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Short communication

Confirmation of radiant catalytic ionization efficacy for airborne SARS-CoV-2 elimination indoors using "COVID19 traps"

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ABSTRACT

Radiant catalytic ionization (RCI) is a novel technology that uses the appropriate wavelength (240-260 nm) and the phenomenon of photo-oxidation leading to permanent removal of viruses, bacteria, and fungi. Here, two analyses were performed. The first of them was a complete analysis of environmental biosecurity in a hospital environment. The second one was a longitudinal study with 40 patients with confirmed COVID19 and high viral load to assess the efficacy of RCI technology eliminating airborne SARS-CoV-2 indoors. A significant decrease in the number of bacteria and fungi colony-forming units (CFUs) was found in rooms with RCI when compared with rooms without it (p=0.03 for both of them). In the second part of the study, 16 samples out of 40 (40%) were positives when RCI technology was absent; whereas, these samples were negative when the equipment was on. Incidence rates (IR) with their Poisson 95% Confidence Intervals (CI) were calculated as the number of positive tests with the purifier or without it, showing an IR difference of 48.5% [CI(15.9-81), p=0.004]. Furthermore, the IR ratio was calculated obtaining a value of 3.3, confirming that RCI diminished more than 3-fold the presence of the SARS-CoV-2 in the air of the patients' rooms, thus laying the first stone in the fight for prevention of SARS-CoV-2 dissemination indoors.

1. Introduction

The importance of SARS-CoV-2 transmission routes is still debated. Aerosol transmission has become the main route of SARS-CoV-2 dissemination (57%), followed by large droplet inhalation (35%) and contact route had the lower probability of transmission with only 8% [1]. Therefore, in an attempt to confirm the importance of COVID19 aerosol transmission, we previously developed "SARS-CoV-2 traps" to measure the capacity of SARS-CoV-2 airborne dissemination [2,3].

Several technologies have been developed to remove SARS-CoV-2 from the air, thus avoiding viral transmission and the risk of multiple infections indoors. One of these technologies is the radiant catalytic ionization (RCI) that can be defined as an active air purification technology. It uses a photo-oxidation mechanism in the presence of UV radiation (240-260 nm) and an appropriate matrix to generate oxidant radicals, such as, superoxide and hydroxyl. In our novel study, the equipment Beyond Guard Air (BGA) is made up of a combination of a HEPA Filter (h14) plus active disinfection of air and surfaces through an ActivePure® reaction chamber with a state-of-the-art patented hydrophilic photocatalytic coating (Dallas, TX, USA), leading to permanent disinfection of the air. This technology can be used without restrictions in environments with people, animals and plants as it does not generate potentially dangerous by-products such as ozone, formaldehyde or carbon monoxide, among others.

Interestingly, RCI efficacy in the removal of SARS-CoV-2 in a real-world cohort of patients has not been demonstrated elsewhere.

2. Material and Methods (Supplemental Material)

Refer Supplemental Material in Appendix A.

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Table 1
RT-PCR Ct cycle of different genes associated to COVID19 detection at 24 h. Samples were taken with or without ActivePure® randomly (1st 24 h or 2nd 24 h). All samples from "COVID19 traps" were analyzed with the Seegene technology.

	Cts With ActivePure®				Cts Without ActivePure®				Patients samples Cts						
Patient	Order	Gen S	Gen RdRp	Gen N	Order	Gen S	Gen RdRp	Gen N	Platform	Gen S	Gen Orf1ab	Gen N	Gen N1	Gen N2	Gen E	Gen RdRp
1	2nd	33,1	34,6	32,3	1st	33,6	33,9	32,1	BDM				13.9	12.9		
2	2nd	N	N	N	1st	N	N	N	MDX	12.5	11.3					
3	1st	N	N	N	2nd	35	N	35,6	GXP					19.5	17.8	
4	1st	N	N	N	2nd	37,1	36,7	35,5	Cobas*		18.1					
5	1st	N	N	N	2nd	32,9	33,9	33,1	MDX	15.9	14.3					
6	2nd	N	N	N	1st	N	N	N	GXP					17.9	18.6	
7	1st	37,1	36,5	33,1	2nd	33,3	34,4	31,2	MDX	17.3	16.9					
8	2nd	34,1	36,7	31,6	1st	37,6	36,9	N	GXP					18.8	19.3	
9	1st	N	N	N	2nd	N	N	N	MDX	18.2	17.9					
10	2nd	N	N	N	1st	34,9	34,7	34,4	Thermo	10.5	12.3	11.6				
11	1st	N	N	N	2nd	36,7	35	34,4	MDX	19.7	19.9					
12	2nd	N	N	N	1st	N	N	N	MDX	13.2	13.3					
13	2nd	N	N	N	1st	N	N	N	MDX	19.2	18.1					
14	1st	N	N	N	2nd	N	N	N	MDX	15.2	15.0					
15	2nd	N	N	N	1st	N	37,2	34,1	MDX	15.6	15.4					
16	1st	N	N	N	2nd	35,9	36,3	N	GXP					16.0	18.0	
17	1st	N	N	N	2nd	N	36.5	36,8	GXP					16.8	19.2	
18	2nd	N	37,9	N	1st	35,7	N	N	MDX	15.0	15.2					
19	1st	N	N	N	2nd	N	N	N	Cobas*		14.4					
20	2nd	N	N	N	1st	N	N	N	MDX	15.2	14.9					
21	2nd	N	37,9	33,2	1st	36,2	35,5	36,1	MDX	11.1	10.9					
22	1st	N	N	N	2nd	N	N	N	GXP					18.5	19.1	
23	2nd	35,9	39,2	33,6	1st	35,1	35,6	N	MDX	14.7	13.9					
24	1st	N	N	N	2nd	37,2	N	35,1	MDX	16.0	15.7					
25	1st	N	N	N	2nd	37,1	39,3	N	MDX	12.1	11.8					
26	2nd	34,1	35,8	32,6	1st	N	39,1	N	MDX	10.7	10.4					
27	1st	N	N	N	2nd	36,6	N	34,1	GXP					16.3	17.4	
28	2nd	N	N	N	1st	35,3	34,9	34,3	MDX	12.0	11.5					
29	1st	N	N	N	2nd	N	N	N	MDX	13.1	12.4					
30	2nd	N	N	N	1st	N	N	36,1	MDX	19.8	18.6					
31	1st	N	N	N	2nd	37.5	36,3	N	MDX	18.6	17.5					
32	2nd	N	N	N	1st	35,8	36,2	34,8	GXP					16.3	18.0	
33	1st	N	N	N	2nd	N	N	N	Thermo	20.7	20.5	21.2				
34	2nd	N	N	N	1st	N	N	N	SEEGENE	17.6		17.2				18.1
35	1st	N	N	N	2nd	N	N	N	MDX	19.2	19.1					
36	2nd	N	N	N	1st	N	36.1	35,6	MDX	16.5	15.4					
37	1st	N	N	N	2nd	N	N	N	MDX	18.3	17.5					
38	2nd	N	N	N	1st	N	N	N	MDX	21.5	20.6					
39	1st	N	N	N	2nd	N	N	N	MDX	19.4	19.8					
40	2nd	N	N	N	1st	N	N	N	MDX	18.2	20.2					

*Cobas Platform detects the two genes (ORf1ab/N) simultaneously in the same fluorophore; therefore, in this case there is only one result.
In yellow are represented the samples that were negative with ActivePure® technology and positive without the machine.

3. Results

In the first part of the study, once the results of the environmental analysis were obtained, a statistical analysis was carried out to verify if the decrease in the number of CFUs observed between the rooms with or without ActivePure® technology showed statistical significance. It was found that there was a significant decrease in the number of bacterial CFUs in rooms with ActivePure® technology (134 CFUs, IR[76-270]) when compared with rooms without ActivePure® (348 CFUs, IR[161-961]) (p=0.03). Similarly, the number of fungi CFUs in rooms with and without ActivePure® diminished [3 CFUs IR (1-6) vs 7 CFUs, IR(4-12), respectively; p=0.03]. ActivePure® technology achieved a 62% decrease in bacteria, and 57% in fungi in the air of the rooms of patients with COVID19.

The results of the second part of the study can be observed in Table 1. In this second part, 40 patients with confirmed COVID19 infection and high viral load were selected. A longitudinal study was performed for 48 h with the same patients and the only difference was the presence or the absence of the BGA equipment in the room. Samples were always obtained from the "SARS-CoV-2 traps" after 24 h. The order of the sampling (with or without ActivePure® technology) was selected randomly. With this experimental design, we assessed that in some patients' rooms the BGA equipment was located the first day of the study and in others in the second day; thus avoiding the presence of a confounder in the statistical analysis.

Importantly, 16 samples out of 40 (40%) were positives when the ActivePure® technology was absent; whereas, these samples were negative when the BGA equipment was on, independently of the day when the samples were taken. Conversely, no positives were observed when the equipment was on and the samples without the ActivePure® technology were also negative. Additionally, 17 samples were negative irrespectively of the presence or the absence of RCI technology.

Table 2
Incidence rates with their Poisson 95% CI comparing rooms with or without ActivePure® technology.

	3 genes	Gene S	Gene RdRp	Gene N
Group 1 IR (with AP)	**21.2**	15.1	21.2	18.1
95% CI	**8.5-43.7**	4.9–35.3	8.5–43.7	6.7–39.6
Group 2 IR (without AP)	**69.7**	51.5	48.5	48.5
95% CI	**44.1-104.6**	30–82.5	27.7–78.7	27.7–78.7
IR difference	**48.5**	36.4	27.3	30.3
95% CI	**15.9-81**	8.5–64.2	-1.2–55.7	2.4–58.2
p-value	**p=0.004**	p = 0.01	p = 0.06	p = 0.03
IR ratio	**3.3**	3.4	2.3	2.7
95% CI	**1.4-9.1**	1.2–11.8	0.9–6.6	1–8.3

Abbreviations: AP: ActivePure; CI: Confidence interval; IR: Incidence rate; N: Nucleocapsid; RdRp: RNA-dependent RNA polymerase gene; S: Spike.

To verify the statistical significance of these results, incidence rates (IR) with their Poisson 95% CI were calculated as the number of positive tests with the BGA purifier [21.2% CI(8.5-43.7)] or without it [(69.7% CI(44.1-104.6)], showing a incidence rate difference of 48.5% CI(15.9-81), p=0.004. Furthermore, the IRR was calculated and a value of 3.3 was obtained, confirming that the use of the ActivePure® technology diminished 3.3-fold the presence of the SARS-CoV-2 in the air of the patients' rooms (Table 2).

4. Discussion

As far as we know, this is the first study achieving the removal of SARS-CoV-2 from airborne in a cohort of patients with confirmed COVID19 infection and high viral load. Thus, the use of ActivePure® could be the first effective confirmed technology to avoid airborne transmission indoors and, therefore, to prevent future infections. Unlike germicidal Ultraviolet (GUV), this technology can be used while patients are in their rooms, as this technology has been proven to be completely harmless for humans and animals. Previously, the effectiveness of this technique in the elimination of SARS-CoV-2 was assessed in two different laboratory analysis showing that this air purifying technology inactivated highly concentrated airborne SARS-CoV-2 virus in an enclosed setting in just 3 min, below detectable levels. Testing of the ActivePure® Technology was conducted by one of the world's top biosafety testing facilities, the University of Texas Medical Branch, which primarily tests for the U.S. military and the Centers for Disease Control [4,5].

Regarding the complete environmental biosecurity assay performed by an external and accredited laboratory, results were similar to those previously performed in the removal of bacteria and fungi, both in real life or in laboratory conditions [6,7]. In one of them, RCI improved the inactivation of *Acinetobacter baumannii, Escherichia coli, Enterococcus faecalis, Pseudomonas aeruginosa* and *Salmonella Enteritidis*, among others, in air and on different surfaces with different outcomes [6]. Previously, another study performed in both, air and surfaces, showed the efficacy of RCI on *K. pneumoniae* reduction in the air and on selected surfaces from a hospital environment [7]. This way, it could be said that ActivePure®, achieved similar results in the elimination of bacteria and fungi in real life conditions when compared with previous analysis in laboratory.

Regarding GUV technology, it seem promising and effective in reducing and managing airborne transmissions in several prediction developed models; however the data available with real-world studies are scarce and, contrary to this study, in some of them patients could not be present in their rooms while this technology was working [8].

To sum up, the capacity of removing SARS-CoV-2 airborne dissemination indoors using RCI technology has been demonstrated for the first time, being a potential solution of this virus dissemination indoors in public places.

5. Limitations, conclusions and future perspectives

This study has limitations. The detection of the virus in the air through RT-PCR assays merely indicates presence and does not provide information regarding viability or infection risk. However, many studies indicated that viral culture is surprisingly difficult, being a reason why virus isolation in cell culture is much less sensitive than detection by molecular methods [9–11]. This way, finding viral RNA in air samples should be interpreted as more likely to indicate the presence of live virus than not, as per the precautionary principle, should always reinforce effective infection control [12]. It is important to remark that patients wore masks in their rooms and medical personnel also wore masks and disposable gloves. Hands disinfection was also mandatory in the medical personnel. Thus, it could be said that ActivePure® Technology is the first one to achieve the reduction of airborne transmission of bacteria, fungi and, what is more important, SARS-CoV-2 in a real-world hospitality environment. Some centuries ago, water purification was the first step to avoid several transmissible infections and millions of deaths have been prevented since then. Nowadays, air purification will be of paramount importance for SARS-CoV-2 and other respiratory diseases transmission prevention. Although further studies are necessary, this study lays the first stone in the fight for prevention of SARS-CoV-2 indoors.

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CRediT authorship contribution statement

Conceptualization: EOP, JCG, DNC, PR. Methodology: EOP, AMD. Investigation: EOP, AMD, JCG, DNC. Visualization: EOP, JAOG. Funding acquisition: EOP, PR. Project administration: EOP. Supervision: EOP, JAOG, PR. Writing – original draft: EOP, JCG, DNC. Writing – review & editing: all authors.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jiph.2022.11.014.

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