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Disinfection of Hospitals: International Experience during COVID-19 Pandemic

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Abstract

Introduction: Several methods of environmental disinfection were used to reduce the risk of COVID-19 transmission including chemical, physical, radiation and combinations of these methods. We summarize and review the latest results about the disinfection methods against COVID-19 in hospital setting.

Methods: The following search term was used: (COVID 19 OR corona OR MERS-CoV-2) AND (disinfect* OR UV OR Ozone OR Chlorine) in the title and abstract. A literature search was also performed to retrieve study articles regarding Covid-19 (SARS-CoV-2) and disinfection in dental clinics. The final search identified that five groups of disinfectants include: Bleach (chlorine containing disinfectants), alcohol, UV irradiation, Hydrogen peroxide, and other disinfectants (e.g., ethylene oxide, glutaraldehyde, quaternary ammonium disinfectants, chlorhexidine Gluconate, povidone iodine, peroxyacetic acid etc.) were used against COVID-19 in different spaces.

Results: The initial search identified 320 articles and then 60 articles that were closely relevant to our subject were selected. After the screening of the titles and abstracts of these articles, 21 articles which include clear information about the types and application of different disinfectants were selected and the full text of them evaluated by two of authors independently. Then the results of these articles extracted and the types of disinfectants which used in different places were determined and summarized.

Conclusions: Many of generally used disinfectants such as alcohol or chlorine containing solutions show a significant effect on the SARS-CoV-2 inactivation. the efficient technologies of deactivation of viruses as SARS-CoV from hospital wastewater are Chlorine (Cl_2) Sodium hypochlorite (NaOCl) Chlorine dioxide (ClO_2) Ozone (O_3) and UV irradiation.

Keywords: COVID-19, Disinfectant, Ozone, Chlorine, Saudi

Introduction

The emergence of COVID-19, the disease caused by SARS-CoV-2, lead to several epidemic waves since 2020 [1]. Coughing by a COVID-19 infected individual can produce about 3000 droplets in a wide size range (10 −1 to 10 2 μm) [2]. During pandemics such as COVID-19, it is essential to note that even a 4-log reduction of the virus should not be taken to mean that sterilized surfaces no longer pose an infectivity threat. In this regard, avoiding close contact with anyone showing COVID-19 symptoms, such as coughing, sneezing, fever, and difficulty breathing, is strongly recommended by various infection control agencies [3]. More recently, various studies identified SARS-CoV- RNA, and not the infectious particle, in municipal wastewater for different countries. However, there is no evidence of COVID-19 transmission through contaminated water so far [4].

Sewer water can provide an alarming and early indication about the presence of COVID-19 infected individuals in a city, town, and even in a housing complex. The study also suggested that sewage sludge monitoring may lead the early detection of COVID-19 patients. Randazzo et al. detected the presence of SARS-CoV- RNA in sewer samples even at the time of initial appearances of COVID-19 cases [5]. The study suggested WBE as a potential tool for pandemic monitoring on the basis of higher viral loading in wastewater with increased number of COVID-19 patient. SARS-CoV- RNA was detected in sewage sample collected from WWTP located in Barcelona Spain 41 days ahead of the declaration of first COVID-19 case indicating the advantage of wastewater based surveillance for early detection of its emergence. Therefore, the monitoring through sewer system can provide an early indication of emergence of COVID-19. Studies related to coronavirus in wastewater and application of for detection of infection, if any and also scale of infection within many communities have been highlighted in several issues which requires special attention for successful implementation of WBE. She several methods currently being used for SARS-CoV-2 detection produce inconsistent results. For example, positive result by one method and negative by another. Variability in results were observed when grab and composite samples were compared, two investigations suggested composite sampling technique to provide more reliable data. Although wastewater samples are collected in majority of the WBE related investigations, the study conducted by Balboa et al. suggested WWTP sludge as more suitable due to the affinity of enveloped viruses towards solids [6]. The finding of no detection of SARS-CoV-2 due to low number of COVID-19 cases expresses the necessity of research for finding detection limit and factors affecting detection limit, study conducted by Hata et al. can provide some light in this regard [7].

Although several investigations reported correlation being observed between SARS-CoV-2 in wastewater/sludge with confirmed COVID-19 cases, few reported lack of correlation [7]. In addition, guidelines have been prepared to recommend people and hospitals to fully clear and disinfect environmental and medical instrument surfaces on a regular basis . More specifically, a disinfecting wipes containing quaternary ammonium solution have also been found to effective against SARS-CoV-2 [8]. In addition UV irradiation and heating are also suggested for wastewater disinfection in other COVID-19 designated hospitals because of fewer by-products and ideal disinfection performance. In addition, government should take measures to improve the management of hospital wastes and wastewater, especially during the COVID-19 pandemic [9]. In the latest COVID-19 pandemic UV air and surface disinfection has attracted tremendous attention, and many products became available on the market.

Throughout the current outbreak, the fight against COVID-19 has been mostly (and understandably) focused on the disinfection of commonly touched surfaces and personal protective equipment. UV radiation, along with chemical disinfectants, have been utilized extensively as a no-touch automated disinfection technique to disinfect surfaces in public transport systems such as airplanes, as well as patient rooms and operating theatres in hospitals. The recent COVID-19 outbreak has been deemed a global health emergency [10]. We summarize and review the latest results about the disinfection methods against COVID-19 in hospital setting.

Methods

The following search term was used: (COVID 19 OR corona OR MERS-CoV-2) AND (disinfect* OR UV OR Ozone OR Chlorine) in the title and abstract. A literature search was also performed to retrieve study articles regarding Covid-19 (SARS-CoV-2) and disinfection in dental clinics. The initial search identified 320 articles and then 60 articles that were closely relevant to our subject were selected. After the screening of the titles and abstracts of these articles, 21 articles which include clear information about the types and application of different disinfectants were selected and the full text of them evaluated by two of authors independently. Then the results of these articles extracted and the types of disinfectants which used in different places were determined and summarized. The final search identified that five groups of disinfectants include: Bleach (chlorine containing disinfectants), alcohol, UV irradiation, Hydrogen peroxide, and other disinfectants (e.g., ethylene oxide, glutaraldehyde, quaternary ammonium disinfectants, chlorhexidine Gluconate, povidone iodine, peroxyacetic acid etc.) were used against COVID-19 in different spaces. Among these groups, bleach (chlorine containing disinfectants) has the most prevalent.

Results and discussion

Many methods of environmental disinfection were used to reduce the risk of COVID-19 transmission including chemical, physical, radiation and combinations of these methods. Chlorine has high reactivity with amino acids and proteins and has a strong capability to inactivate viruses. With rapidly decreasing access of commercial disinfectants, diluted bleach can efficiently disinfect our homes, clinics, and environment to prevent continuous transmission from inanimate items. By obtained results from other coronaviruses, experts are assured that 0.1% sodium hypochlorite could inactivate the virus. These low dilutions of sodium hypochlorite are clinically effective with negligible irritation and it's better to be used within one month of preparation and kept in a closed, impervious container at room temperature [11]. Compared with chlorine disinfection, the investment and operation costs of UV disinfection are significantly lower.

In addition UV irradiation and heating are also suggested for wastewater disinfection in other COVID-19 designated hospitals because of fewer by-products and ideal disinfection performance. Ultraviolet light (UV) refers to the electromagnetic wave with length between 200 nm and 400 nm. The UV was first used in disinfection of drinking water in 1910 [9]. Disinfection could therefore be achieved using 30 min at 56 °C, ether, 75% ethanol, chlorine-containing disinfectants, peracetic acid, or chloroform. Floors of all zones were disinfected twice daily by spraying 1000 mg/L chlorine-containing disinfectants. For areas other than the treatment rooms, air disinfection was conducted using electric ultra-low capacity sprayers with 3% hydrogen peroxide, 5000 mg/L peroxyacetic acid, 500 mg/L chlorine dioxide, and other disinfectants. The areas were then fully ventilated after the disinfection was complete (the time of action of hydrogen peroxide and chlorine dioxide is 30-60 min, and that of peroxyacetic acid is 1 hour [12]. Many treatment technologies of hospital wastewater were investigated by different studies such as ultraviolet irradiation, coagulation-filtration and biocidal agents as gaseous ozone, alcohol, formaldehyde, hydrogen peroxide, peroxyacetic acid, povidone iodine and chlorine-based disinfectants [13]. On the other hand reported that the efficient technologies of deactivation of viruses as SARS-CoV from hospital wastewater are Chlorine (Cl_2) Sodium hypochlorite (NaOCl) Chlorine dioxide (ClO_2) Ozone (O_3) and UV irradiation [14]. chlorine-based disinfectants are widely used for their broad sterilization spectrum, high inactivation efficiency and easy decomposition with little residue, as well as represents the best economic solution. However, excess use of chlorine-based disinfectants can generate more than 600 kinds of disinfection by-products, which are harmful to ecosystems and human health. n the other hand, chlorine reacts with ammonia contains in wastewater and forms a new product (chloramine), which behaves differently to free chlorine during disinfection. However, chlorine dioxide was less effective for the inactivation of SARS-CoV than chlorine.mg L −1 of chlorine dioxide (2.19 mg /L of free residual chlorine) can inactive completely SARS-CoV about 30 min [12].

Far UV-C light at 207-222 nm induced 99.9% inactivation of the airborne βHCoV-OC43 strain in 25 min, and presumably would have a similar effect on the SARS-CoV-2. Studies conducted with UV-C indicate that a dose ranging from 3.7 mJ/cm 2 to 10.6 mJ/cm 2 should inactivate the viruses in 5 min. These alternative methods could be used during commercial shortages of UV devices due to COVID-19. UV light irradiation and in combination with metal ions, e.g. This limitation can be overcome by use of "no-touch" (automated) disinfection approaches such as hydrogen peroxide vapor and ultraviolet light (UV) [15].

Hydrogen peroxide vapor has been widely used for disinfecting coronaviruses. UV disinfection devices contain either a mercury-based source or pulsed-xenon bulb source to generate UV rays. Inhibition of the Middle East respiratory syndrome coronavirus (MERS-CoV) was done by 5 min application of UV-C from an automated whole-room. Recently, a pulsed-xenon-based UV device demonstrated 4.2 log 10 reduction on hard surfaces and 4.79 log 10 and reduction on N95 respirators following 5 min of exposure. UV-A has been shown to have a weaker effect even after 15 min of exposure, suggesting that UV-C is more potent. Viral survivability depends on many factors such as wavelength, dose, distance and duration of UV radiation, which should be studied and tuned prior to use in healthcare and other non-healthcare settings [16]. It was demonstrated that UV-B (315-280 nm) and UV-C (190-290 nm) cause a significant and rapid decrease in infectious SARS-CoV. However, if this behavior occurs, it is evident to take into account the variation of season and geography in UV light availability. According to previous studies, the exposure to UV light can also decrease the activity of coronavirus, especially SARS-CoV, in aquatic environment [17]. The effectiveness of UV light in the inactivation of SARS-CoV-2 is not yet explored to date. The infectivity of SARS-CoV-2 in wastewater has not been assessed, even though culturable viral particles have been detected in the feces of infected individuals. It indicated that the survival of the viruses decreased drastically when the parameters such temperature UV-light and organic matter were unfavorable. On the other hand, previous studies reported that the efficient technologies of deactivation of viruses as SARS-CoV from hospital wastewater are Chlorine (Cl_2) Sodium hypochlorite (NaOCl) Chlorine dioxide (ClO_2) Ozone (O_3) and UV irradiation [18]. The competing processes of ozone generation and dissociation from and to molecular oxygen catalyzed by deep UV irradiation is described in the literature extensively. It is known that radiation in the far-UVC region is capable of generating ozone via photolysis of environmental oxygen molecules [19]. Therefore, systems designed to apply far-UVC radiation for air disinfection could generate ozone during their operation.

The risk posed by this generation is a function of the UV source power output and its emission spectrum, as well as air flow or stagnation and operation duty cycle [10]. Therefore, as a conservative technique, the UV surface disinfection systems should be designed based on a high situation. Based on the available data, the authors of this article hold the opinion that the SARS-CoV-2 can likely be categorized with SARS-CoV-1 as a mildly resistant virus to UV radiation, similar to the hepatitis A virus, influenza virus, and bacteriophage MS2. Over the last few months, a significant number of technical reports, news, and whitepapers have been released, claiming the eligibility of various UV disinfection systems and commercial products against SARS-CoV-2. While obtaining the reported UV doses for SARS-CoV-2 inactivation [20].

Conclusions

Because of the SARS-CoV-2 can remain in the air and on surfaces for several hours to several days, as well as observing individual disinfection guidelines such as regular hand washing and avoiding contact in hospital areas, disinfection of commonly touched surfaces is necessary to decrease SARS-CoV-2 spreading. A number of generally used disinfectants such as alcohol or chlorine containing solutions show a significant effect on the SARS-CoV-2 inactivation. Moreover, although the most suggested disinfectants have been limited to bleach and alcohol, the possibility of using of other disinfectants remains. It is now necessary to perform studies on SARS-CoV-2 sensitivity to different disinfectants in standardized and targeted wards and the production of efficient and non-hazardous disinfectants.

Conflict of interests

The authors declared no conflict of interests.

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