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Research Article

The Effectiveness of The Disinfection Tools of Ultraviolet Radiation Method in Reducing Number of Airborne Microbial in Several Indoors in Hospitals and Offices in Jakarta

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Abstract

Nosocomial infection as an infection high morbidity and mortality rates in the world is an infection that is multifactorial in nature. Airborne microbial are the main exogenous source of this infection.

Disinfection technology using ultraviolet is growing rapidly and getting a lot of progress along with the increasing need for the cleaning/sterilization process both in hospitals and offices. The purpose of this study was to prove the effectiveness of the disinfection device using the ultra violet radiation method in reducing the number of airborne microbial on indoors. The number of airborne microbial was counted in the room that was examined using an air sampler, carried our before and after disinfection using disinfection tools. The microbes that grew were counted using a colony counter and the dominant microbes were identified using an automatic Vitek 2® *Compact with a specific card based on Gram stain. A total of 36 disinfection tools were examined in several indoors hospitals and offices in Jakarta.* The decrease in the number of airborne microbial range from 26.04 - 96.30% with an average reduction of 58.57%. There were 7 species of microbes in the room before being disinfected, while 3 species of microbes were found in the room after being disinfected. The dominant microbes found in the room before and after disinfection were *Staphylococcus epidermidis*, *Bacillus* sp dan *Aspergillus* sp. To increase the disinfecting power of disinfection tools, it is necessary to pay attention to the dose of ultra violet by considering the area of the room, the light intensity used, the distance of the light source to the microbes, the length of time of exposure and the type of microbe itself.

Keywords: Disinfection; UV Radiation; Indoors; Airborne Microbial

Introduction

Infection is still the cause of high morbidity and mortality rates in the world, one of which is nosocomial infection. This infection causes, 1,4 million deaths every day through Indonesia [1]. Nosocomial infections are infections that occur in a hospital setting or various health facilities. Nosocomial infection is acquired while in or undergoing treatment at a hospital or health facility [2]. World Health Organization (WHO) shows data that the highest prevalence of nosocomial infections occurs in the intensive care unit (ICU), surgical and orthopaedic wards and more than 30% occurs in the ICU. These infections most commonly occur in surgical wounds, urinary tract infections, lower respiratory tract infections and infections of the bloodstream [1,3].

The nosocomial infection rate in several countries ranges from 3.3%-9.2% [2]. In Indonesia, a study conducted in 11 hospitals in DKI Jakarta in 2004 showed that 9,8% of inpatients had nosocomial infections [1]. A nosocomial study at a special hospital for infectious diseases in Jakarta showed that out of 285 infections according to

anatomical location, the highest rate was urinary tract infections (15.9%), followed by bacterial infection (10.8%), digestion (2.6%), skin infections (2.4%), oral mucous membrane infections (1.4%), needle intravenous infections and the lowest rates were upper respiratory tract infections (0.6%) [4]. The incidence of urinary tract infections based on data from the Ulin Hospital in Banjarmasin, South Kalimantan, in hospitalized patients in the internal medicine ward has increased from year to year, it was 113 patients in 2008 and 143 patients in 2009 [5].

Nosocomial infections are multifactorial, airborne microbial infections are considered to be one of the main sources of exogenous bacterial contaminants [6]. Hospitals or health facilities are required to always pay attention to room conditions in order to meet standards so the they are free form microorganisms or pathogens that cause disease. There are quite a number of disinfection methods, but the alternatives chosen depend on local conditions and needs [7].

In general, the disinfections process can be done physically and chemically. Alternatives to chemical disinfections usually use chlorine, ozone and halogen compounds. Meanwhile, the physical disinfections process can use ultraviolet light, ultrasonic waves, ultrafiltration and reverse osmosis. Ultraviolet is a part of the electromagnetic spectrum and does not require a propagating medium, has a wavelength between 400 - 100 nm which is between the spectrum of X-rays and visible light [8].

Ultraviolet sources can be obtained naturally and artificially. Artificially ultraviolet sources generally come from special fluorescent lamps, such as low and medium pressure mercury lamps. Medium pressure mercury lamps are capable of producing higher ultraviolet radiation output than low pressure mercury lamps. However, low pressure mercury lamps are more efficient in using electricity than medium pressure mercury lamps. Low pressure mercury lamps procedure maximum radiation at a wavelength of 253,7 nm which is lethal to microorganisms protozoa, viruses dan algae. Meanwhile, medium pressure mercury lamp radiation is emitted at a wavelength of 180 - 1370 nm [8].

Regarding the Covid-19 pandemic, currently disinfection technology using ultraviolet is growing rapidly and getting a lot of progress along with the increasing need for room cleaning/ disinfection processes both in hospitals and offices using ultraviolet light irradiation. This study aims to prove the effectiveness of the disinfection device with the ultra violet radiation method in reducing the number of germs in the various rooms being examined.

Methods

Culture medium

The medium used was nutrient agar (Oxoid) with the composition : lab lemco powder 1.0 gr, yeast extract 2.0 gr, peptone 5.0 gr, sodium chloride 5.0 gr and agar 15 gr. The whole put in 800 ml of water then the sterilizied [9].

Treatment before disinfection

Examination airborne microbial

The air sampler (Merck) is used to count the number of colonies. The air sample is sucked at a constant rate for a specified time, depending on the class of room to be eximed. The air will pass through the head of the tool where there are holes with the appropriate number of uses. The air flow will be directed to a petridish containing nutrient agar whose type will be adjusted to the microbes to be searched for and counted [10,11].

Microbial culture

All examination media were incubated in incubator (Thermo) at 35^{o}C for 18-24 hours. The bacterial colonies that grew were counted using colony counter (WTW BZG 30) and proceed with converting colony bacteria according to the conversion table.[11] The result are averaged according to the air bacteria examination in each room [12].

Staining and culture

The predominantly growing microbes were stained with Gram stain (Becton Dickinson) according to standard procedure [13]. The microbes were then identified using an automatic machine Vitek 2® Compact (Biomerieux) with an identify card according to the Gram stain [14].

Room disinfection treatment

The disinfection device using ultraviolet radiation is palced in the room to be examined, left for 60 minutes according to the procedure of each tool. After finishing the tool is turned off then step of treatment before disinfection be repeated.

Treatment after disinfection

Examination airborne microbial

In the same way with treatment before disinfection, a sample of airborne microbial was taken using the air sample method (Merck). After the incubation period, the growing microbes were counted and compared with conversion tables and adjusted for each room [12]. In the same way, the staining and culture were carried out according to the previous step as described above.

Results

The number of disinfection tools examined can be seen in table 1. The data shows that a total 36 disinfection tools have been examined in several indoors in hospitals and offices in Jakarta, consisting of 10 disinfection tools from different companies (A-J). Disinfection tools C was the disinfectant that was examined most frequently (14 times) followed by disinfection tools D (8 times), disinfection tools H (3 times) and disinfection tools B, E dan F 2 times respectively, while disinfection tools G, I and J only 1 time examined. Overall, the disinfectant tools reduce the number of airborne microbial by up to 58.57%.

Disinfection tools (Code)	Number of airborne microbial (CFU)		Percentage reduction (%)
	Before	After	
A 1	920	228	75.22
A 2	1565	372	76.23
B3	964	247	74.38
B4	611	193	68.41
C5	84	30	64.29
C6	244	142	41.80
C7	156	132	15.38
C8	300	98	67.33
C9	1216	776	36.18
C10	280	156	44.29
C11	520	220	57.69
C12	924	476	48.48
C13	844	320	62.10
C14	1576	448	71.57
C15	904	388	46.02
C16	1014	380	62.52
C17	1160	396	65.86
C18	612	424	30.72
D19	2214	248	88.80
D20	790	184	76.71
D21	192	486	74.69
D22	1028	456	55.64
D23	2076	492	76.30
D24	1652	482	70.82
D25	2060	486	76.41
D26	816	456	44.12
E27	191	91	52.36
E28	145	65	55.48
F29	305	116	61.97
F30	305	66	76.36
G31	1346	498	63
H32	522	412	21.07
H33	253	200	20.94
H34	371	237	36.12
I35	268	126	52.99
J36	433	16	96.30
		Average	58.57

Table 1: Number of airborne microbial before and after disinfection.

The percentage reduction in the number of airborne microbial per tools can be seen in table 2. This data shows that disinfection tool J produced the highest percentage reduction, reaching 96.30%, while disinfection tool H produced the lowest percentage reduction (26.04%).

Disinfection tools (Code)	Percentage reduction (%)
A	75.73
B	71.395
C	51.02
D	70.44
E	53.92
F	69.17
G	63
H	26.04
I	52.99
J	96.30

Table 2: The percentage reduction in the number of airborne microbial per tools.

An example of microbial growth before and after disinfection can be seen in figure 1. A is sterile medium, B is microbes before the UV disinfection process with a number of microbes 84 CFU, while C of microbes after the UV disinfection process with the amount of 30 CFU. These results indicate a decrease in the number of air microbes by 64.29% that the dominant microbe was *Bacillus* sp both before and after the UV disinfection process.

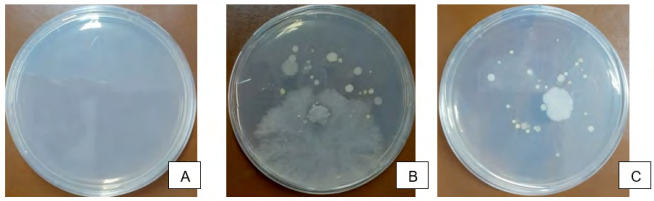

Figure 1: An example of microbial growth before and after disinfection. A. Sterile medium. B. Air microbial before the UV disinfection process. C. Air microbial after the UV disinfection process.

The dominant bacterial growth before and after disinfection can be seen in table 3. Before disinfection, 7 species of microbes were identified, such as *Aeromonas salmonicida, Sphingomonas paucimobilis, Staphylococcus epidermidis, Pseudomonas stutzeri, Bacillus sp, Kocuria rhizophilla* and *Aspergillus sp.,* whereas after disinfection only 3 species of dominant microbes were obtained, such as *Staphylococcus epidermidis, Bacillus* sp and *Aspergillus* sp.

Disinfection tools (Code)	**Microbe**	
	Before	**After**
A1	*Aeromonas salmonicida*	*Staphylococcus epidermidis*
A2	*Sphingomonas paucimobilis*	*Staphylococcus epidermidis*
B3	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*
B4	*Pseudomonas stutzeri*	*Staphylococcus epidermidis*
C5	*Bacillus sp*	*Bacillus sp*
C6	*Pseudomonas stutzeri*	*Staphylococcus epidermidis*
C7	*Kocuria rhizophilla*	*Staphylococcus epidermidis*
C8	*Bacillus sp*	*Bacillus sp*
C9	*Pseudomonas stutzeri*	*Staphylococcus epidermidis*
C10	*Bacillus sp*	*Bacillus sp*
C11	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*
C12	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*
C13	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*
C14	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*
C15	*Bacillus sp*	*Bacillus sp*
C16	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*
C17	*Bacillus sp*	*Bacillus sp*
C18	*Aspergillus sp*	*Aspergillus sp*
D19	*Aspergillus sp*	*Aspergillus sp*
D20	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*
D21	*Bacillus sp*	*Bacillus sp*
D22	*Bacillus sp*	*Staphylococcus epidermidis*
D23	*Bacillus sp*	*Staphylococcus epidermidis*
D24	*Bacillus sp*	*Staphylococcus epidermidis*
D25	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*
D26	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*
E27	*Aspergillus sp*	*Aspergillus sp*
E28	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*
F29	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*
F30	*Bacillus sp*	*Bacillus sp*
G31	*Bacillus sp*	*Bacillus sp*
H32	*Bacillus sp*	*Staphylococcus epidermidis*

H33	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*
H34	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*
I35	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*
J36	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*

Table 3: Predominantly growing microbes before and after disinfection.

Figure 2 shows the predominantly growing microbes before disinfection. *Staphylococcus epidermidis* ranks the highest with the number 15, followed by *Bacillus* sp (12), *Pseudomonas stutzeri* (3), *Aspergillus* sp (3), *Aeromonas salmonicida, Sphingomonas paucimobilis* and *Kocuria rhizophilla* 1 bacteria respectively.

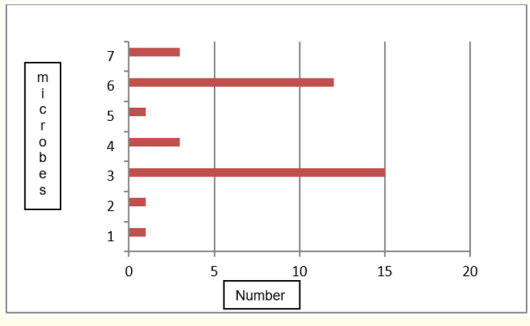

Figure 2: Predominantly growing microbes before disinfection. 1. *Aeromonas salmonicida. 2. Sphingomonas paucimobilis. 3. Staphylococcus epidermidis. 4. Pseudomonas stutzeri. 5. Kocuria rhizophilla. 6. Bacillus sp. 7. Aspergillus sp.*

Figure 3 shows the predominantly growing microbes after disinfection. *Staphylococcus epidermidis* still ranks highest with the number 25, followed by *Bacillus* sp (8) and *Aspergillus* sp (3).

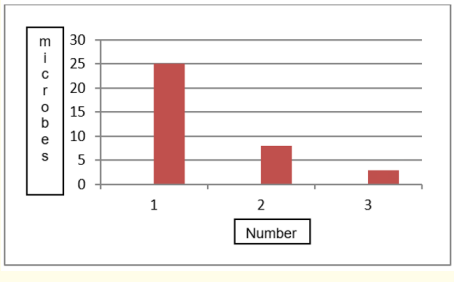

Figure 3: Predominantly growing microbes after disinfection. *1. Staphylococcus epidermidis. 2. Bacillus sp. 3. Aspergillus sp.*

Discussion

The disinfection mechanism using ultraviolet radiations is an energy source that has ability to penetrate the cell walls of microorganisms and change the composition of its nucleic acids. Absorption by DNA or RNA in some viruses can cause these microorganisms to unable to replicate due to formation of double bonds in pyrimidine molecules [15,16]. Cells that are unable to replicate will lose their pathogenicity. Ultraviolet radiation that is absorbed by proteins in the cell membrane will cause cell membrane damage and death [17]. Our research shows that the disinfection process is running very well, from 36 disinfect anion tools examined, average it can reduce the number of airborne microbial by 58.57%. Even disinfection tool J reaching reducing number of airborne microbial up to 96.30%.

It should be noted that some microbes, especially bacteria, do have a functional metabolic system that varies in the mechanism for repairing their nucleic acid damage [18]. Our study shows a decrease in the number of microbial species before and after disinfection. Before disinfection, 7 types of dominant microbial species were identified, while after disinfection there were 3 types of microbes. The ability of microbes to repair damaged cells will affect the efficiency of the disinfection process [19]. However, the mechanism of reactivation of these microorganisms can be overcome by the use of appropriate UV doses [20]. This is a note for the disinfection tool H which produce the lowest percentage reduction (26.04%), in order to increase its effectiveness so as to increase the percentage reduction in the number of microbes.

Ultraviolet light disinfection is a system of transferring electromagnetic energy to a microorganism and destroying the cell to reproduce. Radiation from ultraviolet rays will penetrate the genetic material of a microorganism and slow down its ability to reproduce [21]. Ultraviolet disinfection is electromagnetic radiation with a wavelength shorter than visible light, but longer than X-rays, which ranges 4 nm to 400 nm [22].

Ultraviolet has the highest efficiency for controlling microorganisms at a wavelength of 365 nm. Microorganism are exposed to ultraviolet, causing DNA and RNA from these microorganisms to absorb energy from ultraviolet light. This energy causes the breaking of hydrogen bonds in the nitrogenous base, resulting in chemical modification of the nucleoproteins and causing cross-links between adjacent thymine molecules by

covalently bonding. This will cause changes in the structure of DNA dan RNA, making microorganisms unable to replicate and then die [23]. Bacteria found on the surface of material exposed to ultraviolet rays will die when exposed to ultraviolet light [24]. This is consistent with the results of our study showed that *Pseudomonas stutzeri, Aeromonas salmonicida, Sphingomonas paucimobilis* and *Kocuria rhizophilla* as Gram negative bacteria were not found as dominant bacteria after disinfection process. Our research also shows that *Staphylococcus epidermidis, Bacillus* sp and *Aspergillus* sp are dominant microbes that were identified after disinfection, this is partly due to their ability to repair cell damage. It is known that *Staphylococcus epidermidis* and *Bacillus* sp are Gram positive bacteria which have a thick peptidoglycan layer on their cell walls. In addition, *Bacillus* sp is a spore bacteria that can survive in bad conditions its growing environment. Meanwhile, *Aspergillus* sp is a fungus that is spread cosmopolitan, because fungal spores are easily spread by wind and can easily grow on organic materials or live temporarily in the air in certain rooms.

The effectiveness of ultraviolet light on microbial killing power is influenced by several factors including the area of the room, the intensity of the light used, the distance from the light source to the microbes, the length of time irradiation and the type of microbe itself [25]. Several studies have shown that disinfection using ultraviolet light is proven to be effective in destroying broad-spectrum microorganisms and can be considered as an effective alternative for use as a sterilizer for medical equipment, especially in dentistry [23-25]. Another study using ultraviolet light had an effective time to kill microorganisms for 30 minutes and showed no bacterial colonies growing. However, this time cannot be used as a benchmark for using ultraviolet light disinfection tools because it depends on the tool or material to be sterilized [7,26].

Conclusions

A total of 36 Disinfectant tools were examined, the average decrease in the number of air microbes is 58.57% after disinfection. There was a decrease in predominant microbial species from 7 to 3 after disinfection. The predominant bacteria found before and after disinfection were *Staphylococcus epidermidis, Bacillus* sp *dan Aspergillus* sp. To increase the effectiveness of disinfectant tools, it is necessary to adjust the UV dose in addition to paying attention to the area of the room, the intensity of the light used, the distance of the light source from microbes, the length of time irradiation and then type of microbe itself.

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