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TANAFFOS

Respiratory Support and Clinical Outcomes in Critically Ill Patients with COVID-19 in Intensive Care Unit: A Retrospective Study

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Background: Appropriate respiratory support is crucial for improving the clinical outcomes of critically ill patients infected with the SARS-CoV-2 virus. This study aimed to investigate the different modalities of respiratory support and clinical outcomes in patients with COVID-19 in intensive care units (ICUs).

Materials and Methods: In a retrospective study, we enrolled 290 critically ill COVID-19 patients who were admitted to the ICUs of four hospitals in Mazandaran, northern Iran. Data were extracted from the medical records of all included patients, from December 2019 to July 2021. Patients' demographic data, symptoms, laboratory findings, comorbidities, treatment, and clinical outcomes were collected.

Results: 46.55% of patients died. Patients with ≥2 comorbidities had significantly increased odds of death (OR=5.88, 95%CI: 1.97-17.52, P=0.001) as compared with patients with no comorbidities. Respiratory support methods such as face mask (survived=37, deceased=18, P=0.022), a non-rebreather mask (survived=39, deceased=12, P<0.001), and synchronized intermittent mandatory ventilation (SIMV) (survived=103, deceased=110, P=0.004) were associated with in-hospital mortality. Duration of respiratory support in nasal cannula (survived=3, deceased=2, P<0.001), face mask (survived=3, deceased=2, P<0.001), a non-rebreather mask (survived=3, deceased=2, P=0.033), mechanical ventilation (survived=5, deceased=6, P<0.019), continuous positive airway pressure (CPAP) (survived=3, deceased=2, P<0.017), and SIMV (survived=4, deceased=5, P=0.001) methods were associated with higher in-hospital mortality.

Conclusion: Special attention should be paid to COVID-19 patients with more than two comorbidities. As a specific point of interest, SIMV may increase the in-hospital mortality rate of critically ill patients with COVID-19 connected to mechanical ventilation and be associated with adverse outcomes.

Keywords: COVID-19; Intensive Care Unit; Mechanical Ventilation; Mortality; Respiratory Therapy

INTRODUCTION

The spread of the COVID-19 pandemic has put healthcare systems in serious crisis around the world. The disease has spread rapidly around the world and has placed a burden on intensive care units (ICUs) (1). Despite intensive care and advanced support, the mortality rate of patients with COVID-19 in the ICU is 16 to 87% (1-5). COVID-19 is an infectious disease that leads to acute respiratory distress syndrome (ARDS) and is associated with severe hypoxemia, requiring advanced respiratory support in the ICU (6). A variety of respiratory support strategies are available for managing hypoxemia in critically ill patients with COVID-19, however, there is no uniform agreement on the optimal respiratory support method for these patients (7-10). Although some previous studies have demonstrated a beneficial effect of non-invasive respiratory support on clinical outcomes of COVID-19 patients in ICU, this finding was not supported by other studies (11-13). Due to the importance of this issue, this study was performed to investigate the different modalities of respiratory support and clinical outcomes in critically ill patients with COVID-19 in the ICU.

MATERIALS AND METHODS

Study design and subjects

In a retrospective study, 290 critically ill patients with COVID-19 who were admitted to the ICUs of four hospitals in Mazandaran, northern Iran, were enrolled. These hospitals were the main centers for the treatment of patients with COVID-19 in Mazandaran province, Iran. All patients were confirmed to have SARS-CoV-2 infection by real-time polymerase chain reaction (RT-PCR) from nasopharyngeal swabs. Data were collected via census sampling from December 2019 to July 2021. In this study, the medical records of all ICU admitted COVID-19 patients were assessed and patients with incomplete medical records were excluded from the study. This study was approved by the Research Ethics Committee of Mazandaran University of Medical Sciences (IR.MAZUMS.REC.1399.641).

Data collection

Data collection was performed using a researcher-made checklist including demographic characteristics (age, sex, smoking, alcohol consumption), ABO and Rh blood groups, respiratory complication (pneumonia and ARDS), number of symptoms, physiological parameters, loss of consciousness (LOC), laboratory findings, chest CT scan findings, methods and duration of respiratory support [nasal cannula, face mask, a non-rebreather mask, venturi mask, continuous positive airway pressure (CPAP), bilevel positive airway pressure (BIPAP), continuous mandatory ventilation (CMV), and synchronized intermittent mandatory ventilation (SIMV)], and clinical outcomes.

Statistical analysis

Data analysis was carried out using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). Continuous variables are presented as median [interquartile range (IQR)] and compared using the Mann-Whitney test. Categorical variables are presented as numbers (percentages) and compared using Chi-square test. Multiple logistic regression analysis was also applied to examine the relationships of clinical and demographic characteristics with in-hospital mortality. All statistical tests were two-sided and the level of significance was set at 0.05.

RESULTS

Clinical and demographic characteristics of the participants

A total of 290 critically ill patients with COVID-19 were included in the present study. The mean age of patients was 61 years. Of the participants, 56.6% were male, 34.5% had blood group A, 56.2% had Rh^+, 54.5% had more than two comorbidities, and 55.5% had hypertension. Also, in

chest CT scans 58.3% of patients appeared left unilateral involvement. Finally, 46.55% of all patients died. The clinical and demographic characteristics of the patients are shown in Table 1.

Relationships of clinical and demographic characteristics with in-hospital mortality

As presented in Table 2, multiple logistic regression analyses were conducted to assess the clinical and demographic characteristics of in-hospital mortality. Based on the adjusted analysis, the odds of in-hospital mortality increased with advancing age (OR=1.01, 95% CI: 1.00-1.03), although this increase was not statistically significant (P=0.103). Patients with ≥2 comorbidities had significantly increased odds of death (OR=5.88, 95% CI: 1.97-17.52, P=0.001) as compared with patients with no comorbidities. A higher respiratory rate (OR=1.08, 95% CI: 0.99-1.19, P=0.089), as well as a higher heart rate (OR=1.02, 95% CI: 1.00-1.04, P=0.053), was also marginally associated with in-hospital mortality. Regarding chest CT scan findings, patients with unilateral right lung involvement were at increased risk of death (OR=1.66, 95% CI: 0.94-2.91) as compared with unilateral left lung involvement, although this increase was marginally statistically significant (P=0.078).

Respiratory support among critically ill patients with COVID-19

Respiratory support methods

As presented in Table 3, respiratory support methods such as face mask, a non-rebreather mask, and SIMV were associated with higher in-hospital mortality. All COVID-19 patients were connected to mechanical ventilation. 55 patients (19%) were treated with face mask, of which 18 died (P=0.022). 51 patients (17.6%) were treated with a non-rebreather mask, of which 12 died (P<0.001). 95 patients (32.8%) were treated with CPAP, of which 39 died (P=0.211). 56 patients (19.3%) were treated with BIPAP, of which 21 died (P=0.131). 25 patients (8.6%) were treated with CMV, of which 15 died (P=0.158). 213 patients (73.4%) were treated with invasive mechanical ventilation using SIMV mode, of which 110 died (P=0.004).

Duration of respiratory support

As presented in Table 3, duration of respiratory support in nasal cannula (survived=3, deceased=2, P<0.001), face mask (survived=3, deceased=2, P<0.001), a non-rebreather mask (survived=3, deceased=2, P=0.033), mechanical ventilation (survived=5, deceased=6, P<0.019), CPAP (survived=3, deceased=2, P<0.017), BIPAP (survived=4, deceased=6, P=0.338), CMV (survived=5, deceased=3, P=0.445), and SIMV (survived=4, deceased=5, P=0.001) methods were associated with higher in-hospital mortality.

Table 1. Characteristics of patients with COVID-19 by in-hospital mortality

	Total (n=290)	In-hospital mortality		P
		Survived (n=155)	Deceased (n=135)	
Demographics				
Age (years)	61.0 (47.0 – 71.0)	58.0 (45.0 – 71.0)	63.0 (50.0 – 71.0)	0.044
Age group (years)				
≤ 60	136 (46.9)	81 (52.3)	55 (40.7)	0.049
> 60	154 (53.1)	74 (47.7)	80 (59.3)	
Male Sex	164 (56.6)	94 (60.6)	70 (51.9)	0.132
Active smoking	78 (26.9)	38 (24.5)	40 (29.6)	0.327
Alcohol consumption	11 (3.8)	6 (3.9)	5 (3.7)	0.941
Blood Group				0.969
A	100 (34.5)	52 (33.5)	48 (35.6)	
B	37 (12.8)	21 (13.5)	16 (11.9)	
AB	88 (30.3)	47 (30.3)	41 (30.4)	
O	65 (22.4)	35 (22.6)	30 (22.2)	

Rh +	163 (56.2)	86 (55.5)	77 (57.0)	0.790
Respiratory Complication				0.184
Pneumonia	186 (64.1)	94 (60.6)	92 (68.1)	
ARDS	104 (35.9)	61 (39.4)	43 (31.9)	
Number of Symptoms	2.0 (2.0 – 4.0)	2.0 (2.0 – 4.0)	3.0 (2.0 – 4.0)	0.569
Comorbidities				
Chronic respiratory disease	40 (13.8)	8 (5.2)	32 (23.7)	<0.001
Diabetes	132 (45.5)	54 (34.8)	78 (57.8)	<0.001
Cardiovascular disease	123 (42.4)	61 (39.4)	62 (45.9)	0.259
Kidney Disease	13 (4.5)	4 (2.6)	9 (6.7)	0.093*
Hypertension	161 (55.5)	74 (47.7)	87 (64.4)	0.004
Liver Disease	28 (9.7)	9 (5.8)	19 (14.1)	0.017
Immune System Disease	8 (2.8)	0 (0)	8 (5.9)	0.002
Number of Comorbidities				<0.001
0	24 (8.3)	19 (12.3)	5 (3.7)	
1	108 (37.2)	77 (49.7)	31 (23.0)	
≥ 2	158 (54.5)	59 (38.1)	99 (73.3)	
Physiological Parameters				
Temperature	37.4 (37.1 – 37.7)	37.4 (37.1 – 37.7)	37.4 (37.0 – 37.7)	0.643
SBP	136.5 (129.0 – 143.0)	137.0 (129.0 – 142.0)	135.0 (125.0 – 143.0)	0.758
DBP	82.0 (74.8 – 90.0)	82.0 (74.0 – 88.0)	82.0 (75.0 – 90.0)	0.516
Respiratory Rate	18.0 (16.0 – 20.0)	18.0 (16.0 – 20.0)	18.0 (16.0 – 22.0)	0.122
Heart Rate	84.0 (75.0 – 94.0)	84.0 (74.0 – 92.0)	85.0 (76.0 – 95.0)	0.039
PSo_2	91.0 (88.0 – 92.0)	91.0 (88.0 – 93.0)	91.0 (87.0 – 92.0)	0.286
LOC	23 (7.9)	13 (8.4)	10 (7.4)	0.758
Laboratory Findings				
Na (n=290)	139.0 (136.0 – 142.0)	139.0 (137.0 – 142.0)	138.0 (135.0 – 142.0)	0.243
K (n=289)	4.3 (3.8 – 5.4)	4.3 (3.7 – 5.4)	4.5 (3.8 – 5.4)	0.723
Mg (n=282)	2.4 (2.1 – 3.1)	2.4 (2.1 – 3.4)	2.4 (2.0 – 2.8)	0.132
White Blood Cells (n=289)	8.5 (7.5 – 10.0)	8.5 (7.5 – 10.0)	8.4 (7.5 – 10.0)	0.550
Neutrophils (n=262)	75.0 (71.2 – 81.2)	75.0 (69.8 – 81.0)	75.0 (73.0 – 81.4)	0.090*
Lymphocytes (n=281)	10.7 (9.0 – 15.6)	10.7 (9.0 – 16.2)	10.7 (8.5 – 15.0)	0.753
Monocytes (n=223)	10.2 (8.0 – 12.0)	10.2 (9.0 – 12.0)	10.2 (7.6 – 12.0)	0.229
Eosinophils (n=172)	2.0 (0.8 – 3.0)	2.0 (0.8 – 2.7)	2.0 (0.9 – 3.4)	0.316
Basophils (n=169)	0.9 (0.5 – 1.0)	0.9 (0.5 – 1.0)	0.9 (0.5 – 1.3)	0.400
Platelets (n=274)	200.5 (174.0 – 237.2)	198.0 (175.0 – 239.8)	201.0 (151.8 – 237.2)	0.517
Hemoglobin (n=267)	12.0 (11.0 – 13.1)	12.5 (11.7 – 13.1)	12.0 (10.7 – 13.1)	0.157
LDH (n=237)	489.0 (360.5 – 738.0)	428.0 (299.0 – 712.0)	552.0 (430.0 – 781.0)	<0.001
CPK (n=223)	129.0 (114.0 – 193.0)	124.0 (112.0 – 187.0)	134.0 (120.0 – 214.0)	0.182
BUN (n=250)	27.0 (25.0 – 34.0)	27.0 (25.0 – 34.0)	27.0 (25.0 – 34.0)	0.881
Creatinine (n=278)	1.0 (0.8 – 1.2)	0.9 (0.8 – 1.2)	1.0 (0.8 – 1.2)	0.552
AST (n=262)	31.0 (27.0 – 35.2)	31.0 (27.0 – 34.0)	31.0 (27.0 – 37.0)	0.323
ALT (n=256)	18.0 (16.0 – 19.0)	18.0 (17.0 – 19.0)	18.0 (16.0 – 19.0)	0.386
Glucose (n=276)	191.0 (154.8 – 223.2)	189.0 (145.5 – 220.8)	192.0 (171.0 – 234.0)	0.268
ESR (n=243)	28.0 (26.0 – 34.0)	28.0 (26.0 – 31.0)	31.0 (25.3 – 35.8)	0.028
PT (n=271)	12.0 (11.0 – 14.0)	12.0 (11.0 – 14.0)	12.0 (11.0 – 14.0)	0.549
PTT (n=263)	27.0 (24.0 – 29.0)	27.0 (25.0 – 29.0)	27.0 (24.0 – 28.0)	0.409
INR (n=251)	1.0 (1.0 – 1.0)	1.0 (1.0 – 1.0)	1.0 (1.0 – 1.0)	0.745
Troponin (n=29)	6.0 (0.7 – 29.6)	0.7 (0.1 – 21.8)	10.3 (4.1 – 34.0)	0.013
CRP (n=220)	21.0 (17.0 – 27.8)	22.0 (17.9 – 28.2)	20.6 (16.7 – 27.0)	0.086*
PH (n=282)	7.36 (7.35 – 7.42)	7.37 (7.35 – 7.42)	7.35 (7.32 – 7.42)	0.018
PaO_2 (n=282)	81.0 (72.0 – 84.0)	81.0 (72.0 – 84.0)	80.0 (67.0 – 84.0)	0.028
$PaCO_2$ (n=282)	42.0 (40.0 – 47.0)	42.0 (39.3 – 45.0)	43.5 (40.0 – 48.2)	0.046
HCO_3 (n=281)	23.0 (20.0 – 25.0)	23.0 (20.0 – 25.0)	22.7 (20.0 – 25.0)	0.359
O_2 Sat (n=290)	80.0 (74.0 – 87.0)	81.0 (78.0 – 87.0)	80.0 (71.0 – 87.0)	0.136
CT Chest				0.180
Unilateral left	169 (58.3)	97 (62.6)	72 (53.3)	
Unilateral right	115 (39.7)	54 (34.8)	61 (45.2)	
Bilateral	6 (2.1)	4 (2.6)	2 (1.5)	

Rh: Rhesus; **ARDS:** Acute respiratory distress syndrome; **SBP:** Systolic blood pressure; **DBP:** Diastolic blood pressure; **LOC:** Loss of consciousness.
Values are given as number (percentage) for categorical variables and as median (interquartile range) for continuous variables.
*Significant level was considered P <0.1.

Table 2. Relationships of clinical and demographic characteristics with in-hospital mortality

	Unadjusted analysis		Adjusted analysis	
	OR (95% CI)	**P**	**OR (95% CI)**	**P**
Age	1.02 (1.00 – 1.03)	0.042	1.01 (1.00 – 1.03)	0.103*
Female sex	1.43 (0.90 – 2.28)	0.132	1.45 (0.83 – 2.54)	0.190
Active smoking	0.77 (0.46 – 1.30)	0.328	0.73 (0.40 – 1.35)	0.322
Alcohol consumption	1.05 (0.31 – 3.51)	0.941	0.77 (0.20 – 3.03)	0.710
Blood Group				
A	1		1	
B	0.83 (0.39 – 1.76)	0.620	0.99 (0.42 – 2.33)	0.983
AB	0.95 (0.53 – 1.68)	0.847	0.89 (0.46 – 1.74)	0.742
O	0.93 (0.50 – 1.74)	0.816	0.77 (0.37 – 1.61)	0.482
Rh +	1.07 (0.67 – 1.70)	0.790	1.18 (0.67 – 2.07)	0.566
Respiratory Complication				
Pneumonia	1.39 (0.86 – 2.25)	0.185	1.20 (0.70 – 2.06)	0.519
ARDS	1		1	
Number of Symptoms	1.06 (0.91 – 1.24)	0.460	1.09 (0.90 – 1.30)	0.378
Number of Comorbidities				
0	1		1	
1	1.53 (0.52 – 4.46)	0.436	1.26 (0.41 – 3.88)	0.688
≥ 2	6.38 (2.26 – 17.98)	<0.001	5.88 (1.97 – 17.52)	0.001
Temperature	0.90 (0.60 – 1.35)	0.616	0.77 (0.47 – 1.25)	0.286
SBP	1.00 (0.98 – 1.01)	0.657	0.99 (0.97 – 1.01)	0.193
DBP	1.01 (0.98 – 1.03)	0.648	1.00 (0.98 – 1.03)	0.836
Respiratory Rate	1.08 (0.99 – 1.17)	0.068*	1.08 (0.99 – 1.19)	0.089*
Heart Rate	1.02 (1.01 – 1.04)	0.011	1.02 (1.00 – 1.04)	0.053*
PSo2	1.00 (0.99 – 1.01)	0.492	1.00 (0.99 – 1.01)	0.586
LOC	0.87 (0.37 – 2.06)	0.758	0.87 (0.31 – 2.43)	0.792
CT Chest				
Unilateral left	1		1	
Unilateral right	1.52 (0.94 – 2.45)	0.084*	1.66 (0.94 – 2.91)	0.078*
Bilateral	0.67 (0.12 – 3.78)	0.653	1.18 (0.15 – 9.09)	0.874

OR: Odds Ratio; **CI:** Confidence Interval; **ARDS:** Acute respiratory distress syndrome; **SBP:** Systolic blood pressure; **DBP:** Diastolic blood pressure; **LOC:** Loss of consciousness.
*Significant level was considered P <0.1.

Table 3. Respiratory support among critically ill patients with COVID-19

	Applying Respiratory Support Method				Duration of Respiratory Support Method			
	Total	**In-hospital mortality**		**P**	**Total**	**In-hospital mortality**		**P**
		Survived	**Deceased**			**Survived**	**Deceased**	
Nasal Cannula				0.850				
No	46 (15.9)	24 (15.5)	22 (16.3)					
Yes	244 (84.1)	131 (84.5)	113 (83.7)		3 (2 – 4)	3 (2 – 4)	2 (2 – 4)	<0.001
Face Mask				0.022				
No	235 (81.0)	118 (76.1)	117 (86.7)					
Yes	55 (19.0)	37 (23.9)	18 (13.3)		3 (2 – 3)	3 (2.5 – 6)	2 (2 – 3)	<0.001
A non-rebreather mask				<0.001				
No	239 (82.4)	116 (74.8)	123 (91.1)					
Yes	51 (17.6)	39 (25.2)	12 (8.9)		3 (2 – 4)	3 (2 – 4)	2 (2 – 3)	0.033
Venturi mask				0.188				
No	285 (98.3)	154 (99.4)	131 (97.0)					
Yes	5 (1.7)	1 (0.6)	4 (3.0)		2 (1 – 1)	-	2 (1.25 – 2)	-
Mechanical ventilation				-				
No	0 (0)	0 (0)	0 (0)					
Yes	290 (100)	155 (100)	135 (100)		5 (4 – 8)	5 (4 – 7)	6 (4 – 8)	0.019
CPAP				0.211				
No	195 (67.2)	99 (63.9)	96 (71.1)					
Yes	95 (32.8)	56 (36.1)	39 (28.9)		2 (2 – 4)	3 (2 – 5)	2 (2 – 3)	0.017
BIPAP				0.131				
No	234 (80.7)	120 (77.4)	114 (84.4)					
Yes	56 (19.3)	35 (22.6)	21 (15.6)		4 (3 – 6)	4 (3 – 6)	6 (3 – 7)	0.338
CMV				0.158				
No	265 (91.4)	145 (93.5)	120 (88.9)					
Yes	25 (8.6)	10 (6.5)	15 (11.1)		5 (2 – 7)	5 (2.75 – 7.5)	3 (2 – 7)	0.445
SIMV				0.004				
No	77 (26.6)	52 (33.5)	25 (18.5)					
Yes	213 (73.4)	103 (66.5)	110 (81.5)		5 (3 – 7)	4 (3 – 6)	5 (4 – 7)	0.001

CPAP: Continuous Positive Airway Pressure; **BIPAP:** Bilevel Positive Airway Pressure; **CMV:** Continuous Mandatory Ventilation; **SIMV:** Synchronized Intermittent Mandatory Ventilation. Values are given as number (percentage) for categorical variables and as median (interquartile range) for continuous variables.

DISCUSSION

The findings of the present study showed that 46.55% of critically ill COVID-19 patients in the ICU died. Patients with ≥2 comorbidities had significantly higher odds of death as compared with patients with no comorbidities. A higher respiratory and heart rate was also marginally associated with in-hospital mortality. A longer duration of different respiratory support methods such as face mask, a non-rebreather mask, and SIMV was associated with a greater risk of in-hospital mortality. Using SIMV mode in COVID-19 patients undergoing mechanical ventilation was associated with an increased risk of in-hospital mortality rate and adverse outcomes.

Consistent with the finding of our study, the results of a study in Italy (2) showed that the mortality rate of COVID-19 patients in ICU was 48.7%. In contrast, another study in Australia (1) found that the mortality rate of these patients in ICU was 22%. These discrepancies may be due to different methodologies employed by the different investigators, sample size, patient characteristics such as comorbidities, length of stay in the ICU, and type of respiratory support used for patients. In addition, improper implementation of invasive ventilation can be another cause of a higher mortality rate in this study. Previous evidence has shown that 70 to 90% of COVID-19 patients were on invasive mechanical ventilation within the first 24 hours of admission, which ultimately had a higher mortality rate (14-17). In contrast, a study in Australia found that 39% of patients received mechanical ventilation in the first 24 hours, which ultimately had lower mortality rates (1). A key point in COVID-19 patients is the longer duration of mechanical ventilation compared to previous studies in non-COVID-19 ARDS patients (18). This long period of mechanical ventilation, although not particularly effective in reducing patient mortality, imposes a heavy burden on the ICUs and the hospitals (19). A study in Egypt showed that the use of NIV with a predefined algorithm in COVID-19 patients with moderate-to-severe ARDS was successful in 77% of them (20). Also, another study in Egypt showed that NIV was associated with lower respiratory intervention mortality and morbidity than mechanical ventilation (21).

In this study, patients with ≥2 comorbidities had significantly increased odds of death as compared with patients with no comorbidities. In fact, multiple comorbidities are associated with poor progression in critically ill COVID-19 patients. Based on previous evidence, obesity, history of cardiovascular disease, hypertension, chronic obstructive pulmonary disease, and type 2 diabetes are significantly associated with poor prognosis and higher mortality among COVID-19 patients (22-25).

In the present study, a higher respiratory and heart rate was also marginally associated with an increased risk of in-hospital mortality. Consistent with this finding, a study in the United States (26) found that higher respiratory and heart rates were associated with higher mortality in COVID-19 patients. Also, another study emphasized the impact of abnormal vital signs (oxygen saturation, temperature, respiration rate, and heart rate) on increasing mortality among COVID-19 patients. Therefore, closed monitoring of COVID-19 patients' vital signs and early detection of their abnormality during hospitalization can enable healthcare providers to better treat and care for these patients (27).

As the present study showed, respiratory support methods such as face mask, a non-rebreather mask, and SIMV mode were associated with higher in-hospital mortality. A study in Italy (28) that evaluated the relationship between the use of non-invasive assisted ventilation techniques such as BPAP and CPAP and the mortality rate of 78 COVID-19 patients, showed that there was no significant difference in mortality rates in COVID-19 patients with ARDS who underwent non-invasive ventilation by BPAP and CPAP (mortality rate: 48% for CPAP and 52% for BPAP). A study in Turkey (29) showed a reduction in intubation and mortality if a high-flow nasal cannula (HFNC) was used in COVID-19 patients. In contrast, a systematic review and meta-analysis (30) showed that there was no difference in intubation and

mortality if HFNC was used in COVID-19 patients. In addition, determining the relationship between the types of respiratory support methods and mortality in COVID-19 patients seems a bit difficult due to the influence of various factors such as age, comorbidities, laboratory factors such as serum lactate dehydrogenase (LDH), C-reactive protein (CRP) and D-dimer on patient mortality (28, 31). In contrast, another study found that although the mortality rate of COVID-19 patients was high in both using invasive ventilation and NIV, the use of NIV such as CPAP can be associated with more favorable clinical outcomes for critically ill patients with COVID-19 (32).

Consistent with this finding, the results of the present study showed that the use of SIMV is associated with a higher mortality rate in COVID-19 patients. In the present study, the mortality rate of COVID-19 patients undergoing mechanical ventilation using SIMV mode was 81%. However, previous evidence showed that COVID-19 patients with SIMV-mode mechanical ventilation have a mortality rate of 86% to 97% (33-36). This discrepancy may be due to differences in the clinical status of patients, comorbidities, and the study population. However, further studies are needed to determine if the results would be consistent in a diverse COVID-19 patients' population.

Limitations

Many COVID-19 patients were not included in the study due to incomplete and non-electronic records.

CONCLUSION

Overall, the present study showed a high in-hospital mortality rate of COVID-19 patients that had undergone mechanical ventilation in the ICU. Also, special attention should be paid to COVID-19 patients with more than two comorbidities, who are at increased risk of complication and mortality. Longer duration of respiratory support by nasal cannula, face mask, a non-rebreather mask, mechanical ventilation, CPAP, and SIMV methods was associated with higher in-hospital mortality in these patients. Therefore, healthcare providers should pay special attention to these factors which can affect the in-hospital mortality of critically ill patients with COVID-19 to reduce their mortality.

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