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# Correlation between oxygen reserve index monitoring and blood gas oxygen values during anesthesia in robotic total prostatectomy surgery

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## Abstract

**Introduction-objective** Hyperoxia is associated with acute lung injury and atelectasis. Arterial blood gas measurement is an invasive method. The Oxygen Reserve Index (ORI) was developed to monitor the oxygen values of patients. In this study, we aimed to find out whether safe monitoring against hyperoxia could be achieved in Robotic-Assisted Radical Prostatectomy (RARP) operations by using ORI, which is an easier measurement method compared to arterial blood gas measurements.

**Materials and methods** The study was carried out with adult male patients over the age of 18 who underwent RARP with the diagnosis of prostate cancer. An ORI pulse oximeter was additionally attached to their index fingers for ORI monitoring. The moment when ORI values were first read was considered the baseline, and arterial blood gas and ORI values were recorded simultaneously at the baseline (T1), 30 min later (T2), 1 h later (T3), 3 h later (T4), and 5 h later (T5). The correlations between the simultaneously recorded ORI and arterial blood gas values were analyzed.

**Results** The sample of the study included 24 male patients. The mean age of the patients was 63.30 ± 7.74, their mean BMI (kg/m$^2$) was 26.64 ± 2.84, and their mean duration of operation was 351.52 ± 48.72 min. The mean ORI value in all measurements was 0.36 (median: 0.28, SD: 0.3694). In the ROC curve analysis conducted to determine the optimal cut-off point for ORI to detect $PaO_2 \geq 150$ mmHg, the AUC was 0.901 (95% CI: 0.821–0.981), and the cut-off value obtained based on the ROC curve (cut point ORI) was 0.220 (sensitivity: 0.826, specificity: 0.771). The results of the linear regression analysis showed a strong relationship between ORI and $PaO_2$ ($PaO_2 < 240$ mmHg) [simple linear regression, $n = 90$; $r^2 = 0.505$, $p < 0.001$].

**Conclusion** The results of this study demonstrated a significant connection between ORI and $PO_2$ values in their simultaneous interpretation at $PO_2$ values lower than 240. Because the sensitivity of ORI to $PO_2$ is low in cases of severe hyperoxia, blood gas analyses will be needed.

**Keywords** Robotic surgery, Radical prostatectomy, Hyperoxia, Arterial blood gases, Oxygen reserve index

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## Introduction

In recent years, laparoscopic interventions with a robotic approach have been more prevalently preferred [1]. After the FDA (Food and Drug Administration) approved it for prostate surgery in 2001, the da Vinci Surgical System (Intuitive Inc. Sunnyvale, CA, USA) became the leading technology in urology over the next twenty years. The continuous development of alternative platforms, such as the Hugo™ Robot-Assisted Surgery RAS system, is an important step toward making robotic surgery more widely accessible [2]. Radical prostatectomy is the most commonly performed procedure in urology using a minimally invasive approach [3, 4]. Robotic-assisted radical prostatectomy (RARP) is preferred over open surgery due to factors such as its minimally invasive approach, shorter postoperative recovery times, and lower rates of blood transfusion requirement [5, 6]. The main treatment modality in prostate cancer is radical prostatectomy. The purpose of oncological surgery is to ensure the excision of the tumor while providing the best possible functional results [7]. Many studies have shown that RARP reduces mortality and morbidity rates [8]. To utilize the effects of gravity to move the abdominal viscera away from the surgical site during RARP, the Trendelenburg position is preferred. The implementation of RARP with the steep Trendelenburg lithotomy position and the insufflation of the abdomen (pneumoperitoneum) with carbon dioxide ($CO_2$) may lead to cardiological, pulmonary, and neurohumoral side effects during anesthesia [9]. The increase in blood volume causes physiological stress in the right ventricle, and the workload of the heart increases. Lung volumes decrease by 20%, and an imbalance occurs in ventilation/perfusion (V/Q). Respiratory mechanics are disrupted. With the increase in intraabdominal pressure and the cephalic displacement of the diaphragm, pulmonary compliance, vital capacity, and functional residual capacity (FRC) decrease. In volume-controlled ventilation, to maintain volume per minute, the peak airway pressure and plateau pressure rise [10]. In patients with low preoperative respiratory reserves, it becomes difficult to maintain normocarbia and normal acid-base status. Because of compression atelectasis, V/Q incompatibility develops, dead space increases, pulmonary compliance decreases, and all these factors can cause hypoxia [10]. Pulmonary edema can develop through the absorption of crystalloid fluids [11]. Plateau pressure is recovered by bringing the patient to the supine position after the operation, but it remains slightly above the baseline value before pneumoperitoneum and the steep Trendelenburg position [12]. The main reasons for partial pressure of carbon dioxide ($PaCO_2$) to increase include peritoneal $CO_2$ absorption, increased dead space and metabolism, inadequate ventilation, subcutaneous emphysema, and/or $CO_2$ embolism [13]. As a result of hypercarbia, acidosis, tachycardia, arrhythmias, and increased intracranial pressure are observed. Therefore, to simultaneously maintain normocarbia and low airway pressures, ventilator parameters must be adjusted. End-tidal $CO_2$ ($ETCO_2$) pressure may not be compatible with $PaCO_2$. For this reason, it is needed to monitor $PaCO_2$ in arterial blood gases [13]. Although arterial blood gas measurement is an effective method as demonstrated in various studies, its usage in continuous monitoring is limited because it is an invasive method. The oxygenation levels of the patient may have changed when the results of arterial blood gas measurements arrive. The monitoring of oxygenation using a saturation probe, while non-invasive, has limited usage because it has a delayed response to decreasing partial pressure of oxygen ($PaO_2$) levels in the blood and cannot reflect hyperoxic $PaO_2$ values. While oxygen inhalation is given to prevent hypoxia during anesthesia, hyperoxia can develop. Hyperoxia can lead to an increase in oxygen radicals and oxidative stress. The negative effects of hyperoxia have been shown in children, newborns, and the elderly [14, 15]. It is associated with acute pulmonary injury and atelectasis [16, 17]. It is known that prolonged exposure to $FiO_2$ 1.0% can lead to resorption atelectasis and trigger an inflammatory response in the lungs. Additionally, it may cause coronary and peripheral vasoconstriction, a decrease in cardiac output, or direct damage through oxidative stress [18]. As arterial blood gas measurements for monitoring hyperoxia are invasive and unable to show hyperoxia in oxygen saturation values, the Oxygen Reserve Index (ORI) was developed as another measurement method allowing the perioperative monitoring of oxygen values. ORI is a measurement method that involves the usage of non-invasive hemoglobin sensors [19]. The measurement of this novel variable in patients who are receiving supplementary oxygen has become possible through the ability of multi-wavelength pulse co-oximetry to analyze changes in both arterial and venous pulsatile blood perfusion based on light passing through a finger. When oxygen is provided, $PaO_2$ reaches a value of $>100$ mmHg, and saturation of peripherial oxygen ($SpO_2$) is maximized to a value close to 100%. However, when $PaO_2$ reaches a value of approximately 200 mmHg, the venous oxygen saturation ($SvO_2$) at the site of measurement continues to increase until stabilization (at a saturation rate of approximately 80%) By combining the Fick and oxygen content equations, the change in light absorption over this $PaO_2$ range constitutes the basis of ORI calculations. Thus, ORI is an index with no unit that can take values between 0.00 and 1.00, it is a relative indicator of changes in $PaO_2$ in a moderately hyperoxic range (approximately 100–200 mmHg), and it is intended to be used in patients who are given additional oxygen [19]. A drop in the ORI value can provide an early warning of impending desaturation events

[20]. ORI is recommended in obesity surgery, which has the potential for atelectasis development, laparoscopic interventions, the Trendelenburg position, and single-lung ventilation [21, 22]. During anesthesia induction, it is known that ORI increases due to preoxygenation, and after intubation, when the patient is positioned in the Trendelenburg position, ORI fluctuates in a downward direction. There are studies indicating that ORI is a useful reference for predicting oxygenation and that ORI measurement facilitates early interventions, such as adjusting PEEP levels and performing recruitment maneuvers [23]. In our study, we aimed to check arterial blood gas measurements and ORI values during RARP performed in the Trendelenburg position and present the relationship between them. In the prediction of a shift toward hyperoxia by an increase in $PaO_2$ through oxygen inhalation, as a non-invasive measure, ORI can reduce the number of arterial blood gas measurements. Because the Trendelenburg position constitutes a situation that disrupts respiratory patterns, we wanted to find out whether ORI, which is an easier measurement method in comparison to arterial blood gas measurements, can allow safe monitoring against hyperoxia.

## Materials and methods

After obtaining ethics committee approval (decision date: 28.06.2024, decision number: 390), the study was carried out with adult male patients over the age of 18 who underwent robotic-assisted radical prostatectomy (RARP) operations at a university hospital The inclusion criteria were as follows: Male patients scheduled for radical prostatectomy with robotic surgery that are expected to last longer than 2 h, patients with a BMI below 35, patients who can undergo ORI monitoring, patients that have invasive arterial monitorization, and the patients classified as American Society of Anesthesiologists (ASA) physical classes 1, 2, or 3 .The exclusion criteria were as follows: Male patients scheduled for radical prostatectomy with robotic surgery that are expected to last less than 2 h patients with a BMI above 35 (BMI > 35 $kg/m^2$), patients who cannot undergo ORI monitoring, patients who can cause hemodynamic instability and respiratory distress, and are classified as ASA 4.

After pre-anesthesia evaluations, in the operating room, five-lead electrocardiography (ECG), $SpO_2$ measurement, and non-invasive blood pressure monitoring were performed in each patient. After peripheral venous cannulation, 0.05 mg/kg midazolam (iv) was given, and invasive hemodynamic monitoring was performed by radial artery cannulation. Preoxygenation was provided to the patients at a rate of 6 L/min. For anesthesia induction, the patients were given propofol at 1–2 mg/kg, fentanyl at 1 mcg/kg, ketamine at 1-1.5 mg/kg, and rocuronium at 0.6 mg/kg (iv), they were intubated using cuffed endotracheal tubes, and they were connected to a mechanical ventilator. A 50% oxygen-air mixture was given during anesthesia maintenance. Considering airway pressures and ensuring that ET $CO_2$ values would be 30–35 mmHg, volume-controlled ventilation was provided by implementing 5–8 ml/kg tidal volume, a respiratory rate of 12–14/min, and 5 mmHg positive end-expiratory pressure (PEEP). In anesthesia maintenance, in addition to intravenous remifentanil infusion and 50% $O_2$-air and sevoflurane inhalation, intermittent iv bolus doses of rocuronium were used. After general anesthesia induction, because the patient was going to be put in a lithotomy and steep Trendelenburg position during RARP, he was fastened to the operation table using chest straps and soft shoulder supports to prevent him from sliding. The body parts of the patient that could be exposed to compression such as his elbows, axilla, shoulders, and back were supported with soft pads. During robotic surgery, muscle relaxants were administered every 35–40 min, taking into account the patient's muscle relaxant metabolism. This approach was necessary to ensure adequate muscle relaxation throughout the procedure, as the robotic arms require the patient to remain still and immobile. Due to the prolonged surgery and repeated doses of muscle relaxants, the patients were extubated with sugammadex (4 mg/kg) after they had warmed up sufficiently in the intensive care unit and cleared the relaxant. No pulmonary complications occurred in any of the patients. Recruitment maneuvers were not routinely performed on every patient.

For the ORI monitoring of the patient, an ORI pulse oximeter was placed on his index finger. The moment when ORI values were first read was considered the baseline, and arterial blood gas and ORI values were recorded simultaneously at the baseline (T1), 30 min later (T2), 1 h later (T3), 3 h later (T4), and 5 h later (T5). The correlations between the simultaneously recorded ORI and arterial blood gas values were analyzed.

### Statistical analysis

The collected data were analyzed using SPSS (Statistical Package for the Social Sciences) version 26 (IBM Corp, USA). The normality of the variables was tested using visual methods (histogram and probability plots) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk tests). The results are presented as mean ± standard error values.

For analyzing the data on $PaO_2 < 240$ mmHg ($n = 90$), correlation analyses were performed using Pearson's correlation coefficient, and a simple linear regression analysis was performed.

The threshold of $PaO_2 < 240$ mmHg was chosen according to a previous study that investigated the relationship between ORI and $PaO_2$ [Applegate RL 2nd, Dorotta IL,

**Table 1** Patient demographic data and the duration of Anesthesia (Mean ± SE, **n**)

| | |
|---|---|
| Age (years) | 63.30 ± 7.74 |
| BMİ (kg/m$^2$) | 26.64 ± 2.84 |
| Gender (Male) | 24 (100) |
| Duration (min) | 351.52 ± 48.72 |

Wells B, Juma D, Applegate PM.The relationship between ORI values and values of arterial partial pressure of oxygen during surgery was examined. Anesth Analg. 2016;123:626–33. https://doi.org/10.1213/ANE.00000 00000 00126 2.]. Additionally, 95% prediction intervals were determined in the data on $PaO_2 < 240$ mmHg ($n = 90$).

To obtain the optimal cut-off ORI value to detect $PaO_2 \geq 150$ mmHg, a receiver operating characteristic (ROC) curve analysis was performed. In order to confirm the predictability and diagnostic ability of the ROC curve, the area under the curve (AUC) and its 95% confidence interval (95% CI) were also determined.

To assess the trending ability of ORI, a four-quadrant plot analysis was performed. For the analysis, all 120 datasets, that is, 90 changes (5 changes per case) in $PaO_2$ ($\Delta PaO_2$) and ORI ($\Delta$ORI), were used.

## Results

The sample of the study included 24 male patients. The mean age of the patients was 63.30 ± 7.74, their mean BMI (kg/m$^2$) was 26.64 ± 2.84, and their mean duration of operation was 351.52 ± 48.72 min (Table 1). The ASA scores were as follows: 66.6% (n: 16) of the patients were ASA 2, and 33.3% (n:8) were ASA 3.The values of ORI, $pO_2$, pH, and $pCO_2$ obtained at different measurement times are presented in Table 2. The lowest mean ORI value was 0.26 ± 0.07 at T2, while the highest mean ORI value was measured as 0.49 ± 0.09 at T5. The mean ORI value in all measurements was 0.36 (median: 0.28, SD: 0.3694). The lowest and highest mean $PO_2$ values were 135.60 ± 8.35 at T2 and 168.91 ± 19.92 at T5. Among all measured $PO_2$ values, the lowest $PO_2$ value was 58.40, whereas the highest one was 483. The mean $PO_2$ value in all measurements was 154.53 (SD: 66.60). The lowest mean pH value was 7.31 ± 0.02 at T5, whereas the highest $PCO_2$ value was measured also at T5 (Table 2).Towards the end of the operation, the patients' pH levels were decreasing, while their $CO_2$, ORI, and $PO_2$ levels were increasing.

### Cut-off ORI value for hyperoxemia

Figure 1 shows the ROC curve that was used to obtain the optimal cut-off ORI value to detect $PaO_2 \geq 150$ mmHg. The AUC was 0.901 (95% CI: 0.821–0.981), and the cut-off value obtained based on the ROC curve (cut point ORI) was 0.220 (sensitivity: 0.826, specificity: 0.771).

### Relationship between ORI and $PaO_2$

Figure 2 shows the relationship between the ORI and $PaO_2$ values of all 100 datasets, and Fig. 3 shows the scatter diagram of ORI values obtained when $PaO_2 < 240$ mmHg ($n = 90$).

The results of the simple linear regression analysis are shown in Table 3.

## Discussion

In this study, we reported the relationship between $PaO_2$ values in arterial blood gas measurements and ORI values in patients who underwent RARP in the Trendelenburg position. The mean arterial gas $PaO_2$ value of the patients was 154.5352 (median: 141, min: 58.40, max: 483.00), while their mean ORI value was 0.3676 (median: 0.28: 0, max: 1). It can be stated that in patients given 50% oxygen in the Trendelenburg position, a relatively safe range was achieved by keeping $PaO_2$ at a mean value of 154 and ORI at a mean value of 0.36 (Table 2). In all measurements except for T2, increases in $PaO_2$ and those in ORI were observed simultaneously. In our study, ORI decreased at T2 (0.26 ± 0.07), while $PaO_2$ also dropped to 135.60 ± 8.35. T1 was the time point at which ORI values were first read, and it reflected the synchronization of the baseline blood gas values and ORI values. The lower ORI and $PaO_2$ values at T2 compared to other time points can be explained by the intubation process.In a similar study, ORI values were found to identify momentary changes in $PO_2$ values during intubation sooner than saturation readings [19]. In this study, during rapid sequence intubation, the change in ORI values was observed before the decrease in oxygen saturation. Hence, the simultaneous monitoring of ORI values and saturation readings is recommended. In another similar study conducted on obese patients, the ORI values at the end of preoxygenation were not significantly different from those at the beginning of intubation (0.49 ± 0.18 vs. 0.41 ± 0.09), but they slightly decreased once ventilation resumed (0.36 ± 0.12). In contrast, the ORI values of normal BMI patients decreased between the end of preoxygenation and the

**Table 2** The ORI, $PO_2$, pH, and $PCO_2$ data obtained at different measurement times

| | T-1 | T-2 | T-3 | T-4 | T-5 |
|---|---|---|---|---|---|
| ORI | 0.29 ± 0.07 | 0.26 ± 0.07 | 0.36 ± 0.07 | 0.46 ± 0.08 | 0.49 ± 0.09 |
| $PO_2$ | 161.30 ± 19.07 | 135.60 ± 8.35 | 153.10 ± 10.70 | 155.54 ± 11.10 | 168.91 ± 19.92 |
| pH | 7.40 ± 0.01 | 7.41 ± 0.01 | 7.37 ± 0.01 | 7.33 ± 0.02 | 7.31 ± 0.02 |
| $PCO_2$ | 40.45 ± 1.27 | 36.22 ± 1.59 | 39.34 ± 1.70 | 43.34 ± 1.98 | 44.68 ± 2.02 |

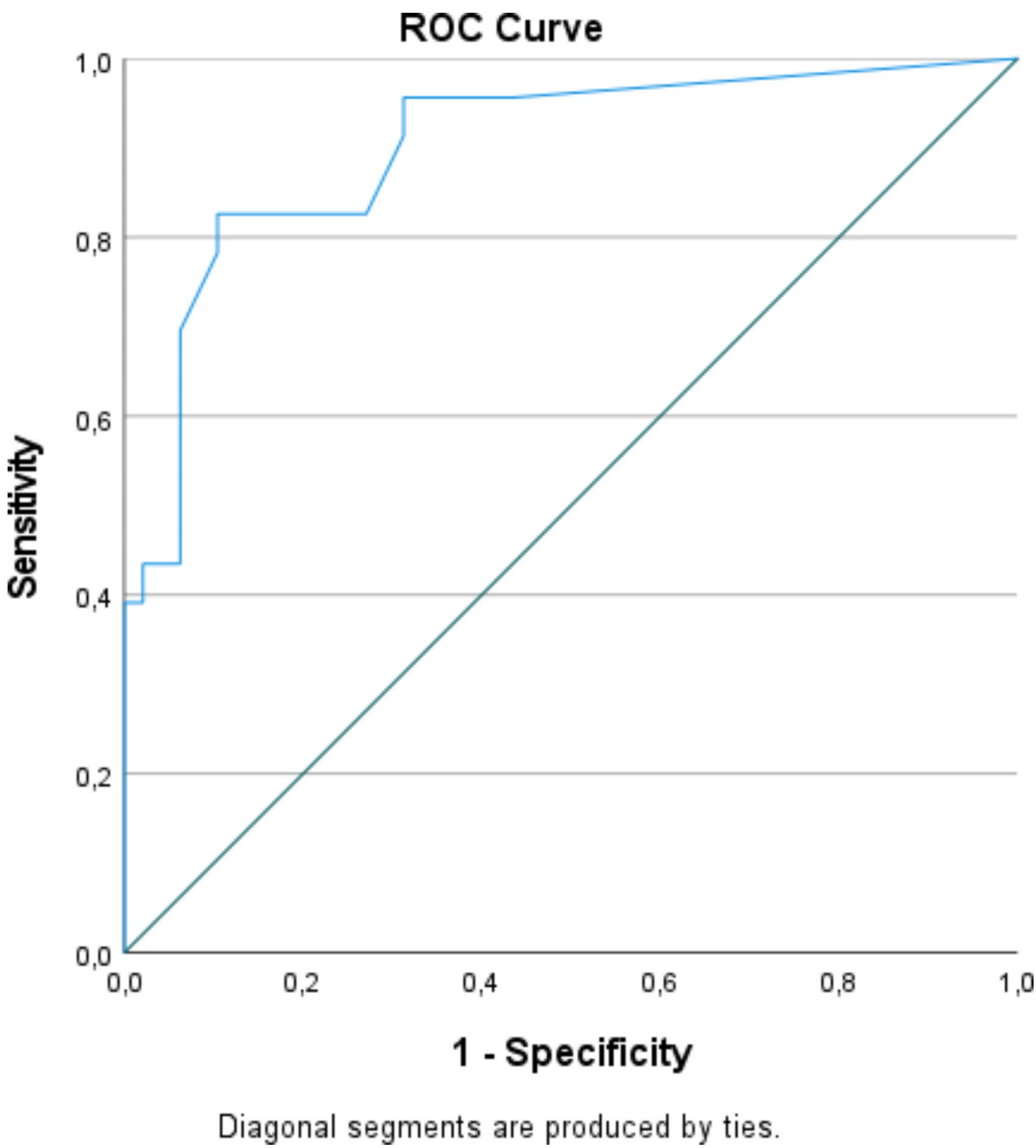


**Fig. 1** The ROC curve to obtain the optimal cut-off ORI value to detect $PaO_2 \geq 150$ mmHg. An optimal cut point was defined as the point at which the sum of the sensitivity and specificity was maximized on the ROC curve

beginning of intubation (0.67 ± 0.25 vs. 0.57 ± 0.26), and further decreased once ventilation resumed (0.43 ± 0.18). The ORI values of obese patients were lower at both the end of preoxygenation and the beginning of intubation compared to normal BMI patients [24]. In our study, the average BMI of patients was 26.64 ± 2.84, which is close to the normal range.

We were unable to find any studies that involved constant oxygen inhalation among studies on ORI. In this study, we aimed to present the relationship between oxygen and ORI by using a constant oxygen value. In future

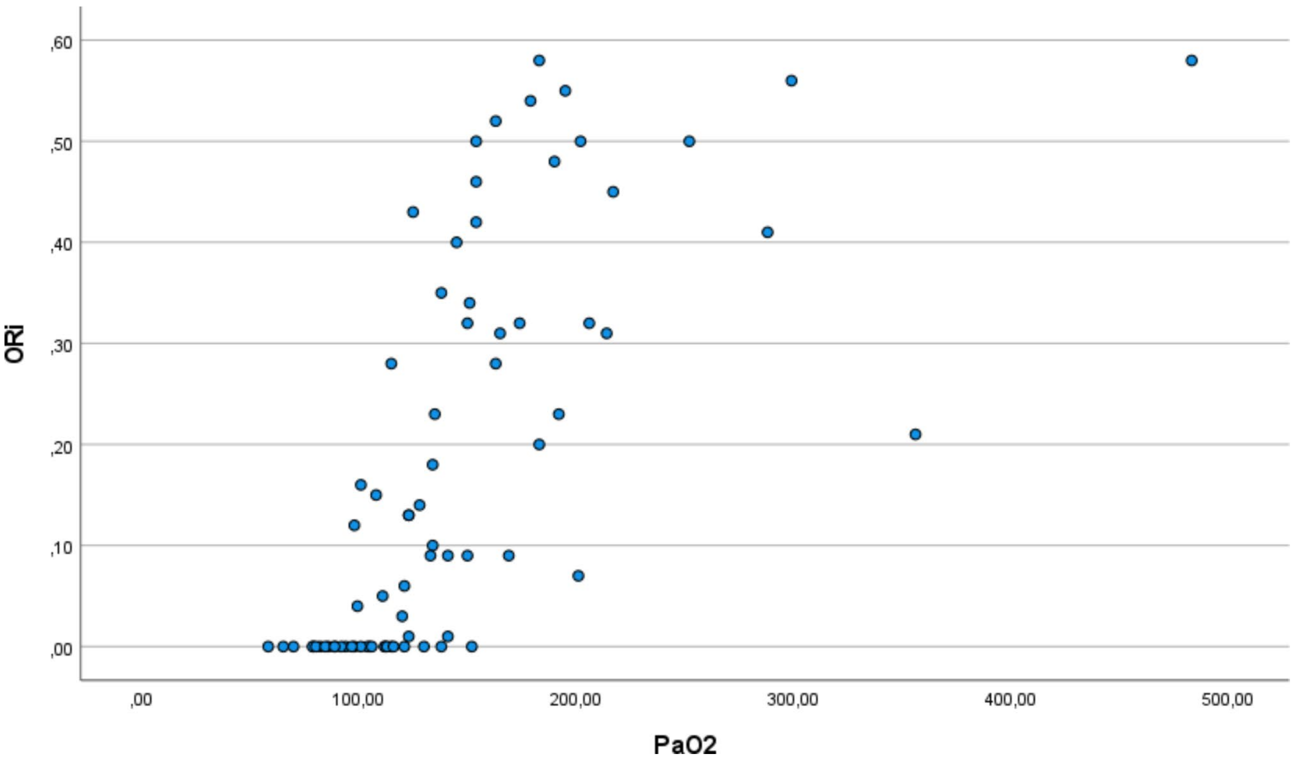


**Fig. 2** Scatter plot of all ORI and $PaO_2$ values ($n = 100$). The 100 datasets, with the $PaO_2$ plotted on the horizontal axis and the ORI plotted on the vertical axis

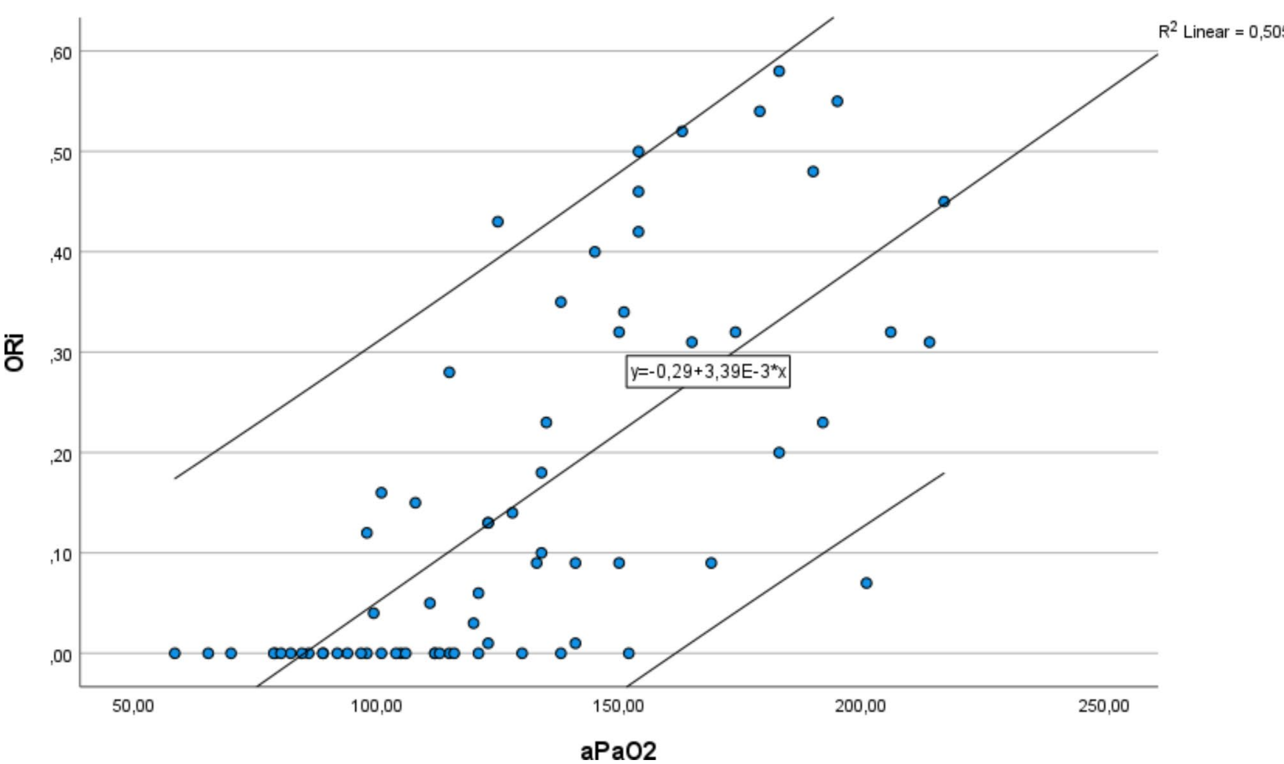


**Fig. 3** The relationship between ORI and $PaO_2$ ($PaO_2 < 240$ mmHg, $n = 90$) and 95% prediction intervals. The data ($n = 90$) are shown with the $PaO_2$ values plotted on the horizontal axis and the ORI values plotted on the vertical axis. The linear regression analysis (solid line) showed a relatively strong positive relationship ($r^2 = 0.505$)

**Table 3** Relationship between ORI and $PaO_2$ ($PaO_2 < 240$ mmHg) [simple linear regression, $n = 90$; $r2 = 0.505$]

| | Estimate | Standard error | t value | *P* value |
|---|---|---|---|---|
| Intercept | -0.289 | 0.055 | -5.253 | < 0.001 |
| $PaO_2$ | 0.003 | 0.000 | 8.330 | < 0.001 |

studies, $FiO_2$ values can be optimally adjusted with reference to ORI by taking into account the correlation between $PaO_2$ and ORI when oxygen is kept constant. For instance, in the study conducted by Yoshida et al., $FiO_2$ values were changed so that ORI would be 0.5,0.2,0, and correlations of these values with blood gas measurements were examined [23]. A $PaO_2$ value of 150 mmHg has been suggested as an acceptable target to identify hyperoxia in many studies. In our study, for the identification of a target $PaO_2$ value of ≥ 150 mmHg, we found the optimum ORI cut-off value to be AUC 0.901 (95% CI: 0.821–0.981), and the cut-off value obtained based on the ROC curve was 0.22 (sensitivity: 0.826, specificity: 0.771) (Fig. 1). It seems that keeping ORI below 0.22 in cases where blood gas measurements are not made would prevent hyperoxia. While precautions taken against hypoxia under general anesthesia are important, $FiO_2$ values that are kept high can result in hyperoxia. ORI measurements can be helpful in the determination of suitable $FiO_2$ values to prevent hyperoxia. In cases of hyperoxia, conventional oxygen saturation monitoring may not provide clear information about $PaO_2$. When saturation is at 100%, $PaO_2$ may have a value higher than 128 mmHg. Saturation would never exceed 100% despite further elevations in $PaO_2$ values [25]. This demonstrates that saturation monitoring is inadequate in the prevention of hyperoxia. ORI can be used along with saturation monitoring to predict hyperoxia. In a similar study, in the ROC analysis they conducted to identify $PaO_2 \geq 150$ mmHg, Yoshida et al. found the cut-off point of ORI as 0.21 (sensitivity: 0.950, specificity: 0.755), which was very close to the value found in our study. While the results of the linear regression analysis for ORI and $PaO_2$ ($PaO_2 < 240$ mmHg) in our study were [simple linear regression, $n = 90$; $r^2 = 0.505$, $p < 0.001$], in the study conducted by Yoshida et al., the result was $r^2 = 0.706$. In other studies supporting this relationship, a strong relationship was identified between ORI and $PaO_2$ at $PaO_2$ values below 240 mmHg [26, 27]. Our study and other studies have demonstrated a significant connection between ORI and $PO_2$ values in the context of their simultaneous interpretation at $PO_2$ values below 240 mmHg. Regarding the variation between ORI and its matching $PaO_2$, Applegate et al. [25] also reported that there was no correlation between ORI and $PaO_2$ when $PaO_2$ was 240 mmHg or higher ($r^2 = 0.0016$). Because ORI has low sensitivity to $PaO_2$ in cases of severe hyperoxia, blood gas analyses would be needed. While ORI is not an alternative to blood gas analyses, if it is greater than zero in robotic or other surgical procedures performed in the Trendelenburg position, it may be considered that the patient is not hypoxic. In cases where respiration is compromised such as those where general anesthesia leads to atelectasis as a consequence of the Trendelenburg position compromising lung capacity, practitioners tend to increase oxygen inhalation levels to prevent potential hypoxemia and hypoxia. With the help of ORI monitoring, if ORI values are greater than 0, they can assume that $FiO_2$ values are sufficient. $FiO_2$ can be adjusted based on $PaO_2$ values by checking blood gases in the next step. Although ORI is not an alternative to blood gas measurements, it can reduce the frequency of blood gas measurements. However, the need for an appropriate monitor and probe for ORI monitoring can increase the cost and limit its usage.

The limitations of this study included the fact that our sample size was small, and there were variations in some parameters of the patients such as hemoglobin levels, body temperature, tissue perfusion, age, and BMI Conducting a power analysis in our study constitutes another limitation.There is a need for new studies with a larger number of patients in multicenter settings.

## Conclusion

Although it is not an alternative to blood gas measurements, ORI can be recommended in the prediction of mild hyperoxemia in a safe range in cases that compromise respiration such as the Trendelenburg position. By ORI monitoring, unnecessary $FiO_2$ elevations and hyperoxia development can be prevented to a certain extent. In the future, the use of ORI monitoring in bariatric surgery, robot-assisted surgeries, procedures requiring single-lung ventilation, and other operations performed in the Trendelenburg position could contribute to the identification of more effective and safer treatment methods, enabling the administration of sufficient oxygen without causing hyperoxia.

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**Author contributions**
Conceptualization, HZ.; methodology, HZ.; software, HZ.; validation, HZ.; formal analysis, HZ.; investigation, HZ.; resources, HZ.; data curation, HZ.; writing—original draft preparation, HZ.; writing—review and editing, HZ.; visualization, HZ.; supervi-sion, HZ.; project administration, HZ.; funding acquisition, HZ. Author had read and agreed to the published version of the manuscript.

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**Data availability**
No datasets were generated or analysed during the current study.

## Declarations

### Ethics approval and consent to participate
Consent has been obtained from the Ethics Committee of Gülhane Training and Research Hospital, Health Sciences University.(Decision date: 28.06.2024, decision number: 390). Informed consent was obtained from all participants involved in the study.

### Consent for publication
Not applicable.

### Competing interests
The authors declare no competing interests.

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### References
1. Esperto F, Cacciatore L, Tedesco F, Testa A, Callè P, Ragusa A, et al. Impact of Robotic technologies on prostate Cancer patients' choice for Radical Treatment. J Pers Med. 2023;13(5):794. https://doi.org/10.3390/jpm13050794
2. Gandi C, Marino F, Totaro A, Scarciglia E, Presutti S, Bellavia F, et al. Hugo™ Versus daVinci™ Robot-assisted radical prostatectomy: 1-Year propensity score-matched comparison of functional and oncological outcomes. J Clin Med. 2024;13(22):6910. https://doi.org/10.3390/jcm13226910
3. Civitella A, Prata F, Papalia R, Citriniti V, Tuzzolo P, Pascarella G, et al. Laparoscopic versus Ultrasound-guided Transversus Abdominis Plane Block for postoperative Analgesia Management after Radical Prostatectomy: results from a single Center Study. J Pers Med. 2023;13(12):1634. https://doi.org/10.3390/jpm13121634
4. Anceschi U, Morelli M, Flammia RS, Brassetti A, Dell'Oglio P, Galfano A, et al. Predictors of trainees' proficiency during the learning curve of robot-assisted radical prostatectomy at high- -volume institutions: results from a multicentric series. Cent Eur J Urol. 2023;76(1):38–43. https://doi.org/10.5173/ceju.2023.260
5. Mian AH, Tollefson MK, Shah P, Sharma V, Mian A, Thompson RH, et al. Navigating now and next: recent advances and Future Horizons in Robotic Radical Prostatectomy. J Clin Med. 2024;13(2):359.
6. Coughlin GD, Yaxley JW, Chambers SK, Occhipinti S, Samaratunga H, Zajdlewicz L, et al. Robot-assisted laparoscopic prostatectomy versus open radical retropubic prostatectomy: 24-month outcomes from a randomised controlled study. Lancet Oncol. 2018;19(8):1051–60.
7. Ragusa A, Brassetti A, Prata F, Iannuzzi A, Callè P, Tedesco F, et al. Predictors of urinary continence recovery after laparoscopic-assisted radical prostatectomy: is Surgical urethral length the only key factor? Life (Basel). 2023;13(7):1550. https://doi.org/10.3390/life13071550
8. Nahas WC, Rodrigues GJ, Rodrigues Gonçalves FA, Sawczyn GV, Barros GG, Cardili L, et al. Perioperative, Oncological, and functional outcomes between Robot-assisted laparoscopic prostatectomy and open Radical Retropubic Prostatectomy: a Randomized Clinical Trial. J Urol. 2024;212(1):32–40.
9. Gainsburg DM. Anesthetic concerns for robotic-assisted laparoscopic radical prostatectomy. Minerva Anestesiol. 2012;78(5):596–604.
10. Hafiani H, Choubhi M, Ameur A, Bensghir M, Abouelalaa K. Anesthetic considerations in robotic surgery: a comprehensive review. J Robot Surg. 2024;18(1):220. https://doi.org/10.1007/s11701-024-01974-y.
11. Hong JY, Oh YJ, Rha KH, Park WS, Kim YS, Kil HK. Pulmonary edema after Da Vinci-assisted laparoscopic radical prostatectomy: a case report. J Clin Anesth. 2010;22(5):370–2.
12. Kalmar AF, Foubert L, Hendrickx JF, et al. Influence of steep Trendelenburg position and CO(2) pneumoperitoneum on cardiovascular, cerebrovascular, and respiratory homeostasis during robotic prostatectomy. Br J Anaesth. 2010;104(4):433–9.
13. Pandey R, Garg R, Roy K, Darlong V, Punj J, Kumar A. Perianesthetic management of the first robotic partial cystectomy in bladder pheochromocytoma. A case report. Minerva Anestesiol. 2010;76(4):294–7.
14. Fan Q, Chen M, Fang X, Bond Lau W, Xue L, Zhao L, Zhang H, et al. Aging might augment reactive oxygen species (ROS) formation and affect reactive nitrogen species (RNS) level after myocardial ischemia/reperfusion in both humans and rats. Age (Dordr). 2013;35:1017–26.
15. Fan Q, Chen L, Cheng S, Fang L, Lau WB, Wang LF et al. Aging aggravates nitrate mediated ROS/RNS changes. Oxid Med Cell Longev. 2014; 2014:376515. [PMC free article] [PubMed] [Google Scholar].
16. Kallet RH, Matthay MA. Hyperoxic acute lung injury. Respir Care. 2013;58:123–41.
17. Suzuki S, Eastwood GM, Peck L, Glassford NJ, Bellomo R. Current oxygen management in mechanically ventilated patients: a prospective observational cohort study. J Crit Care. 2013;28:647–54.
18. Meyhoff CS, Staehr AK, Rasmussen LS. Rational use of oxygen in medical disease and anesthesia. Curr Opin Anaesthesiol. 2012;25(3):363–70. https://doi.org/10.1097/ACO.0b013e328352b402
19. Scheeren TWL, Belda FJ, Perel A. The oxygen reserve index (ORI): a new tool to monitor oxygen therapy. J Clin Monit Comput. 2018;32(3):379–89.
20. Yoshida K, Isosu T, Noji Y, Hasegawa M, Iseki Y, Oishi R, et al. Usefulness of oxygen reserve index (ORi™), a new parameter of oxygenation reserve potential, for rapid sequence induction of general anesthesia. J Clin Monit Comput. 2018;32:687–91.
21. Ishida Y, Nakazawa K, Okada T, Tsuzuki Y, Kobayashi T, Yamada R, et al. Anesthetic management of a morbidly obese patient with endometrial cancer during robot-assisted laparoscopic surgery. JA Clin Rep. 2021;7(1):30.
22. Campos JH, Sharma A. Predictors of Hypoxemia during one-lung ventilation in thoracic surgery: is Oxygen Reserve Index (ORi) the answer? J Cardiothorac Vasc Anesth. 2020;34(2):423–5. https://doi.org/10.1053/j.jvca.2019.08.017
23. Yoshida K, Isosu T, Noji Y, et al. Adjustment of oxygen reserve index (ORi™) to avoid excessive hyperoxia during general anesthesia. J Clin Monit Comput. 2020;34(3):509–14.
24. Tsymbal E, Ayala S, Singh A, Richard L, Applegate RL II, Fleming NW. Study of early warning for desaturation provided by oxygen reserve index in obese patients. J Clin Monit Comput. 2020. https://doi.org/10.1007/s10877-020-00531-w. [DOI] [PMC free article] [PubMed].
25. Applegate RL 2nd, Dorotta IL, Wells B, Juma D, Applegate PM. The relationship between oxygen reserve index and arterial partial pressure of oxygen during surgery. Anesth Analg. 2016;123:626–33.
26. Koishi W, Kumagai M, Ogawa S, Hongo S, Suzuki K. Monitoring the oxygen reserve index can contribute to the early detection of deterioration in blood oxygenation during one-lung ventilation. Minerva Anestesiol. 2018;84:1063–9.
27. Collins JA, Rudenski A, Gibson J, Howard L, O'Driscoll R. Relating oxygen partial pressure, saturation and content: the haemoglobin-oxygen dissociation curve. Breathe (Sheff). 2015;11(3):194–201.

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