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Original Article

Role of Oxygenation Saturation Index as a Predictor of Clinical Outcome of Acute Respiratory Distress Syndrome Patients in ICU

Md. Touhidul Islam[1], Mirza Nahiduzzaman[2], Suman Kundu[3], Shubamay Deb Nath[4], Manas Kanti Mazumder[5], Rajeebshankar Karmakar[6]

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Abstract:

Background: *Acute respiratory distress syndrome (ARDS) continues to pose major prognostic challenges, with high mortality rates and traditional oxygenation indices limited by their reliance on invasive arterial blood gas measurements. Growing evidence supporting noninvasive markers such as the ratio of oxygen saturation in pulse oximetry and fraction of inspired oxygen (SpO_2/FiO_2) and oxygen saturation index (OSI) prompted this study to explore OSI as a safer, practical predictor of clinical outcomes in critically ill ARDS patients.*

Methods: *This prospective observational study enrolled 150 adult ARDS patients at Dhaka Medical College Hospital, following strict Berlin diagnostic criteria and PEEP-supported ventilation. After obtaining ethical approval and informed consent, detailed demographic, clinical, and comorbidity data were collected at admission. Daily monitoring during the first four ICU days included hemodynamics, ventilator settings, ABG analysis, and calculation of APACHE II, Oxygenation Index (OI) and Oxygenation Saturation Index (OSI) values. Key outcomes, ventilation duration, length of ICU stay, multiorgan failure, and hospital mortality, were recorded to evaluate the predictive performance of oxygenation indices.*

Result: *Most of the study population were in older age groups, with males comprising 64% and occupations spanning service, business, day labour, and household roles. Hypertension (48%), smoking (40%), diabetes (32%), and obesity (20%) were the major risk factors, while severe traumatic injury (48%) and sepsis-related causes dominated the etiological profile. In-hospital mortality was 36%, and patients experienced prolonged ventilation, ICU stay, and hospitalization. Multiple variables, including age ($p<0.001$), APACHE II score ($p<0.001$), oxygenation indices (OI $p=0.001$; OSI $p<0.001$), MAP ($p=0.001$), and oxygenation ratios (SpO_2/FiO_2 $p=0.009$; PaO_2/FiO_2 $p=0.015$), were significantly associated with ICU mortality. OSI demonstrated strong positive correlations with OI, APACHE II score, ventilation duration, and ICU stay, while SpO2/FiO2 closely correlated with PaO_2/FiO_2. In ROC analysis, OSI (AUC 0.645, $p=0.003$) and OI (AUC 0.641, $p=0.004$) outperformed traditional oxygenation ratios, while APACHE II (AUC 0.847, $p<0.001$) remained the strongest predictor of hospital mortality.*

Conclusion: *This study demonstrates that OSI closely mirrors illness severity and reliably predicts mortality in ARDS, performing on par with or better than conventional oxygenation indices. Its strong correlations and noninvasive nature position OSI as a practical bedside tool for early risk stratification, especially in settings where frequent arterial blood gas analysis is challenging.*

Key words: *ARDS, fraction of inspired oxygen, ICU, Oxygen saturation in pulse oximetry, Oxygen saturation index.*

Introduction

Acute respiratory distress syndrome (ARDS) remains a critical cause of hypoxemic respiratory failure marked by stiff, noncompliant lungs, where survival without mechanical ventilation is unlikely[1]. Earlier defined by the AECC criteria[2], ARDS was later refined by the Berlin Definition, which stratified disease severity using partial pressure of arterial oxygen to fraction of inspired oxygen ratio (PaO_2/FiO_2) thresholds and mandatory PEEP settings[3]. Despite five decades of research, global data continue to show unacceptably high mortality, rising from 34.9% in mild to 46.1% in severe ARDS, showing persistent prognostic challenges[4]. Traditional indices such as PaO_2/FiO_2 and the Lung Injury Score provide limited predictive value and require arterial blood gas (ABG) sampling, a constraint amplified in resource-limited settings and by the growing shift away from routine arterial line use[5, 6]. Noninvasive substitutes such as the SpO_2/FiO_2 ratio have shown strong correlation with PF ratios[6-7], and emerging evidence suggests that the Oxygenation Saturation Index (OSI), which integrates SpO_2/FiO_2 with mean airway pressure, may predict mortality and ventilator outcomes comparably to the invasive Oxygenation Index[5,8]. Concerns persist regarding the accuracy of pulse oximetry in states of hypoperfusion, anemia, or vasopressor use[8]. Given that invasive measures such as PaO_2/FiO_2 and OI depend on repeated ABG analysis, exposing patients to risks of vascular injury, infection, thrombosis, and increased cost[9], a reliable, noninvasive bedside marker is urgently needed. This study was undertaken to evaluate OSI as a predictor of key clinical outcomes in ARDS, providing a safer and more practical alternative to invasive oxygenation assessment in critically ill patients.

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Materials and Methods

The study followed a prospective observational design and was carried out in the ICU of the Department of Anaesthesia, Analgesia, Palliative & Intensive Care Medicine at Dhaka Medical College Hospital (DMCH) from September 2017 to February 2020. Using purposive sampling, a total of 150 adult patients diagnosed with ARDS according to the Berlin criteria and supported with PEEP ventilation were enrolled, provided they met the inclusion criteria and none of the extensive exclusion criteria applied. Ethical approval was taken from the Ethical Review Committee (ERC) of DMCH, and informed written consent was also taken from patients or their guardians before participation. At enrollment, demographic characteristics, medical history, comorbidities, and admission diagnoses were documented. Daily clinical data, including hemodynamic parameters, ventilator settings, and arterial blood gas analysis, were collected during the first four ICU days to compute APACHE II scores and record PaO_2/FiO_2 and SpO_2/FiO_2 ratios. Oxygenation Index (OI) and Oxygenation Saturation Index (OSI) were calculated using standardized formulas, while outcomes such as ventilation duration, ICU stay, multiorgan failure, and hospital mortality were tracked systematically.

The study examined the predictive and correlative performance of OSI in relation to PaO_2/FiO_2, SpO_2/FiO_2, OI, APACHE II score, and MAP. Cutoff values for OI, OSI, and oxygenation ratios were determined, and continuous variables were summarized using means, standard deviations, or medians; categorical variables were presented as frequencies and percentages. Associations were analyzed using Student's t-test and Pearson's chi-square test, while ROC curve analysis evaluated the predictive accuracy of severity indices and identified optimal OSI thresholds. Statistical processing was performed using SPSS version 22.0, with significance set at $p < 0.05$, ensuring a rigorous and methodologically sound evaluation of OSI as an outcome predictor in ARDS.

1. Assistant Professor, Critical Care Medicine, Rangpur Medical College, Rangpur, Bangladesh
2. Assistant Professor, Critical Care Medicine, Department of Anesthesia, Analgesia and Intensive Care, National Gastroliver Institute and Hospital, Dhaka, Bangladesh
3. Intensivist, Department of Critical Care Medicine, Kuwait Bangladesh Friendship General Hospital, Dhaka, Bangladesh
4. Consultant, ICU, Chattogram Maa o Shishu Hospital and Medical College, Chattogram, Bangladesh
5. Assistant Professor, Critical Care Medicine, Department of Anesthesia, Analgesia and Intensive care, Bangladesh Medical University, Dhaka, Bangladesh
6. Resident Surgeon, Faridpur Medical College and Hospital, Faridpur, Bangladesh

Corresponding Author:

Md. Touhidul Islam
MD (Critical Care Medicine)
Assistant Professor, Critical Care Medicine Rangpur Medical College
Rangpur, Bangladesh
Email: drtouhiddolar@gmail.com

Ethical Considerations: Ethical clearance for the study was obtained from the Academic and Institutional Review Board (IRB) of the Dhaka Medical College Hospital (DMCH), and necessary permissions were also secured from the relevant departments of the institute. Written informed consent was obtained from either the patient or their legal guardian through a transparent and respectful process that clearly outlined the potential benefits and risks associated with the procedure. Confidentiality was strictly maintained, and no data were disclosed without the explicit permission of the respondents. No force was applied, and interviews were conducted only with those who willingly agreed to participate.

Result

The study population reflected a wide clinical and demographic spectrum, as illustrated in Figure 1, where patients clustered predominantly in middle and older age groups. Sex distribution (Figure 2) showed a clear male predominance, while occupational patterns (Figure 3) revealed representation from diverse socioeconomic backgrounds. Risk factors such as hypertension, diabetes, obesity, and smoking (Table I) were frequently encountered, painting a clinical picture of patients with substantial comorbidity burdens. The etiological pattern of ARDS (Table II) was dominated by severe traumatic injury alongside sepsis, pneumonia, and aspiration events, highlighting the varied pathways through which patients progressed to critical illness. Clinical characteristics at admission (Table III) suggested significant physiological derangements, and the hospital course (Table IV) demonstrated prolonged ventilation, extended ICU stay, and variable recovery trajectories. In-hospital mortality (Table V) remained considerable, highlighting the severity of disease and the need for reliable markers that can aid early prognostication and guide decisions throughout the ICU stay.

Across the analytical framework of the study, several physiological and clinical markers demonstrated meaningful associations with patient outcomes. Multiple variables, including age, illness severity, oxygenation indices, and hemodynamic parameters, showed significant discriminatory value for predicting ICU mortality, as outlined in Table VI. OSI, in particular, emerged as a strong marker of adverse outcomes, including development of multiorgan failure (Table VII). Strong linear relationships were evident between OI and OSI (Figure 4), between OSI and APACHE II score (Figure 5), and between OSI and outcomes such as ventilation duration (Figure 6) and ICU stay (Figure 7), confirming the physiological coherence of OSI as an integrative marker of both oxygenation and mechanical ventilatory burden. The close relationship between SpO_2/FiO_2 and PaO_2/FiO_2 ratios (Figure 8) further supported the utility of noninvasive indices in ARDS monitoring. The ROC analysis (Figure 9, & table VIII) demonstrated that among bedside markers, OSI performed comparably to OI and at times outperformed conventional oxygenation ratios in predicting hospital mortality, strengthening its promise as a practical, noninvasive prognostic tool for critically ill ARDS patients.

Table I: Distribution of Respondents according to Risk Factors (N=150)

Risk Factors	Frequency	Percent (%)
HTN	72	48%
Smoking	60	40%
DM	48	32%
Obesity	30	20%

Table II: Distribution of Respondents according to Etiology of ARDS (N=150)

Etiology	Frequency	Percent (%)
Severe traumatic injury	72	48%
Non-pulmonary sepsis	30	20%
Pneumonia	21	14%
Aspiration	18	12%
Others	6	4%
Multiple transfusion	3	2%

Table III: Distribution of Respondents according to Clinical Characteristics (N=150)

Clinical Characteristics	Mean±SD	Range
APACHE II score	25.58 ± 4.68	17-39
Lowest S_pO_2/F_iO_2 ratio	159.76 ± 35.57	94-234
Lowest P_aO_2/F_iO_2 ratio	148.66 ± 32.77	89-209
Mean Airway Pressure (MAP), in mmHg	18.46 ± 2.45	12-23
Oxygenation index (OI)	13.38 ± 4.67	6-26
Oxygen Saturation Index (OSI)	12.46 ± 4.54	6-25

Table IV: Distribution of Respondents according to Hospital Outcomes (N=150)

Hospital outcome (in days)	Mean±SD	Range
Ventilation duration	6.30 ± 1.97	2-12
ICU stay	8.16 ± 2.22	4-15
Hospital stay	12.16 ± 3.93	4-21
Ventilation free days	6.93 ± 2.87	2-13

Table V: Distribution of Respondents according to In-hospital Mortality (N=150)

In-hospital Mortality	Frequency	Percent (%)
Survived	96	64%
Expired	54	36%

Table VI: Variables and their association for Predicting ICU Mortality of ARDS patients (N=150)

Variables		Survived (n=96) No. (%)	Expired (n=54) No. (%)	OR	(95% CI)	P value
Age (In years)		44.97±12.03	54.44±10.78	1.074	(1.04 to 1.11)	<0.001
Sex	Male (ref: female)	63 (65.63%)	33 (61.11%)	0.823	(0.41 to 1.64)	0.581
	Female (ref: male)	33 (34.37%)	21 (38.89%)	1.215	(0.609 to 2.423)	0.581
APACHE II score		23.56 ± 3.55	29.17 ± 4.31	1.45	(1.28 to 1.64)	<0.001
Lowest S_pO_2/F_iO_2 ratio		165.56 ± 31.23	149.44 ± 40.49	0.987	(0.977 to 0.997)	0.009
Lowest P_aO_2/F_iO_2 ratio		153.63 ± 30.94	139.83 ± 34.35	0.987	(0.976 to 0.997)	0.015
MAP in mmHg		17.94 ± 2.46	19.39 ± 2.16	1.32	(1.12 to.55)	0.001
Oxygenation index (OI)		12.38 ± 3.93	15.17 ± 5.33	1.141	(1.06 to 1.23)	0.001
Oxygen Saturation Index (OSI)		11.41 ± 3.47	14.33 ± 5.55	1.16	(1.07 to 1.26)	<0.001

Table VII: Association of OSI in predicting Development of Multi-Organ Failure (MOF) among ARDS patients (N=150)

	MOF developed (n=34)	MOF not developed (n=116)	OR (95% CI)	P value
OSI	15±5.23	11.72±4.05	1.17 (1.07 to 1.27)	<0.001

Table VIII: Receiver Operator Curve showing Performance of Clinical Marker in Predicting Hospital Mortality (N=150)

	AUC	Cut-Off value	Sensitivity	Specificity	95% CI		P value
					Lower	Upper	
APACHE II score	.847	25.5	77.8%	75%	.787	.908	<0.001
SpO2/FiO2 ratio	.372	159	44.4%	46.9%	.272	.471	.009
PaO2/FiO2 ratio	.383	147.5	44.4%	46.9%	.286	.479	.017
OI	.641	11.5	66.7%	50%	.546	.737	.004
OSI	.645	10.5	72.2%	50%	.546	.744	.003

Figure 1: Distribution of Respondents according to Age

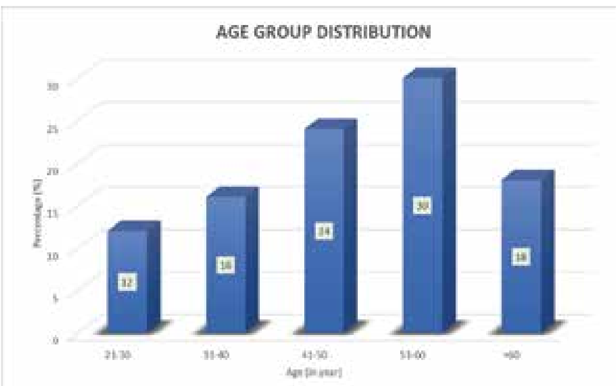


Figure 2: Distribution of Respondents according to Sex

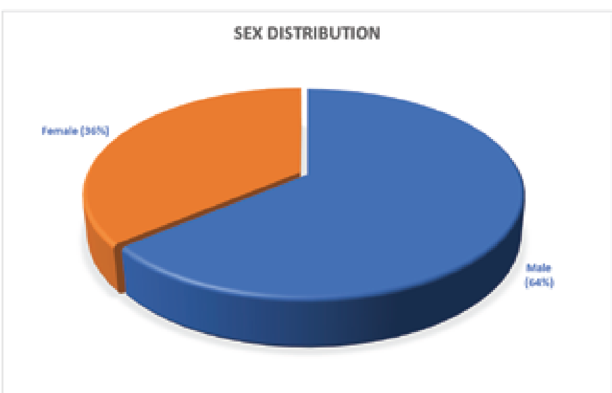


Figure 3: Distribution of Respondents according to Occupation

Figure 4: Correlation between OI and OSI among patients

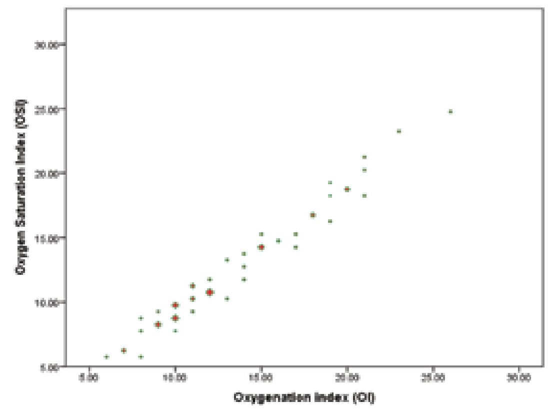


Figure 5: Correlation between APACHE II score and OSI among patients

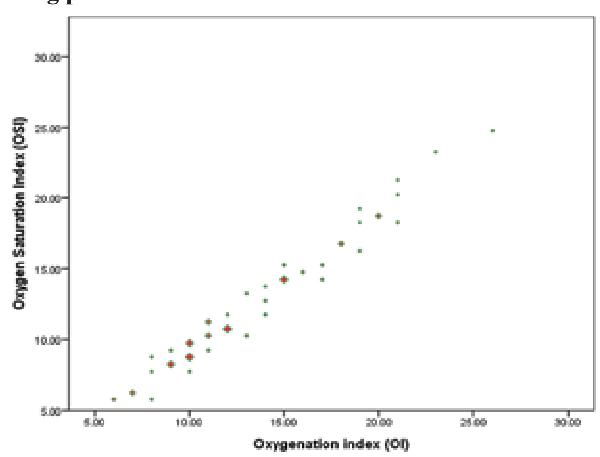


Figure 6: Correlation between OSI and Ventilation duration among patients

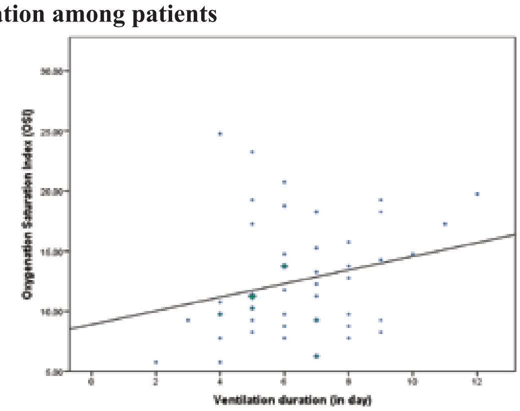


Figure 7: Correlation between OSI and ICU stay among patient

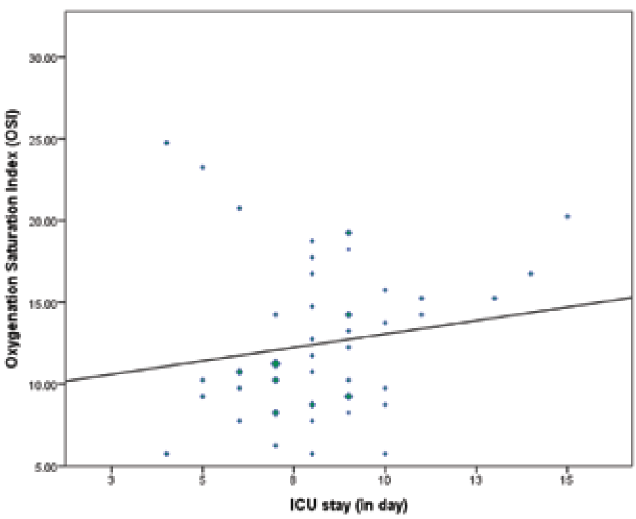


Figure 8: Correlation between lowest SpO2/FiO2 and PaO2/FiO2 ratio among patients

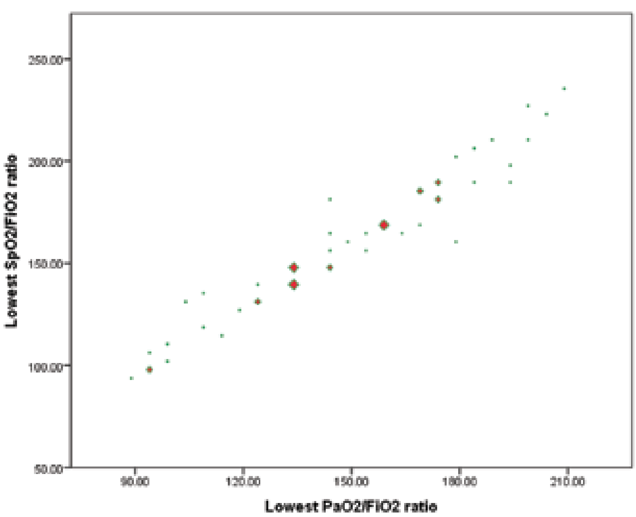
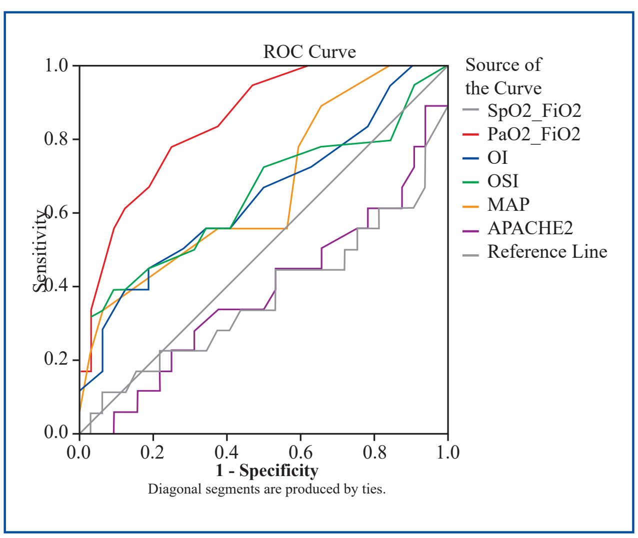


Figure 9:



Discussion

The oxygenation index (OI) has long served as a central metric for evaluating hypoxic respiratory failure and ARDS severity, largely because it incorporates mean airway pressure (MAP). Our study reflected a demographic pattern consistent with previous ARDS cohort studies, middle-aged predominance, male majority, and similar epidemiological features, as described in landmark and contemporary investigations[10-13]. Etiologically, traumatic injury constituted nearly half of all cases, closely paralleling findings by a study[5], although other studies have highlighted pneumonia as the leading cause[8,14].

Hospital mortality in this cohort reached 36%, and OSI displayed a strong and statistically significant association with death, with rising OSI values corresponding to increased mortality risk ($p<0.05$). OSI outperformed lowest PaO_2/FiO_2 and SpO_2/FiO_2 ratios and demonstrated prognostic strength comparable to OI. Univariate analysis confirmed significant associations of mortality with age, APACHE II score, oxygenation indices, MAP, and oxygenation ratios (all $p<0.001$), while OSI showed a higher odds ratio for mortality prediction than OI or the conventional oxygenation ratios. These findings aligned closely with prior studies in which OSI independently predicted mortality with comparable or superior AUC values[5,8]. Strong correlations emerged between lowest SpO_2/FiO_2 and PaO_2/FiO_2 ($r>0.96$) and between OSI and OI ($r>0.98$), corroborating previous physiological observations that noninvasive oxygenation measures mirror ABG-based indices[6,15]. OSI also correlated positively, though modestly, with ventilation duration and ICU stay, and strongly with APACHE II scores, demonstrating coherence with overall illness severity. ROC analysis further confirmed that OSI (AUC 0.645, $p=0.003$) provided superior mortality prediction compared to OI, SpO_2/FiO_2, and PaO_2/FiO_2, while APACHE II remained the strongest overall predictor. These findings reinforce previous evidence supporting SpO_2-based metrics as feasible surrogates for invasive oxygenation measurements, with advantages in patient comfort, reduced procedural risks, and applicability in resource-limited settings[16-17].

Although OSI offers clear clinical advantages, its limitations must be acknowledged, particularly in conditions that impair pulse oximetry accuracy, such as methemoglobinemia, poor perfusion, shock states, or motion artifacts[18]. By excluding measurements with $SpO_2 \geq 97\%$, this study minimized inaccuracies associated with the flat portion of the oxyhemoglobin dissociation curve, in line with established ICU oxygenation practices[16]. The study demonstrates that OSI is significantly associated with mortality, correlates strongly with established severity markers, and may serve as a useful, noninvasive prognostic indicator in adult ARDS patients.

Limitations

This study was limited by its single-center design and purposive sampling, which may restrict the generalizability of the findings beyond similar ICU settings. The reliance on pulse oximetry introduces potential measurement bias in conditions affecting perfusion or hemoglobin function. The observational nature of the study limits causal inference, leaving room for unmeasured confounders that could influence both severity markers and outcomes.

Conclusion

This study highlights that the Oxygen Saturation Index (OSI) is strongly associated with illness severity and mortality among adults with ARDS, performing comparably to and often better than traditional oxygenation indices. Its close correlation with OI, APACHE II scores, oxygenation ratios, and key clinical outcomes highlights its physiological coherence and practical value at the bedside. By reducing dependence on arterial blood gas analysis, OSI offers a safer, more accessible alternative for continuous monitoring, particularly in resource-limited settings. OSI emerges as a promising prognostic tool that can enhance early risk stratification and guide clinical decision-making in critically ill ARDS patients.

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