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The Effect of Ultraviolet Radiation on Coronavirus (SARS-CoV-2): A Review Study

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ABSTRACT

Aim: The global outbreak of the new coronavirus (SARS-COV2) threatens human health around the world. The presence of the SARSCOV2 virus on surrounding surfaces and protective equipment such as respirators increases the transmission of the virus. One way to reduce the spread of the virus is through disinfection techniques. The aim of this study is to review the investigations carried out in the area of the ultraviolet (UV) effect on the SARS-CoV2 virus, the UV disinfection spectra, the effect of this radiation on surface disinfection and the N95 respirator.

Method and Materials: The search was carried out from December 2019 to August 2020 in the databases including Scopus, Science Direct, Web of Science and Pubmed with the keywords UV and Covid19, UV and Sars-Cov2, UV and Covid19 as well as UV and sars-Cov2. By checking the titles and abstracts of the articles, based on the defined inclusion and exclusion criteria, related articles were separated from the irrelevant ones and also duplicate articles were eliminated.

Findings: This study showed that UV light generally has antiseptic properties and were effective against SARS-Cov2 virus, so it could eliminate Covid-19 virus and similar types of viruses on the surfaces and respiratory masks. The typical wavelength used in the studies was 254 nm.

Conclusion: The results of this study revealed that UV can be used to disinfect surfaces, respiratory masks and it helps us choose appropriate spectra of this radiation, especially during Covid-19 pandemic, however, the current studies in this field are insufficient and further studies are needed.

Keywords: Ultra-Violet Radiation, Disinfection, Wave-Length, Covid-19.

Introduction

Coronavirus Disease 2019 (COVID-19) was first discovered in December 2019 in China's Hubei Province by the Wuhan City Commission, and preliminary information on the outbreak was sent to the World Health Organization (WHO) [1]. Coronaviruses are positive single-stranded RNAs viruses and can be classified into four types: alpha, beta, delta, and gamma. Its alpha and beta types have the ability to infect humans. SARC-COV2 virus is a single-stranded RNA virus of beta species and its origin is in human and animal [2]. The main symptoms of this disease include fever, fatigue, dry cough, pain and shortness of breath and may eventually lead to death; It has also been reported that many infected people are asymptomatic, which will hamper efforts to control the spread of the virus [3, 4]. The World Health Organization has declared this disease as a pandemic or global pandemic that has spread rapidly through human-to-human in the world [5]. Studies have shown that the SARS-COV2 virus can survive for up to three days on surfaces such as plastics and steel. Widespread and long-term survival of the virus leads to indirect transmission [6]. In order to prevent the spread of viral infections in healthcare professionals, the use of Personal Protective Equipment (PPE) such as gloves, masks, goggles, face shields and gauze is recommended. The use of UV radiation is one of the methods to prevent the spread of Covid-19, which has rarely been considered [7]. The UV spectrum consists of 4 general sections include: 100 -200 nm Vacuum Ultra-Violet Radiation (VUV) and Ultra-Violet A, B and C with a spectral range of 200 to 280, 280 to 315 and 315 to 380 nm [8]. Ultraviolet radiation can damage nucleic acids of influenza and coronavirus. Use of UV radiation has been suggested to kill SARS-Cov-2 as a disinfectant for medical devices [9]. Ultra-Violet Germicidal Irradiation technology(UVGI), inactivates microorganisms by damaging DNA (short wavelength 245 nm) and have a long history of disinfecting hospital air [1,2,11]. UV-C can inactivate other families of SARS-Cov-2 virus, including SARS-CoV-1(Severe Acute Respiratory Syndrome Virus), MERS-CoV (Middle East Respiratory Syndrome Virus), and Influenza [12]. Physicians believe that N95 respirator made them feel more secure during the outbreak of the SARS-Cov-1 virus in 2003 [11, 13]. Filtering Facepiece Repirators (FFR) can filter more than 95% of airborne particles up to 0.3 micrometers in air [11].

The lack of N95 respirators in epidemics, especially the Covid-19 epidemic, raises this question that whether in the current outbreak of the COVID-19 virus, respiratory equipment, especially the N95 mask, can be disinfected and reused without altering its performance and structural integrity. When searching the databases, no review study has been found to investigate the effect of ultraviolet radiation on SARS-Cov2 virus by examining the effect of this radiation on disinfection of surfaces and respiratory mask simultaneously. Therefore, this study was done to response this question.

Method and Materials

In this study searching was done from December 2019 to August 2020 in Scopus, Science Direct, Web of Science and PubMed databases with the keywords UV and Covid-19, UV and SARS-Cov2, Ultraviolet and Covid19, Ultraviolet and SARS-Cov2 which overall, 468 articles were found. To increase the sensitivity of search, the references of the selected articles were reviewed and a search was made on the links of related articles. Then, by reviewing the title and abstract of the collected articles, the related articles were separated from the unrelated ones and also the duplicate articles were removed. It should be noted that we just reviewed English articles. Finally, the full text of the articles that were collected as relevant were analyzed. According to the defined inclusion criteria, 10 articles that 3 of which were review and 7 articles were original research, were included in the study. The review and original research articles which mentioned the relationship between UV and Covid-19 in title and in the abstract were defined as inclusion criteria.

Findings

In this paper, the effect of ultraviolet light on Covid-19 was studied in three general sections: ultraviolet light and surface disinfection, ultraviolet light in disinfection of N95 breathing masks and ultraviolet disinfection spectra.

A) **Ultraviolet light and surface disinfection:** A study that indirectly addressed this issue on pathogens similar to SARS-Cov-2 virus and other pathogens was a study by Cadnum et al on "Using UV-C to disinfect airport plastic bins." This study was performed in a laboratory setting and used a trash can model. In this study, benign bacteria was used instead of viral pathogens.

These pathogens included Methicillin-Resistant Staphylococcus Aureusand (MRSA) and MS2, PhiX174, and Phi6 bacteriophages, and evolved RNA virus was used instead of various types of coronaviruses [9]. The results of this study showed that in order to investigate the possibility of using ultraviolet light in disinfection of surfaces, further studies in real conditions and exclusively for SARS-Cov-2 virus is needed.

B) Ultraviolet light in disinfection of N95 breathing masks

The results of a review study by McNally et al. on the use of Ultraviolet Germicidal Irradiation (UVGI) technology in disinfecting N95 respirators showed that the use of UVGI with UV-C light did not affect the performance of N95 Filtering Face Respirator (FFR) and these radiations can disinfect mask surfaces exposed to the virus in vitro without significant change in the appearance or odor of FFR. Disinfection by using ultraviolet radiation in vitro shows that it can be a successful method in eliminating infectious pathogens from FFR. Future studies should focus on the effect of UVGI disinfection in the real environment and determining the effect of UVGI on the mask [14].

The study of Cadnum et al which was performed by laboratory simulation on 3 brands of N95 respiratory mask with 3 disinfection methods showed that UV-C reduced N95 respiratory mask contamination with bacteriophages Phi6, MS2 and MRSA. However, its effectiveness varies for different types of respirators and different parts of respirators, and further studies are needed to evaluate the antiseptic properties of N95 respirators that used in clinical settings [12]. In another study, Kohli et al. investigated this issue and proposed a model based on it. To measure the change in dose received by different parts of the N95 mask, two factors including the effect of the curvature of the N95 mask and the distance of the radiation location from the lamp were considered [13]. This study provided a model for evaluating the effect of UVC on N95 respirator disinfection. Although a special UVC device and a type of N95 respirator were used, the assessment could be generalized to other UVGI devices and other types of respirators, but to ensure proper disinfection, other UV devices and other types of respirators should be used [13]. In addition to UVGI technology, Simmons et al. proposed the use of UV-C from a pulsed xenon source (PX-UV) in eliminating SARS-CoV-2 on hard surfaces and the N95 respirator. The use of PX-UV is not a new concept; it has been used to prevent infections in hospitals, including multidrug-resistant organisms such as methicillin-resistant Staphylococcus aureus and Clostridioids difficile. This PX-UV device is the first non-contact disinfection system that directly kills the SARS-CoV-2 virus on surfaces. Simmons et al. concluded that rapid disinfection using PX-UV devices could effectively reduce the load of SARS-Cov-2 in a laboratory setting on both sides of N95 respirators. It should be noted that the results of this study cannot be generalized to other parts of the UV spectrum because the UV-C from a PX-UV system differs from UV produced by other disinfection systems such as low-pressure mercury vapor lamps or light-emitting diode sources. UV-C emitted from a PX-UV system produces a wide range of wavelengths that covers the entire microbicide UV range from 200 to 280 nm and potentially has a greater virulence effect than wavelengths generated by other sources. [14]. In addition to the UV disinfectant effect, its thermal effect can also be another effective factor that has been suggested in the study of Banerjee et al. The simultaneous effect of these two agents is not limited to the removal of SARS-CoV-2 but can also be used for other infectious agents [15].

C) Ultraviolet disinfection spectra

A study by Heilingloh et al. Showed that SARS-CoV-2 can be effectively inactivated by UVC radiation, even at high viral titers, while UVA radiation is much less effective (16). Heßling et al. concluded that two methods

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of irradiation (365 nm (UVA) and daylight) showed virus reduction. Of course, it seems to be much less effective than radiation at 254 nm. Therefore, in general, it can be assumed that UV rays with a wavelength of 365 nm and daylight can be used for SARS-CoV-2 and all future mutations [7]. Currently, the most common UVC light sources are mercury discharge lamps, especially low-pressure mercury vapor lamps with peak emission at 254 nm, which are close to the maximum absorption (about 260 nm) [7]. Improper use of UV germicidal lamps has the potential to cause side effects [17]. Another UV-C spectrum is the range (207 to 222 nm) proposed in the study by Buonanno et al. Far UVC light is strongly absorbed by proteins through peptide bonds and other biological molecules, so its ability to penetrate biological materials is very limited compared to conventional UV microbicide with a wavelength of 254 nm or higher [18-20]. Unlike microbicide UVGI, far UVC radiation cannot penetrate and damage the human stratum corneum, the lacrimal layer, and even the cytoplasm of human cells [21]. UVC light is expected to have the same antimicrobial properties of ordinary UV light without any health effects. Far UVC radiation can be used in public settings to prevent the transmission of coronaviruses from one person to another, and this spectrum inactivates 99.9% of similar strains of the coronavirus [22]. Because all human coronaviruses have the same genomic size and this is the main determinant of radiation sensitivity, far UVC radiation has a similar inactivation effect against human coronaviruses, including SARS-CoV-2 [22].

Discussion

According to the studies, the disinfecting effect of ultraviolet light is definite. This effect is related to disinfectant and thermal effect. The disinfecting effect of ultraviolet light is greater in the UV-C range than in UV-A and daylight. Far UVC radiation inactivates 99.9% of coronavirus. Studies that investigate the effect of different ultraviolet spectra on SARS-Cov-2 family viruses show effective and positive results that can be generalized due to the similarity of the SARS-Cov-2 genome. The common spectrum used in UV studies is 254 nm (UVGI). The use of ultraviolet radiation in vitro shows that it can be a successful method in eliminating infectious pathogens from Filtering Face piece Respirators (FFR). Future studies should focus on the effect of UVGI and UV-C in reducing the contamination of N95 respiratory mask and FFR in the real environment. Pulsed xenon source (PX-UV) kills the SARS-CoV-2 virus on surfaces but it cannot be generalized to other parts of the UV spectrum. UVC light can inactivate SARS-CoV-2 and it does not have health effects. Due to the fact that the studies were performed in laboratory conditions, other studies should be performed in real exposure conditions in public, health and other environments.

In general, ultraviolet light has an effective antiseptic effect on SARS-Cov-2 virus. Although studies show the positive effect of this disinfection method in eliminating Covid-19 and similar types on respiratory surfaces and masks. At present, the use of this method can be considered appropriate, but the effects of ultraviolet radiation on the human body is an obstacle that has made it difficult to use this method. This limitation should be considered in future studies

Conclusion

The results of this study revealed that UV can be used to disinfect surfaces, respiratory masks and it helps us choose appropriate spectra of this radiation, especially during Covid-19 pandemic, however, the current studies in this field are insufficient and further studies are needed.

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Authors Contribution

FMT and ET were the main investigators. They collected and analyzed the data and wrote the first draft of the manuscript. FN supervised the study. SSK contributed to drafting, editing and interpretation of data. All authors read and approved the final manuscript.

Conflicts of Interests

The authors declare that they have no conflicts of Interest.

Ethical Permission: This is a review study.All ethical principals were considered in the study.

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