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Efficacy of an automated multi-emitter whole room UV-C disinfection system against Coronaviruses MHV and MERS-CoV

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Abstract

The virus responsible for Middle Eastern respiratory syndrome, MERS-CoV is a lineage C betacoronavirus similar to the mouse hepatitis virus type A59 (MHV-A59). The first reported case of MERS occurred in Saudi Arabia in 2012 and resulted in 76 deaths[1]. Outbreaks of MERS have since occurred not only in the Middle East but South Korea as well[2]. Rapid, efficient, and automated methods of disinfecting surfaces contaminated with the MERS-CoV virus may prevent the spread of the virus in the healthcare setting. Here we report on the use of an automated triple-emitter whole room disinfection system to inactivate the MHV-A59 and the MERS-CoV viruses on surfaces with a greater than 5 $\log_{10}$ reduction on MERS in 5 minutes of UV-C exposure.

Introduction

Coronaviruses like MHV-A59 were first identified as the causative agents in outbreaks of Severe Acute Respiratory Syndrome (SARS) in 2002 in China, and Middle Eastern Respiratory Syndrome (MERS) in the Middle East in 2012 [3–5]. Since that time outbreaks of MERS have continued to occur in both the Middle East as well as in South Korea and China. MERS has a reported mortality rate of approximately 40%[4–6].

MERS is thought to be transmitted from camels to humans through direct contact, however obvious camel to human interaction has not been documented in all cases. Human-human transmission has also been identified in hospital and household transmission during MERS outbreaks. The ability of Coronaviruses to rapidly mutate increases the risk of a pandemic outbreak in the near future [4]. MHV-A59 is structurally similar to the MERS-CoV but causes hepatic and neuronal tropic disease in mice. It has been shown to also induce acute pneumonia and severe lung injuries similar to MERS in humans when given by intranasal inoculation to mice[7]. The MHV-A59 virus is an ideal model virus to study the effects of Surfacide UV-C against MERS. Along with studies of MHV-A59 the Surfacide multiple emitter system was also tested against the MERS-CoV virus.

The Study

Triplicate 10µl aliquots of MHV-A59 were loaded onto sterile glass coverslips at a concentration of 1.6e8 pfu/ml and allowed to dry. MHV-A59 was stable when dried on glass coverslips for at least 60 minutes. Coverslips containing dried virus were then placed in a UV transparent petri dish (Sarstedt) and either left untreated or exposed to UV-C radiation from the Surfacide system for predetermined times between 0 and 60 minutes. The coverslips containing dried virus were then placed in DMEM media on ice to re-suspend the virus. Serial 1:10 dilutions were inoculated onto Hela cells and allowed to incubate for 45 minutes at 37°C. Media containing virus was removed and the cells were allowed to incubate overnight in D10 media. Plaque counts were determined the following day by combining 1% neutral red with 2× media plus agarose and incubating the cells for approximately 3 hours. All studies were conducted in triplicate with replicate experiments. Plaque counts indicated that the UV-C energy emitted from the Surfacide disinfection device was able to reduce the viral titers by an average of 2.71 $\log_{10}$ in 5 minutes and 6.11 $\log_{10}$ in 10 minutes of exposure (Figure 1).

Figure 1

Log reduction of MHV-A59 following Surfacide UV-C exposure at a 4-foot distance (1.22 meters). Virus was reduced by 2.71 $\log_{10}$ in 5 minutes and 6.11 $\log_{10}$ reduction in 10 minutes to undetectable levels.

Testing MERS-CoV sensitivity to UV-C virus was conducted under strict containment protocols due to the infective nature of the virus and all steps were carried out above bleach soaked pads to prevent virus spread. The presence of bleach in the biosafety cabinet prevented drying of the virus onto glass coverslips. MERS-CoV was therefore loaded onto glass coverslips as small droplets, placed in UV-C permeable dishes and exposed to UV-C energy from the Surfacide emitter at a distance of 4-feet (1.22) and samples removed at several time points between 0 and 30 minutes. Virus resuspension and dilution was carried out as described above. Virus dilutions were placed onto 90% confluent Vero cells at 37°C for 40 minutes. Following the 40 min incubation media containing virus was removed and replaced with 2× medium plus 1.2% agarose and allowed to solidify. DMEM was then layered on top to prevent drying and the plates incubated at 37°C for 3 days to allow for plaque formation. On the third day formalin was added to fix the cells for 20 minutes. Formalin, media, and agarose were then removed and replaced with 0.1% crystal violet for a 5 min incubation followed by a PBS wash prior to counting plaques. Again all samples were prepared in triplicate. A UV-C exposure time of only 5 minutes resulted in undetectable virus levels that remained undetectable following 30 minutes of total exposure for a 5.9 $\log_{10}$ reduction. (Figure 2).

Figure 2

Log reduction of MERS-CoV following Surfacide UV-C exposure at a 4-foot distance. Virus was reduced to 5.91 $\log_{10}$ in 5 minutes to undetectable levels.

Conclusions

The Surfacide triple emitter continuous UV-C disinfection system was greater than 99.999% effective against MHV-A59, a mouse analog of MERS-CoV and SARS-CoV in 10 minutes. Applying those same studies to droplets of MERS-CoV resulted in undetectable levels of MERS-CoV virus after only 5 minutes of exposure to the Surfacide UV-C emitter or a percent reduction of greater than 99.999%. This study is the first to document the effectiveness of the Surfacide automated whole room UV-C system or any whole room disinfection system against RNA viruses like MHV-A59, MERS-CoV and SARS-CoV. The use of the Surfacide whole room UV-C disinfection system during MERS outbreaks may prevent the nosocomial spread of the virus and protect staff in the process.

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