Review Article

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Environmental disinfection against COVID-19 in different areas of health care facilities: a review

<https://doi.org/10.1515/reveh-2020-0075>

Received June 13, 2020; accepted July 27, 2020; published online August 26, 2020

Abstract: The coronavirus disease 2019 (COVID-19) originated in bats and human-to-human transmission through respiratory droplets and contact with surfaces of infected aerosol are the main ways of transmitting this virus. Until now, there is no effective pharmaceutical treatment; conclusively it is important to evaluate the types of applied disinfectants in different areas against Severe Acute Respiratory Syndrome Corona Virus 2 (SARS-CoV-2), the virus that causes COVID-19. The aim of this review was to summarize the information about environmental disinfection for preventing of COVID-19. We performed a review of the science direct database to find articles providing information on disinfection used for SARS-CoV-2. The extracted results were given the original data on inactivation coronaviruses by disinfectants in different places of health care facilities. The final search recognized that five groups of disinfectants include: chlorine containing disinfectants, alcohol, UV irradiation, Hydrogen peroxide, and other disinfectant were used against SARS-CoV-2 in different environments. Among these groups, bleach (chlorine containing disinfectants) has the most applicability. Also, in many studies by using disinfectants with 62–71% ethanol can reduce coronavirus in contaminated areas. Furthermore, after the using of operating room for COVID-19 patients, hydrogen peroxide and UV irradiation should be used for 24 h before it can be used again. The povidone-iodine or the chlorhexidine, could be recommended when there is a risk of SARS-CoV-2 contamination especially for open wounds. According to the different studies on SARS-CoV-2 disinfection, because of the SARS-CoV-2 can

remain in the air and on surfaces, as well as observing individual disinfection guidelines in different hospital areas, disinfection of surfaces is necessary to decrease SARS-CoV-2 spreading. Moreover, the most suggested disinfectants have been limited to bleach and alcohol, it's better to be considered the potential of other disinfectants in different areas.

Keywords: alcohol; bleach; coronavirus disease-2019 (COVID-19); disinfectants; environmental disinfection.

Introduction

Coronavirus disease 2019 (COVID-19) is a major public and environmental health concern. World Health Organization (WHO) announced the outbreak a global pandemic, and China declared the novel coronavirus infection as a first-class infectious disease (considered as the most dangerous class of infections) [1, 2]. The mortality rate of COVID-19 for the critically patients was as high as 61.5% and blocking of the transmission pathways is the most important strategy for prevention of COVID-19 [3, 4].

Corona viruses have a lipid envelope, which efficiently disrupted by most disinfectants [5]. Use of ultraviolet light (UV) irradiation, 62–75% alcohol, 0.5% hydrogen peroxide or 0.1% sodium hypochlorite within 1 min have been confirmed to be effective in inactivating of the virus(4). Other biocide agents such as 0.05–0.2% benzalkonium chloride or 0.02% chlorhexidine digluconate are less effective against coronaviruses [5, 6]. All public areas and instruments must be aerated, cleaned, and disinfected severely. Specially, for those areas with inappropriate ventilation including elevators, public toilets, waiting-room, and basement garages, are required to be disinfected daily [7, 8]. Some of the disinfection procedures that have been announced have no logical basis and confirmed to be unsuccessful. For example, although the COVID-19 is an airborne virus, disinfection the air in the cities is known to be not effective for infection management and should be stopped [1, 9].

In some places such as hospitals, each ward reacts to the emergency under the specific regulation of emergency

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response system [10]. Lack of necessary information, including correct methods of preparation and application of disinfectants, use of personal protective equipment during the application of disinfectants, and safe storage of disinfectants were reported by several researchers [11, 12]. Base on the best of our knowledge there is not comprehensive review studies on the disinfection of hospitals and health care facilities and particular disinfection recommendations during COVID-19 pandemic in the literature. We summarize and review the latest results about the disinfection methods against COVID-19 in different spaces of health care facilities.

Methods

Science Direct as one of the most comprehensive scientific databases was selected for searching and all scientific documents providing any information about coronaviruses disinfection until 4/15/2020 were reviewed.

The following search term was used: COVID 19+ disinfect* in the whole of text. The initial search identified 194 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, 34 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 (SMS and AHN) independently. Then the results of these articles extracted and the types of disinfectants which used in different places were determined and summarized.

Results

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 applicability. The related information about these disinfectants is summarized in Table 1.

Discussion

According to the information obtained from Table 1 and the study of different parts of health care facilities, the disinfectants used in these areas are divided into five groups as follows:

Table 1: Types of disinfectants in various places.

		Types of disinfectants					Ref
		Bleach	Alcohol	UV irradiation	Hydrogen peroxide	Other disinfectant	
Various places	Burn ward	✓		✓	✓		[10]
	Histopathology and cytology laboratories	✓	✓	✓		✓	[13, 14]
	Endoscopy	✓			✓	✓	[15, 16]
	Radiology	✓	✓		✓		[17–19]
	Radiotherapy	✓	✓	✓	✓	✓	[20]
	Hemodialysis patients	✓					[21]
	Eye care practitioners	✓					[22]
	Oxygen therapy and respiratory care	✓	✓				[23]
	Dermatology and wound care	✓					[24]
	Doctors fighting the COVID-19	✓					[25]
	Long-term care facilities	✓					[26]
	Trauma patients	✓	✓		✓	✓	[27]
	Pathology-urology interaction		✓				[28]
	Indoor air sampling in patient rooms		✓			✓	[29]
	Disinfection of respirator			✓	✓		[30, 31]
	Cardiac point of care ultrasound and ultrasound examination services			✓	✓		[5, 32]
	Noncontact ultraviolet surface disinfection			✓			[33]
	Center of diagnosis and treatment			✓			[34]
	Tracheal intubation			✓			[35]
	Anesthesia management				✓	✓	[36, 37]

Bleach (chlorine containing disinfectants)

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 [2, 13]. 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.

In department of endoscopy, for disinfection of surface and patient-care utensils, Repici et al. currently use 1:100 dilutions of bleach and water [16]. Also final cleaning of the machine, walls, and floor in scan room of radiology department is performed by diluted bleach (6 mg chlorine releasing disinfectant tablet to 1 L water). The scan room is ventilated for no less than 30 min to permit the disinfected surfaces to be dried adequately before the scan of another patient [18]. In burn ward, for ground disinfection 1,000 mg/L chlorine-containing disinfectant will use to wipe or spray from the outdoor to indoor, at least 30 min for each time [10]. Furthermore, Grounds of all areas in radiotherapy center were disinfected twice daily by spraying 1,000 mg/L chlorine-containing solution [20]. Also Chlorine-containing disinfectants were used every day by staff to disinfect equipment and floors in the dialysis center [15, 21]. Recently, Wang et al. reported that sodium hypochlorite, chlorine dioxide, and liquid chlorine disinfections are commonly used for hospital wastewater disinfection during COVID-19 pandemic [38].

Although this is not recommended as an appropriate choice for contact lens disinfection, cleaning of virus-infected contact lenses with both water/detergent and bleach is possible [22]. Wang et al. research in oxygen therapy and respiratory care center demonstrated that the disposable catheters considered as infectious healthcare waste, and send them for sterilization after soaking in a chlorine-containing solution (1,000–2,000 mg/L) for 30 min [23]. In another study, The small volume spills (<10 mL) of blood or body fluids are disinfected with chlorine containing (5,000 mg/L) solution, whereas peroxyacetic acid or higher concentrations of chlorine disinfectant (10,000 mg/L) is used for large volume spills [25].

In long-term care facilities, disinfection is necessary for all touched surfaces for example, bed railings, door handles, tables, bathrooms, light switches, etc. Disinfection have a two-step process including initial cleaning with a detergent afterward disinfection with hospital disinfectant or a diluted

bleach [26]. A cleaning biocide package with a gauze pad soaking in sodium hypochlorite 0.1% for at least 1 min can be used for disinfection of trauma patient's hands [27].

However, a study by Gharpure et al. revealed gaps in awareness about appropriate preparation, usage, and storage of disinfectants and 39% of respondents reported engaging in dangerous practices with the intent of inhibiting SARS-CoV-2 transmission, for instance washing food products with bleach, applying disinfectants to unprotected skin, and intentionally ingesting or inhaling these products [11]. Therefore, it should to be noted that adequate attention is necessary during using additional volumes or mismanagement of chlorine containing disinfectants, because corrosive injury through mucous membrane or skin contact is possible [24].

Alcohol

It has been confirmed that disinfectants with 62–71% ethanol can reduce coronavirus contamination on surfaces within 1 min [2, 13, 28]. For example, a cleaning biocide package with a gauze pad soaking in ethanol 62–71% for at least 1 min can be used for disinfection of trauma patient's hands [27].

For contaminated areas in radiotherapy centers, all surfaces, such as keyboards and mice were disinfected twice every day with 75% ethanol or disposable disinfecting wipes. Also, Final disinfection was used to all spaces after daily treatments by wiping all surfaces with 75% ethanol [20]. In oxygen therapy and respiratory care center, the surfaces of the respirator disinfected by 75% alcohol every day [23]. Chen et al. has proposed that the medical staff should replace their masks and disinfect repeatedly touched objects including personal medical services, electronic appliances, pens, and other items with a 75% alcohol disinfectant after completing their clinical responsibilities in radiation oncology facility [17].

Prior to each sampling measurement of SARS-CoV-2 in the patient rooms, all experimental systems must be disinfected using 70% alcohol solution [29]. In the study of Goh et al. in radiology department, for exterior surfaces of portable X-ray devices, disinfection are accomplished two times a day by diluted bleach solution, for delicate parts of the machine (e.g., control console, collimators, and exposure buttons), iso-propyl alcohol 70% is better than bleach for disinfection after every patient. Also, the surfaces of plastic sheets which are used for lining of CT scan couches for suspect cases are disinfected with isopropyl alcohol 70% [18].

UV irradiation

Ultraviolet germicidal irradiation (UVGI) is a disinfection technique that uses ultraviolet C (UVC) radiation to inactivate microorganisms by damage to deoxyribonucleic acid (DNA) and inhibiting replication. Previous studies have revealed that UVC can inactivate coronaviruses [20, 31]. The UV irradiation for 60 min on coronaviruses resulted in undetectable limits [13].

UVGI is a method for ventilator disinfection to enable the reuse of dwindling requirements. By using the irradiance of 17 mW/cm² for 60–70 s significantly (≥ 3 log) reduce viable coronaviruses in used and contaminated respirators under simulated soiling environments [31]. However, a study by Cheng et al. revealed that, using of UV irradiation for N95 respirator disinfection, degraded the polymers and lead to a small increase in particle infiltration [30].

In critical care echocardiograph, after the scanning, the devices were kept in a room for UV and air disinfection [32]. Mazzoleni et al. reported that for noncontact UV surface disinfection, self-directed or remote-controlled robots can be used for disease prevention [33]. In the center of diagnosis and treatment of cancer patients, Lyu et al. proposed that before the next surgery, use UV disinfection for about 15–20 min [34]. Moreover, after the tracheal intubation for COVID-19 patients, hydrogen peroxide and UV should be used for appropriate disinfection for 24 h before it can be used again [35]. In the study of Li et al. the circulating air sanitizer was used for disinfection of the burn ward three times a day, more than 30 min for each time [10].

Hydrogen peroxide

Hydrogen peroxide solution works by damaging hydroxyl free radicals [5]. In the study of Zhang et al. device probes were disinfected by hydrogen peroxide after each scan in critical care echocardiography center [32]. Hydrogen peroxide can also be used for ultrasound probes disinfection in the endoscopy ward [16]. In radiotherapy centers, the action time of hydrogen peroxide is 30–60 min [20].

De Vitis et al. reported that a cleaning biocide package with a gauze pad soaking in hydrogen peroxide 0.5% for at least 1 min can be used for disinfection of trauma patient's hands and to decrease the chance of bacterial infection on uncovered fractures or dirty injuries, other packing is added for at least 2 min with hydrogen peroxide wipes, followed by washing with a minimum of 1 L of saline Solution 0.9% [27]. In a study by He et al. on anesthetic management it has proposed that first layer of gloves of anesthesiologists, after

tracheal intubation, should be disinfected with a hydrogen peroxide solution and the outer layer gloves must be removed, and the inner gloves should be disinfected with hydrogen peroxide solution again [37].

In perioperative infection control, to disinfect the interior inhalation circuit, vaporized hydrogen peroxide used to kill remaining pathogenic agents such as COVID-19 [36]. For infection control in the special channel used by suspected patients in the medical imaging department, the hydrogen peroxide sprayed by an air sterilizer [19]. In burn ward, disinfection of air must be done by hydrogen peroxide and acid peroxide which will be used for ultra-low capacity spray disinfection three times a day without people in place [10].

Other disinfectant

The SARS-CoV-2 is sensitive to UV irradiation and high temperature [6, 20], and several coronaviruses were disinfected by the following exposure times and temperatures (90 min at 56 °C, 60 min at 67 °C, and 30 min at 75 °C) [13]. In the study of Faridi et al. prior to each sampling of SARS-CoV-2 in the patient rooms, all experimental systems were autoclaved and disinfected [29]. The results of a study by Henwood showed that inactivation of several coronaviruses and SARS-CoV-2 would be similarly affected by formalin fixation and heating to 56 °C in histopathology laboratories [13]. Wei et al. reported that in radiotherapy center, disinfection could be achieved using 30 min at 56 °C, ether, 75% ethanol, chlorine-containing disinfectants, per acetic acid, or chloroform [20].

Pambuccian to determine the applicability of surface disinfectants use on cytology slides, reported that different surface disinfectants, especially ones with short contact times, can be tried. It is recommended to disinfect all work surfaces multiple times per day, using United States Environmental Protection Agency (USEPA) approved disinfectant solutions, wipes or sprays since the virus can remain on stainless steel and plastic surfaces for up to 72 h [14]. In perioperative infection control to inactivate pathogenic agents such as SARS-CoV-2 and to disinfect the interior inhalation circuit, spreading disinfectants such as ethylene oxide, per acetic acid or glutaraldehyde can be used [36]. Although quaternary ammonium can be used for ultrasound probes disinfection in the endoscopy ward, these compounds should be avoided because they can damage the casing of the endoscopes [16]. Abramowicz and Basseal for safely ultrasound examination and cleaning equipment suggested using of chemical “wet” disinfection such as 3.2% glutaraldehyde products, non-

glutaraldehyde agents, Cidex PA (hydrogen peroxide & peroxyacetic acid) and appropriate multistage disinfectant wipes containing chlorine dioxide, used extensively in the UK and Australia (Tristel Duo®) [5].

In the operating room for trauma patients, skin preparation is accomplished by the usual disinfection: a solution of chlorhexidine Gluconate 20 mg/mL and isopropyl alcohol 0.7 mL/mL (ChloraPrep™), or povidone iodine 10% in case of open wounds [27]. Udwardia and Raju suggested that bronchoscopes must be disinfected with 0.23% of peroxyacetic acid followed by high level of disinfection in an automatic disinfection machine, and finally sterilized with ethylene oxide [25]. Wei et al. reported that in radiotherapy ward, the action time of peroxyacetic acid is 1 h, and of chlorine dioxide is 30–60 min [20]. According to the results, it is necessary to discuss the concentration of disinfectants used in different areas and sensitivity of SARS-CoV-2 to different disinfectants in the future studies.

Conclusion

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 nonhazardous disinfectants.

Acknowledgment: The authors would like to Acknowledge Vice-chancellor of Research and Technology, Isfahan University of Medical Sciences for approval and financial support of the present study.

Research funding: Financial support by Isfahan University of Medical Sciences.

Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Competing interests: Authors state no conflict of interest.

Informed consent: Not applicable.

Ethical approval: Not applicable.

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