

An UV disinfection robot combined cleaning and housekeeping strategy for the hospital during COVID-19 pandemic: How we protect the hospital cleaning staff?

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Abstract

Background

The Coronavirus Disease 2019 (COVID-19) pandemic presents important infection control challenges for the health care facilities. Proper cleaning of the patient's room after the discharge of the patients is important to protect the housekeeping staff as well as other patients

Methods

In this study, we reviewed our experience with a novel multipurpose hybrid UV disinfecting and air disinfecting robot and the impact of it for preventing hospital cleaners getting occupational COVID-19 infection.

Results

Between 11, March 2020 and 11 December 2020, a total of 301 children with COVID-19 were hospitalized at the COVID-19 ward. The mean hospital stay was 3.77 ± 2.71 days (range from 1 to 20 days) and total COVID-19 related-care. The mean working time was 9.4 ± 1.6 months (range 5 to 10 months). The total working hours for a month for one hospital cleaner was 196 to 204 hours per month. The total duration of the UVC-robot was 491 hours 33 minutes for fans and 473 hours 20 minutes for UV lamps. During the follow-up period, two of the hospital cleaners had definitely community-acquired COVID-19 infection, but none of them had symptomatic COVID-19 infection during the study period.

Conclusions

During the COVID-19 pandemic, none of the hospital cleaners got hospital-associated COVID-19 infection. The combination of personal protective equipment in addition to UVC-robot integrated environmental disinfection is an important strategy to protect health-care workers.

Background

The Coronavirus Disease 2019 (COVID-19) pandemic presents important infection control challenges for the health care facilities (1). The transmission was reported to occur via droplet, fomite and airborne routes as a result of aerosol-generating procedures (2–4). In addition to respiratory route, contact with contaminated surfaces possess the transmission (2, 5). The proper housekeeping and cleaning the patients' rooms after the discharge of the patients with COVID-19 is essential to avoid cross-infection to the upcoming new patients. The appropriate designed negative pressure isolation rooms in even developed countries are not enough regarding the COVID-19 pandemic. Isolation of the patients with COVID-19 infection in these rooms not only protects the patients but also protect the healthcare workers

(HCWs). Also, proper cleaning of the patient's room after the discharge of the patients is important and crucial because the environmental contamination by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was well demonstrated (2, 4, 5). Moreover, the housekeeping personnel also spends at least 20–30 minutes for cleaning, disinfecting including high-touch surfaces, thus will increase the time spent in the patient room and will increase the risk of the cleaners especially at the inadequately ventilated rooms.

For now, a regular, standard and detailed cleaning of the surfaces in the patients' rooms is required. There is also a necessity to reduce human exposure to probable contaminated surfaces. Therefore, cleaning and disinfection robots may promise solutions (6–12). In such cases, currently the robots are used routinely for cleaning the Hong Kong metro and the Smart Field Hospital in Wuhan in an attempt to reduce the spread of SARS-CoV-2 (13, 14).

In this study, we reviewed our experience with a novel multipurpose hybrid ultraviolet (UV) disinfecting and air disinfecting robot and the impact of it for preventing hospital cleaners getting occupational COVID-19 infection during working at COVID-19 pandemic.

Methods:

Setting

This cohort study was performed at the COVID-19 pandemic clinic at Dr Behçet Uz Children's Hospital, a 400-bed academic hospital in İzmir, Turkey during the period between 11, March 2020 to 11 December 2020. The COVID-19 pandemic ward has 13 rooms with a 25-bed capacity. Starting from the announcement of the first COVID-19 case in Turkey (March 11, 2020), the ward has been serving as a referral COVID-19 service for children. From the first announcement of the first COVID-19 case in Turkey, dedicated COVID-19 wards, a total of 301 children with COVID-19 patients were hospitalized at the ward. Patients were generally hospitalized with their COVID-19 parents in which the COVID-19 status was not clear or COVID-19 real time – polymerized chain reaction (RT-PCR) was present.

We defined COVID-19-related hospitalizations by a positive SARS-CoV-2 reverse-transcription polymerase chain reaction (RT-PCR) test result during a hospitalization or within the 14 days before admission (15). The occupational COVID-19 infection was defined as the presence of symptoms, positive for RT-PCR for SARS-CoV-2, exposure to COVID-19 patient with at least one of the personal protective equipment (PPE) was absent at least for 14 days and with no history of close contact with any person with known covid-19 infection in the social life. The data of housekeeping personnel, are reviewed by one infection control physician independently reviewed the medical records of each case to determine whether COVID-19 was most likely acquired at hospitalization during or in the hospital-based on the timing of symptoms and RT-PCR tests and potential exposures within or outside the hospital (15). The housekeepers were monitored for the symptoms and screened for COVID-19 according to Centers for Disease Control and Prevention (CDC) risk assessment for HCWs (16).

Ultraviolet robot and cleaning procedure:

X-CLR UV+® (Asotech, İstanbul, Turkey) is a patented air circulating sterilization, and disinfection in addition to ultraviolet (UV) sterilization and disinfection of the surfaces (image 1). The robot is equipped with high-power UV lamps (4 x 36 watts) in addition to another high-power UV lamp inside a channel in which air passes through two HEPA filtration. The volume of the air volume was 1250 m³/h (image 1). The rotation of the device on its axis is 2 rev/min. The machine's artificial intelligence automatically measures the volume of the room that will be cleaned and calculates the time for the sterilization of the total air in the room. The UV doses for Multiple Log Reductions for Various Spores were calculated within the published papers concerning harmful organisms (11,17,18)

Cleaning and disinfection procedure:

After a COVID-19 patient was discharged, the UV disinfection robot was placed to the patient's room by a hospital cleaner. The hospital cleaner existed the room with closing the room door and hang a warning sign for not entering the room. The UV robot was settled for automatic calculation and starts to work after 20 seconds of safety pause.

None of the HCWs was allowed to enter the patient's room while the UV robot was working, and warning signs are put for occupational safety concerns. The hospital cleaners entered the room with full PPE after the end sign of the UV robot and did the cleaning procedure according to the infection control committee protocols including first mechanical cleaning with 1/100 chlorine solution (600 ppm), then all devices, goods, beds, walls, surfaces and corner with a disinfectant chlorine solution, then the bath and restroom were cleaned.

Data was analysed with SPSS Software version 20 (IBM Corporation, Armonk, NY, USA).

Descriptive analyses of patient and working duration were analysed using relative frequencies, numerical variables using median or mean (depending on whether they show normal distribution) values. Significance level was taken as $p \leq 0.05$.

The study was approved by Institutional review board of Dr. Behçet Uz Children's' Training and Research Hospital

Results:

Between 11, March 2020 and 11 December 2020, a total of 301 children with COVID-19 were hospitalized at the COVID-19 ward. The mean age of the patients with COVID-19 infection was 8.1 ± 5.6 years (range from 1 month to 17 years). The mean hospital stay was 3.77 ± 2.71 days (range from 1 to 20 days) and total COVID-19 related-care days were 1132 days.

A total of 9 housekeepers have been working actively during the study period. Among them 7 (77.8%) were female, and 2 (22.2%) were male. The age was 40.2 ± 7.9 years (range 28 to 52 years). The mean working time was 9.4 ± 1.6 months (range 5 to 10 months). The total working hours for a month for one hospital cleaner was 196 to 204 hours per month. The total duration of the UV robot was 491 hours 33 minutes for fans and 473 hours 20 minutes for UV lamps.

During the follow-up period, two of the hospital cleaners had COVID-19 infection. These two housekeepers were defined as definitively community-acquired COVID-19 infection. One of them had close contact with his father with proven COVID-19 infection during the earthquake that happened in the city. The second housekeeper had definitively acquired community-acquired COVID-19 infection secondary to contact with an individual with COVID-19 at a family meeting held to celebrate the birth of her grandchild. The remaining housekeepers had no symptomatic COVID-19 infection during the study period.

Discussion:

In this retrospective cohort study, the housekeepers were monitored for having occupational COVID-19 infection related to their daily practice at COVID-19 ward in addition to the daily practice with UV disinfection robot. The UV disinfection robot was found to be highly effective to protect housekeepers in addition to other precautions including PPE. The two-step cleaning procedure using manual cleaning the patient's room after the UV-robot is a reasonable strategy, while the need for 20 to 30 minutes per room requires good planning of the cleaning services.

Although the hospital housekeepers are on the frontline, little data was available including their status during COVID-19 pandemic. Information about caregivers is usually made up of newspaper clippings or websites (19). Comparing the high-risk procedures, disinfection of the room after the discharge of the patient is not a high-risk procedure. The current recommendations of some paediatric hospitals recommended wearing a mask for any of the personal entering patient room within 30 minutes after discharge, supporting a possible risk for the hospital cleaners (20). According to the CDC, although uncommon, SARS-CoV-2 appears to be airborne especially in the presence of infectious person producing respiratory tract droplets for longer than 30 minutes in an enclosed, non-well ventilated room (21). Regarding this statement, in a daily-day scenario, if a hospital housekeeper who uses an inappropriate PPE enters the patient's room after a short time after the discharge of a patient with COVID-19, can get SARS-CoV-2 virus. The hybrid UV robots, with appropriate HEPA filters and UV systems in which air passes through, will be effective to clean the air in addition to the cleaning of the environment will help in two ways. In our daily hospital practice, the hybrid UV robot was settled to the middle of the room before any hospital housekeeper enters the patient room for cleaning after the discharge. This strategy of using UV robot in our clinic prevented hospital housekeepers from having symptomatic COVID-19 infections exposure outside the hospital during the COVID-19 pandemic.

Contamination of surfaces that frequent touched in healthcare settings might play role in transmission of the virus (21). Human coronaviruses were reported to remain infectious on inanimate surfaces at room temperature for up to 9 days, however, the exact role of this finding and survival on the hands are not well-known (22). The fact about aerosol production with highly contagious patients, the degree of viral load of SARS-CoV-2 might be an important factor. The World Health Organization recommends ensuring that environmental cleaning and disinfection procedures are followed consistently and correctly. The conventional environmental surfaces cleaning with water and detergent and applying commonly used hospital-level disinfectants (such as sodium hypochlorite) are effective and sufficient procedures (23). Recent studies reported that UV had successfully inactivated the SARS-CoV-2 (13, 29–31) Also, a recent review, suggested common UV disinfection procedures also inactivated and SARS-CoV-2 virus was highly UV sensitive, supporting the usage of UV robots in the daily practice as well (12,21). Moreover, the recent researches had filled a big gap and reported that current regulatory exposure limit ($\sim 3 \text{ mJ/cm}^2/\text{hour}$) would result in $\sim 90\%$ viral inactivation in ~ 8 minutes, 95% in ~ 11 minutes, 99% in ~ 16 minutes and 99.9% inactivation in ~ 25 minutes (7). In our practice, an average of 20–25 minutes of UV robot was used to ensure the optimal disinfection of the surfaces and the conventional cleaning was performed after the performance of UV robot.

There are some limitations with the study, the COVID-19 infection was screened with the symptom-based (according to the CDC criteria) and no routinely serological tests were performed to demonstrate the asymptomatic infection. Also, the microbiological efficacy tests for UV on SARS-CoV-2 were not tested, and the regulations were done according to the previous reports.

During the COVID-19 pandemic, none of the hospital cleaners got hospital-associated COVID-19 infection. The combination of using PPE properly with strict rules in addition to UV-robot integrated environmental disinfection, is an important strategy to protect health-care workers. The nearly half an hour per one room seems to belong especially for the clinics with high turn-over may harbour time problems, however with a detailed planning and adequate number of UV robots, this problem can be easily solved

Declarations

Data availability statements:

- Data is available when required

Declarations:

- Ethics approval and consent to participate: The study was approved by Institutional review board of Dr. Behçet Uz Children's' Training and Research Hospital. The chief physician had granted the permission to access the hospital records in the above.
- Consent for publication: Not applicable

- Availability of data and materials: The datasets generated and/or analysed during the current study are not publicly available due [the hospital procedure] but are available from the corresponding author on reasonable request.
- Competing interests: İlker Devrim had educational grant from BD and İlker Devrim has educational webinars for BD. However, all authors have no conflicts of interest about this manuscript
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- Authors' contributions: İD and AC had analyzed and interpreted the data, and İD and NB were the contributors in writing the manuscript. All authors read and approved the final manuscript.
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Abbreviations

COVID-19: Coronavirus Disease 2019

HCW: Healthcare worker

SARS-CoV-2: Severe acute respiratory syndrome coronavirus 2

UV: Ultraviolet

RT-PCR: Real time – polymerized chain reaction

PPE: Personal protective equipment

CDC: Centers for Disease Control and Prevention

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Figures



Figure 1

The patented air circulating sterilization, and disinfection in addition to ultraviolet (UV) sterilization and disinfection of the surfaces. The robot is equipped with high-power UV lamps (4 x 36 watts) in addition to another high-power UV lamp inside a channel in which air passes through two HEPA filtration. The machine's artificial intelligence automatically measures the volume of the room that will be cleaned and calculates the time for the sterilization of the total air in the room.