ORIGINAL ARTICLE

HYPEROXEMIA IN POTENTIALLY CRITICALLY ILL ELDERLY PATIENTS TREATED IN HOSPITAL WARDS: A RETROSPECTIVE STUDY

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Abstract

Introduction: Hyperoxemia is associated with poor outcomes; however, its incidence and risk factors in elderly patients remain unclear.

Materials and Method: This retrospective study aimed to identify the incidence of hyperoxemia in potentially critically ill elderly patients treated in wards at an academic tertiary hospital. Elderly patients managed in wards between April 1, 2024, and January 31, 2025, were included. Patients were categorized into two groups: hyperoxemia (partial pressure of oxygen [PaO2] ≥ 120 mmHg) and normoxemia (60 mmHg ≤ PaO_2 < 120 mmHg). Statistical analyses were conducted using the Chi-square, Fisher's exact, and Mann–Whitney U tests. Independent risk factors for hyperoxemia were identified through regression analysis. A two-tailed p-value <0.05 was considered statistically significant.

Results: A total of 276 elderly patients were included. The incidence of hyperoxemia was 52.2%. Patients with hyperoxemia required intensive care unit admission more frequently and exhibited higher in-hospital and 28-day mortality rates compared to patients with normoxemia. Lymphocyte count ≤ 0.8 × 10^3/μL (odds ratio [OR], 2.17; 95% confidence interval [CI], 1.27–3.72; *p*=0.005), atelectasis (OR, 2.03; 95% CI, 1.13–3.67; *p*=0.019), fraction of inspired oxygen ≥ 40% (OR, 2.10; 95% CI, 1.11–3.95; *p*=0.022), and type IV respiratory failure (OR, 2.34; 95% CI, 1.09–5.06; *p*=0.030) were identified as independent risk factors for hyperoxemia.

Conclusions: Elderly patients receiving supplemental oxygen therapy are susceptible to hyperoxemia, even when treated in general wards. Further research is warranted to develop preventive strategies for hyperoxemia in this population.

Keywords: Critical Illness; Critical Care; Aged; Hyperoxia; Respiratory Therapy.

INTRODUCTION

The administration of supplemental oxygen is a common therapeutic intervention in the management of critically ill patients (1). However, inappropriate use can lead to hyperoxemia, which is associated with poor outcomes and inefficient use of healthcare resources (2). Meanwhile, projections indicate that the proportion of the global population aged 60 years and older will exceed 20% by the year 2050 (3). Consequently, the number of elderly patients requiring critical care and the administration of supplemental oxygen therapy to this population is expected to increase over time.

Hyperoxemia has been shown to induce the production of reactive oxygen intermediates, which can overwhelm antioxidant defenses, leading to cellular damage or death (4). The administration of high concentrations of oxygen has also been demonstrated to increase the right-to-left shunt fraction, raise the dead space to tidal volume ratio, and decrease both lung compliance and diffusing capacity (5,6). Over the long term, hyperoxemia may result in interstitial fibrosis, capillary proliferation, epithelial hyperplasia, and diffuse alveolar damage (7,8). Furthermore, hyperoxemia has been associated with coronary vasoconstriction and decreased cardiac output (9), as well as an elevated risk of generalized tonic-clonic seizures (10). A previous study involving nonoperative patients in wards identified admission status, chronic kidney disease, and age as risk factors for hyperoxemia, whereas admission time, sequential organ failure assessment (SOFA) score, and reason for admission were associated with a lower risk (11). Existing literature has documented the impact of hyperoxemia on patient outcomes, particularly in critical care settings (2,12,13) and among operative patients (14–16). However, data are lacking on the effects of hyperoxemia on outcomes among potentially critically ill elderly patients receiving treatment in general wards.

Therefore, the present study was designed to determine the incidence of hyperoxemia and to identify factors associated with hyperoxemia among elderly patients treated in hospital wards who were considered potentially critically ill. Additionally, the study aimed to evaluate the effect of hyperoxemia on patient outcomes.

MATERIALS AND METHOD

Study design, setting, and selection of participants

This retrospective cohort study was conducted at Şişli Hamidiye Etfal Training and Research Hospital following approval by the local ethics committee (date: 02/25/2025, IRB number: 2918, document number: 4763). The study population consisted of elderly patients (aged 65 years or older) who were evaluated by an intensivist, at the request of their attending physician, to determine the need for critical care treatment between April 1, 2024, and January 31, 2025, while receiving care in hospital wards. In wards, the decision to initiate supplemental oxygen therapy and adjust oxygen levels was contingent upon the clinical methodologies employed by each ward. The patients were grouped as follows: hypoxemic, normoxemic, and hyperoxemic, according to the level of partial pressure of oxygen (PaO_2) in arterial blood gas analysis performed on the day of intensivist consultation. Hypoxemia was defined as a $PaO_2 < 60$ mmHg, normoxemia as 60 mmHg $\leq PaO_2 < 120$ mmHg, and hyperoxemia as $PaO_2 \geq 120$ mmHg. Patients under the age of 65, those admitted to the emergency department or secondary-level intensive care units, patients transferred to an external center, patients with hypoxemia, and those with a hospital stay of less than one day were excluded. The study was conducted in accordance with the ethical standards outlined in the Declaration of Helsinki (17). The requirement for written informed consent was waived due to the retrospective nature of the study.

Variables

Data were collected from each patient's paper charts and electronic medical records. Patient characteristics, including demographic data, comorbidities, the presence of chronic respiratory failure requiring respiratory support, and prognostic scores such as the Glasgow Coma Scale (GCS), Charlson Comorbidity Index (CCI), Acute Physiology and Chronic Health Evaluation II (APACHE II), and Sequential Organ Failure Assessment (SOFA) scores, were recorded. The dataset also included information on the presence, type, and underlying cause of respiratory failure; the type of respiratory support provided in the ward, along with the fraction of inspired oxygen (FiO_2) level; and laboratory data. In addition, hospitalization characteristics—such as the reasons for hospital admission, the ward where patients were staying, length of hospital stay, and the need for treatment in critical care settings—were documented. Outcomes included in-hospital mortality and 28-day mortality rates following admission.

Outcomes

The primary outcome of this study was to determine the incidence of hyperoxemia among elderly patients who were considered potentially critically ill and receiving treatment in hospital wards. Secondary outcomes included identifying independent factors associated with hyperoxemia and assessing the impact of hyperoxemia on patient outcomes, such as length of hospital stay, need for critical care admission, in-hospital mortality, and 28-day mortality.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics software (Version 29.0.1.0; Armonk, New York, IBM Corporation, USA). Categorical variables were presented as numbers and percentages, while continuous variables were expressed as medians and interquartile ranges, and/or mean ± standard deviation. The distribution of the continuous variables was analyzed by using Kolmogorov-Smirnov and Shapiro-Wilk tests. To compare continuous and categorical variables in the univariate analysis, the Mann–Whitney U test or t-test and the Chi-square or Fisher's exact tests were used, respectively. Binary logistic regression analysis was conducted to identify independent factors associated with hyperoxemia among potentially critically ill elderly patients treated in hospital wards. A model was constructed using the enter method in logistic regression analysis, incorporating variables related to hyperoxemia that could influence the results. For each independent factor, the analysis provided an adjusted odds ratio (OR) along with a 95% confidence interval (CI). A two-tailed *p*-value of less than 0.05 was considered statistically significant.

RESULTS

Patient characteristics

Initially, a total of 4524 consultations were screened. In the first step, 415 elderly patients were identified for analysis after excluding 2469 consultations from the emergency department, 879 consultations for patients under 65 years of age, 391 duplicate consultations, and 370 consultations from secondary-level intensive care units. Among the remaining patients, 123 were excluded due to transfer to an external center. An additional 14 patients were excluded due to hypoxemia (PaO_2 < 60 mmHg), and 2 patients were excluded because their hospital stay was shorter than one day. The final cohort consisted of 276 patients, of whom 144 (52.2%) exhibited hyperoxemia during their treatment in the wards.

The patient characteristics are summarized in Table 1. The mean and median age of the patients was 78 ± 9 and 77 (71–84) years, respectively, and 51.1% of them were male. Most patients (39.9%) were classified as younger elderly (65–74 years), while 37.3% were older elderly (75–84 years), and 22.8% were classified as oldest elderly (≥85 years). The median CCI was 7 (5–9), and the median GCS

Table 1. Patient Characteristics

Characteristics	All (n = 276)	Hyperoxemia (n = 144)	Normoxemia (n = 132)	*P* value
Age	77 (71–84)	77 (70–84)	77 (71–84)	0.96
	78 ±9	78 ± 9	78 ± 9	0.97
Younger elderly (65–74 years)	110 (39.9)	56 (38.9)	54 (40.9)	0.81
Older elderly (75–84 years)	103 (37.3)	54 (37.5)	49 (37.1)	1.00
Oldest elderly (≥85 years)	63 (22.8)	34 (23.6)	29 (22.0)	0.78
Sex, men	141 (51.1)	66 (45.8)	75 (56.8)	0.07
CCI	7 (5–9)	7 (6–9)	7 (5–9)	0.19
SOFA score*	5 (3–8)	6 (3–9)	4 (3–7)	**0.018**
APACHE II*	19 (13–26)	22 (15–29)	17 (12–23)	**<0.001**
GCS*	14 (10–15)	13 (9–15)	14 (10–15)	**0.035**
Comorbidity	259 (93.8)	136 (94.4)	123 (93.2)	0.80
Hypertension	173 (62.7)	98 (68.1)	75 (56.8)	0.06
Diabetes mellitus	120 (43.5)	71 (49.3)	49 (37.1)	0.05
Malignancy	94 (34.1)	47 (32.6)	47 (35.6)	0.61
Solid organ malignancy	91 (33.0)	45 (31.3)	46 (34.8)	0.61
Hematological malignancy	3 (1.1)	2 (1.4)	1 (0.8)	1.00
Coroner artery disease	87 (31.5)	51 (35.4)	36 (27.3)	0.16
Chronic kidney disease	75 (27.2)	46 (31.9)	29 (22.0)	0.08
Congestive heart failure	65 (23.6)	39 (27.1)	26 (19.7)	0.16
Cerebrovascular disease	52 (18.8)	22 (15.3)	30 (22.7)	0.13
Alzheimer's disease	50 (18.1)	21 (14.6)	29 (22.0)	0.12
COPD	48 (17.4)	26 (18.1)	22 (16.7)	0.87
Chronic liver disease	29 (10.5)	15 (10.4)	14 (10.6)	1.00
History of thromboembolism	5 (1.8)	3 (2.1)	2 (1.5)	1.00
Obesity	4 (1.4)	2 (1.4)	2 (1.5)	1.00
Respiratory support at home				
Home-BIPAP/CPAP	3 (1.1)	2 (1.4)	1 (0.8)	1.00
Oxygen concentrator	9 (3.3)	5 (3.5)	4 (3.0)	1.00
Nebulizer	10 (3.6)	3 (2.1)	7 (5.3)	0.20

The values are expressed as median and interquartile range, and/or mean ± standard deviation for continuous variables, and as numbers and percentages for categorical variables.

Abbreviations: CCI, Charlson comorbidity index; SOFA score, sequential organ failure assessment score; COPD, chronic obstructive pulmonary disease; BIPAP, bilevel positive airway pressure; CPAP, continuous positive airway pressure.

*Calculated on the day of consultation.

score was 14 (10–15). The median SOFA score and Acute Physiology and Chronic Health Evaluation II (APACHE II) score were 5 (3–8) and 19 (13–26), respectively. Univariate analysis revealed that patients with hyperoxemia had significantly higher SOFA and APACHE II scores compared to those with normoxemia. Additionally, the median GCS score was significantly higher in patients with hyperoxemia than in those with normoxemia. Most patients had at least one comorbidity, with the most prevalent being hypertension (67.2%), diabetes mellitus (43.5%), and malignancy (34.1%). The proportion of patients requiring respiratory support at home was notably low.

Respiratory characteristics

The respiratory characteristics of the patients are presented in Table 2. Most patients (87.7%) exhibited respiratory failure. The most frequent type of respiratory failure was hypoxemic (type I), followed by shock-induced (type IV), perioperative (type III), and hypercapnic (type II) respiratory failure. The most common causes of respiratory failure were pneumonia (42.4%), pleural effusion (36.6%), and atelectasis (27.2%). Arterial blood gas analysis revealed a significantly higher rate of hyperoxemia in patients with respiratory failure, particularly among those with type IV respiratory failure, compared to other types. The underlying causes of respiratory failure showed no significant differences in relation to oxygenation status, except for atelectasis, where the proportion of patients with hyperoxemia was significantly higher. Conversely,

Table 2. Respiratory Characteristics of the Patients

Characteristics	All (n=276)	Hyperoxemia (n=144)	Normoxemia (n=132)	*P* value
Presence of respiratory failure	242 (87.7)	132 (91.7)	110 (83.3)	**0.044**
Type I	129 (46.7)	61 (42.4)	68 (51.5)	0.15
Type II	18 (6.5)	11 (7.6)	7 (5.3)	0.47
Type III	32 (11.6)	14 (9.7)	18 (13.6)	0.35
Type IV	63 (22.8)	46 (31.9)	17 (12.9)	**<0.001**
Causes of respiratory failure				
Pneumonia	117 (42.4)	60 (41.7)	57 (43.2)	0.81
Pleural effusion	101 (36.6)	57 (39.6)	44 (33.3)	0.32
Atelectasis	75 (27.2)	49 (34.0)	26 (19.7)	**0.010**
Pulmonary edema	50 (18.1)	31 (21.5)	19 (14.4)	0.16
COPD exacerbation	11 (4.0)	3 (2.1)	8 (6.1)	0.13
Pulmonary aspiration	20 (7.2)	8 (5.6)	12 (9.1)	0.35
Pulmonary embolism	4 (1.4)	1 (0.7)	3 (2.3)	0.35
Pneumothorax	1 (0.4)	1 (0.7)	0 (0.0)	1.00
Interstitial lung disease	2 (0.7)	1 (0.7)	1 (0.8)	1.00
ARDS	2 (0.7)	0 (0.0)	2 (1.5)	0.23
Bronchiectasis	2 (0.7)	1 (0.7)	1 (0.8)	1.00
Type of respiratory support				
No respiratory support	34 (12.3)	0 (0.0)	34 (25.8)	**<0.001**
Conventional oxygen therapy	194 (70.3)	107 (74.3)	87 (65.9)	0.15
Nasal cannula	47 (17.0)	26 (18.1)	21 (15.9)	0.75
Oxygen mask	125 (45.3)	65 (45.1)	60 (45.5)	1.00
Mask with reservoir	22 (8.0)	16 (11.1)	6 (4.5)	**0.048**
IMV[±]	48 (17.4)	37 (25.7)	11 (8.3)	**<0.001**
FiO_2, %	37.0 (29.0–47.0)	40.0 (35.0–50.0)	35.0 (25.0–40.0)	**<0.001**
FiO_2 ≥ 40%	117 (42.4)	79 (54.9)	38 (28.8)	**<0.001**

All values are expressed as median and interquartile range or as number and percentage.

Abbreviations: COPD, chronic obstructive pulmonary disease; ARDS, acute respiratory distress syndrome; IMV, invasive mechanical ventilation; FiO_2, fraction of inspired oxygen.

[*]Performed on the day of consultation.

[±]The patients received invasive mechanical ventilation in wards until they were transferred to an intensive care unit due to the lack of available beds in intensive care units.

patients who were not receiving respiratory support tended to exhibit normoxemia. However, patients receiving supplemental oxygen therapy via mask with reservoir or respiratory support through invasive mechanical ventilation had a significantly higher proportion of hyperoxemia. Additionally, an FiO_2 level of 40% or greater was associated with the occurrence of hyperoxemia.

Laboratory data

The laboratory data of the patients are summarized in Table 3. No statistically significant differences

Table 3. Laboratory Findings of the Patients

Characteristics	All (n=276)	Hyperoxemia (n=144)	Normoxemia (n=132)	*P* value
WBC, × 10^3/μL	11.48 (7.87–16.37)	11.07 (8.14–16.48)	11.77 (7.70–16.29)	0.58
Neutrophil, × 10^3/μL	9.21 (6.17–14.89)	9.19 (6.28–15.27)	9.36 (6.07–14.00)	0.96
Hemoglobin, g/dL	9.3 (8.2–10.7)	9.2 (8.0–10.5)	9.6 (8.3–10.8)	0.18
	9.6 ± 2.2	9.5 ± 2.1	9.7 ± 2.2	0.32
Lymphocyte, × 10^3/μL	0.9 (0.6–1.36)	0.8 (0.5–1.2)	1.05 (0.66–1.56)	**0.002**
Lymphocyte ≤ 0.8 × 10^3/μL	121 (43.8)	75 (52.1)	46 (34.8)	**0.005**
Platelet, × 10^3/μL	205.0 (132.3–285.0)	193.5 (114.5–271.0)	237.0 (142.0–306.0)	**0.002**
	215.2 ± 115.1	193.6 ± 107.3	238.9 ± 119.0	**0.001**
HS Troponin I, ng/L	42.0 (16.3–136.3)	49.0 (19.1–245.9)	32.2 (13.3–93.6)	0.05
BUN, mg/dL	35.7 (22.1–57.9)	41.1 (23.8–65.8)	31.5 (19.7–49.8)	**0.003**
Creatinine, mg/dL	1.36 (0.82–2.40)	1.66 (0.98–2.90)	1.20 (0.71–1.92)	**<0.001**
Total Bilirubin, mg/dL	0.85 (0.51–1.44)	0.90 (0.50–1.86)	0.83 (0.55–1.39)	0.66
AST, U/L	32 (21–78)	33 (21–103)	31 (20–65)	0.48
ALT, U/L	21 (10–45)	21 (10–55)	23 (11–40)	0.77
CRP, mg/L	120.0 (58.0–187.8)	111.5 (61.0–194.5)	125.0 (50.2–182.7)	0.63
Procalcitonin, ng/mL	0.38 (0.16–2.63)	0.30 (0.16–2.45)	0.50 (0.16–2.74)	0.29
Blood gas analysis				
pH	7.42 (7.33–7.48)	7.39 (7.30–7.47)	7.45 (7.38–7.49)	**0.001**
PCO_2, mmHg	34.0 (28.0–40.3)	33.6 (27.3–40.8)	35.0 (29.6–39.9)	0.29
PaO_2, mmHg	122.0 (85.1–162.8)	160.0 (138.0–190.6)	84.5 (71.7–100.0)	<0.001
HCO_3, mEq/L	22.0 (17.0–26.0)	21.0 (15.4–25.5)	23.1 (18.5–26.9)	0.013
	21.7 ± 7.2	20.7 ± 7.8	22.8 ± 6.3	0.015
Base excess	-2.0 (-7.9–1.98)	-3.05 (-8.50–1.25)	-0.6 (-5.4–3.3)	0.011
Base excess ≤ -2.0	139 (50.4)	83 (57.6)	56 (42.4)	0.016
Lactate, mmol/L	1.69 (1.20–3.18)	1.64 (1.11–3.83)	1.73 (1.29–2.79)	0.61
SO_2, %	98.0 (96.0–99.0)	99.0 (99.0–99.2)	96.0 (94.0–98.0)	<0.001
PaO_2 / FiO_2	342.9 (259.3–418.7)	393.8 (337.7–474.0)	273.9 (200.5–342.0)	<0.001
	347.1 ± 123.6	411.0 ± 112.0	277.4 ± 94.9	<0.001

The values are expressed as median and interquartile range, and/or mean ± standard deviation for continuous variables, and as numbers and percentages for categorical variables.

Abbreviations: WBC, white blood cell; HS Troponin I, high sensitive troponin I; BNP, brain natriuretic peptide; BUN, blood urea nitrogen; AST, aspartate aminotransferase; ALT alanine aminotransferase; LDH, lactate dehydrogenase; ALP, alkaline phosphatase; CRP, C-reactive protein; PCO_2, partial pressure of carbon dioxide; PaO_2, partial pressure of oxygen; SO_2, oxygen saturation; FiO_2, fraction of inspired oxygen.

*Performed on the day of consultation.

were observed between patients with and without hyperoxemia regarding hemoglobin levels, liver function tests, cardiac injury markers, or infection markers such as C-reactive protein and procalcitonin. Patients with hyperoxemia exhibited elevated blood urea nitrogen (BUN) and creatinine levels, along with decreased platelet and lymphocyte counts. Moreover, the proportion of patients with a lymphocyte count of 0.8 × 10^3/μL or lower was significantly higher among those with hyperoxemia compared to patients with normoxemia. In addition, patients with hyperoxemia had lower bicarbonate levels and more negative base excess values compared to those with normoxemia. Notably, patients with a base excess of −2.0 or lower demonstrated a significantly higher frequency of hyperoxemia compared to those with higher base excess values.

Hospitalization characteristics

As shown in Table 4, neither the underlying reasons for hospital admission nor the ward where patients stayed demonstrated a significant association with oxygenation status. However, the need for treatment in critical care settings was significantly higher among patients with hyperoxemia compared to those with normoxemia (108 [75.0%] vs. 69 [52.3%], $p< 0.001$). Furthermore, both in-hospital mortality (89 [61.8%] vs. 53 [40.2%], $p< 0.001$) and 28-day mortality (62 [43.1%] vs. 37 [28.0%], $p=0.012$) were significantly higher in patients with hyperoxemia compared to those with normoxemia.

Independent factors associated with hyperoxemia

Independent factors associated with hyperoxemia are presented in Table 5. The analysis identified a lymphocyte count of 0.8 × 10^3/μL or lower (OR, 2.17; 95% CI, 1.27–3.72; $p=0.005$) in laboratory tests, atelectasis as an underlying cause of respiratory failure (OR, 2.03; 95% CI, 1.13–3.67; $p=0.019$), an FiO_2 level of 40% or higher (OR, 2.10; 95% CI, 1.11–3.95; $p=0.022$), and type IV respiratory failure (OR, 2.34; 95% CI, 1.09–5.06; $p=0.030$) as independent

Table 4. Hospitalization Characteristics of the Patients

Characteristics	All (n=276)	Hyperoxemia (n=144)	Normoxemia (n=132)	*P* value
Reasons for hospital admission				
Infection	100 (36.2)	57 (39.6)	43 (32.6)	0.26
Renal/metabolic	69 (25.0)	37 (25.7)	32 (24.2)	0.89
Digestive	46 (16.7)	24 (16.7)	22 (16.7)	1.00
Soft tissue/skin/orthopedic	37 (13.4)	14 (9.7)	23 (17.4)	0.08
Cardiovascular	16 (5.8)	9 (6.3)	7 (5.3)	0.80
Neurologic	16 (5.8)	8 (5.6)	8 (6.1)	1.00
Ward where the patients stayed				
Medical wards	193 (69.9)	103 (71.5)	90 (68.2)	0.60
Surgical wards	83 (30.1)	41 (28.5)	42 (31.8)	
Length of hospital stay, days	16 (9–31)	16 (8-30)	16 (10-34)	0.19
Critical care unit admission	177 (64.1)	108 (75.0)	69 (52.3)	**<0.001**
28-day mortality	99 (35.9)	62 (43.1)	37 (28.0)	**0.012**
In-hospital mortality	142 (51.4)	89 (61.8)	53 (40.2)	**<0.001**

All values are expressed as median and interquartile range or as number and percentage.

Table 5. Independent Factors Associated with Hyperoxemia

Factors related to hyperoxemia	OR (95% CI)	*P* value
Laboratory data		
Lymphocyte count ≤ 0.8 × 10^3/μL	2.17 (1.27–3.72)	**0.005**
Base excess ≤ -2	1.48 (0.86–2.56)	0.16
Underlying reason for respiratory failure		
Atelectasis	2.03 (1.13–3.67)	**0.019**
Respiratory support		
FiO_2≥ 40%	2.10 (1.11–3.95)	**0.022**
IMV	1.40 (0.55–3.61)	0.48
Type of Respiratory Failure		
Type IV	2.34 (1.09–5.06)	**0.030**
Prognostic scores		
SOFA score	1.68 (0.86–3.29)	0.13
APACHE II score	1.42 (0.73–2.73)	0.30

Abbreviations: FiO_2, fraction of inspired oxygen; IMV, invasive mechanical ventilation; SOFA score, Sequential Organ Failure Assessment score; APACHE II score; Acute Physiology and Chronic Health Evaluation II score.

factors significantly associated with an increased likelihood of hyperoxemia among potentially critically ill elderly patients treated in hospital wards.

DISCUSSION

This study examined the risk factors for hyperoxemia among elderly patients who were deemed potentially critically ill and receiving treatment in hospital wards. The analysis revealed that the incidence of hyperoxemia was 52.2%. Moreover, patients with hyperoxemia had a greater likelihood of requiring treatment in critical care settings compared with those without hyperoxemia. Furthermore, both in-hospital and 28-day mortality rates were significantly higher among patients with hyperoxemia than among those with normoxemia. The independent factors associated with hyperoxemia were identified as a lymphocyte count of 0.8 × 10^3/μL or lower, atelectasis as an underlying cause of respiratory failure, an FiO_2 level of 40% or higher, and type IV respiratory failure among potentially critically ill elderly patients treated in wards.

The deterioration of ventilation-perfusion matching with age results in an increased alveolar-arterial oxygen gradient among elderly patients (18). Additionally, the age-associated increase in physiological dead space may contribute to this phenomenon (18). In contrast, a previous study examining nonoperative patients admitted to hospital wards demonstrated that age was an independent factor for hyperoxemia (11). However, the univariate analysis conducted in the present study did not reveal any significant differences in arterial oxygen content across the overall study population or among different age groups.

This study also found that neither the CCI nor any individual comorbidities influenced oxygenation status among patients. A previous study analyzing adult patients found that higher SOFA scores were associated with a lower incidence of hyperoxemia (11). However, in the present study, patients with higher APACHE II and SOFA scores— indicators of critical illness— were more likely to have hyperoxemia. Additionally, univariate analysis

revealed that patients with hyperoxemia had a significantly higher median GCS score than those with normoxemia. Yet, multivariate analysis did not confirm this association. This may suggest a prevailing tendency among caregivers to administer high concentrations or flows of supplemental oxygen to patients in clinically compromised conditions, reflected by higher APACHE II and SOFA scores and lower GCS scores, potentially contributing to the development of hyperoxemia in this population. Moreover, the administration of respiratory support at home, including the use of oxygen concentrators, was not associated with normoxemia, contrary to the anticipated outcome.

Supplemental oxygen therapy is a customary component in the management of critically ill patients, particularly those with respiratory failure (1). The present study revealed that patients with respiratory failure, especially those with type IV respiratory failure, exhibited a tendency to develop hyperoxemia rather than maintain normoxemia. In patients diagnosed with type IV respiratory failure, particularly those presenting with acute decompensated heart failure, supplemental oxygen therapy is recommended when SpO_2 levels fall below 90%. However, clinicians should exercise caution and avoid the routine use of oxygen therapy in patients without hypoxemia to prevent reductions in cardiac output and coronary vasoconstriction (9). Septic shock, another etiology of type IV respiratory failure, increases tissue metabolic demand, which must be counterbalanced by enhanced tissue oxygen delivery (19). Nevertheless, when hemodynamic disturbances surpass the cardiovascular system's compensatory capacity, tissue perfusion declines, leading to impaired microcirculation (19,20). As a result, the administration of oxygen at high concentrations and/or flow rates may become predominant among clinicians treating patients with septic shock, particularly those with clinical deterioration due to impaired metabolic balance associated with microcirculatory dysfunction and increased tissue oxygen demand. This phenomenon was reflected in the present study, where patients with high SOFA and APACHE II scores showed a higher incidence of hyperoxemia. Additionally, this study found that median hemoglobin levels did not differ significantly between patients with and without hyperoxemia. This finding contrasts with the well-established role of hemoglobin in facilitating oxygen delivery in critically ill patients (21). Therefore, clinicians must prioritize interventions that ensure hemodynamic stability and maintain adequate oxygen delivery to meet the patients' metabolic demands.

The present study demonstrated the expected relationship between the absence of respiratory support and normoxemia, as well as the association of respiratory support via mask with reservoir or invasive mechanical ventilation with hyperoxemia. Furthermore, the study found that respiratory support with an FiO_2 of 40% or greater, or the presence of atelectasis, were independently associated with hyperoxemia. For patients receiving supplemental oxygen therapy, current guidelines recommend targeting an SpO_2 range of 94–98%, or 88–92% in patients at risk of hypercapnic respiratory failure (22). These thresholds apply to a variety of clinical conditions, including sepsis, shock, acute coronary syndromes, stroke, pneumonia, anaphylaxis, and major trauma (22). It is important to underscore that pulse oximetry should be readily available in all settings where supplemental oxygen therapy is administered (22). Moreover, the prescription of supplemental oxygen should be guided by the target saturation range rather than the FiO_2 or flow rate (22). It is also crucial to emphasize that patients requiring escalating concentrations of oxygen supplementation should undergo urgent clinical reassessment (22).

Although no significant relationship was observed between cardiac enzymes, liver function

tests, and arterial oxygen content, associations were identified between certain laboratory parameters and hyperoxemia, notably elevated BUN and creatinine levels, along with lower pH, bicarbonate, and base excess levels, which may suggest acute renal failure. Hyperoxemia has previously been associated with impaired renal blood flow (22). Additionally, a prior study identified chronic kidney disease as a risk factor for hyperoxemia among nonoperative adult patients (11). The effect of hyperoxemia during cardiac anesthesia on postoperative kidney function also remains a subject of ongoing debate (16,23). Moreover, a low lymphocyte count— potentially indicative of severe infection or immunodeficiency— was identified as an independent factor associated with hyperoxemia in the study population. In this context, potentially critically ill patients experiencing tachypnea, whether due to pulmonary or non-pulmonary conditions such as renal or metabolic disorders, may be at increased risk of developing hyperoxemia induced by supplemental oxygen therapy. Consequently, it is imperative to investigate the underlying causes of tachypnea and to reassess the need for oxygen support in this patient population by carefully evaluating potential pulmonary and non-pulmonary pathologies.

The impact of hyperoxemia on patient outcomes remains a subject of debate in the literature. The findings of the present study indicated that hyperoxemia in elderly patients with potentially critical illnesses was associated with an increased need for treatment in critical care settings and a higher risk of 28-day and in-hospital mortality. Nonetheless, it can be argued that hyperoxemia may not be the primary causative factor for these outcomes. Instead, the observed associations may reflect a tendency among practitioners to administer high concentrations and flows of oxygen to patients with more severe illnesses. A systematic review demonstrated a dose-dependent increase in both early and long-term mortality among patients treated with liberal oxygen therapy. However, no significant differences were observed in disability or length of hospital stay (2). A subsequent study also revealed an association between hyperoxemia and mortality in critically ill patients, including those with both severe hyperoxemia and mild hyperoxemia or normoxemia (12). Conversely, a randomized trial found no significant differences in the number of ventilator-free days or 6-month mortality between patients receiving liberal versus conservative oxygen therapy (24). Another study showed that hyperoxemia increased the risk of in-hospital mortality by 1.8-fold among patients admitted to critical care following cardiopulmonary resuscitation (13). In the field of anesthesiology, particularly in cardiac anesthesia, existing literature suggests a correlation between hyperoxemia and perioperative pulmonary complications (14), although this association does not appear to extend to postoperative cognitive outcomes (25). Meanwhile, the impact of hyperoxemia on postoperative kidney function remains controversial (16,23). It is important to note, however, that these studies have employed heterogeneous definitions of hyperoxemia, a factor that has likely contributed to inconsistencies in reported outcomes.

LIMITATIONS

This study has several limitations. Although the study population was defined as elderly patients deemed at risk of developing critical illness and receiving treatment in hospital wards, it included only those patients who were evaluated by an intensivist to determine the need for critical care following are quest by the attending physician. Therefore, not all elderly patients who remained in the hospital wards during the study period were included. Furthermore, the decision to initiate supplemental oxygen therapy for patients treated in hospital wards was contingent on clinical decision-making processes that exhibited

variability across different wards, as opposed to a uniform protocol. Moreover, the existence of a consensus among attending physicians regarding the utilization of target SpO_2 or PaO_2 values to adjust supplemental oxygen therapy remains to be elucidated. Additionally, the inclusion of patients from surgical wards may have introduced some heterogeneity into the study population.

Nevertheless, this study has several notable strengths. The investigation of the impact of hyperoxemia on length of hospital stay, the need for critical care admission, and both in-hospital and 28-day mortality represents a significant contribution to the field. Furthermore, the study identifies specific hyperoxemia-related factors, offering valuable insights into which patients receiving oxygen therapy and/or ventilatory support should be monitored closely by healthcare practitioners for the potential development of hyperoxemia.

CONCLUSION

Clinicians should avoid hyperoxemia not only in patients treated in critical care settings or operating rooms but also in elderly patients with potentially critical illnesses who are treated in hospital wards. The findings of the present study indicate that patients with lymphopenia, atelectasis, type IV respiratory failure, or receiving supplemental oxygen with an FiO_2 level of 40% or higher are likely to have an increased risk of hyperoxemia. A proactive approach is imperative for this patient population, necessitating the determination of the target SpO_2 level as opposed to the prescription of the oxygen flow or FiO_2. This imperative is crucial for enhancing patient outcomes and ensuring the efficient utilization of healthcare resources.

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REFERENCES

1. Martin DS, Grocott MPW. Oxygen therapy in critical illness: precise control of arterial oxygenation and permissive hypoxemia. Crit Care Med 2013;41(2):423-432. (DOI: 10.1097/CCM.0b013e31826a44f6).
2. Chu DK, Kim LHY, Young PJ, et al. Mortality and morbidity in acutely ill adults treated with liberal versus conservative oxygen therapy (IOTA): a systematic review and meta-analysis. Lancet 2018;391(10131):1693-1705. (DOI: 10.1016/S0140-6736(18)30479-3).
3. World Health Organization. Global Health and Ageing [e-book] NIH Publication; 2022. [Internet]. Available from: https://www.who.int/news-room/fact-sheets/detail/ageing-and-health. Accessed: 03.03.2025.
4. Winslow RM. Oxygen: the poison is in the dose. Transfusion 2013;53(2):424-437. (DOI: 10.1111/j.1537-2995.2012.03774.x).
5. Elliott CG, Rasmusson BY, Crapo RO, Morris AH, Jensen RL. Prediction of pulmonary function abnormalities after adult respiratory distress syndrome (ARDS). Am Rev Respir Dis 1987;135(3):634-638. (DOI: 10.1164/arrd.1987.135.3.634).
6. Singer MM, Wright F, Stanley LK, Roe BB, Hamilton WK. Oxygen toxicity in man: A prospective study in patients after open-heart surgery. N Engl J Med 1970;283(27): 1473-1478. (DOI: 10.1056/NEJM197012312832701).
7. Petty TL, Stanford RE, Neff TA. Continuous oxygen therapy in chronic airway obstruction. Observations on possible oxygen toxicity and survival. Ann Intern Med 1971;75(3):361-367. (DOI: 10.7326/0003-4819-75-3-361).
8. Chawla A, Lavania AK. Oxygen Toxicity. Med J Armed Forces India 2001;57(2):131-133. (DOI: 10.1016/S0377-1237(01)80133-7).
9. Park JH, Balmain S, Berry C, Morton JJ, McMurray JJ. Potentially detrimental cardiovascular effects of oxygen in patients with chronic left ventricular systolic dysfunction. Heart 2010;96(7):533-538. (DOI: 10.1136/hrt.2009.175257).
10. Manning EP. Central Nervous System Oxygen Toxicity and Hyperbaric Oxygen Seizures. Aerosp Med Hum Perform 2016;87(5):477-486. (DOI: 10.3357/AMHP.4463.2016).

11. da Silva PB, Fernandes SES, Gomes M, et al. Hyperoxemia induced by oxygen therapy in nonsurgical critically ill patients. Am J Crit Care 2024;33(2):82-92. (DOI: 10.4037/ajcc2024723).

12. Helmerhorst HJ, Arts DL, Schultz MJ, et al. Metrics of arterial hyperoxia and associated outcomes in critical care. Crit Care Med 2017;45(2):187-195. (DOI: 10.1097/CCM.0000000000002084).

13. Kilgannon JH, Jones AE, Shapiro NI, et al. Association between arterial hyperoxia following resuscitation from cardiac arrest and in-hospital mortality. JAMA 2010;303 (21):2165-2171. (DOI: 10.1001/jama.2010.707).

14. Douin DJ, Pattee J, Scott B, et al. Hyperoxemia during cardiac surgery is associated with postoperative pulmonary complications. Crit Care Explor 2023;5(3):e0878. (DOI: 10.1097/CCE.0000000000000878).

15. Douin DJ, Pattee J, Scott B, et al. Hyperoxemia during cardiac surgery is associated with postoperative pulmonary complications. Crit Care Explor 2023;5(3):e0878. (DOI: 10.1097/CCE.0000000000000878).

16. Bae J, Kim J, Lee S, et al. Association between intraoperative hyperoxia and acute kidney injury after cardiac surgery: a retrospective observational study. J Cardiothorac Vasc Anesth 2021;35(8):2405-2414. (DOI: 10.1053/j.jvca.2020.11.054).

17. World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. JAMA 2013;310(20):2191-2194. (DOI: 10.1001/jama.2013.281053)

18. Mellemgaard K. The alveolar-arterial oxygen difference: its size and components in normal man. Acta Physiol Scand 1966;67(1):10-20. (DOI: 10.1111/j.1748-1716.1966.tb03281.x).

19. Wysocki M, Besbes M, Roupie E, Brun-Buisson C. Modification of oxygen extraction ratio by change in oxygen transport in septic shock. Chest 1992;102(1):221-226. (DOI: 10.1378/chest.102.1.221).

20. Potter EK, Hodgson L, Creagh-Brown B, Forni LG. Manipulating the Microcirculation in Sepsis - the Impact of Vasoactive Medications on Microcirculatory Blood Flow: A Systematic Review. Shock 2019;52(1):5-12. (DOI: 10.1097/SHK.0000000000001239).

21. Hameed SM, Aird WC, Cohn SM. Oxygen delivery. Crit Care Med 2003;31(Suppl 12): 658-667. (DOI: 10.1097/01.CCM.0000101910.38567.20).

22. O'Driscoll BR, Howard LS, Earis J, et al. BTS guideline for oxygen use in adults in healthcare and emergency settings. Thorax 2017;72(Suppl 1):1-90. (DOI: 10.1136/thoraxjnl-2016-209729).

23. Lopez MG, Shotwell MS, Hennessy C, et al. Intraoperative oxygen treatment, oxidative stress, and organ injury following cardiac surgery: a randomized clinical trial. JAMA Surg 2024;159(10):1106-1116. (DOI: 10.1001/jamasurg.2024.2906).

24. Mackle D, Bellomo R, Bailey M, et al. Conservative oxygen therapy during mechanical ventilation in the ICU. N Engl J Med 2020;382(11):989-998. (DOI: 10.1056/NEJMoa1903297).

25. Shaefi S, Shankar P, Mueller AL, et al. Intraoperative oxygen concentration and neurocognition after cardiac surgery. Anesthesiology 2021;134(2):189-201. (DOI: 10.1097/ALN.0000000000003650).