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An assessment of the impact of recommended anesthesia work area cleaning procedures on intraoperative SARS-CoV-2 contamination, a case-series analysis☆

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To the Editor,

Basic perioperative infection control measures can reduce *S. aureus* transmission and surgical site infections (SSIs) [1]. Perioperative COVID-19 defense recommendations at the start of the pandemic leveraged this empiric evidence [2,3], but without data specific to SARS-CoV-2. We conducted a case-series analysis to test our primary hypothesis that effective implementation of perioperative COVID-19 cleaning procedures would be associated with a low rate of anesthesia work area (AWA) SARS-CoV-2 nucleic acid transmission and our secondary hypothesis that ultraviolet-C germicidal irradiation (UV-C) would augment surface disinfection cleaning [2,3]. This work extends simulated study of sterile dye [4,5] to the assessment of actual SARS-CoV-2 nucleic acid transmission in the operating room theatre.

Perioperative COVID-19 recommendations [1] were implemented in April 2020, 7 months prior to enrollment of the first of 11 patients (Table 1) at the University of Iowa. Adult patients confirmed positive for COVID-19 by real-time PCR analysis preoperatively within 90 days of surgery were considered eligible for enrollment. For each patient enrolled we assessed in parallel the effectiveness of recommended anesthesia work area cleaning procedures, the rate of within-case anesthesia work area SARS-CoV-2 transmission, and environmental SARS-CoV-2 detection with and without Helios UV-C (Surfacide, Waukesha WI 53186). We evaluated thirteen proven AWA reservoirs [1] and twelve proximal and distal environmental locations [4–6] (before surface disinfection cleaning, after surface disinfection cleaning, and after surface disinfection cleaning and UV-C) for each enrolled patient to test our primary and secondary hypotheses, respectively. The effectiveness of recommended cleaning procedures was defined a priori by an anesthesia work area *S. aureus* transmission rate of <12.5% [7]. *S. aureus* and SARS-CoV-2 transmission events were defined by reservoir detection at case end but not at case start or by detection among ≥2 distinct reservoirs [1,7]. SARS-CoV-2 detection was defined by the amplification of at least 2 SARS-CoV-2 genes (ORF, N, S) by visual inspection of amplification plots with CT (cycle threshold) < 35 [8]. See supplementary material for additional detail regarding sample locations, sampling and microbiological methodology, and assessment of infectivity.

We relied on our secondary hypothesis for sample size calculations given lack of available data for the primary hypothesis. We hypothesized that less SARS-CoV-2 nucleic acid detection would be observed after UV-C than after surface disinfection for every patient. With negative pairwise differences for all of 9 patients, $P = 0.0020$ for a reduction. We anticipated the possibility of patients for which none of the 12 samples detected SARS-CoV-2 in the period after cleaning but before UV-C treatment. If that were so for 3 patients (i.e., there are 6 differences that aren't both zero valued), $P = 0.016$. Therefore, the basis for our selection of $N = 9$ patients was that this provided for up to 3 patients to have 0 of 12 samples positive after cleaning. We enrolled 11 patients because UV-C treatment was excluded for two patients due to operating room management decisions involving case scheduling and time constraints.

Simple descriptive statistics were used to characterize anesthesia work area *S. aureus* and SARS-CoV-2 transmission. The exact 95% confidence interval for the ratios of the proportion of samples positive for nucleic acid detection for anesthesia work area reservoirs during the process of patient care vs. other environmental sites was obtained by inverting the two-sided test (StaXact-12, Cytel, Cambridge MA). For the secondary outcome, the exact 95% confidence interval for the ratios of the proportion of samples positive for nucleic acid detection with surface disinfection cleaning alone vs. after surface disinfection cleaning and UV-C treatment was obtained by inverting the two-sided test. This same approach was used to compare nucleic acid detection before and after

☆ Permission from the patient or an authorized individual was obtained to publish this report which complies with the EQUATOR publishing guidelines for case reports (CARE: Consensus-based Clinical Case Reporting). The study was IRB approved (202005391) with a requirement for informed, written patient consent and registered at clinical trials.gov (NCT04443803) prior to patient recruitment.

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Table 1
Patient enrollment.

Patient number	Age	Date	Symptomatic	Urgent	[a]SARS-CoV-2 positive ≤ 10 days	Anesthesia type	Procedure
3	46	November 2020	No	Yes	Yes	General	Incision and drainage of his left elbow
5	59	November 2020	Yes[b]	No	Yes	General	Sacral nerve stimulator generator placement
8	65	December 2020	No	Yes	Yes	General	Vitrectomy
9	64	December 2020	No	Yes	Yes	Monitored anesthesia care	Transcutaneous angioplasty
10	74	December 2020	No	Yes	Yes	General	Burr hole placement
1	77	November 2020	No	No	No	Regional/sedation	Total knee arthroplasty
2	33	November 2020	No	No	No	Monitored anesthesia care	Open reduction and internal mandibular fixation
4	54	November 2020	No	No	No	General	Cholecystectomy
6	28	December 2020	No	No	No	General	Tympanoplasty
7	72	December 2020	No	No	No	General	Open colectomy
11	25	December 2020	No	No	No	General	Left thyroidectomy

[a] For patients positive for SARS-CoV-2 within 10 days of surgery, recommendations included use of personal protective equipment (PPE) including but not limited to use of a properly fitted and tested N-95 mask covered by a simple face mask or the equivalent, coverage of the N-95, eye and/or face shields, gowns, shoe covers, and double gloves.

[b] Lack of taste (a symptom considered low risk by the perioperative team). Recovered from the patient nose sampled at the end of the case. Infectivity was confirmed for this symptomatic patient undergoing surgery.

surface disinfection. The viability of all samples positive for SARS-CoV-2 nucleic acid detection was assessed.

A total of 473 intraoperative reservoir samples were tested. There was negligible detection of *S. aureus* anesthesia work area transmission [0% (0/108)]. There was negligible SARS-CoV-2 anesthesia work area transmission [1% (1/108)] (Table 2). UV-C was associated with reduced SARS-CoV-2 detection [17/126 (13.5%) after surface disinfection (cleaning) vs. 6/107 (5.6%) with UV-C, RR 0.42, 95% confidence interval 0.15–0.99, $P = 0.046$]. Pooling the environmental sites during patient care [9/154, 5.8%] versus after surface disinfection [17/126, 13.5%], there was more SARS-CoV-2 detection after cleaning [RR 2.31, 95% confidence interval 1.04–5.08, $P = 0.030$]. There was no association of timing of diagnosis (≤ 10 days) with detection (Table 3, Supplementary material).

Basic perioperative infection control measures proven to reduce *S. aureus* transmission and surgical site infections (SSIs) [1] may also be useful in controlling intraoperative SARS-CoV-2 spread [2,3]. Indeed, our case series analysis shows association of effective implementation of recommended cleaning procedures (0% *S. aureus* transmission) and a low rate of AWA SARS-CoV-2 transmission. These findings are consistent with similar susceptibility of SARS-CoV-2 and *S. aureus* to disinfection agents [9]. We also found that use of UV-C was associated with a ≈ 2-fold reduction in SARS-CoV-2 detection as compared to surface disinfection cleaning.

Prior studies of simulated SARS-CoV-2 contamination have been ingenious [4,5] but are limited by lack of correlation between a reduction in dye florescence and a reduction in pathogen acquisition [10]. The observed increase in SARS-CoV-2 detection following cleaning is consistent with that reported for other aerosolized pathogens [10], another indication for ongoing monitoring of the efficacy of cleaning procedures.

Primary and secondary outcomes were assessed in parallel for every patient regardless of diagnosis timing and/or symptoms with no association of diagnosis timing (i.e. ≤ 10 days) with nucleic acid detection. In principle, just like with sterile dye, effective cleaning procedures should be associated with particulate removal, regardless of infectivity. The methodology employed can be used to guide future study. Theoretical concerns of detection limitations would apply to both groups, and there was substantial detection. Additional study should be conducted to validate these findings because the reproducibility in other operating room settings is unknown.

In conclusion, recommended anesthesia work area cleaning procedures are associated with negligible SARS-CoV-2 nucleic acid transmission, and UV-C is associated with reduced environmental SARS-CoV-2 detection. Further validation is indicated.

Table 2
Transmission events involving *S. aureus* and SARS-CoV-2 in the anesthesia work area, blank cells showing 0 detection.

Reservoir Sampled	*Staphylococcus aureus*		SARS-CoV-2		
	Isolation N(%)	Transmission N(%)	Detection ≤ 10 days	Detection > 10 days	Transmission N(%)
Anesthesia machine pre-induction ($N = 11$)					
Hands pre-induction					
Anesthesia attending ($N = 4$)	1(25)				
Anesthesia assistant (N = 9)	1(11)				
Patient beginning					
Patient axilla ($N = 9$)				1(11)	
Patient nares (N = 9)			1(11)	1(11)	
	4(44)				
Patient groin ($N = 5$)	1(20)			0	
Patient end					
Patient axilla ($N = 10$)			1(10)	1(10)	
Patient nares (N = 11)	4(36)		1(9)		
Patient groin ($N = 7$)					
Hands post-induction					
Anesthesia attending ($N = 3$)					
Anesthesia assistant ($N = 8$)	1(12)				
Anesthesia machine post-induction (N = 11)					
Stopcock (N = 11)			1 (9)		1(9)
Total	12/108 (11%)	0/108 (0%)	4/108 (4%)	3/108 (3%)	1/108 (1%)

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CRediT author statement

Dr. Loftus helped with conceptualization, methodology, investigation, data curation, project administration, writing the original draft, and reviewing and editing. Dr. Dexter helped with conceptualization, methodology, formal analysis, writing the original draft, and reviewing and editing. Lance Evans helped with study methodology and sample collection. Alysha Robinson helped with methodology and sample processing. Abby Odle and Dr. Perlman performed the viral cultures.

Declaration of Competing Interest

Randy W. Loftus reported research funding from Sage Medical Inc., BBraun, Draeger, and Kenall, has one or more patents pending, and is a partner of RDB Bioinformatics, LLC, and 1055 N 115th St #301, Omaha, NE 68154, a company that owns OR PathTrac, and has spoken at educational meetings sponsored by Kenall (AORN) and BBraun (APIC). One of the donors, Gunner Lyslo, is CEO/founder and partner of Surfacide (Naperville, Il), the company that makes the Helios® UV-C Disinfection System evaluated in the study.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclinane.2021.110350.

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