Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

European Journal of Internal Medicine 100 (2022) 127–129

Contents lists available at ScienceDirect

European Journal of Internal Medicine

journal homepage: www.elsevier.com/locate/ejim

Double-gloving in an Intensive Care Unit during the COVID-19 pandemic

ARTICLE INFO

Keywords
Double-gloving
COVID-19
Intensive Care Unit

Dear Editor,

Coronavirus infectious disease 2019 (COVID-19) pandemic caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) presents a significant challenge for healthcare personnel (HCP). The main route of exposure to SARS-CoV-2 is through large respiratory droplet particles. Another accepted mode of transmission is through inhaling aerosols. SARS-CoV-2 remains viable for many days on smooth surfaces and at lower temperature and humidity (e.g., air-conditioned environment). Transmission of infection through contaminated surfaces to the mucosa of eyes, nose, or mouth via unwashed hands is a possible route of transmission [1].

HCP treating patients with COVID-19 are at increased risk of infection themselves. Personal protective equipment (PPE) is used to shield HCP from droplets, aerosols and contaminated surfaces. Contamination of HCP skin and clothing occurs frequently during removal of contaminated gloves or gowns [2]. Transfer of viruses to hands during PPE removal is significantly more frequent with single gloving than with double-gloving [3]. Additionally, high levels of anxiety among HCP caring directly for COVID-19 patients may be reduced by double-gloving. The Infectious Diseases Society of America guidelines on infection prevention for HCP caring for patients with suspected or known COVID-19 state further studies are needed to compare different glove doffing strategies to prevent infection in HCP performing usual care on COVID-19 patients [4]. We aim to share our positive experience of HCP using double gloves in a COVID-19 Intensive Care Unit (ICU).

We conducted an observational study at Soroka University Medical Center, a 1100-bed tertiary medical center in southern Israel. The study cohort included all severe and critical patients admitted to the COVID-19 ICU from July 2020 through April 2021. Data from patients' medical records were collected. Clinical and laboratory parameters on ICU-admission, mechanical ventilation, insertion of a urinary catheter, central venous catheter and nasogastric feeding tube were identified. Bacteriology data, antibiotic therapy, length of ICU stay, and in-ICU mortality rate were included. Active surveillance for Carbapenemase-resistant *Enterobacteriaceae* (CRE) colonization (rectal culture) and *Acinetobacter baummanii* colonization (skin and tracheal aspirate cultures) was implemented on patient admission into the unit and twice weekly throughout their ICU stay.

The COVID-19 ICU abided by local hospital guidelines for PPE while treating SARS-CoV-2 positive patients with severe COVID-19, in accordance with the Centers for Disease Control and Prevention recommendations. Additionally, HCP wore a second pair of gloves when treating patients, the first pair of gloves was not removed while the HCP were inside the COVID-19 ICU. Hand hygiene was performed on the first pair of gloves, acting as the workers' skin using propyl-alcohol 70% and chlorhexidine gluconate 0.5% (Septol, Vitamed Pharmaceutical Industries, Israel) for a minimum of 10 s10 seconds according with the 5 moments of hand hygiene recommendations. PPE removal sequence began with removal of the outer glove, followed by hand hygiene on the inner glove, then removal of face shield, gown, N95 respirator, and finishing with removal of the inner glove followed by hand hygiene (on bare skin), avoiding handling of PPE with ungloved hands.

Microbiology analysis of active surveillance and clinical specimens was performed according to routine bacteriological procedures. Multidrug-resistant bacterial isolates were subject to whole genome sequencing using Illumina short read sequencing after DNA extraction and library preparation using the Nextera FLEX protocol (Illumina, Sparks, MD, USA).

During the study period, 163 patients, aged (mean ± SD) 58.0 0 ± ± 17.1 y/o, were admitted to the COVID-19 ICU; 65% were male. The most frequent patient comorbidities included: hypertension 76 (46.6%), obesity (BMI ≥ 30) 63 (38.6%) and smoking 33 (20.2%). The main reason for ICU admission was respiratory failure (93%). During their ICU-hospitalization, most patients were treated with mechanical ventilation (76.1%), had a urinary catheter (90%), a central venous catheter (86.5%), and a nasogastric feeding tube (75.5%). 23 patients (14.1%) required extracorporeal membrane oxygenation. Length of stay (median, inter-quartile range) in the COVID-19 ICU was 13, 5–23 days. Of the 163 patients, 83 (50.9%) died in the COVID-19 ICU, 44 (27%) were transferred to a COVID-19 step-down unit, 23 (14.1%) to an internal medicine department, and 13 (8%) to a respiratory ICU. Patients in the last two groups became SARS-CoV-2 PCR negative and did not require further airborne isolation conditions.

Bacteriology culture results are presented in Table 1. We had no nosocomial infection outbreaks in our COVID-19 ICU. Only few multidrug-resistant bacterial isolates were isolated from blood cultures, including: eight Enterobacteriaceae extended-spectrum beta-lactamase (ESBL) producer isolates, and two carbapenem-resistant *Acinetobacter*

https://doi.org/10.1016/j.ejim.2022.02.005
Received 30 January 2022; Accepted 3 February 2022
Available online 14 February 2022

Table 1
COVID-19 ICU patients laboratory culture results.

Variable N (%)			Blood culture$n = 149$	Urine culture $n = 141$	Sputum culture $n = 122$	CRE screening culture $n = 150$	Acinetobacter screening culture $n = 149$
No growth			93 (66.4)	63 (44.7)	40 (32.8)		
Coagulase-negative *Staphylococci*			25 (17.9)	6 (4.3)	1 (0.7)		
Staphylococcus aureus		Methicillin sensitive	4 (2.9)	1 (0.7)	17 (13.9)		
		Methicillin resistant	1 (0.7)	1 (0.7)	2 (1.6)		
Streptococcus sp.			3 (2.1)	2 (1.4)	8 (6.6)		
Enterococcus faecalis			3 (2.1)	21 (14.9)	0		
Enterobacteriaceae	sensitive		8 (4.9)	24 (17)	29 (23.8)		
	ESBL		8 (4.9)	11 (7.8)	17 (13.9)		
	CRE	CP	0	1 (0.7)	0	3 (2)	
		Non-CP	0	0	0	13 (8.7)	
Pseudomonas aeruginosa			3 (2.1)	11 (7.8)	18 (14.8)		
Stenotrophomonas malophilia			2 (1.4)	0	8 (6.6)		
Acinetobacter baumanii	sensitive		1 (0.7)	0	6 (4.9)		3 (2)
	Carbapenem resistant		2 (1.4)	0	2 (1.6)		3 (2)
Candida sp.			2 (1.4)	41 (29.1)	20 (16.4)		

baumanii (CRAB) isolates. Whole genome sequencing demonstrated that the two CRAB isolated were phylogenetically closely related, and two out of three *Klebsiella pneumonia* ESBL-producer isolates analyzed belonged to the same clone (ST147) while the third belonged to a different clone (ST147). There were no cases of carbapenemase-producing (CP) or non-CP CRE bacteremia or vancomycin-resistant *Enterococcal* (VRE) bacteremia. Central-line associated bloodstream infection (CLABSI) rate in our COVID-19 ICU during the study period was zero, and the incidence rate of non-CLABSI was 16.5 per 1000 patient-days was. The ventilator-associated pneumonia rate was 8.87 per 1000 ventilation days. Of 80 HCP working in the COVID-19 ICU, five (6.3%) tested positive for SARS-CoV-2 PCR; four of these were infected from household-contacts according to our epidemiological investigations.

The COVID-19 pandemic provoked a significant increase of anxiety and fear amongst front-line HCP with close contact with infected patients, including those working in ICUs. Several factors contribute to HCP expansion of psychological pressure including working in the isolation wards, concern about being infected, and shortage of PPE [5]. Martin et al. found a greater overall infection rate of 12.6% among staff working in units that were highly exposed to COVID-19 during a period of six-months, through infection rate among COVID-19 ICU staff was only 6% [6]. In our study we show similar results, 6.3% of our COVID-19 ICU HCP tested positive for SARS-CoV-2 PCR during the 10-month study period; however, only one worker seems to have become infected in the ICU.

A significant and critical issue in treating these severely ill patients is prevention of cross-infection and acquisition of nosocomial infections. Several outbreaks of multidrug-resistant organism have been described in ICUs dedicated to COVID-19 patients, including NDM-1-producing *Klebsiella pneumonia* [7], VRE [8], and multidrug-resistant *Acinetobacter baumannii* [9]. One of the main measures to prevent these outbreaks remains compliance with hand hygiene. In our COVID-19 ICU, we had no CPE, VRE or CRAB outbreaks while double-gloving was used by all HCP in the unit.

A Study by Giacobbe et al., documented an incidence rate of 47-acquired bloodstream infections per 1000 patient-days in critically ill patients with COVID-19 in two ICUs in Northern Italy, 73% corresponding to primary bacteremias and catheter-related bacteremia [10]. In our study, there was an incidence rate of 16.5 bloodstream infections per 1000 patient-days in the COVID-19 ICU, and no cases of CLABSI.

Hand hygiene rate in our ICU during 2017 through 2019, prior to the COVID-19 pandemic, measured according to 1000–1200 opportunities observed per year, was 76%, 79.3% and 75%, respectively. During the pandemic, hand hygiene was only partially followed due to technical difficulties as an observer could not enter the unit and cameras installed inside the unit allowed for a limited observation of hand hygiene opportunities (measured according to the World Health Organization five moments of hand hygiene).

We conclude that in this ongoing challenging era of SARS-CoV-2 pandemic, double-gloving together with PPE, as in our study, appears to offer increased protection to front-line medical staff. We would stress that double-gloving should not be implemented in routine ICU tasks. However, in COVID-19 ICUs this practice could be implemented together with a strict active bacteriological surveillance without the risk of increasing cross-transmission into the unit.

Financial support

All authors report no financial support.

Conflict of interest

All authors declare they have no conflict of interest.

Acknowledgments

The study team acknowledges with gratitude the hard work and commitment of the entire COVID-19 ICU staff throughout this difficult and challenging period.

Appendix

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