values during hypoxia condition in morbidly obese and non-obese cases. In our study, the oxygen reserve index alert period was observed as 31s in morbidly obese patients and 92s in non obese patients while the SpO2 alert time was observed as 13s in morbidly obese and 32s in non-obese cases.

Although pulse oximetry is an indispensable monitoring tool for detecting hypoxemia, the decrease in SpO2 and PaO2 is not always linear in the event of impending hypoxia. SpO2 may not decrease before PaO2 drops below 70 mmHg [18,

19]. This is one of the factors limiting its use in cases where early hypoxia should be detected, such as morbid obesity. Although many studies reported that ORi®, a new generation pulse oximeter, provides early warning in predicting hypoxia, to the best of our knowledge, no studies have focused on morbidly obese patients. ORi® might have a significant difference in morbidly obese patients as they perform poorer gas exchange even at rest compared with normal-weight individuals [20].

On the other hand, a value of SpO2 higher than 95% is considered normal by the American Lung Association. For this reason, we determined the period of peripheral oxygen saturation change from 97 to 95%. Due to the principle of Hemoglobin Oxygen Dissociation curve, the time for decrease of peripheral oxygen saturation from 97 to 95% is significantly rapid. Considering the relationship between arterial partial pressure of oxygen and SpO2 is not linear, SpO2 may be recorded as 98% even if the arterial partial pressure of oxygen is as low as 70 mmHg [6].

There was another study by Fleming et al. [21] where in patients undergoing cardiac surgery, determined the time of ORi®, SpO2, added warning time and tolerable apnea time as 80.4 s, 29.0 s, 48.4 s, 9.6±2.2 min respectively.

In the study of Cheng et al. [22], ORi® alarm triggers were adjusted according to the ORi® peak and ORi® 0.55 values, and it was reported to provide 300 s and 145 s of significant added warning time compared to SpO2 ($p<0.0001$).

The study by Yoshida et al. [8] observed that ORi® could predict reduced levels of oxygen 30 s before the SpO2 in patients undergoing rapid sequence intubation. In 2021, Tsymbal et al. [23] in their study recorded that in normal and obese patients, they determined the ORi® alert period was longer than the SpO2 alert period, and the added warning time provided by ORi® in obese patients was shorter (46.5 s vs. 87 s). The same researchers also found the tolerable apnea time as 256 s in morbidly obese and 381 s in patients with normal BMI.

The ORi® alarm times were declared as significantly shorter than SpO2 in studies conducted on one-lung ventilation and pediatric patients [24, 25]. Obesity may aggravate the morbid condition in patients by causing anatomical, functional and systemic changes. Therefore, morbidly obese patients are considered to be at high risk for anesthesia [26,27].

In this study, we evaluate the oxygen reserve index alert time to be more than the SpO2 alert time in both morbidly obese and non-obese cases.

CONCLUSION

When it comes to anticipating hypoxaemia, oxygen reserve index is more accurate than SpO2, giving clinicians more time to intervene and also when it comes to improving surgical patient outcomes, oxygen reserve index is a potentially useful approach for morbidly obese patients. To confirm these results and encourage ORI's wider use in clinical practice, more research is required.

Declarations:

Conflicts of interest: There is no any conflict of interest associated with this study

Consent to participate: We have consent to participate.

Consent for publication: We have consent for the publication of this paper.

Authors' contributions: All the authors equally contributed the work.

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