An Operating Room Germicidal Air Decontamination Technology Does Not Interfere with Return Air Ducts

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Introduction

The dynamic nature of operating room (OR) environments leads to air contamination from various events that lead to changes in the physical, chemical and biological conditions of the enclosed occupational space.[1-3] Operating rooms (ORs) have HEPA filtered, unidirectional airflow that is emitted from central overhead vents and is a preventative measure that inhibits surgical site infections.[4-7] Return air ducts remove the air in the room as fresh air is constantly replenished. Understanding various factors that can potentially affect airflow in the OR environment is an ongoing topic of interest.[8,9] Improving air quality in ORs requires the adoption of new technologies. Some medical devices recirculate air in local regions of the OR. A UV germicidal air cleaning device, manufactured under the name Illuvia®, has been garnering increasing interest as a potent tool in combating biological and chemical contamination in the operating room. Its demonstrated effectiveness includes the removal of SARS-CoV-2 bioaerosols.[10] When interfaced with a catalytic foam, the device removes formaldehyde from the air.[11] In order to gain a fuller understanding of the relationship between the Illuvia and airflow properties in an OR, we measured the airflow at the return air ducts in a simulated OR with the Illuvia *on* and *off*. We found no correlation between the airflow values at each air duct when the device was *on* or *off*, indicating that the air recirculation properties of the Illuvia do not interfere with the return airflow ducts.

Methods

Testing was performed with a 50 m^3 simulated operating room containing a single entry/exit door that automatically closes. The room included a ceiling mounted 44 $ft.^2$ array delivering unidirectional HEPA-filtered supply air and four lower wall mounted air return ducts. The system supplied 20 air exchanges per hour (ACH) and 0.03 in. H_20 (7.5 Pa) of positive pressure to the outside environment. The room was equipped with typical OR air flow obstructions including surgical lights, tables and medical equipment. The room also contained healthcare worker manikins. A diagram of the experimental set-up is shown in Figure 1. An Illuvia® air decontamination unit (Aerobiotix, Inc., Miamisburg, OH) was stationed in the corner of the OR, 16 inches from the wall on which duct 3 is mounted. A digital thermo anemometer (471B) (Dwyer, Michigan City, Indiana) was used for airflow measurements. The tip of the measuring probe was placed approximately 1 cm from the face of each return duct. The probe was clamped to a portable ring stand to maintain a steady position. Airflow values were averaged over a 30 s period. Airflow was measured for 1 minute and the final value was recorded. Measurements were performed

with the Illuvia *off* and *on*. The Illuvia was switched *on* and *off* consecutively for each measurement. After taking a measurement with the Illuvia *on*, the Illuvia was then switched *off* and a new measurement was taken, after which it was turned *on* for the following measurement. This cycle was repeated so that 20 measurements were taken with the device *off*, and 20 measurements with the device *on*. This cycling procedure allows for direct comparison with the values immediately before and after. The difference between the *on* and *off* state was calculated for each cycle and averaged. For these calculations, the *on* value was subtracted from the prior *off* value. This procedure was performed for each of the four wall mounted return ducts. Airflow values were compared when the device was *on* and *off*. The overall average and standard deviation for each condition were calculated and compared.

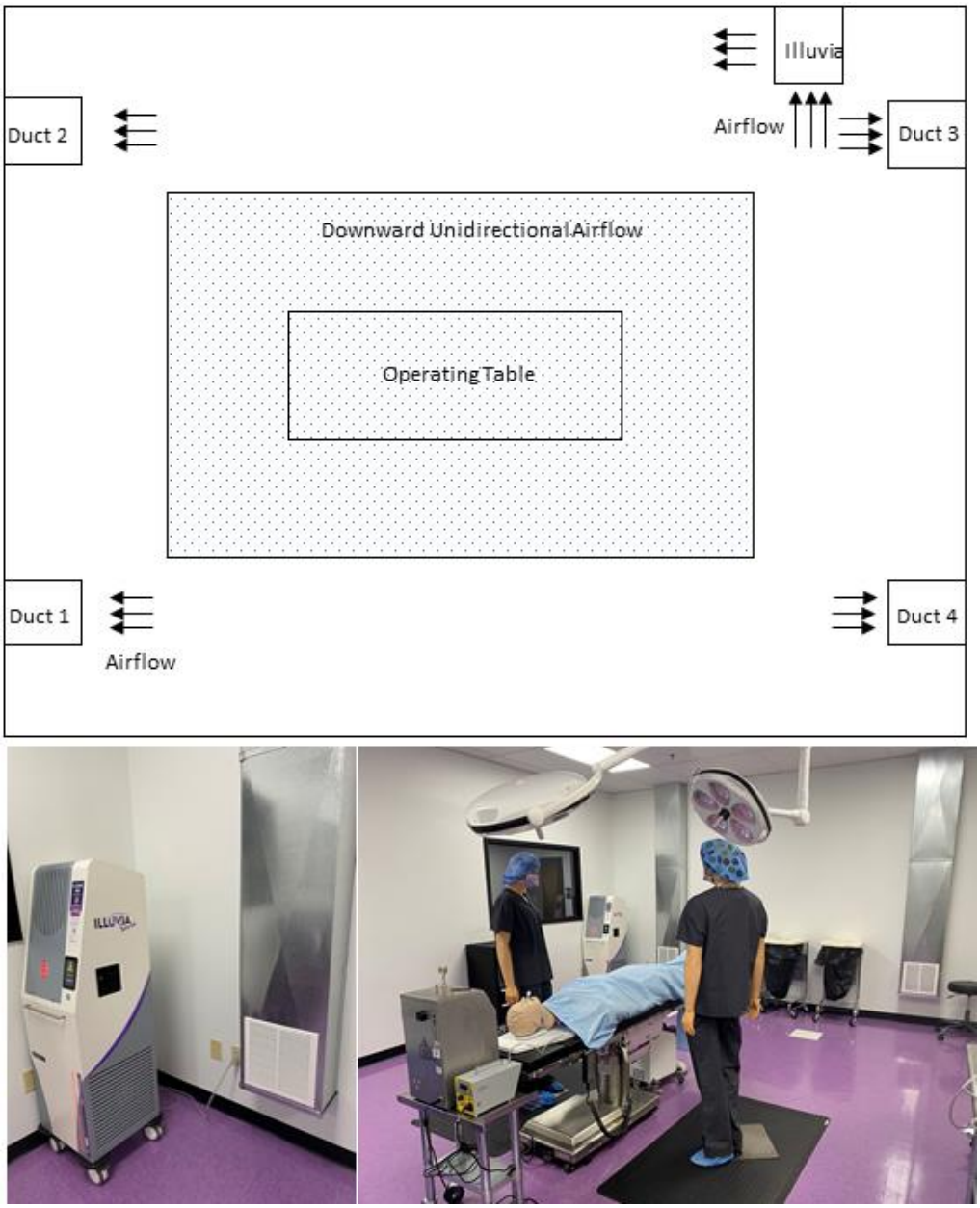

Figure 1: The configuration of the simulated OR is shown. Downward unidirectional airflow delivers HEPA filtered air at the center of the room. Near each corner of the room are return air ducts. The

Illuvia® air decontamination unit, which takes in air and recirculates it back into the OR, is located near duct 3. The direction of airflow for the ducts and the Illuvia input and output are shown by a series of three arrows. Pictures of the set-up are shown including the position of the Illuvia near duct 3.

Results and Discussion

In order to understand if the Illuvia air recirculating device can interrupt return airflow in an OR environment, airflow readings were recorded in a simulated OR containing an Illuvia. The air cleaning system was positioned in the corner of the room as shown in Figure 1 near air return duct 3. Airflow readings were measured at each of the four return air ducts with the device *on* and *off*. Measurements were cycled between *on* and *off* states of the Illuvia as shown in Figure 2. The graph shows that the airflow values at the return ducts stay within a narrow range when the air recirculation device is *on* or *off*. Switching the device to either an *on* or *off* state does not result in significant changes in the measured airflow values, nor does it show a clear directional preference of increased or decreased airflow values. The results for each condition were averaged and compared as shown in Table 1. Duct 1 has an average (standard deviation) airflow of 1.09 (.01) m/s when the Illuvia is *off* and 1.09 (.01) m/s when the Illuvia is *on*. The average of the differences calculated for each *on*/*off* cycle is 0 (.02) m/s. Duct 2 has an average (standard deviation) airflow of 0.98 (.01) m/s when the Illuvia is *off* and 0.99 (.02) m/s when the Illuvia is *on*. The average of the differences calculated for each *on*/*off* cycle is 0.00 (.02) m/s. Duct 3 has an average (standard deviation) airflow of 1.01 (.01) m/s when the Illuvia is *off* and 1.02 (.01) m/s when the Illuvia is *on*. The average of the differences calculated for each *on*/*off* cycle is -.01 (.01) m/s. Duct 4 has an average (standard deviation) airflow of 1.02 (.01) m/s when the Illuvia is *off* and 1.02 (.02) m/s when the Illuvia is *on*. The average of the differences calculated for each *on*/*off* cycle is 0 (.02) m/s. The average *on* and *off* values for each air duct are essentially the same; the average values are either equivalent or within the standard deviation. The largest average difference is 0.01 m/s, which is equal to or less than the standard deviation and equal to the systemic instrumental uncertainty in the measurement, hence no significant difference can be deduced.

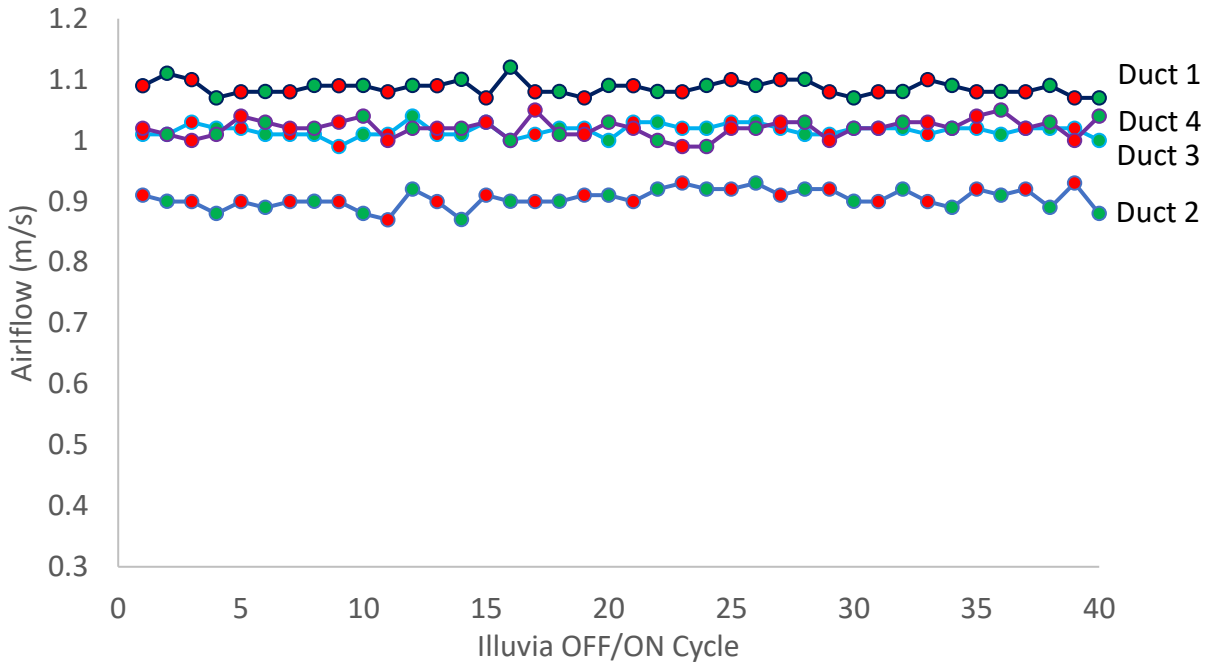

Figure 2: Each airflow measurement performed at each return duct is shown. Measurements were performed with the Illuvia® *off* (red data points) and *on* (green data points). 20 *on*/*off* cycles were performed at each duct. In all cases, the values for the airflow stay in a steady range. A consistent rise or drop corresponding to *on* and *off* states of the Illuvia® is not observed.

	Illuvia OFF	Illuvia ON	OFF/ON Difference
Duct 1 Airflow (m/s)	1.09 (.01)	1.09 (.01)	0.00 (.02)
Duct 2 Airflow (m/s)	0.98 (.01)	0.99 (.02)	0.00 (.02)
Duct 3 Airflow (m/s)	1.01 (.01)	1.02 (.01)	-0.01 (.01)
Duct 4 Airflow (m/s)	1.02 (.01)	1.02 (.02)	0.00 (.02)

Table 1: For each of the four air ducts, the average (standard deviation) airflow value when the Illuvia® is *on* and *off* are shown. The average of the differences for each *on*/*off* cycle are also shown.

The Illuvia air cleaning device is stationed in the perimeter of the OR and delivers directed airflow at a rate of 450 cfm. It is of interest to examine whether portable airflow devices interfere with the efficiency of OR ventilation. The results show that there is no significant difference in the detected levels of airflow at each return duct when the Illuvia is *on* and *off*. This is expected as the Illuvia recirculates the air that it uptakes back into the room. Operation of the Illuvia does not change the pressure in the room. Entry of air into the Illuvia does not preclude entry of air into the air ducts. Additionally, the room is constantly supplied with fresh air coming from overhead vents in the center of the OR. Recirculation of the air in a localized region of the room does not impact the flow of air into the return duct. Note that the Illuvia was not stationed directly in front of an air duct, but was stationed near duct 3 as shown in Figure 1. The corner of the Illuvia was approximately 17 in. from the nearest corner of the air duct. Given that this close proximity showed no effect, further distances are not expected to produce a difference in airflow at the duct. The germicidal and particle removal benefits of the Illuvia carry no negative side effects in regard to the efficiency of the return air ducts.

Conclusions

Operation of the Illuvia does not reduce airflow at the return air ducts in the OR.

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