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Monitoring environmental contamination caused by SARS-CoV-2 in a healthcare facility by using adenosine triphosphate testing

We read with great interest the recent article by Wu et al[1] describing a study of environmental contamination by SARS-CoV-2. The authors reported that the touchable surfaces were heavily contaminated in the designated hospital for 2019 novel coronavirus diseases (COVID-19). Environmental management in healthcare facilities is essential for preventing hospital outbreaks of SARS-CoV-2 during the 2019 novel coronavirus disease (COVID-19) pandemic.[2] Assessment of environmental contamination with Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) by real-time reverse transcriptase-polymerase chain reaction (RT-PCR) or culture-based method is not cost effective and time consuming. Adenosine triphosphate (ATP) monitoring is utilized as a surrogate marker for hygiene in hospitals.[3] The detection of ATP indicates a biologic reaction that produces light such as organic matter, including microbes, feces, dirt.[4] ATP is required during viral lifecycles, especially during viral replication.[5] However, the correlation between viral concentration and ATP measurement has not been well documented. The objective of this study was to determine the contamination degree of an isolation room of a patient with COVID-19 using additional ATP monitoring, before and after cleaning, to determine the proper approach to prevent the hospital spread of SARS-CoV-2.

An adult patient with COVID-19 was treated in a negative-pressure isolation room in March 2020 at our tertiary care hospital in South Korea. Surface samples in the isolation room and bathroom inside the isolation room were collected using an eNAT sampling kit (Copan, Brescia, Italy) at 25 sites for real-time RT-PCR analysis for SARS-CoV-2. The sampling sites were divided into routine disinfection sites and sites that were not disinfected. The samples at routine disinfection sites were collected before and after daily cleaning measures. Samples from nondisinfected sites were collected once before the routine cleaning measures. The routine cleaning of the room was done once daily with 0.2% sodium hypochlorite (Clorox). The samples were taken on the fifth hospital day. ATP monitoring was performed immediately before sampling for RT-PCR of SARS-CoV-2. The real-time RT-PCR was performed using a STANDARD M nCOV Real-Time Detection Kit (SD biosensor, Osong, Korea) following the manufacturer's instructions with an ABI 7,500 fast instrument (Applied Biosystems, CA). The target genes were *RdRp* and *E* genes.[6] The amplification curve of each gene was checked and the Ct values were recorded regardless of cutoff value (Ct ≤36), as suggested by the manufacturer. ATP bioluminescence was measured in relative light units (RLUs) using a 3 M Clean-Trace Surface ATP meter (3 M, St. Paul, MN) following the manufacturer's protocol. The results were represented as RLUs. The threshold value for the ATP measurement was 100 RLU/100 cm^2.

A 25-year-old male patient was admitted to the isolation room for COVID-19 on the second day of symptom onset, and the samples were collected on the seventh day of symptom onset. The patient had a slight dry cough without fever on the date of sampling. The patient did not wear any type of mask. The severity of COVID-19 was mild. The patient had high viral shedding of SARS-CoV-2 on the sampling day, with cycle threshold values of 29.94, 29.19, and 21.88 in the oropharynx, nasopharynx, and sputum, respectively. The RT-PCR of all environmental samples showed negative results. The results of ATP monitoring before and after cleaning are shown in Table 1. The isolation room floor, mattress, bathroom sink, and pillow showed high ATP measurements, whereas the toilet seat cover, shower handle, and ventilator hole in the isolation room revealed negative results for ATP monitoring. The median ATP measurement decreased by 47% after cleaning [before cleaning: 328 (131-794) RLU vs. after cleaning: 157 (113-179) RLU]. The difference between the ATP measurement results before and after cleaning was significant by the paired *t* test analysis ($P = .03$).

Even though previous studied have reported extensive environmental contamination of the healthcare facilities housing COVID-19 patients, by SARS-CoV-2,[7] SARS-CoV-2 was not detected in any surface sample in our study. In line with our results, Wang et al. also failed to detect SARS-CoV-2 RNA among various environmental surface samples.[8] These results suggested that environmental contamination may not always happen at the level that can be detected by RT-PCR when the patient has only a mild cough.

In our study, post cleaning ATP value was significantly decreased. These results indicate that routine cleaning may be enough to manage the hospital environment for preventing the outbreak of COVID-19. There were limited studies regarding association between viral contamination and ATP measurement. Laura et al. reported that ATP measurement does not represent the viral load on surfaces.[9] These results suggest that the ATP assay merely has a role in the assessment of surface contamination.

In conclusion, routine cleaning effectively controls environmental contamination in a COVID-19 isolation room, according to ATP monitoring. The ATP system could be used to monitor environmental cleanliness, and its usefulness as a SARS-CoV-2 contamination screening tool should be evaluated in future studies.

Table 1
Results of ATP monitoring and RT-PCR according to environmental sampling sites before and after cleaning

Sites	Before cleaning			After cleaning		
	ATP monitoring	Relative light unit	RT-PCR	ATP monitoring	Relative light unit	RT-PCR
Routine disinfection sites						
Floor	Positive	3,896	Negative	Positive	1,062	Negative
Light switch at wall	Positive	388	Negative	Positive	214	Negative
Bed rail	Positive	415	Negative	Positive	120	Negative
Light switches at bed	Positive	633	Negative	Positive	123	Negative
Call bell at bed	Positive	267	Negative	Positive	179	Negative
Bedside table	Positive	862	Negative	Negative	81	Negative
Telephone at bedside table	Positive	142	Negative	Positive	168	Negative
Bed mattress	Positive	2,778	Negative	Positive	169	Negative
Medical fluid hanger	Positive	107	Negative	Positive	153	Negative
Door handle of refrigerator	Positive	157	Negative	Positive	160	Negative
Remote control	Positive	161	Negative	Negative	84	Negative
Patient's monitor screen	Positive	134	Negative	Positive	117	Negative
Door handle of bathroom	Positive	392	Negative	Positive	179	Negative
Light switch at bathroom	Positive	122	Negative	Positive	102	Negative
Toilet seat cover	Negative	79	Negative	Positive	116	Negative
Shower handle at bathroom	Negative	76	Negative	Positive	172	Negative
Water tap at bathroom	Positive	771	Negative	Negative	98	Negative
Sink at bathroom	Positive	1,159	Negative	Positive	197	Negative
Non-disinfected sites						
Cellphone	Positive	267	Negative	-	-	-
Television screen	Positive	163	Negative	-	-	-
Bed headboard	Positive	100	Negative	-	-	-
Blood pressure cuff	Positive	217	Negative	-	-	-
Pillow	Positive	8,811	Negative	-	-	-
Ventilator hole at isolation room	Negative	99	Negative	-	-	-
Ventilator hole at bathroom	Positive	414	Negative	-	-	-

ATP, adenosine triphosphate; *RT-PCR*, real-time reverse transcriptase-polymerase chain reaction.

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The higher temperature and ultraviolet, the lower COVID-19 prevalence–meta-regression of data from large US cities

To the Editor:

Higher temperature and ultraviolet (UV) index in Northern Europe have been reported as the most important meteorological protective factors for the transmission of influenza virus.[1] On the other hand, a recent study in China suggests that higher temperature and UV radiation may not be associated with a decrease in the epidemics of coronavirus disease 2019 (COVID-19).[2] To determine whether prevalence of COVID-19 is modulated by meteorological conditions, we herein conducted meta-regression of data from large US cities.