

Determination of Appropriate Personal Protective Equipment for Management of Patients With COVID-19

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Short report

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Abstract

Objectives

Few studies have investigated the contamination of personal protective equipment (PPE) during the management of patients with severe to critical coronavirus disease (COVID-19). This study aimed to determine the necessity of coveralls and foot cover for body protection during the management of patients with COVID-19.

Methods

PPE samples were collected from physicians exiting a room after the management of a patient with severe to critical COVID-19 who was within 14 days after symptom onset. The PPE sites were categorized into coverall-only parts (the frontal surface of the head, anterior neck, dorsal surface of the foot cover, and back and hip) and gown-covered parts (the anterior side of the forearm and the abdomen). Environmental sampling was performed in patient rooms. We tried to identify significant differences in contamination with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) between the coverall-only and gown-covered parts.

Results

A total of 105 swabs from PPE and 28 swabs from patient rooms were collected. Of the PPE swabs, only three (2.8 %) swabs from gown-covered parts were contaminated by SARS-CoV-2. However, 23 of the total 28 sites (82.1%) from patient rooms were contaminated. There was significant difference in the contamination of PPE between coverall-only and gown-covered parts (0.0 vs 6.7%, $p = 0.022$).

Conclusions

Coverall contamination rarely occurred while managing severe to critical COVID-19 patients residing in negative pressure rooms in the early stages of the illness. Long-sleeved gowns may be used safely in the management of COVID-19 patients.

Introduction

The World Health Organization (WHO) recommends the rational use of personal protective equipment (PPE) according to the setting, personnel, and type of activity, because of the recent global shortage of PPE [1]. The WHO recommends the use of medical masks, goggles or facial shields, gowns, and gloves when providing direct care to patients with coronavirus disease (COVID-19) in the absence of aerosol generating procedures (AGPs) [1]. However, discrepancy was observed between international and local guidelines with regards to the social circumstances [2]. Initially, the Korea Centers for Disease Control and Prevention recommended the use of coveralls and foot covers for body protection, but after several updates, it is recommended to use either a coverall or a water-resistant long-sleeves gown during the management of patients with COVID-19 [2]. Although recent evidence suggests that the transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) through contact with fomite is rare [3, 4], there are still concerns about viral contamination; thus, many hospitals in Korea still use coveralls with foot covers rather than gowns for body protection while managing patients with COVID-19 [5].

The research indicates that the PPE of healthcare workers is not contaminated extensively in the management of patients with COVID-19 [6–11], but few studies have investigated the contamination of PPE during the management of patients with severe to critical COVID-19. Therefore, we conducted this pilot study to determine the necessity of coveralls for body protection during the management of patients with severe to critical COVID-19 in the early stages of the illness.

Methods

Study design and patients

This study was conducted in an academic medical center in the Republic of Korea. All patients involved this study were managed in isolated negative pressure rooms. The ventilation rate in the negative pressure room was 20 air changes per hour. Routine room cleaning and disinfection of high contact areas around patient environment were performed daily using sodium hypochlorite.

Between February 17 and April 19, 2021, patients with severe to critical COVID-19 who were within 14 days after symptom onset were included. If supplementary oxygen was required in patients with radiologic pneumonia, they were classified as having severe disease, and

patients with severe oxygenation impairment ($\text{PaO}_2/\text{FiO}_2$ of ≤ 300) were classified as having critical disease according to the WHO classification [12].

Sample and data collection and analysis

PPE samples were acquired from seven sites of 15 physicians exiting from nine patient rooms. The sampled sites comprised the frontal surface of the head, anterior neck, anterior side of forearm, abdomen, dorsal surface of the foot cover, and back and hip (Fig. 1). To assess environmental contamination, we acquired samples from seven sites of four patient rooms. The environmental sampling sites were the bed linen around the patient's head, bed controller, both side rails, remote control for the television, call-button, and bed-side table (Fig. 2). Pre-moistened sterile swabs were used to collect samples in 20×20 cm areas. Real-time reverse transcriptase-polymerase chain reaction (RT-PCR) targeting E, S, RdRP/S genes was used to detect SARS-CoV-2 (Allplex™ SARS-COV-2 Assay, Seegene Inc.) [13]. Clinical data (day of illness, symptoms, disease severity, RT-PCR results of respiratory specimens) were collected. Activities and spending time of physicians in the patient room were recorded.

Coveralls cover the whole body including the head, lower legs, and back side of the body, but long-sleeved gowns do not cover the head and lower legs, and protection of the back side is compromised because of the open back design. To identify the necessity of coveralls for body protection, the PPE sites were classified into coverall-only parts (the frontal surface of the head, anterior neck, dorsal surface of the foot cover, and back and hip) and gown-covered parts (the anterior side of the forearm and the abdomen) (Fig. 1). Fisher's exact test was used to identify differences in contamination between the two parts. A p-value of < 0.05 was considered statistically significant.

Results

A total of 105 swabs from PPE and 28 swabs from the environment were collected. The median of sampling days from symptom onset was 9 days (range 2–12 days). The median of sampling days from admission was 3 days (range 1–7 days). The median contact time with patients was 20 min (range 10–30 min). Activities commonly performed by physicians in the patient room were general care, physical examination, and acquisitions of respiratory samples. AGPs such as intubation, suctioning of airway, or nebulizer therapy were performed in five cases. Of the PPE swabs, only three (two from the abdomen and one from the forearm) were contaminated by SARS-CoV-2. All swabs from the coverall-only parts were negative. There was a significant difference in the contamination of PPE between the coverall-only and gown-covered parts (0.0 vs 6.7%, $p = 0.022$). The detailed clinical information regarding the included patients and contamination of PPE are shown in Table 1. Of the environment swabs, 20 of the total 28 sites (82.1%) were contaminated. The detailed contamination sites and cycle threshold of the environment are presented in Table 2.

Table 1

Clinical characteristics of included patients and contamination of personal protective equipment according to the type of activity and contact time

PPE	Patient	Type of oxygen delivery	PF ratio	Sampling days from admission	Sampling days from symptom onset	Type of activity	Aerosol generating procedures	Contact time (min)	Ct value of respiratory samples	Sites of PPE contamination (Genes, Ct value)
1	A	HFNC	73	5	10	Examination, general care	No	20	22.52	ND
2	B	HFNC	125	3	11	Examination, general care	No	10	20.13	ND
3	A	HFNC	73	6	11	Examination, general care, acquisition of nasopharyngeal and lower respiratory sample	No	10	26.54	ND
4	A	MV	72	7	12	Examination, intubation, acquisition of nasopharyngeal and lower respiratory sample, suctioning of airway	Yes (intubation, suctioning of airway)	20	26.54	ND
5	C	HFNC	94	1	9	Examination, general care, acquisition of nasopharyngeal and lower respiratory sample	No	30	19.65	ND
6	C	HFNC	94	1	9	Examination, general care	No	30	19.65	ND
7	C	HFNC	69	2	10	Examination, general care	No	15	15.56	Abdomen (RdRP/S 38.62, E 38.17, N ND)
8	D	NP	243	2	2	Examination, general care, suctioning of airway	Yes (suctioning of airway)	15	13.88	ND
9	C	MV	92	3	11	Examination, general care, acquisition of nasopharyngeal and lower respiratory sample, suctioning of airway	Yes (suctioning of airway)	20	22.19	Forearm (RdRP/S ND, E 37.91, N ND)

PPE, personal protective equipment; PF ratio, the ratio of arterial oxygen partial pressure to fractional inspired oxygen; Ct, cycle threshold; HFNC, high flow nasal canula; MV, mechanical ventilation; ND, not detected

PPE	Patient	Type of oxygen delivery	PF ratio	Sampling days from admission	Sampling days from symptom onset	Type of activity	Aerosol generating procedures	Contact time (min)	Ct value of respiratory samples	Sites of PPE contamination (Genes, Ct value)
10	D	HFNC	73	7	7	Examination, general care, acquisition of nasopharyngeal and lower respiratory sample, suctioning of airway	Yes (suctioning of airway)	20	24.23	ND
11	F	HFNC	75	3	6	Examination, general care, acquisition of nasopharyngeal and lower respiratory sample	No	30	22.63	ND
12	G	HFNC	150	2	5	Examination, general care, acquisition of nasopharyngeal and lower respiratory sample	No	20	16.87	ND
13	G	HFNC	113	5	8	Examination, general care, acquisition of nasopharyngeal and lower respiratory sample, nebulizer	Yes (nebulizer)	20	22.09	ND
14	H	HFNC	108	5	10	Examination, general care, acquisition of nasopharyngeal and lower respiratory sample	No	20	19.10	ND
15	I	HFNC	110	2	8	Examination, general care, acquisition of nasopharyngeal and lower respiratory sample	No	30	21.43	Abdomen (RdRP/S 37.91, E ND, N ND)
PPE, personal protective equipment; PF ratio, the ratio of arterial oxygen partial pressure to fractional inspired oxygen; Ct, cycle threshold; HFNC, high flow nasal canula; MV, mechanical ventilation; ND, not detected										

Table 2
Severe acute respiratory syndrome coronavirus 2 contamination of the environment

Patient	Sampling days from admission	Sampling days from symptom onset	Environmental contamination (Ct value)						
			Bed linen	Bed controller	Bedrail, right	Bedrail, left	Remote control	Call button	Bedside table
F	3	6	ND	E (33.87) RdRP/S (34.19) N (32.09)	E (38.15) RdRP/S (38.05)	ND	ND	E (38.06) RdRP/S (38.64)	E (38.30) RdRP/S (39.03)
					N (38.11)			N (37.90)	N (ND)
G	2	5	E (35.50) RdRP/S (36.60) N (35.02)	E (37.59) RdRP/S (37.75) N (35.01)	E (35.15) RdRP/S (35.17) N (33.64)	E (34.94) RdRP/S (37.61) N (35.60)	E (33.38) RdRP/S (35.19) N (33.22)	E (33.82) RdRP/S (34.37) N (34.08)	E (37.94) RdRP/S (ND) N (37.17)
H	5	10	E (31.25) RdRP/S (31.40) N (32.23)	E (35.31) RdRP/S (35.14) N (34.32)	E (36.80) RdRP/S (37.99) N (36.70)	E (36.99) RdRP/S (35.71) N (37.03)	E (36.26) RdRP/S (35.64) N (37.50)	ND	E (35.70) RdRP/S (35.66) N (36.29)
I	2	8	E (38.22) RdRP/S (36.64) N (ND)	E (35.99) RdRP/S (37.55) N (35.36)	E (35.84) RdRP/S (36.17) N (37.11)	E (35.73) RdRP/S (36.93) N (36.34)	E (34.36) RdRP/S (35.84) N (33.85)	E (34.59) RdRP/S (34.01) N (35.79)	ND
Ct, cycle threshold; ND, not detected									

Discussion

This study aimed to determine the necessity of coveralls for body protection during the management of patients with severe to critical COVID-19 in the early stages of the illness. Our results revealed that coverall contamination rarely occurred during the management of patients with severe to critical COVID-19 in the early stages of the illness, although environmental contamination was common. In particular, the coverall-only parts were not contaminated.

In previous studies, PPE contamination was not observed during the management of asymptomatic or mild COVID-19 patients [8–10]. In some studies [6, 7, 11], some parts of the PPE, even on the top of the head or foot covers, were contaminated during the routine care of patients over an extended period (4 h) [7], but most parts of the PPE were not contaminated, and the viability of virus was not confirmed.

Donning coveralls requires more time than donning long-sleeve gowns, which makes it difficult to respond to emergency situations. Further, because coveralls cover the whole body, they can induce heat stress more easily than gowns, causing dehydration and exhaustion, which may influence performance [14]. In addition, coveralls are not familiar to healthcare workers and contamination occurs frequently during the doffing process, meaning regular training is required [15, 16]. Inadequate and overuse of PPE shown in mass media can cause excess fear in the general public, leading to social issues such as mental health problems and stigma [17–19]. Considering the disadvantages of coveralls and global shortage of PPE, protective clothing should be reasonably used according to the risk of contamination.

Because contamination of PPE, particularly the coverall-only parts, rarely occurred during the short-term management of COVID-19 patients regardless of disease severity, it can be expected that long-sleeved gowns could provide sufficient protection from SARS-CoV-2 contamination. Recent evidence suggests that the dominant route of viral transmission is via the respiratory tract by droplet or aerosol and that transmission through contact with fomite is rare [3, 4, 20]; therefore, the use of long-sleeved gowns in conjunction with hand hygiene and routine cleaning and disinfection of the hospital environment may protect healthcare workers from SARS-CoV-2 infection during the management of patients with COVID-19.

This study has some limitations. First, although we acquired samples from PPE in various situations including AGPs, the sample size was relatively small, and these results cannot be extrapolated to the case of managing patients at high risk of airborne transmission. Second, as this study was conducted only in isolated negative pressure rooms with high ventilation rates, further study is needed to identify contamination of PPE when managing patients admitted to general wards without negative pressure.

Conclusion

In the present study, we found that coverall contamination rarely occurred while managing severe to critical COVID-19 patients admitted to negative pressure rooms in the early stages of the illness. Long-sleeved gowns may be used safely when managing COVID-19 patients.

List Of Abbreviations

World Health Organization (WHO), personal protective equipment (PPE), coronavirus disease (COVID-19), aerosol generating procedures (AGPs), severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), reverse transcriptase-polymerase chain reaction (RT-PCR)

Declarations

Ethics approval and consent to participate

The study was approved by the institutional review board (IRB) of Seoul National University Bundang Hospital (B-2006/619–105). The requirement for informed consent was waived by IRB.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the study are available from the corresponding author on reasonable request.

Competing interests

There are no conflicts of interest to declare.

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Author's contributions

Conceptualization, Methodology, Writing – original draft, Investigation, Data curation, Formal analysis: J.J, K.H.S, H.J.J, H.S.Y. Acquisition of swab samples: J.J, H.J.J, H.S.Y. Data interpretation, Writing – review & editing: H.J.J, H.S.Y., E.S.K, H.B.K., K.H.S. All authors have provided final approval for the final version of the manuscript.

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Figures

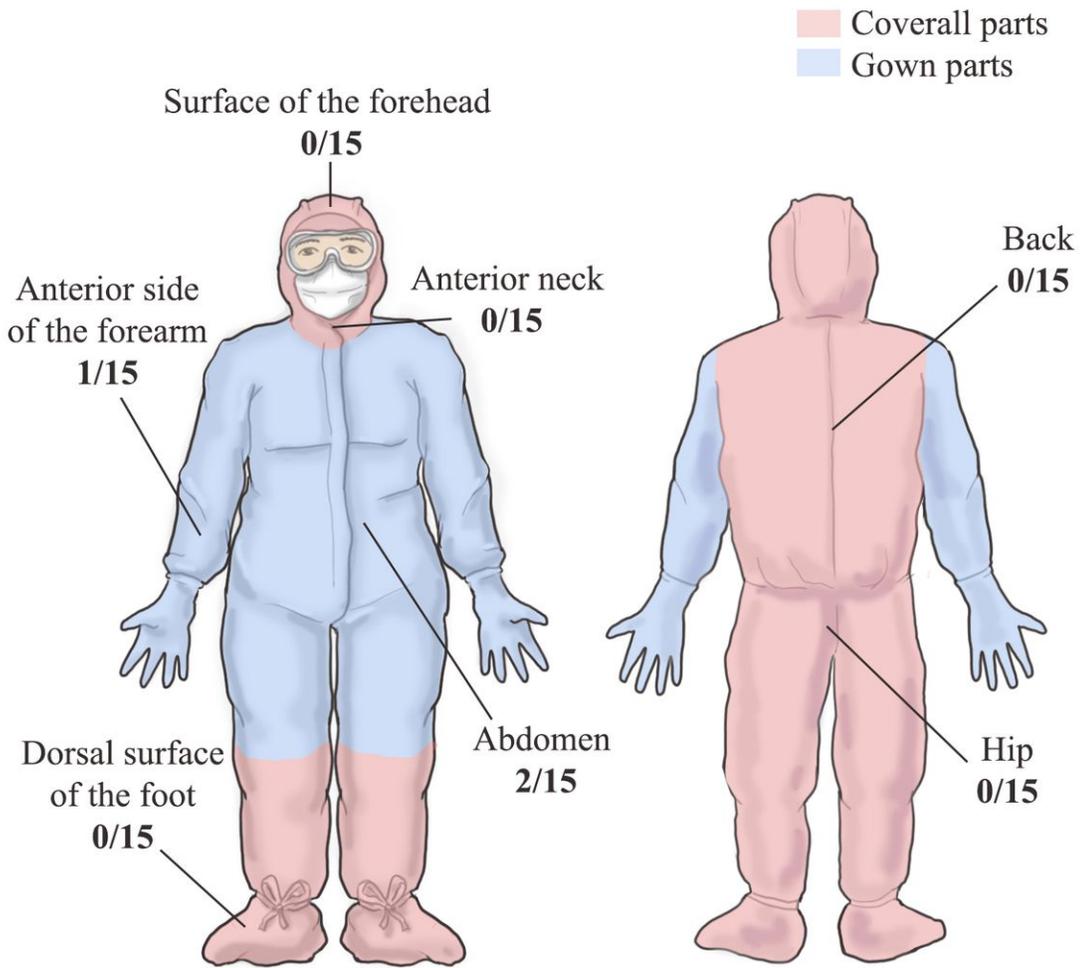


Figure 1

Sampled sites of coverall and contamination by severe acute respiratory syndrome coronavirus 2. The proportions of contaminated samples to the total collected samples are indicated at each sampled site.

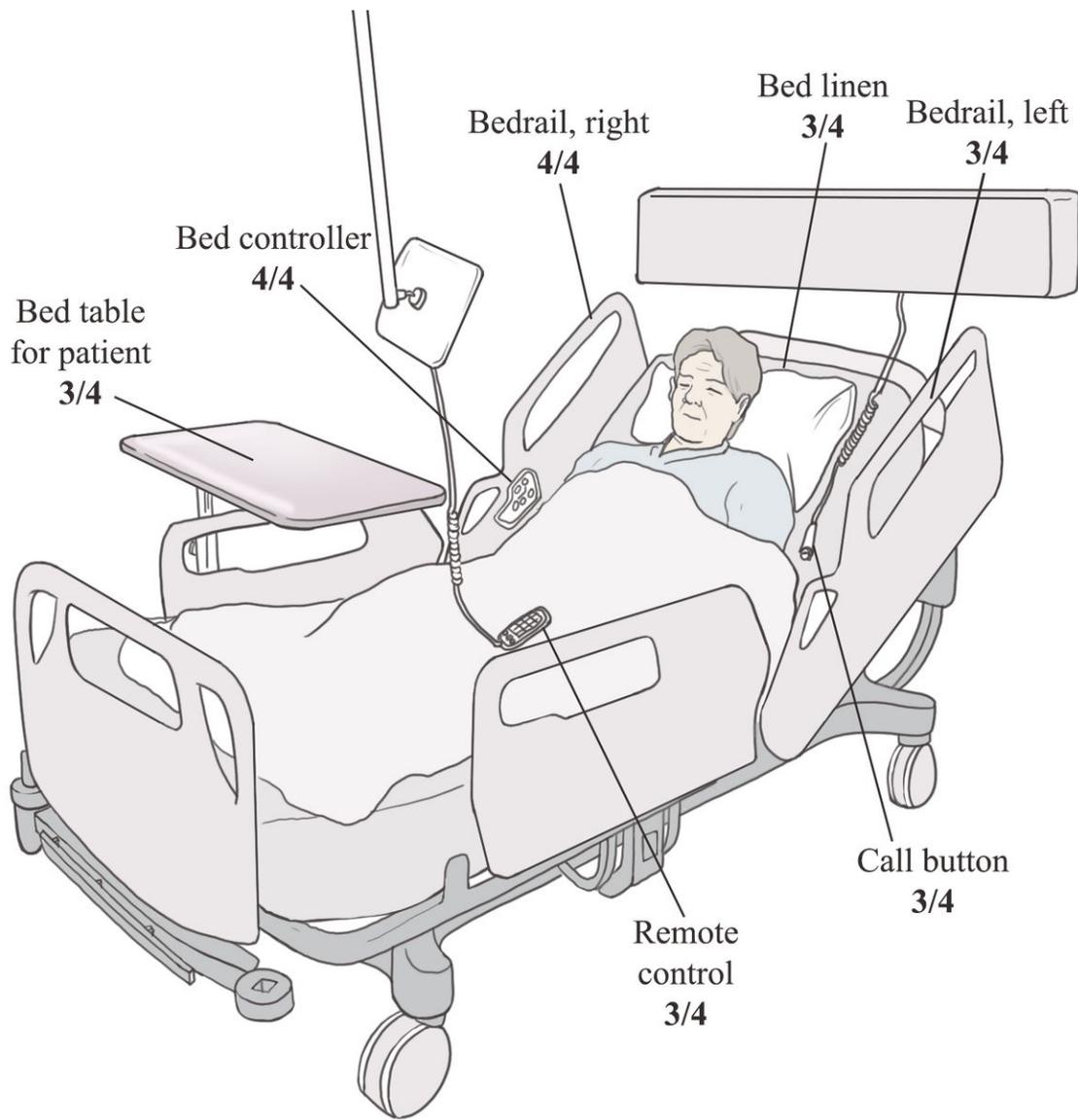


Figure 2

Sampled sites of environment around the patient and contamination by severe acute respiratory syndrome coronavirus-2. The proportions of contaminated samples to the total collected samples are indicated at each sampled site.