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Review Article

Application of Service Robots for Disinfection in Medical Institutions

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Abstract

Service robots are increasingly present in all fields of medicine. This paper presents a review of the service robots in medicine with an emphasis on service robots for disinfection in medical institutions. It is shown and described how more and more disinfectant service robots are contributing to a very simple, fast and effective disinfection in medical institutions. Work of the service robot with all necessary components for its function as well as its good and bad sides are in details elaborated and clarified. The aim is to demonstrate the application and use these service robots in medical institutions. Use of these service robots reduces the risk of infection, cost of traditional cleaning and disinfection, and most importantly acquires confidence and security in medical facilities.

Keywords: Service Robots; Medical Facilities; Disinfection; Infection

Introduction

At every visit to hospitals or clinics, we avoid touching anything. This is because of the danger of new bacteria is high. The most frequent infections killer are MRSA methicillin resistant (*Staphylococcus aureus* and *C. diff* (*Clostridium difficile*), VRE (Vancomycin-resistant enterococci) and some new pathogens such as MERS (respiratory syndrome). These microorganisms are resistant to antibiotics, and commonly referred to as "superbugs". In the case of infection by this pathogen often involves considerable pain and suffering and many deaths. These infections are major problems and significant costs of modern health sector. Cleaning and disinfection are expensive and are not effective enough due to inaccessible areas. Because it is not possible to force anyone to disinfect their hands, the only solution is to introduce a disinfection robot.

The robots, which will be described in this paper is an attempt to reduce the risk of hospital infections. There are many ways of transmitting infections, and studies have shown that the greatest cause of contact surface such as: remote control, door handles or cabinets, a button to call for help, etc. UV-C disinfection robot provides an economical and effective measure in limiting the spread of bacteria. When bacteria are exposed to UV-C light of their DNA absorbs light energy and causes cell damage that prevents new infecting others. The robot is controlled by the medical staff and the time for which disinfect a room is 10 - 15 minutes depending on the size of the room. When operating the robot nobody should be present in the room because the UV-C light damages eyesight and adversely affects orgnaizam people.

Studies have shown that this method of disinfection kills more than 70% of bacteria compared to the traditional way, so it is necessary to introduce these robots in hospital for prevention, reducing the spread of infections and reduce the cost of treatment of the same.

UV light

UV-C is a proven and reliable method that facilitates disinfection of air, water and instruments for more than a century. After Niels Finsen was awarded the Nobel Prize for medicine in 1903, the treatment of diseases direct disinfection of skin has become commonplace. By the 1930s, UV became non-replaceable in air and water treatment hospitals and World War II, UV was used daily in processing plants, water treatment plants, and any microbiological contamination. UV gained fame in the 1950s for help in the eradication of tuberculosis before fading in use in the 1960s with the proliferation of antibiotics and chemical disinfectants [8,9].

UV once again climbed the top of the list in the war against superbugs, but now with an immediate focus on solving the drug-resistance crisis. UV and after 100 years of use in health care found a new use in hospitals providing surface disinfection room patients, bathroom and operating rooms (ORS).

Today, by far the strongest source of ultraviolet radiation in our environment is the sun. Light, heat and ultraviolet radiation are the main sources of solar energy. The UV radiation spectrum is divided into three regions called UVA, UVB and UVC. All UVC and most UVB is absorbed by ozone, water vapour, oxygen and carbon dioxide. UVA will not be filtered as significantly by the atmosphere.

At wavelengths of about 260 nm to 270 nm, UV breaks molecular bonds within the DNA of microorganisms, creating a thymine dimer, which can kill or disable organisms [9]. Some examples of UV bulbs are:

- o Live-light bulbs emitting UV light at 253.7 nm.
- o Ultraviolet Light Emitting Diodes (UV - C LED) lamps emit UV light between 255 and 280 nm.
- o Pulsed-xenon lamps emit UV light across the entire UV spectrum with emission near 230nm [9].

Figure 1 shows the life expectancy of a UV light bulb.

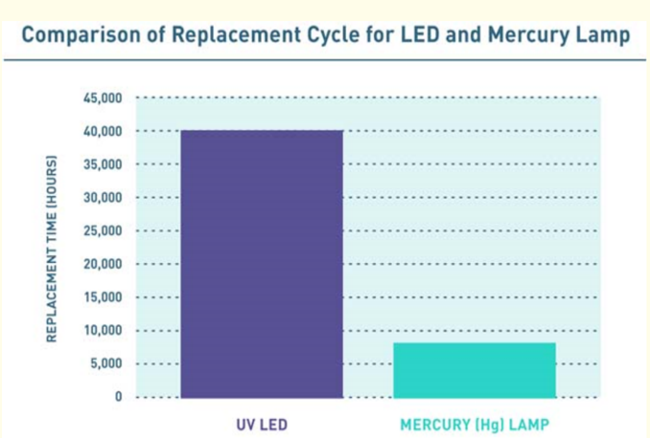

Figure 1: Comparison of UV LED and Mercury Lamp.

Approximately 95% of the UV radiation reaching the Earth's surface. It is possible to penetrate deeper layers of skin and is responsible for the current tanning effect,and it also contributes to skin ageing and wrinkling. However, it has long been thought that UVA can not cause any permanent damage but recent studies strongly suggest that it may also enhance the development of skin cancers.

Service Robots for Disinfection in Medical Institutions

Robots have broad application in healthcare (Figure 2). Such robots include ipad-mounted roving machines to provide a doctor's telemedicine. Other robots are in the research and development phase now and other other robotics applications in healthcare are being considered for the future. The world of service robots is in progress [3,4].

Figure 2: Service robots in medicine.

Robots and robotics have dramatically reverted to healthcare [3]. Many situations and needs are solved in a new and different way, and sometimes, for the first time! Robots are already widely used in healthcare and surgery, in ambassadors for disabilities, hospital operations, neuro-muscular rehabilitation, and emotional care and aging, on behalf of several. Research into new applications of robotics in healthcare is both successful and exciting [3].

Since robots will take care of our more intimate needs, such as personal custody, human beings and robots on human interaction will become the central focus of study, philosophical discussion and research.. The ultimate eligibility of robots in intimate environments, or at work for now is unknown. Eligibility and approval of a robot may depend on multiple variables, such as an individual, a culture, a particular application, age, or industry. Trust is the center of the use of autonomous robots in health care, and security must be proven and verified [5].

When all qualifications of optimal design, needs, security and trust are met, "sky is the limit" for robots and robotics in healthcare! [3].

Service Robots for disinfection

To solve the hospital disinfection problem, several design requirements had to be imposed. There is a myriad of design requirements for a commercial robotic disinfector and even more if the robot is to operate in a hospital. The robot produces UV light in a hospital room and in five minutes it can drastically reduce the germs in room [6].

The device is run when the room is empty after a patient discharge and terminal cleaning. The xenon bulb in the device will pulse for five minutes disinfecting an area around the device (Figure 3 and 4). During this time the user stays outside the room. UVC light cannot go through safety glasses, walls or windows. However, with prolonged exposure UVC could damage eyes so always run the robot in an empty room. For additional safety there is an orange cone that stays outside of the room and guards at the door as well as caution signs for the door. Inside the room the grey cone watches the entrance to the room and detects motion. Should motion be detected during the pulsing of the light the grey cone will turn the device off? You will use the device after you've finished cleaning a room but before the bed is made. For most rooms treating the bathroom with the UVC light first will save time because it is possible to work in the room while it is treating the bathroom.

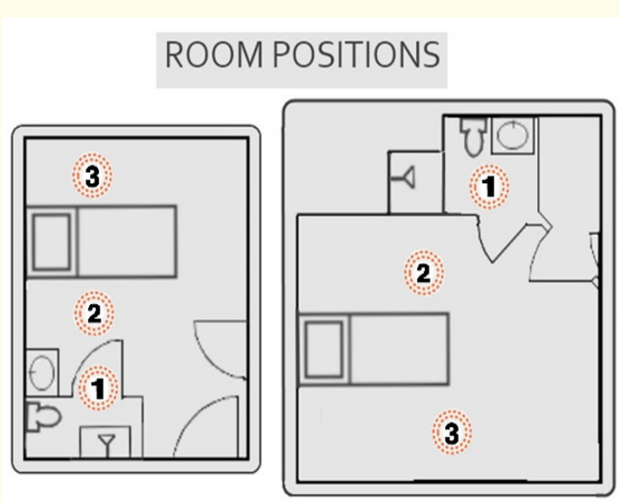

Figure 3: Position of the robot in the room.

Figure 4: Room disinfection process.

Like common illnesses for which humans ingest antibiotics, each pathogen that causes the most common healthcare associated infections has a known dosage, specifically a UVC dosage, at which it is deactivated or terminated. UVC disinfection dosage is a function of total intensity of UVC light and the length of exposure. Using higher intensity UVC light decreases the time needed to reach the appropriate dosage. Likewise, using lower intensity UV light lengthens the amount of time needed to reach the right UV dosage to kill dangerous pathogens [9].

What that means is that running a UV robot for less time than needed to achieve the germ-killing UV dosage enables HAI-causing pathogens to survive, creating the opportunity for patients to become seriously ill. The best way to prevent under-dosing, is to use UV robots that automatically measure room conditions in real time to calculate the power and time needed to achieve the right dosage.

With germ-killing UV light robots, there’s no guessing when disinfection is achieved. This patent pending Smart Dosage UV technology incorporates proprietary algorithms that automatically adjust UVC dosage and treatment time as the robot operates, ensuring effective, complete treatment irrespective of variables such as room size, layout, furnishings, and environmental characteristics.

Figure 5 shows a robot which is used for disinfection of surgical theatres. From this we conclude that their use in medical institutions is represented in all departments. UVC robots provide hospitals, nursing homes and other critical care environments with the assurance that dangerous pathogens like *Clostridium difficile* (C. diff), *Acinetobacter* and M.R.S.A., to name a few, will be attacked before the next patient occupies the room [5].

Figure 5: Disinfection process of surgical theatres.

There is a large database of UVC effect on various organisms, from bacteria and viruses to fungi and spores. Standard term used effective dose is defined as the UVC light required to inactivate 90% of a given population (also called log1). Effective dose is defined as H UVC power X time/irradiated area (Ws/m^2). For example, *E. coli* requires a dose 30Ws/m^2, while the standard fungi like Aspergillus niger requires a dose of 1320 Ws/m^2.

Headgear-mers virus is one of RNA viruses and are categorized together should dose between 15 - 400 ws/m^2. Examples of well-known RNA virus doses are 110 ws poliovirus/m^2, Newcastle disease 15 Ws/m^2, SARS 226 Ws/m^2. The assessment measured in the same region as high SARS can calculate real-time inactivity like to achieve 90% [9,10].

Robot "IRIS 3200m"

IRIS 3200m (Figure 6) is the most powerful system for disinfecting UV light in the world. His continuous UVC generate up to 20 times the UVC output tested xenon pulse system and three times the power of other constant light competitors.

The patented Power Boost technology enables iris 3200m UVC robot to provide the whole room disinfection one position in far less time than any other unit on the market, but unlike most of the competition, attacking shadows where many of the harmful organisms are staying (in some cases many months).

Figure 6: Robot IRIS 3200m.

Built Patent Smart Dosage, together with the patented box Balance and Power Boost technology allow iris 3200m UV lighting system of disinfection for automatically measuring conditions the room environment, such as the size of the room, temperature and humidity in order to determine in real time the appropriate dose , time, number and power of the lamp is required for complete disinfection of all while providing maximum power permitted in the United States for the production of germicidal UVC energy.

IRIS 3200m is ideal for the hospital which require the maximum disinfection least amount of time. Managed by easy-to-use, wireless handheld Steri-Strip controller, iris 3200m germ killing robot frees Environmental Services staff perform other tasks while the system is disinfected the whole room in one procedure.

Benefits Iris 3200m UV light disinfection systems are:

- Faster treatment room
- Higher productivity
- More effective treatments

- o Highly pathogenic kills prices
- o Whole-room treatments
- o One placement
- o One treatment

Xenex Germ-Zapping Robots

High intensity ultraviolet light is produced by xenon flash lamps across the entire disinfecting spectrum known as UV-C. UV-C energy is very easy to pass through cell walls of bacteria, viruses and bacterial spores. The RNA, DNA and proteins inside the microorganism will absorb this intense UV-C energy. Xenex Full Spectrum UV-C provides four mechanisms of damage against pathogens (Figure 6).

Pathogens are vulnerable to UV-C light damage at different wavelengths depending on the organism. Xenex Pulsed Xenon Lamps can produce full spectral germicidal light throughout the spectrum of disinfection delivered in millisecond impulses [11,12].

The primary types of cellular damage caused by Pulsed Xenon UV are photo hydration (pulling water molecules into the DNA that prevents transcription), photo splitting (breaking the backbone of the DNA as shown in the picture 7), and photo dimerization (improper fusing of DNA bases), all of which prevent cell replication. Additionally, photo crosslinking causes cell wall damage and can cause cell lysis, an irreversible form of cell death. Disinfecting across the entire spectrum helps prevent pathogens from repairing themselves [12].

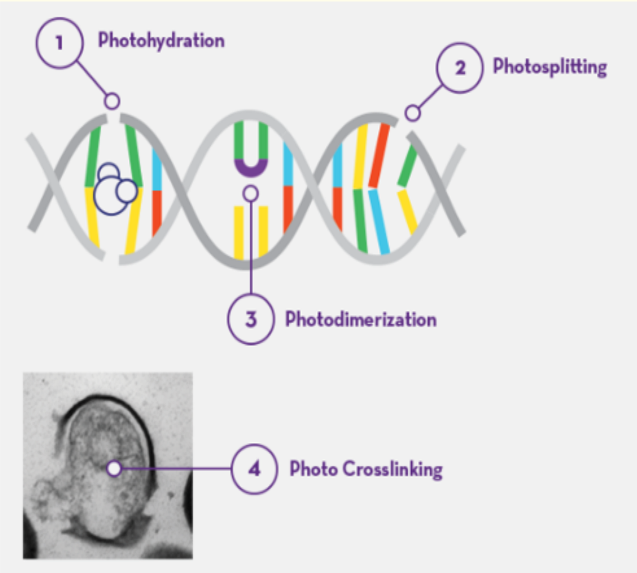

Figure 7: Four mechanisms of damage against pathogens [12].

There are cheaper ways to generate disinfecting UV light. For example, mercury lamps have been used to disinfect surfaces and liquids for decades, and the bulbs are only about $100. However, they are 25,000 times less intense than a Xenon bulb and the disinfection process can take hours, making them impractical for hospital use. LEDs could also provide cheaper UV light, but they are also far less intense than Xenon bulbs, according to Hart [3,12].

The greatest advantage of UV light is the ability to destroy the germ without the use of chemicals, but in order to achieve the best result of the surface, they must first be cleaned of liquids and dust. UV light as the last line of defence adds the final layer of protection, which is the goal of using this light in healthcare. The goal of Xenex, shown in figure 8, is to destroy everything we do not see and to which areas we cannot reach by hand [3]. The ray of light produced here on Earth can be blocked by a barrier like a thin plastic bag, but for every case the robot comes with a motion sensor that switches off if it feels the least movement in the room while at work [9,10].

Figure 8: Xenex Germ-zapping Robot with LED Xenon bulb.

Conclusion

Study showed that a "no-touch" semi-automated system, the UV light, was effective in substantially reducing the heterotrophic bacterial and MRSA burden on high-touch surfaces in rooms vacated by MRSA-positive patients.UVC disinfection may add to the armamentarium against HAI's without risking the adaptive genetic resistance incurred by pharmaceutical weapons. Implementation including training personnel to operate the device is minimal, and time spent cleaning was not increased. Because there were separate cycles for bathroom and living room, the surface reduction in aerobic colony counts may be better than with other UV systems; a head-to-head comparison of UV area disinfection devices may be warranted.

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Volume 2 Issue 8 November 2018