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The relationship between the need for oxygen concentrator after discharge in COVID-19 patients and mortality

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ABSTRACT

Aims: The COVID-19 pandemic has severely burdened healthcare systems worldwide due to the rapid rise in cases, often resulting in respiratory distress requiring oxygen therapy. However, research on the availability and long-term usage of oxygen concentrators upon discharge is limited. This study aimed to identify factors associated with the need for oxygen concentrators in discharged COVID-19 patients, as well as device acquisition and mortality rates.

Methods: This study, conducted at a single center, comprised retrospective and prospective phases. Data were gathered from hospitalized COVID-19 patients, with follow-up conducted one year later for those prescribed oxygen concentrators at discharge. Sociodemographic and clinical variables were recorded, and statistical analyses were conducted to determine factors associated with oxygen concentrator need and duration of use.

Results: Among 229 patients, 15.7% required oxygen concentrators at discharge. Factors associated with this need included older age, asthma, bilateral lung lesions, and the severity of lesions detected on thoracic computed tomography scans. Patients with corticosteroid use and hypertension required oxygen concentrators for over three months. Economic limitations impeded the acquisition of devices for 22.2% of patients who were prescribed them. Two to three months post-discharge, 72.2% of patients still used oxygen concentrators. Mortality analysis showed a 16.6% fatality rate among oxygen concentrator prescribed patients within one year, with shorter survival observed in those unable to obtain the device.

Conclusion: This study highlights the significance of assessing factors impacting oxygen concentrator requirement in COVID-19 patients and their long-term prognosis. These findings should inform healthcare providers and policymakers in pandemic preparedness efforts, emphasizing tailored treatment approaches based on individual patient characteristics. Ensuring device accessibility and regular patient follow-up are crucial for optimizing healthcare delivery during similar crises.

Keywords: Oxygen concentrator, mortality rates, pandemic preparedness, COVID-19, coronavirus disease

INTRODUCTION

The COVID-19 pandemic has caused a significant global health crisis.[1] The pandemic has strained global healthcare systems, stretching hospital resources beyond capacity due to a rapid increase in cases, particularly in meeting treatment needs such as beds, medications, and oxygen.[2]

The deadly impact of COVID-19 often results from lung parenchyma and airways involvement.[3] Lung involvement in COVID-19 can lead to acute respiratory distress syndrome (ARDS) in the early stages and varying degrees of fibrosis in the chronic stages. These conditions may result in respiratory failure and hypoxia, requiring oxygen support therapy. As approximately 15% of hospitalized patients need oxygen, clinically stable patients with ongoing oxygen requirements are discharged with an oxygen concentrator.[4,5] While many studies explore factors associated with the need for oxygen concentrators, there's a limited number of studies assessing the availability of the device and its long-term usage.[4,5]

This study aimed to identify factors associated with the necessity for oxygen concentrators upon discharge of COVID-19 patients, alongside investigating device acquisition and mortality rates.

METHODS

Ethics

The study adhered to the Helsinki Declaration and received approval from the Gaziantep University Clinical Researches Ethics Committee (Date: 18.01.2023, Decision No: 2022/454).

Study Population

This study included patients diagnosed with COVID-19 pneumonia and treated at Gaziantep University's Chest Diseases Clinic. A sample size of 102 was determined using power analysis (α=0.05; 1-β=0.80) with G Power 3.9.1

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software. Eligible participants were adults aged 18 and above with moderate to severe COVID-19 confirmed via real-time reverse transcriptase polymerase chain reaction (RT-PCR) from throat swab samples. Patients with prior oxygen concentrator use were excluded from the study.

Study Design

This single-center study involves retrospective and prospective phases. In the retrospective phase, data were gathered from the Hospital Information System on COVID-19 patients hospitalized between 01.03.2019 and 30.12.2022. Patient forms were used to record this data. During the prospective phase, discharged patients prescribed with oxygen concentrators were contacted via telephone one year later to assess their usage. Mortality status within the past year was obtained from the Hospital Information System.

Variables

Patients' sociodemographic and clinical characteristics, including age, gender, length of hospital stay, oxygen requirement during hospitalization, COVID-19 severity, presence and number of comorbidities (asthma, COPD, bronchiectasis, Type 2 Diabetes Mellitus, hypertension), unilateral/bilateral lesions on posteroanterior chest X-ray, thoracic computed tomography (CT) involvement score, were documented. Additionally, the use of corticosteroids, antibiotics, low molecular weight heparin, interleukin-6 blocker, and route of oxygen delivery during hospitalization were recorded. Upon discharge, the prescription of oxygen concentrators was noted. Follow-up after one year included recording the duration of oxygen concentrator usage, reasons for non-usage if applicable, and mortality status.

Severity of COVID-19 disease: During hospitalization, patients presenting pneumonia symptoms with room air oxygen saturation (SpO_2)≥90% were categorized as having "moderate" COVID-19 disease, while those with SpO_2<90% were classified as having "severe" disease.[6]

The thoracic computed tomography (CT) involvement score was determined by assessing findings consistent with COVID-19 pneumonia (GE64R, Japan). Each lobe's pathological findings were scored as follows: 0 for no involvement, 1 for ≤5% involvement, 2 for involvement between 5% and 25%, 3 for involvement between 25% and 50%, 4 for involvement between 50% and 75%, and 5 for involvement >75%.[7]

Indications for prescribing oxygen concentrators upon discharge were as follows: Patients treated at the Chest Diseases Clinic, hospitalized for at least 24 hours, without dyspnea, cough, sputum, or fever, and lacking hemodynamic instability (systolic blood pressure <90 mmHg, heart rate >120 bpm), were categorized as "patients requiring oxygen concentrator upon discharge-Group I" if their room air SpO_2 was ≤88%. Those with SpO_2>88% were classified as "patients not requiring oxygen concentrator upon discharge-Group II".[4]

Statistical Analysis

Data analysis was conducted using IBM SPSS Statistics (version 22.0, IBM Corp., Armonk, NY, USA). Descriptive statistics, including frequencies, percentages, means, and standard deviations, were employed. The Shapiro-Wilk test assessed the normality of continuous variables. Student's t-test was used to examine differences in means between groups, while the Mann-Whitney U test assessed differences in medians. Nominal variables were evaluated using Pearson's chi-square test or Fisher's exact test. Variables showing significance through basic statistical methods underwent further evaluation using logistic regression. Mortality rate within one year was analyzed using the Kaplan-Meier method. A p-value <0.05 was considered statistically significant.

RESULTS

The study included 229 patients with a mean age of 62.9±15.4 years, of whom 125 (54.6%) were male. The median hospitalization duration was 6.1 days. Oxygen was required by 192 patients (83.8%) during hospitalization, with 114 (51.6%) classified as having moderate and 107 (48.4%) as having severe COVID-19 infection. Eight patients lacked sufficient information for disease severity assessment. Some demographic and clinical characteristics of patients shown in Table 1.

Table 1. Some demographics and clinical characteristics of patients

Variables	n, %
Age (mean±SD)	62.9±15.4
Gender	
Male	125,54.6%
Female	104,45.4%
Total days of hospitalization (median/min-max)	6.1/1-25
Oxygen requirement during hospitalization	
Yes	192,83.8%
No	37,16.2%
COVID-19 case severity	
Moderate	114,51.6%
Severe	107,48.4%
Number of comorbidities	167,72.9%
Presence of comorbidities	
Asthma	42,18.3%
COPD	13,5.7%
Bronchiectasis	9,3.9%
Diabetes mellitus	77,33.6%
Hypertension	64,27.9%
Lesion on chest X-ray	
Unilateral	24,10.5%
Bilateral	205,89.5%
Lesion severity on thoracic CT (mean±SD)	11.2,±6.6
Treatments used during hospitalization	
Corticosteroid	97,42.4%
Antibiotic	222,96.9%
LMWH	145,63.3%
IL6 blocker	11,4.8%
Oxygen support	
Nasal oxygen	162,84.4%
Non-invasive mechanical ventilation	30,15.6%
Discharge status	
Discharged with recovery	207,90.4%
Transferred to intensive care	20,8.7%
Exitus	2,0.9%
Oxygen concentrator need at discharge	
Yes	36,15.7%
No	194,84.3%
Acquisition of oxygen concentrator	
Yes	18,50%
No	8,22.2%
Unreachable	10,27.8%

SD: Standart deviation, Min: Minimum, Max: Maximum, COPD: Chronic obstructive pulmonary disease, CT: Computed tomography, LMWH: Low molecular weight heparin

The comparison of the characteristics of Group I and Group II is shown in Table 2. In Group I (n=36, 16.1%), patients had an average age of 68.3±12.5 years, while in Group II (n=193, 83.9%), the average age was 61.9±15.7 years (p=0.01). Although Group I had more severe COVID-19 cases, comorbidities such as asthma, bilateral lesions on PA chest X-ray, and extensive thoracic CT lesions compared to Group II, logistic regression analysis did not identify these variables as independent risk factors for determining the need for oxygen concentrator upon discharge.

Table 2. A comparison between patients requiring oxygen concentrator upon discharge and those not

Variables	Patients Requiring Oxygen Concentrator (n=36), n (%)	Patients Not Requiring Oxygen Concentrator (n=193), n (%)	p value
Age (mean±SD)	68.3±12.5	61.9±15.7	0.01
Gender			0.52
Male	20 (55.6%)	105 (54.4%)	
Female	16 (44.4%)	88 (45.6%)	
Total days hospitalized (median/min-max)	8 (2-23)	6 (1-25)	0.12
Oxygen requirement at admission			0.01
Yes	35 (97.2%)	157 (81.3%)	
No	1 (2.8%)	36 (18.7%)	
Severity of COVID-19			0.01
Moderate	11 (31.4%)	103 (55.4%)	
Severe	24 (68.6%)	83 (44.6%)	
Presence of comorbidities	29 (80.6%)	138 (71.5%)	0.94
Asthma	12 (33.3%)	30 (15.5%)	0.01
COPD	0 (0%)	13 (6.7%)	0.23
Bronchiectasis	2 (5.6%)	7 (3.6%)	0.63
Diabetes mellitus	12 (33.3%)	65 (33.7%)	0.56
Hypertension	10 (4.27.8%)	54 (28.0%)	0.57
Lesion on chest X-ray			0.03
Unilateral	0 (0.0%)	24 (12.4%)	
Bilateral	36 (100%)	170 (87.6%)	
Lesion severity on thorax CT (mean±SD)	13.7±7.7	10.6±6.2	0.03
Treatments during hospitalization			
Corticosteroid	19 (52.8%)	78 (40.4%)	0.19
Antibiotic	34 (94.4%)	188 (97.4%)	0.30
LMWH	19 (52.8%)	126 (65.3%)	0.18
IL6 blocker	4 (11.1%)	7 (3.6%)	0.07
Nasal oxygen	29 (82.9%)	133 (84.7%)	0.79
NIMV	6 (17.1%)	24 (15.3%)	
Outcome one year after prescription of oxygen concentrator			0.65
Alive	30 (80%)	150 (77.7%)	
Exitus	6 (20%)	43 (22.3%)	

SD: Standart deviation, Min: Minimum, Max: Maximum, COPD: Chronic obstructive pulmonary disease, CT: Computed tomography, LMWH: Low molecular weight Heparin, IL-6: Interleukin-6, NIMV: Non-invasive mechanical ventilation

Oxygen Concentrator Prescribed Patients' Characteristics

Out of 36 patients prescribed oxygen concentrators, 50% obtained the device, 22.2% did not use it due to economic reasons, and 27.8% were unreachable for evaluation at the end of the first year. Among those who obtained the device, 16.6% used it for one month, 11.1% for two to three months, 16.6% for four to six months, and 55.5% for seven to twelve months.

The comparisons between patients using the device for less than three months and those using it for longer, as shown in Table 3, did not reveal statistically significant differences in most characteristics. However, corticosteroid use and hypertension during hospitalization were significantly higher in patients using the device for less than three months compared to those using it for more than three months (p=0.03, p=0.01 respectively).

When comparing oxygen concentrator usage durations (less than one month vs. one month and more, less than four months vs. four months and more, less than six months vs. six months and more) with various patient characteristics, including age, gender, total length of hospital stay, oxygen requirement during hospitalization, severity of COVID-19 cases, number of comorbidities, presence of asthma, COPD, bronchiectasis, diabetes mellitus, hypertension, unilateral/bilateral lesions on PA chest X-ray, lesion density on thoracic CT, use of corticosteroids, antibiotics, LMWH, and IL-6 blocker, no statistically significant difference was found (p>0.05).

Mortality Analysis of Patients Prescribed With Oxygen Concentrators

Among 36 patients discharged with oxygen concentrators, the one-month mortality rate was 0%, three-month mortality rate was 2.7%, and one-year mortality rate was 16.6%, with an average one-year survival time of 11.2 months. Six patients died after one year; among them, two were unreachable, and four were unable to obtain the oxygen concentrator. Excluding the unreachable patients, the average one-year survival time was 17.7 months for those who couldn't obtain the device and 22.3 months for those who obtained it, as shown in Figure.

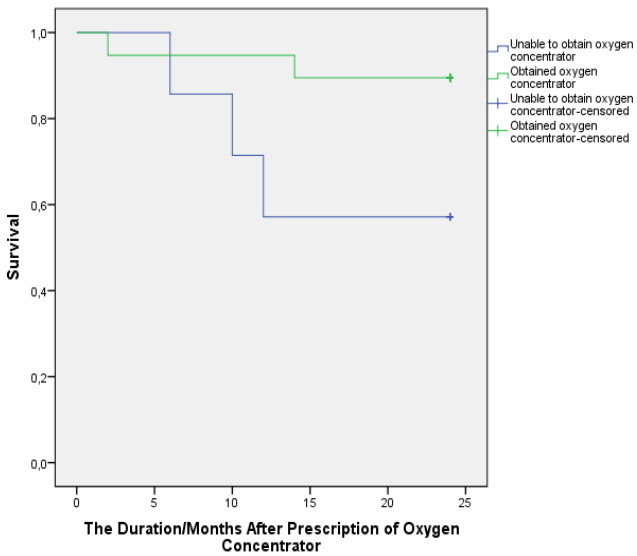

Figure. One-year mortality rates of patients using and not using oxygen concentrator

Table 3. Comparison of characteristics between patients who used oxygen concentrator for more than three months and less

Variables		Duration of oxygen concentrator usage			
		Usage of less than three months, n%	Usage of more than three months, n%	Total	p value
Age (mean±SD)		67.2±12.6	66.38±14.0		0.91
					0.27
Gender	Female	0 0%	4 22.2%	4 22.2%	
	Male	5 27.8%	9 50.0%	14 77.8%	
Total days of hospitalization median/min-max		8/3-18	9/4-13		0.71
Presence of oxygen requirement at admission		5 27.8%	13 72.2%	18 100%	Constant
Severity of COVID-19 case					0.65
	Moderate	1 5.6%	2 11.1%	3 16.7%	
	Severe	4 22.2%	11 61.1%	15 83.3%	
Comorbidities					0.70
	No	1 5.6%	3 16.7%	4 22.2%	
	Yes	4 22.2%	10 55.6%	14 77.8%	
Number of comorbidities		1.8±0.8	1.8±1.2		0.94
Asthma					0.24
	No	5 27.8%	8 44.4%	13 72.2%	
	Yes	0 0.0%	5 27.8%	5 27.8%	
Chronic obstructive pulmonary disease					Constant
	No	5 27.8%	13 72.2%	18 100%	
	Yes	0	0	0	
Bronchiectasis					0.86
	No	5 27.8%	11 61.1%	16 89.9%	
	Yes	0 0.0%	2 11.1%	2 11.1%	
Diabetes mellitus					0.58
	No	3 16.7%	10 55.6%	13%	
	Yes	2 11.1%	3 16.7%	5 27.8%	
Hypertension					0.01
	No	2 11.1%	12 66.7%	14 77.8%	
	Yes	3 16.7%	1 5.6%	4 22.2%	
Lesion on chest X-ray					
	Unilateral	0	0	0	Constant
	Bilateral	5 27.8%	13 72.2%	18 100%	
Severity of lesion on chest CT (mean±SD)		16.4±8.9	11.4±5.8		0.18
Treatments used during hospitalization					
Corticosteroid					0.03
	No	5 27.8%	5 27.8%	10 55.6%	
	Yes	0 0.0%	8 44.4%	8 44.4%	
Antibiotic					0.72
	No	0 0.0%	1 5.6%	1 5.6%	
	Yes	5 27.8%	12 66.7%	17 94.4%	
Low molecular weight heparin					0.32
	No	1 5.6%	6 33.3%	7 38.9%	
	Yes	4 22.2%	7 38.9%	11 61.1%	
IL-6 blocker					0.65
	No	4 22.2%	11 61.1%	15 83.3%	
	Yes	1 5.6%	2 11.1%	3 16.7%	

SD: Standart deviation, Min: Minimum, Max: Maximum, CT: Computed tomography, IL-6: Interleukin-6

DISCUSSION

This study found that older age, prior oxygen requirements, asthma, bilateral lung lesions, and severity of lesions on thoracic CT scans were associated with a higher need for oxygen concentrators at discharge. Patients using corticosteroids and those with hypertension required oxygen concentrators for over three months. Patients who were unable to purchase oxygen concentrators due to economic constraints experienced a higher mortality rate.

The observed need for oxygen concentrators upon discharge (15.7%) matched rates in other studies (13%-23%).[8] Obesity and African descent were linked to increased device necessity.[4] Individuals aged 50 and older with three or more comorbidities were 3.4 times more likely to need oxygen.[9]

In this study, patients needing oxygen concentrators were older compared to those not requiring the device. Similarly, Ray et al.[9] found higher oxygen requirements in patients over 60 years old compared to those under 50 years old. This suggests age as a determinant factor in oxygen requirements, emphasizing the need for age-specific treatment strategies.

Consistent with previous findings, showed no significant gender difference in oxygen requirement.[9] Diabetes mellitus (DM) remains consistently linked to COVID-19-related oxygen needs, underscoring the need for careful monitoring of discharged DM patients,[3,9,10] While previous studies often cite COPD among oxygen concentrator users, we observed a higher requirement in asthma patients.[11] However, our study's exclusion of COPD patients initially using concentrators may have inflated the proportion of asthma patients, contributing to this disparity.

The present study confirmed that patients with higher lesion density required more oxygen support initially. Literature suggests higher lesion density on thoracic CT scans at diagnosis correlates with increased oxygen requirement, while long-term requirements decrease as lesion density declines.[12,13] However, lesion density did not differ significantly between patients using oxygen concentrators for over three months and those using them for a shorter duration. This implies that while lesion density may predict short-term oxygen needs, its predictive value for long-term device requirement is limited. Thus, lesion density should be evaluated dynamically in early pandemic oxygen support decisions.

In this study, 22.2% of patients couldn't get oxygen concentrators due to economic issues, a new finding. Economic factors strongly affect healthcare access. Implementing economic support mechanisms could boost treatment adherence and enhance health outcomes.

Literature presents conflicting findings on oxygen concentrator need post-discharge. While one study showed a 38% usage rate one month post-discharge[14] another found only 6.5% requiring home oxygen support within two months. In our study, 72.2% still used the device two to three months post-discharge. Patient accessibility during follow-up may influence usage rates.[15]

In Kaul et al.'s[4] study, 32% of patients still required oxygen concentrators at the end of the sixth month, whereas in our study, it was 55.5%. Regular monitoring and treatment in Kaul et al.'s[4] study may have reduced the need for oxygen concentrators. Regular monitoring may have influenced outcomes.

Serrano et al.[16] found 12.4% needing concentrators at one year, while our study reported 27.7%. Differences in patient characteristics and methods may explain the variance.

In literature, patients with low saturation during hospitalization in the first three months, those in intensive care, and those with pre-existing lung disease have a 40% higher need for oxygen concentrators.[9] However, in our study, corticosteroid use and hypertension were associated with prolonged usage, suggesting their impact warrants further investigation.

In this study, the 30-day mortality rate was 0%, while the one-year mortality rate among patients prescribed with oxygen concentrators was 16.6%. Terp et al.[17] reported a 30-day mortality rate of 1.4% for patients discharged with oxygen concentrators, and Banerjee et al.[18] reported a 30-day mortality rate of 1.3%. However, these studies did not specify whether mortality was attributed to COVID-19, and the predominance of patients followed up in the emergency department may have influenced the results.

In current study, patients unable to obtain oxygen concentrators experienced shorter survival times. Implementing specialized follow-up programs and improving device accessibility are crucial. Incorporating patients' relatives' phone numbers into hospital systems may alleviate follow-up challenges.

Limitations

The main limitations include the small sample size, although it's comparable to similar studies. Lack of data on patients' COVID-19 vaccination status may have impacted outcomes. Some patients couldn't be reached during the one-year follow-up, potentially introducing bias. We didn't investigate the duration of device daily usage and compliance, which is another limitation.

CONCLUSION

This study highlights factors influencing oxygen concentrator need in COVID-19 patients and their status one year later, including age, oxygen requirement during hospitalization, disease severity, comorbidities like asthma, HT, and thoracic CT findings. Additionally, it is crucial to note economic barriers preventing the acquisition of the device. These insights can inform personalized treatment strategies for future pandemics.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of Gaziantep University Clinical Researches Ethics Committee (Date: 18.01.2023, Decision No: 2022/454).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process
Externally peer-reviewed.

Conflict of Interest Statement
The authors have no conflicts of interest to declare.

Financial Disclosure
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Author Contributions
All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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