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Effect of Caring of Critically Sick Patients with COVID-19 Pneumonia at Undesignated ICU Wards on Secondary Infections

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Abstract

Introduction: COVID-19 has caused high rates of mortality. During pandemic peak, a significant number of patients were admitted to undesignated ICU areas before transferring to designated ICU, owing to unavailability of ICU beds. We aimed to record the effect of care of critically sick patients with COVID-19 on prevalence of secondary bacterial infection. ***Methods:*** We retrospectively studied all critically ill patients with COVID-19 pneumonia meeting ICU admission criteria who were admitted to Dubai hospital between January 1, 2020, and June 30, 2020. All the patients who transferred to wards other than designated ICU constitute category as cases. All patients who directly admitted to the designated ICU ward from emergency department constitute controls. The demographics, clinical parameters, and treatment profile of these patients were recorded and compared. Prevalence of secondary bacterial infection was calculated. ***Results:*** Patients with COVID-19 had high prevalence of secondary bacterial infection. Patients who stayed at undesignated ICU wards had higher occurrence of inpatient fever, hypoxemia, and they were more likely to be sedated and paralyzed than patients who stayed in designated ICU wards. Multiple logistic regression analysis showed care outside designated ICU ward does not predict increase in secondary nonviral microbial infections. ***Conclusion:*** Care of patients at undesignated ICU wards prior to admission to designated ICU does not impact prevalence of secondary bacterial infection.

Introduction

The coronavirus disease 2019 (COVID-19) pandemic caused by severe acute respiratory syndrome coronavirus has recently caused high rates of morbidity and mortality worldwide [1]. At the start of pandemic from Wuhan China in 2020, hospitals were overwhelmed by the excessive number of critical patients requiring intensive care more than the available capacity of hospitals. Therefore, a significant number of patients stayed in emergency areas or transferred to general wards until an ICU bed become available [2]. Some of these areas were serviced by regis-

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Table 1. Sample characteristics (categorical variables)

	All patients (*N* = 239) (100%)	Designated ICU (*N* = 132) (54.5%)	Undesignated ICU (*N* = 107) (44.5%)	*p* value*
Clinical features				
Male, *n* (%)	208 (87.8)	117 (90)	91 (85)	0.247
Fever	216 (91.1)	118 (90.8)	98 (91.6)	0.825
Cough	190 (80.5)	105 (80.8)	85 (80.2)	0.911
Dyspnea	190 (80.5)	103 (79.8)	87 (81.3)	0.778
Gastric symptoms	28 (11.8)	19 (14.5)	9 (8.4)	0.147
Diabetes	102 (43)	52 (40)	50 (46.7)	0.298
Hypertension	59 (25)	31 (23.8)	28 (26.4)	0.650
CAD	16 (6.8)	9 (6.9)	7 (6.6)	0.935
Renal disease	29 (12.2)	18 (13.7)	11 (10.3)	0.417
Outpatient dialysis	16 (6.7)	6 (4.6)	10 (9.3)	0.144
Immunodeficiency	9 (3.8)	5 (3.8)	4 (3.7)	0.966
Clinical variables				
Inpatient fever	205 (86.5)	107 (82.3)	98 (91.6)	0.037
Tachycardia	187 (78.6)	100 (76.3)	87 (81.3)	0.352
Hypotension	119 (50)	62 (47.3)	57 (53.3)	0.362
Hypoxia	206 (86.6)	108 (82.4)	98 (91.6)	0.040
Mechanical vent	203 (85.3)	107 (81.7)	96 (89.7)	0.081
Vasopressers	188 (79)	100 (76.3)	88 (82.2)	0.266
CRRT	72 (30.3)	38 (29)	34 (31.8)	0.644
Secondary infection	106 (44.3)	59 (44.6)	47 (43.9)	0.905
Treatment				
Steroids	188 (79.3)	99 (76.2)	89 (83.2)	0.184
Tocilizumab	38 (16)	21 (16.2)	17 (15.9)	0.956
Sedatives	211 (88.7)	109 (83.2)	102 (95.3)	0.003
Narcotics	181 (76.7)	96 (73.8)	85 (80.2)	0.252
Paralytics	202 (84.9)	104 (79.4)	98 (91.6)	0.009
GI prophylaxis	228 (96.6)	125 (95.4)	103 (98.1)	0.259

CAD, coronary artery disease; CRRT, continuous renal replacement therapy. * χ^2 to compare categorical variables.

tered nurses not trained for ICU patients. Isolation of patients required negative pressure rooms in wards which were created progressively. Large number of hospitals created negative pressure rooms and ICU beds outside designated ICU areas. As a result, many critical patients were transferred among wards when a negative pressure room or ICU bed becomes available. Whenever these mechanically ventilated patients are being transferred, they require change of ventilator to mobile ventilator which may result in change in endotracheal tube or transfer of respiratory secretions within pulmonary system. These transfers may require temporary hold on dynamic monitoring equipment (clamping arterial line) which may affect chances for contamination and infection. Schwebel et al. [3] documented that patients with intrahospital transport are 1.9 times likely to develop a complication (atelectasis, Ventilator-associated pneumonia, hypoglycemia, or hyperglycemia). Sydney Braman also documented increase in complications from Intrahospital Transport in Critically III patients and also documented that these complications can be prevented [4]. Impact of these transfers is unknown for COVID-19 ARDS patients as such many patients' transfers are unprecedented. We aim to record occurrence of transfers and evaluate impact of these transfers on prevalence of secondary bacterial infection. Our primary aim was to observe impact of care at non-designated ICU wards on prevalence of secondary nonviral (bacterial and fungal) infections.

Methods

We retrospectively collected the data from electronic medical records of all critically ill patients with COVID-19 pneumonia meeting ICU admission criteria who were admitted to Dubai hos-

Table 2. Sample characteristics continuous variables

Continuous variables	Total (*N* = 239)		Designated ICU (*N* = 132)		Undesignated ICU (*N* = 107)		*p* value
	median	IQR	median	IQR	median	IQR	
Age, years	49	13	46.5	13	51.5	13	0.460
BMI, kg/m^2	27.6	6.17	27.3	5.2	28.1	6.36	0.127
Days to seroconversion	16	17	11	16	16	16	0.235
Ferritin, ng/mL	1,334	1,424	1,453	1,515	1,138	1,291	0.189
D-dimer, ng/mL	1.31	3.4	1.96	4.71	0.98	2.9	0.123
Procalcitonin, ng/mL	0.33	0.59	0.40	1.03	0.23	0.46	0.001
CRP, mg/L	131	121	142.5	108.7	122.2	141.4	0.096
Creatinine, mg/dL	0.9	0.35	0.9	0.45	0.9	0.32	0.182
CPK, units/L	231	616	354.5	660	239.5	518.3	0.407
ABG PH	7.39	0.13	7.36	0.13	7.39	0.16	0.021
PCo2 (Torr)	37.7	15.4	36.6	13.9	37.8	18.8	0.540
PO2 (Torr)	64	35.1	63.2	31.8	69.1	38	0.318
Lactate, mmol/L	1.7	1.1	1.7	0.9	1.7	1.2	0.312
Bicarbonate, mEq/L	22.2	5.3	22.2	4.3	22.7	6	0.025
Magnesium, mg/dL	2.05	0.36	2.04	0.5	2.06	0.32	0.815
Platelets, 10^3/mL	201	111	189	114	205	106	0.820
Days on Mech. Vent.	16	19	11	14	18	19	0.001
LOSICU, days	19	22	15	14	21.5	19	0.001
LOSH, days	29	29	21	26	32	28	0.001
APACHE-2 scores	15	7	17	9	15	7	0.093

BMI, body mass index; CRP, C-reactive protein; CPK, creatine phosphokinase.

pital between January 1, 2020, and June 30, 2020. All the patients who transferred to wards other than medical intensive care unit (MICU) or surgical intensive care unit (SICU) constitute the cases as they were taken care at non-designated ICU areas. All other patients who transferred to MICU or SICU directly from emergency department without going to any other ward constitute controls. Primary variable of interest was prevalence of infection therefore all culture results of sputum, blood, pleural or peritoneal fluid, or pneumonia panel were recorded to calculate prevalence of secondary bacterial infection.

Record of confounding variables include the demographics recorded were as follows: age, gender, body mass index, clinical parameters recorded, number of days of symptoms, and presence of symptoms, such as cough, fever, dyspnea, and gastric complaints on admission. Data on comorbidities includes diabetes, hypertension, coronary artery disease, renal failure, and outpatient dialysis. Inpatient clinical data on admission including fever, tachycardia, blood pressure, hypoxia, use of oxygen (L/min), mechanical ventilation, use of pressers, and inpatient dialysis. Laboratory parameters includes disease activity markers or inflammatory markers (C reactive protein, ferritin, and procalcitonin levels), hematologic indices (WBC and platelet counts), and chemistries (electrolyte levels). We calculated APACHE-2 scores within 24 h of admission to assess the severity of illness.

Statistical Analysis

Sample characteristics were compared between the group of patients who went to non-ICU wards before reaching MICU or SICU for administrative reasons (lack of available bed in MICU or SICU) and the group that admitted directly to the designated ICU (MICU or SICU). χ^2 tests were performed for categorical variables and Mann-Whitney U test for continuous variables as data were found to be not normally distributed. Infection prevalence rates were calculated and compared between cases and controls.

We performed univariate logistic regression analysis to determine the variables significant as predictor of secondary bacterial infection. A *p* value of 0.05 was considered significant. All analyses were performed with SPSS version 27 (IBM Corp., Armonk, NY, USA).

Results

The characteristics of total sample and 2 groups (admitted to undesignated ICU wards [cases] and direct transfer to designated ICU bed [controls]) are shown in Table 1 for categorical variables and in Table 2 for continuous variables. Both groups were similar in outpatient clinical characteristics. Patients cared at undesignated ICU had higher proportions of fever on admission (91% vs. 82%, $p = 0.037$) and higher proportion of hypoxia (91% vs. 82%, $p = 0.04$). They also had higher proportion of use of sedative (95% vs. 83%, $p = 0.003$) and paralytics

Table 3. Organism in positive cultures

Organism	Blood		Sputum		Urine	
	sensitive	resistant	sensitive	resistant	sensitive	resistant
Achromobacter xylosoxidans	1		1			
Acinetobacter	6		1			
Aspergillus niger			1			
Candida species	18		38		24	
Citrobacter koseri			1			
Elizabethkingia anophelis			1			
Enterobacter	1					2
Enterococcus faecalis/faecium	16		3		8	
Escherichia coli	2	9	2	2		12
Geotrichum capitatum	1		1			
Klebsiella oxytoca	1		2			
Klebsiella aerugenes			1	1		
Klebsiella pneumoniae	4	6	12	3	9	1
Leuconostoc lactis	2					
Methylobacterium	3					
Morganella morganii	1	1	1	1		
Providencia rettgeri			1			
Pseudomonas aeruginosa	7	2	13	3	5	
Serratia marcescens	1	1	2			
Staphylococcus epidermidis					1	
Staphylococcus aureus	5	6	8	6		1
Staphylococcus capitis	4					
Staphylococcus epidermidis	5					
Staphylococcus haemolyticus	5		1			
Staphylococcus hominis	12					
Stenotrophomonas maltophilia			7			
Stenotrophomonas	8					
Streptococcus constellatus	1					
Streptococcus maltophilia			1			
Streptococcus pyogenes	1					

(91% vs. 79%, $p = 0.009$). Patients with care at undesignated ICU had more days on MV (median [IQR]) (18 [19] vs. 15 [14], $p = 0.001$), LOSICU (21.5 [19] vs. 15 [14], $p = 0.001$), and LOSH (32 [28] vs. 21 [26], $p = 0.001$) but similar prevalence of secondary bacterial infection (43% vs. 44%, $p = 0.905$). Length of stay at the undesignated area was median of 7 days with an IQR of 1–15.5 days. Details of the organisms on positive culture results in blood, sputum, and urine is provided in Table 3.

Discussion

COVID-19 pandemic exhausted the healthcare systems worldwide. Shortage of healthcare facilities in general and ICU beds particularly [5] produced high amount of stress on the systems and healthcare workers. World responded with great responsiveness with novel solutions [6, 7]. Negative pressure rooms were created throughout hospitals on urgent basis. Temporary hospitals (makeshift/tents) were also created to provide critical care [8]. Concept of rationing was developed to ensure the fair allocation of scarce resources [8]. Hence, the concern was obvious if care provided under these unprecedented conditions was associated with any increase in secondary nonviral secondary bacterial or fungal infections.

We found that care at non-designated ICU wards did not increase prevalence of secondary nonviral secondary bacterial or fungal infections. Prior studies have showed frequency of hospital-acquired infections in patients with COVID-19 ranging from 10 to 45% [9–11]. Ventilator-associated pneumonia has already been reported as a well-known complication in COVID-19-hospitalized patients [12, 13]. The incidence rate of blood stream infec-

tions (BSI) is high, and the cumulative risk of developing BSI increased with ICU stay [14]. Catheter-related blood stream infections are significantly more frequent in COVID-19 patients [15]. Critically ill patients with COVID-19 are at high risk for hospital-acquired infections, especially ventilator-associated pneumonia and BSIs resulting from multidrug resistant (MDR) organisms.

We found similar rates of infections in cases and controls, but secondary infections were associated with longer stay in hospital, ICU, and on ventilator. Similar results were documented by others with observation of increased mortality in patients with septic shock [16]. Some reported that ICUs were overwhelmed by an unexpected number of critically ill patients and personnel from different wards had to be recruited for ICU. They attributed high incidence of infections resulting from MDR germs may be from suboptimal adherence to the standard infection control practices [16]. In addition, infections by MDR bacteria may have been favored by the selective pressure of antibiotic therapies [16]. To our knowledge, no study has studied the impact of caring for these patients at non-designated ICU wards. Therefore, our results are reassuring that it does not adversely affect prevalence of secondary nonviral infections.

We identified the following limitations of our study: it was a single-center, retrospective study with a small sample size. The population was predominantly young male from the United Arab Emirates. Hence, it may be improper to generalize and extrapolate the study findings to the worldwide population. We did not record the nurse-to-patient ratio for both clinical settings. Antibiotic strategy and medical treatment were under physician directions and not uniform. Study design does not allow a comparison between the cohorts of patients with COVID-19 with that of patients with ARDS of a different cause, so our results are only applicable to COVID-19 patients. Nonetheless, this was the first step to document and reassure that care outside designated proper ICU areas did not increase secondary nonviral infections.

Conclusion

Care of COVID-19 ARDS patients outside designated ICU areas does not seem to affect prevalence of secondary bacterial or fungal infection.

Statement of Ethics

This research is done and complies with the guidelines of human subjects of Helsinki Declaration. Ethical approval was provided by DSREC-05/2021_18/approved on June 10, 2021. Patients visiting Dubai Health Authority Clinics are signing General Information Consent in SALAMA System to use their de-identified data in education and research purposes.

Conflict of Interest Statement

No conflicts of interest to declare.

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Author Contributions

R.N. conceived the research idea, contributed to proposal writing, data collection, data analysis, and manuscript writing. M.Z. and A.S. conceived the idea, contributed to proposal writing, and reviewed the final manuscript. A.H., R.H.A.S., K.K., S.K., I.B., A.M., and I.B. contributed to idea conception and data collection.

Data Availability Statement

The data that support the findings of this study are not publicly available due to privacy and security reasons but are available from the corresponding author upon reasonable request.

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