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Concise Communication

Severe acute respiratory coronavirus virus 2 (SARS-CoV-2) RNA and viable virus contamination of hospital emergency department surfaces and association with patient coronavirus disease 2019 (COVID-19) status and aerosol-generating procedures

Scott C. Roberts MD[1], Elliana S. Barbell MPH[2], Douglas Barber MD[4], Suzanne E. Dahlberg MS, CIC[3], Robert Heimer PhD[2], Karen Jubanyik MD[4], Vivek Parwani MD[4], Melinda M. Pettigrew PhD[2], Jason M. Tanner MD, PhD[4], Andrew Ulrich MD[4], Martina Wade BS[2], Anne L. Wyllie PhD[2], Devyn Yolda-Carr BS[2], Richard A. Martinello MD[1,a] and Windy D. Tanner PhD[2,a]

[1]Department of Internal Medicine, Yale University, New Haven, Connecticut, [2]Department of Epidemiology of Microbial Diseases, Yale School of Public Health, New Haven, Connecticut, [3]Infection Prevention, Yale New Haven Hospital, New Haven, Connecticut and [4]Department of Emergency Medicine, Yale University, New Haven, Connecticut

Abstract

Emergency departments are high-risk settings for severe acute respiratory coronavirus virus 2 (SARS-CoV-2) surface contamination. Environmental surface samples were obtained in rooms with patients suspected of having COVID-19 who did or did not undergo aerosol-generating procedures (AGPs). SARS-CoV-2 RNA surface contamination was most frequent in rooms occupied by coronavirus disease 2019 (COVID-19) patients who received no AGPs.

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The emergency department (ED) serves as the gateway for hospital admission for severe coronavirus disease 2019 (COVID-19). Many of these patients require respiratory aid via aerosol-generating procedures (AGPs), which can contaminate environmental surfaces through aerosol deposition. Severe acute respiratory coronavirus virus 2 (SARS-CoV-2) environmental contamination after procedures carries implications for transmission, and characterizing this contamination can guide infection prevention practices. We determined the occurrence and viability of SARS-CoV-2 on ED surfaces when COVID-19 patients did and did not receive AGPs.

Methods

Patients presenting to the Yale New Haven Hospital Adult ED, composed of 101 beds across 2 campuses, were evaluated for COVID-19. From January through December 2021, environmental swabs were collected from a convenience sample of rooms housing patients actively infected with or under investigation for COVID-19. Sampling was prioritized for rooms of patients receiving AGPs. AGPs were classified as endotracheal intubation or extubation, manual bag-valve-mask (BVM) ventilation, cardiopulmonary resuscitation, noninvasive positive-pressure ventilation (NPPV), high-flow oxygenation, bronchoscopy, and nebulizer therapy.[1]

From each room, 5 samples were collected while occupied by the patient or immediately following discharge or transfer, but prior to cleaning. Among these samples, 4 were from fixed surfaces, selected based on touch frequency and aerosol source proximity: high-touch surfaces within and farther than 2 m (6 feet) from the patient (bedrail, door handle, respectively), and low-touch surfaces within and farther than 2 m (6 feet) from the patient: vital signs monitor frame, air return vent (standard rooms) or procedure light (resuscitation rooms), respectively. A fifth sample was taken from the reusable AGP equipment or oxygen gauge behind the bed. Surface swabs underwent RNA extraction and RT-qPCR using N1 primers, and RNA copies were quantified via a standard curve using controls of known copy number. Positive samples were cultured using Vero E6 cells and were examined for cytopathic effect. Severity was classified using a previously validated COVID-19 ordinal severity index.[2] Differences between AGP and non-AGP room SARS-CoV-2 RNA contamination frequency

Author for correspondence: Windy Tanner, Yale School of Public Health, LEPH 711, 60 College Street, New Haven, CT 06510. E-mail: windy.tanner@yale.edu

[a]Authors of equal contribution.

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Table 1. Percentage of Rooms and Surface Swabs Testing Positive for SARS-CoV-2 RNA or Infectious Virus by RT-qPCR or Culture

COVID-19 Status	Aerosol-Generating Procedure (AGP)	Rooms Sampled, No.	Rooms (%) Positive for SARS-CoV-2 RNA, No. (%)	Swabs Collected, No.	Swabs Positive for SARS-CoV-2 RNA, No. (%)	Average SARS-CoV-2 RNA Copies per 100 cm^2 Swabbed Surface Area[a]	Swabs Positive by Viral Tissue Culture, No.
Positive	Yes	42	6 (14.3)	210	8 (3.8)	52.1	0
Positive	No	45	13 (28.9)	225	16 (7.1)	147.6	1
Negative	Yes	115	10 (8.7)	575	12 (2.1)	24.1	0
Total		202	29 (14.4)	1,010	36 (3.6)		**1**

Note. RT-qPCR, reverse-transcription quantitative polymerase chain reaction.
[a]Mean copies, as determined by RT-qPCR curve determined from known quantities of PCR.

Table 2. Emergency Department Room Surfaces Positive for SARS-CoV-2 Contamination

Surface	Surface Area Sampled (cm^2)	Samples Collected, No.	Positive Surface Swabs, No. (%)	RNA Copies/cm^2			
				Total	Mean	Range	IQR
High touch, near patient (< 2 m): bedrails	129	202	10 (5.0)	84.8	15.9	4.7–538.1	8.7–70.2
High touch, distant from patient (>2 m): door handle	65	202	3 (1.5)	35.9	36.1	32.3–39.4	34.2–37.7
Low touch, distant from patient (>2 m):							
Air return vent	15	133	13 (9.8)	91.1	28.6	5.0–686.6	9.6–71.7
Resuscitation room procedure lights	232	69	2 (2.9)	31.0	31.0	11.9–50.1	21.4–40.5
Low touch, near patient (<2 m): vital signs monitor frame	194	202	4 (2.0)	178.0	92.5	22.2–504.7	33.4–237.1
Reusable AGP equipment							
Glidescope	155	4	0 (0.0)	...			
Noninvasive positive pressure ventilation control screen frame (BiPAP; CPAP)	226	53	0 (0.0)	...			
High-flow oxygen control	219	36	1 (2.8)	15.9	15.9	...	...
Oxygen gauge (swabbed for nebulizer treatments and when no AGP‡ was administered)	97	56	1 (1.8)	64.8	64.8	...	...
Mechanical ventilation control screen frame	226	49	2 (4.1)	36.3	36.3	25.8–46.8	31.0–41.6

Note. BiPAP, bilevel positive airway pressure; CPAP, continuous positive airway pressure; AGP, aerosol-generating procedure.

were analyzed with the Fisher exact test and concentrations were analyzed with the Kruskal-Wallis test. Additional methods are in the Supplementary Material (online).

Results

Sample collection yielded 1,010 environmental specimens from 202 rooms. Room types included resuscitation bays (n = 69, 34.2%), airborne-infection isolation rooms (n = 56, 27.7%), and standard rooms (n = 77, 38.1%). AGPs were performed in 157 rooms (77.7%), and included intubation (n = 52), NPPV (n = 47 BiPAP and 2 CPAP), high-flow oxygenation (n = 34), nebulizer therapy (n = 13), and BVM ventilation (n = 1), or multiple AGPs (n = 8). Of 202 rooms, 87 housed SARS-CoV-2–positive patients (43.1%), approximately half of whom received AGPs (n = 42, 48.3%). These included high-flow oxygenation (n = 28), NPPV (n = 4), nebulizers (n = 4), intubation (n = 4), or multiple (n = 2).

In total, 36 swabs (3.6%, n = 1,010) from 29 rooms (14.4%, n = 202) were positive for SARS-CoV-2 RNA (Table 1). Of 87 COVID-19 patient rooms, 19 (21.8%) had SARS-CoV-2 RNA on at least 1 surface, including 13 rooms (28.9%, n = 45) where AGPs were not performed and 6 rooms (14.3%, n = 42) where AGPs were performed ($P = .123$). Patients spent more time in the room prior to environmental swab collection when surfaces were SARS-CoV-2 RNA-positive (mean, 295.4 minutes; n = 19) versus negative (mean, 223.8 minutes; n = 68), but this was not statistically significant ($P = .213$). SARS-CoV-2 RNA was detected in 10 rooms (8.7%, n = 115) occupied by SARS-CoV-2–negative patients. The mean estimated concentration of SARS-CoV-2 RNA on contaminated surfaces was 24.1 (median, 20.2) copies per 100 cm^2 in rooms housing SARS-CoV-2–negative patients, 52.1 (median, 48.1) copies per 100 cm^2 in rooms housing COVID-19 patients who underwent AGPs, and 147.6 (median, 43.7) copies per 100 cm^2 in rooms housing COVID-19 patients who did not undergo an AGP ($P = .239$).

Of the 6 SARS-CoV-2 RNA-contaminated rooms of SARS-CoV-2–positive patients where AGPs occurred, high-flow oxygenation occurred in 5 rooms (n = 28), and nebulizer therapy occurred in 1 room (n = 4). No SARS-CoV-2–positive patient room surfaces were contaminated after intubation (n = 4) or NPPV (n = 4).

SARS-CoV-2 RNA was most frequently detected on air-duct return vents (13 of 133, 9.8%), followed by bedrails (10 of 202, 5.0%), reusable equipment (4 of 202, 2.0%), monitors (4 of 202,

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2.0%), door handles (3 of 202, 1.5%), and procedure lights (2 of 69, 2.9%) (Table 2). SARS-CoV-2 RNA contamination ranged from 5–687 copies per 100 cm^2 on vents, 6–74 copies per 100 cm^2 on bedrails, 32–39 copies per 100 cm^2 on door handles, 16–65 copies/100 cm^2 on reusable equipment, and 22–504 copies per 100 cm^2 on the monitor frame (Table 2 and Supplementary Table 1 online). Most contaminated rooms had only 1 SARS-CoV-2–positive surface; however, 6 rooms had multiple positive surfaces. A higher percentage of nonresuscitation rooms were positive (17.9%, n = 24 of 134) than resuscitation rooms (7.4%, n = 5 of 68; $P = .055$).

Of the 36 SARS-CoV-2 RNA-positive samples (bedrail, non-AGP COVID-19 patient), 1 sample was positive by viral tissue culture, exhibiting extensive cytopathic effect. SARS-CoV-2 RNA copy number in pre- and post-incubation tissue culture medium went from undetectable to 3.5×10^8 copies, respectively.

COVID-19 patients occupied 13 of the 202 sampled rooms (6.4%) immediately preceding the occupant present during sampling. One of these rooms had an equipment surface positive for SARS-CoV-2 RNA while occupied by the subsequent SARS-CoV-2–negative patient.

The median severity of patient illness on arrival was 5.0 (IQR, 2.5–6.0) in rooms with SARS-CoV-2 contamination compared to 6.0 (IQR, 4.75–6.0) in rooms without contamination ($P = .259$). The median number of days from symptom onset to ED presentation was 4.0 (IQR, 3.0–7.0) in rooms with detectable SARS-CoV-2 contamination compared to 7.0 (IQR, 3.0–8.5) in rooms without ($P = .507$) (Supplementary Fig. 1A and B online).

Discussion

SARS-CoV-2 RNA contamination was detected on at least 1 surface in >20% of rooms housing patients with COVID-19. Surface contamination was detected more frequently in rooms of COVID-19 patients who did not have an AGP. We suspect that this finding is due to the natural progression of COVID-19 in which viral loads peak around symptom onset, and more severe disease occurs later in the hyperinflammatory phase of illness when viral load is diminished.[3,4] This carries infection control implications; mitigating transmission earlier in the disease course when viral transmission potential is greatest may be more impactful, regardless of aerosol deposition.

We observed SARS-CoV-2 contamination in 9% of SARS-CoV-2–negative patient rooms. Given the rapid turnover of ED rooms, prior patients could have contributed to contamination, especially on air-return vents because these are not disinfected between patients. This finding also highlights the ability of upward airflow, even in rooms maintained without negative pressure, to move SARS-CoV-2 aerosols to surfaces unlikely to be implicated in viral transmission.

One sample grew SARS-CoV-2 in tissue culture. Infectious virus has rarely been recovered from hospital surfaces, and positive surfaces are typically within close range of the patient.[5–7] SARS-CoV-2 remains viable on surfaces up to 21 days, with a half-life of ~2–5 days,[8] whereas SARS-CoV-2 RNA exhibits a 1-log reduction over the same period.[9] Therefore, failure to detect viable virus in more samples with high viral concentrations is not unexpected and supports the evidence of a minimal role of surface and fomite transmission in SARS-CoV-2 spread.[10] Study limitations include observations at a single emergency department and limited comparisons between AGPs due to small sample sizes. It is unclear whether these findings would be replicated in asymptomatic COVID-19 populations.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/ice.2023.183

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Conflicts of interest. All authors report no conflicts of interest relevant to this article.

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