ORIGINAL CLINICAL RESEARCH REPORT

Anesthesiologists' and Intensive Care Providers' Exposure to Coronavirus Disease 2019 Infection in a New York City Academic Center: A Prospective Cohort Study Assessing Symptoms and Coronavirus Disease 2019 Antibody Testing

Miguel Morcuende, MD, Jean Guglielminotti, MD, PhD, and Ruth Landau, MD

BACKGROUND: Protecting first-line health care providers against work-related Coronavirus Disease 2019 (COVID-19) infection at the onset of the pandemic has been a crucial challenge in the United States. Anesthesiologists in particular are considered at risk, since aerosol-generating procedures, such as intubation and extubation, have been shown to significantly increase the odds for respiratory infections during severe acute respiratory syndrome (SARS) outbreaks. This study assessed the incidence of COVID-19–like symptoms and the presence of COVID-19 antibodies after work-related COVID-19 exposures, among physicians working in a large academic hospital in New York City (NYC).

METHODS: An e-mail survey was addressed to anesthesiologists and affiliated intensive care providers at Columbia University Irving Medical Center on April 15, 2020. The survey assessed 4 domains: (1) demographics and medical history, (2) community exposure to COVID-19 (eg, use of NYC subway), (3) work-related exposure to COVID-19, and (4) development of COVID-19–like symptoms after work exposure. The first 100 survey responders were invited to undergo a blood test to assess antibody status (presence of immunoglobulin M [IgM]/immunoglobulin G [IgG] specific to COVID-19). Work-related exposure was defined as any episode where the provider was not wearing adequate personal protective equipment (airborne or droplet/contact protection depending on the exposure type). Based on the clinical scenario, work exposure was categorized as high risk (eg, exposure during intubation) or low risk (eg, exposure during doffing).

RESULTS: Two hundred and five health care providers were contacted and 105 completed the survey (51%); 91 completed the serological test. Sixty-one of the respondents (58%) reported at least 1 work-related exposure and 54% of the exposures were high risk. Among respondents reporting a work-related exposure, 16 (26.2%) reported postexposure COVID-19–like symptoms. The most frequent symptoms were myalgia (9 cases), diarrhea (8 cases), fever (7 cases), and sore throat (7 cases). COVID-19 antibodies were detected in 11 of the 91 tested respondents (12.1%), with no difference between respondents with (11.8%) or without (12.5%) a work-related exposure, including high-risk exposure. Compared with antibody-negative respondents, antibody-positive respondents were more likely to use NYC subway to commute to work and report COVID-19–like symptoms in the past 90 days.

CONCLUSIONS: In the epicenter of the United States' pandemic and within 6–8 weeks of the COVID-19 outbreak, a small proportion of anesthesiologists and affiliated intensive care providers reported COVID-19–like symptoms after a work-related exposure and even fewer had detectable COVID-19 antibodies. The presence of COVID-19 antibodies appeared to be associated with community/environmental transmission rather than secondary to work-related exposures involving high-risk procedures. (Anesth Analg XXX;XXX:00–00)

KEY POINTS

- **Question:** Within the first weeks of the Coronavirus Disease 2019 (COVID-19) outbreak in New York City, what is the extent of exposure to COVID-19 infection among anesthesiologists and affiliated intensive care providers caring for COVID-19 patients, and does development of COVID-19 symptoms and specific antibodies occur?
- **Findings:** In a large academic hospital in New York City with available personal protective equipment, 15% of the surveyed physicians reported COVID-19–like symptoms that they attributed to a work-related exposure, and COVID-19 antibodies were found in 12% of tested participants.
- **Meaning:** In this single-institution sample of anesthesiologists and affiliated providers, work-related exposure to COVID-19 was associated with a relatively low risk of COVID-19–like symptoms and positive antibody testing.

DOI: 10.1213/ANE.0000000000005056

GLOSSARY

AGP = aerosol-generating procedure; **BCG** = Bacillus Calmette-Guérin; **BIPAP** = bilevel positive airway pressure; **CI** = confidence interval; **COVID-19** = Coronavirus Disease 2019; **CPAP** = continuous positive airway pressure; **CUIMC** = Columbia University Irving Medical Center; **ED** = emergency department; **ELISA** = enzyme-linked immunosorbent assay; **HCP** = health care provider; **ICU** = intensive care unit; **IgG** = immunoglobulin G; **IgM** = immunoglobulin M; **IQR** = interquartile range; **NYC** = New York City; **NYPH** = NewYork-Presbyterian Hospital; **OR** = operating room; **OR-ICU** = operating room-intensive care unit; **PGY** = postgraduate year; **PPD** = purified protein derivative; **PPE** = personal protective equipment; **PUI** = person under investigation; R_0 = reproductive number; **RT-PCR** = reverse-transcription polymerase chain reaction; **SARS** = severe acute respiratory syndrome; **SARS-CoV-2** = severe acute respiratory syndrome-coronavirus-2; **US FDA** = United States Food and Drug Administration

The Coronavirus Disease 2019 (COVID-19) pandemic reached the United States early 2020, with New York City (NYC) reporting its first case on March 1, 2020. The magnitude of transmission in the community has made NYC a global epicenter of COVID-19, with over 151,797 identified cases 7 weeks later.[1] Among 215 pregnant women admitted between March 22 and April 4, 2020, 15.3% tested positive for COVID-19 of which only 12% were symptomatic on admission, emphasizing the epidemiologic relevance of universal testing protocols in communities with a high rate of COVID-19 infection.[2]

Minimizing the transmission of COVID-19 in the community and protecting health care providers (HCP) remains challenging, with airborne versus droplet/contact risk exposure guiding recommendations on personal protective equipment (PPE).[3] One of the challenges resides in the dynamics of transmission of the severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2). The reproductive number (R_0) represents the number of secondary infections resulting from 1 COVID-19–infected individual; the median R_0 value may be as high as 5.7 (95% confidence interval [CI], 3.8–8.9).[4] Based on pooled data evaluating pathogen transmission during severe acute respiratory syndrome (SARS) outbreaks within the past 2 decades, the odds of infection for HCP during aerosol-generating procedures (AGP) such as tracheal intubation was 6.6-fold higher compared to HCP not exposed to intubation.[5] In a publication from China, 5 of 44 (11.4%) anesthesiologists performing spinal anesthesia for cesarean delivery in COVID-19 patients subsequently developed confirmed COVID-19 infection,[6] although direct causality of transmission during the neuraxial procedure remains controversial.[7]

Antibody seroconversion has been evaluated during previous viral outbreaks and is thought to be useful to assess PPE efficiency, past exposure, and the potential for establishing herd immunity.[8–13] In the absence of clinical symptoms, confirmation of COVID-19 infection relies on the timely detection of SARS-CoV-2 by reverse-transcription polymerase chain reaction (RT-PCR). Detecting SARS-CoV-2 antibodies offers the opportunity to confirm past exposure,[14] which may be of particular interest in the case of asymptomatic or subclinical transmissions.

We identified several unresolved questions on the impact of work-related exposures for physicians working in close contact with COVID-19 patients. Deployment of physicians from affiliated specialties into direct patient care roles with participation in high-risk airway management procedures for critically ill COVID-19 patients occurred at our institution.[15,16] We therefore designed this descriptive study to (1) assess self-reported work-related exposures and COVID-19–like symptoms, and (2) detect the presence of COVID-19–specific antibodies among anesthesiologists and affiliated physicians working at the time of COVID-19 outbreak.

METHODS

With Columbia University Irving Medical Center (CUIMC) Institutional Review Board approval, physicians working in close clinical interaction with patients during the COVID-19 outbreak, between March 1, 2020 and April 21, 2020, in either the general operating rooms (OR), the emergently constructed operating room-intensive care unit ("OR-ICU"; 78-bed intensive care unit [ICU] built in the general OR), participating in the general adult and pediatric COVID-19 intubation team at the Columbia campus of NewYork-Presbyterian Hospital (NYPH) or caring for parturients admitted to the Morgan Stanley Children's Hospital Labor and Delivery Unit, were

From the Department of Anesthesiology, Columbia University Vagelos College of Physicians and Surgeons, New York, New York.

Accepted for publication June 5, 2020.

Funding: None.

The authors declare no conflicts of interest.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's website (www.anesthesia-analgesia.org).

Reprints will not be available from the authors.

Address correspondence to Ruth Landau, MD, Department of Anesthesiology, Columbia University Vagelos College of Physicians and Surgeons, New York, NY 10032. Address e-mail to rl262@cumc.columbia.edu.

approached by e-mail for participation in this prospective observational survey study. Written informed consent was obtained from all participants.

COVID-19 Cases

Early March, institutional protocols recommending screening for COVID-19 infection were implemented. Patients with signs or symptoms of COVID-19 infection were considered as person under investigation (PUI); these included fever, cough, shortness of breath, diarrhea, and recent travel. Additional elements later included loss of sense of smell or taste and being in contact with someone known to have been infected. All PUIs were tested for COVID-19 infection (see below).

The first intubation on a confirmed case of COVID-19 infection occurred on March 13, 2020, with total number of intubations performed by the CUIMC anesthesia COVID-19 intubation team of 525 patients between March 13, 2020 and April 21, 2020 (ie, 14 intubations per day). The first confirmed obstetric case of COVID-19 infection requiring obstetric anesthesia care was on March 19, 2020. The OR-ICU admitted the first patient on March 23, 2020.[16]

COVID-19 RT-PCR Testing

At the institution level, all PUIs and all patients requiring intubation for suspected COVID-19 infection were tested for SARS-CoV-2 as of early March. For nonobstetric cases, about 50% of patients requiring urgent intubation in the emergency department (ED), surgical units, and ICUs were confirmed to be COVID-19 positive at the time of intubation; the remainder was deemed PUI while results were pending.

Universal testing using RT-PCR was implemented for all obstetric patients admitted to the labor and delivery unit on March 22, 2020.

For HCPs, COVID-19 RT-PCR testing was not available before April 8, 2020 and during the study period was only available if symptomatic (fever, cough, shortness of breath, sore throat, fatigue, myalgia, congestion/runny nose, loss of smell or taste, diarrhea).

Study Enrolment

On April 15, 2020, an e-mail was to the CUIMC Department of Anesthesia list-server and forwarded to surgeons providing OR-ICU coverage and obstetricians (N = 205), inviting them to participate by means of completing an online survey (Qualtrics Electronic Survey Platform, Provo, UT). The first 100 survey responders were then invited to undergo the blood test to assess antibody status (presence of immunoglobulin M [IgM] and/or immunoglobulin G [IgG] specific to SARS-CoV-2).

The survey comprised 49 questions, assessing 4 domains: (1) participants demographics and general personal health information, (2) possible community exposure (eg, use of NYC subway), (3) perceived work-related exposure, specifying nature of exposure (eg, unprotected face to face interaction with a patient subsequently testing positive for a COVID-19 infection, insufficient protection during intubation/extubation), and (4) occurrence of possible postwork exposure COVID-19 infection symptoms with date and characteristics (Supplemental Digital Content, Appendix 1, http://links.lww.com/AA/D137).

Work-Related and Community Exposure

For the purposes of the study, work-related exposure was defined as any episode where the HCP was not wearing adequate PPE either during an AGP (airborne protection) or while in contact with bodily fluids (contact/droplet protection). Procedures or events qualifying as a high- or low-risk exposure are defined in Table 1.

Community exposure was defined as living with a person that qualified as a PUI or was tested COVID-19 positive with RT-PCR or using public transportation to get to work. Being in close contact with a coworker who was PUI or was tested COVID-19 positive with RT-PCR (as mentioned above, HCPs were not routinely tested even if deemed exposed or sick) was also considered a community exposure.

Personal Protective Equipment

At CUIMC, all anesthesia providers are required to complete an annual respirator (N95) fit testing at the Workforce Health & Safety office, which was

Table 1. Definition of High- and Low-Risk Work-Related Exposure

High-risk exposure
I was the provider who directly performed the AGP or event (eg, intubation)
I was a direct provider during airway management and patient was coughing or bucking
I was within 6 feet of patient during high-risk droplet episode (eg, vomiting), and I came in direct contact with bodily fluids (eg, gastric content)
I was a direct provider of cardiopulmonary resuscitation
I was a direct provider while patient on high-flow nasal cannula or CPAP/BIPAP
Other situation
Low-risk exposure
I was in the room (but not directly performing procedure) during AGP
I was within 6 feet of patient for more than 10 min without droplet contact precautions, but I did not come in direct contact with bodily fluids
I was exposed during doffing

Work-related exposure was defined as any episode where the provider was not wearing appropriate personal protection equipment during procedures or events with high-risk of aerosolization and/or droplet contact while caring for a PUI/COVID-19 patient.

Abbreviations: AGP, aerosol-generating procedure; BIPAP, bilevel positive airway pressure; COVID-19, Coronavirus Disease 2019; CPAP, continuous positive airway pressure; PUI, person under investigation.

completed on August 30, 2019. As of March 1, 2020, N95 masks were available in all anesthesia areas, including cesarean deliveries, with instructions to be used by anesthesia and affiliated providers for all AGP on PUIs and COVID-19 patients. Each provider carried 1 N95 mask at all times, which was conserved and reused as deemed necessary. Airborne protection was used for all AGPs—including intubations—of PUI/COVID-19 patients, with institution-wide PPE protocols aligning with regulatory agency recommendations.[17,18]

As of March 20, 2020, airborne protection (N95 masks, face-shield, impervious gown) for all HCP present in the OR was recommended for all cesarean deliveries under neuraxial or general anesthesia, after an asymptomatic parturient intubated during cesarean delivery for management of intraoperative hemorrhage was subsequently found to be COVID-19 positive.[19,20] This case exposed close to 20 HCP without adequate PPE and resulted in the 2 institutional policies mentioned above (universal testing for all parturients admitted to the labor and delivery unit and airborne protection for all HCP present during cesarean delivery regardless of anesthesia modality).

Antibody Testing of the Survey Respondents

Capillary blood samples were tested between April 15 and 21, 2020. The test was run according to the manufacturers' instructions (COVID-19 IgM/IgG Rapid Test Cassette, Product/Model: GCCOV-402a, Zhejiang Orient Gene Biotech Co Ltd, Huzhou, Zhejiang, China).[21] The Zhejiang Orient Gene Biotech Co assay had not yet obtained Emergency Use Authorization by the United States Food and Drug Administration (US FDA) at the time the data were collected[22]; it was issued on May 29, 2020 for this test.[23]

Two drops of capillary blood were added to the test slide, followed by 2–3 drops of the buffer provided in the kit. Results were read after 5 minutes (maximum 15 minutes) by the investigators (M.M. and R.L.). Only tests in which the control line changed its color were deemed as valid. If a line was observed for IgM and/or IgG, the test was considered positive, the intensity of the color was not judged. This assay has been independently validated to have a sensitivity of 69% for IgM and 93.1% for IgG, and an overall specificity of 100% for IgM and 99.2% IgG, with positive and negative predictive values for IgM of 100% and 93.2%, respectively, and 96.4% and 98.4% for IgG.[14]

Descriptive Statistics

Results are presented as count (%) and median (interquartile range).

Two univariate comparisons were performed: one between respondents with or without work-related exposure, and one between respondents with or without positive antibody testing. Comparisons used χ^2 tests or Fisher exact test for categorical variables and Wilcoxon rank-sum tests for continuous variables.

This survey study was conceived as a descriptive one and did not aim to test a priori hypotheses. We chose therefore not to conduct a multivariable analysis for the risk of work-related exposure or positive antibody testing.

RESULTS

During the 1-week enrollment period (April 15–21, 2020), 205 HCPs were contacted by e-mail; 105 completed the survey (response rate 51%) and 91 completed the antibody test. There were no cassette failures, and all tests resulted in a readable result.

Respondents were anesthesia residents (N = 58; 55.2%), anesthesia fellows (N = 8; 7.6%), anesthesia attendings (N = 23; 21.9%), maternal-fetal-medicine obstetricians working in our labor and delivery unit (N = 3; 2.9%), affiliated intensive care providers (N = 13; 12.3%) including "redeployed" ear nose and throat surgeons, interventional radiologists and neurosurgeons working in the OR-ICU. Their median age was 31 and 43% were woman.

Sixty-one of the 105 respondents (58%) reported at least 1 work-related exposure. In the univariate analysis, work-related exposures were more commonly reported by the anesthesia attendings (78.3%) compared with that reported by anesthesia fellows and residents (P = .046). Work-related exposed and unexposed respondents did not differ regarding community exposure to COVID-19 or COVID-19–like symptoms (Table 2). There were 13 respondents (12.4%) who had been tested for COVID-19 infection with RT-PCR at the time of the study, of which 5 (4.8%) tested positive.

Characteristics of the work-related exposures are presented in Table 3. Among the 99 scenarios of exposure reported, 54 were considered to have been high risk (54.5%). The COVID-19 status of the patients was reported by the respondents for 59 of 61 work-related exposures. The patient was known to be COVID-19 positive at the time of exposure in 25 cases (42.4%) or found to be positive after the exposure in 24 cases (40.7%).

Among respondents reporting a work-related exposure, 16 (26.2%) reported COVID-19–like symptoms after the exposure. The most frequent symptoms were myalgia (9 cases or 14.8%), diarrhea (8 cases or 13.1%), fever (7 cases or 11.5%), and sore throat (7 cases or 11.5%).

COVID-19 IgM/IgG test was positive in 11 of 91 tested respondents (12.1%), with no difference between the rate of positive antibody testing among those reporting a work-related exposure (6 of 51; 11.8%) and those not reporting an unprotected

Table 2. Comparison of the Survey Respondents With and Without Work-Related Exposure

	No Work-Related Exposure (N = 44)	Work-Related Exposure (N = 61)	*P*
General characteristics			
Provider role			.075
Anesthesia residents (PGY1-4; N = 58)	29 (50%)	29 (50%)	
Anesthesia fellows (PGY5; N = 8)	3 (37.5%)	5 (62.5%)	
Anesthesia attendings (N = 23)	5 (21.7%)	18 (78.3%)	
Maternal-fetal medicine/obstetrician attendings (N = 3)	0 (0%)	3 (100%)	
Affiliated intensive care providers (N = 13)	7 (53.8%)	6 (46.2%)	
Age (y)	31 (30–36)	31 (29–35)	.664
Female gender	22 (50.0%)	38 (62.3%)	.291
Smoker	1 (2.3%)	0 (0.0%)	-
History of asthma	3 (6.8%)	9 (14.8%)	.325
History of positive PPD skin test or tuberculosis	6 (13.6%)	12 (19.7%)	.584
BCG vaccine	7 (15.9%)	18 (29.5%)	.167
Possible community exposure to COVID-19			
History of air travel within the past 3 mo	22 (50.0%)	32 (52.5%)	.656
Contact with a friend, relative, or coworker with COVID-19–like symptoms	17 (38.6%)	22 (36.1%)	.948
NYC subway as transport mode (commute to work)	18 (40.9%)	30 (49.2%)	.522
History of COVID-19–like symptoms			
At least 1 of the 4 following COVID-19–like symptom within the last 10 d	10 (22.7%)	9 (14.8%)	.429
Cough	9 (20.5%)	5 (8.2%)	-
Myalgia	7 (15.9%)	6 (9.8%)	-
Fever	5 (11.4%)	3 (4.9%)	-
Shortness of breath	5 (11.4%)	3 (4.9%)	-
At least 1 of the 4 following COVID-19–like symptom within the last 90 d	23 (52.3%)	20 (32.8%)	.071
Cough	15 (34.1%)	13 (21.3%)	-
Myalgia	14 (31.8%)	13 (21.3%)	-
Fever	17 (38.6%)	14 (23.0%)	-
Shortness of breath	10 (22.7%)	8 (13.1%)	-
COVID-19 RT-PCR testing at the time of survey participation			
Not tested (N = 92)	38 (86.4%)	54 (88.5%)	.687
Tested negative (N = 8)	3 (6.8%)	5 (8.2%)	
Tested positive (N = 5)	3 (6.8%)	2 (3.3%)	

Results are expressed as count (%) or median (IQR).

Abbreviations: BCG, Bacillus Calmette-Guérin; COVID-19, Coronavirus Disease 2019; IQR, interquartile range; NYC, New York City; PGY, postgraduate year; PPD, purified protein derivative; RT-PCR, reverse-transcription polymerase chain reaction.

work-related exposure (5 of 40; 12.5%; Table 4). Among anesthesiologists, the proportion of attendings with positive antibody testing (13%) was not higher than that among anesthesia fellows and residents ($P = .68$). No significant difference was observed between antibody-positive and antibody-negative respondents, except for a higher use of NYC subway in antibody-positive patients and reporting COVID-19–like symptoms in the last 90 days, but not in the last 10 days (Table 5). There was only 1 HCP with a positive RT-PCR COVID-19 test who tested negative for IgM/IgG.

DISCUSSION

To the best of our knowledge, this is the first study in the United States evaluating the rate of COVID-19–specific IgM/IgG among physicians exposed to aerosolizing medical procedures during the current COVID-19 pandemic. The major findings of this study evaluating the relationship between early community transmission, perceived work-related COVID-19 exposure, COVID-19–associated symptoms, and rate of antibody within 6–8 weeks of the COVID-19 outbreak in NYC, are that despite 58% of participants reporting a work-related exposure of which 26.2% experienced postexposure symptoms, only 12.1% of the tested participants were found to have COVID-19–specific IgM/IgG. The rate of COVID-19 antibodies was similar among those reporting a work-related exposure (11.8%) and those not (12.5%) suggesting that community exposure rather than exposure at work contributed to COVID-19 infection in this cohort of predominantly young anesthesiologists. This assumption is suggested by a more frequent use of NYC subway among antibody-positive respondents and COVID-19–like symptoms in the last 90 days.

There was one significant exposure on March 20, 2020, with 8 anesthesiologists providing anesthesia care to an asymptomatic parturient, subsequently found to be COVID-19 positive[20]; all participated in the study. Initially, a resident and obstetric anesthesia attending provided neuraxial labor analgesia (low exposure with close contact, including more than 10 minutes face to face interaction <6 feet apart without the patient or the anesthesiologists wearing a surgical mask), neither reported any symptoms following

Table 3. Characteristics of Work-Related Exposures

Respondents reporting at least 1 exposure without adequate protection (N = 105)	61 (58.1%)
High-risk exposures (N = 54)	
I was the provider who directly performed the AGP or event (eg, intubation)	30 (55.6%)
I was a direct provider during airway management and patient was coughing or bucking	8 (14.8%)
Other situation	7 (13.0%)
I was within 6 feet of patient during high-risk droplet episode (eg, vomiting) and I came in direct contact with bodily fluids (eg, gastric content)	5 (9.3%)
I was a direct provider of cardiopulmonary resuscitation	2 (3.7%)
I was a direct provider while patient on high-flow nasal cannula or CPAP/BIPAP	2 (3.7%)
Low-risk exposures (N = 45)	
I was in the room (but not directly performing procedure) during AGP	25 (55.6%)
I was within 6 feet of patient for more than 10 min without droplet contact precautions, but I did not come in direct contact with bodily fluids	13 (28.9%)
I was exposed during doffing	7 (15.6%)
Locations during exposure(s)	
OR-ICU	22 (26.8%)
Emergency department	19 (23.2%)
Labor and delivery unit	12 (14.6%)
Labor room	5 (6.1%)
Obstetric OR	7 (8.5%)
Other (including pediatric hospital)	12 (14.6%)
Adult ICU	9 (11.0%)
Surgical units	8 (9.8%)
Patient COVID-19 status at the time of exposure (N = 59)	
Patient was known to be COVID-19 positive	25 (42.4%)
Patient was asymptomatic and found to be COVID-19 positive after the exposure	24 (40.7%)
Patient was under investigation (COVID-19 status was pending)	10 (16.9%)

Results are expressed as count (%).

Abbreviations: AGP, aerosol-generating procedure; BIPAP, bilevel positive airway pressure; COVID-19, Coronavirus Disease 2019; CPAP, continuous positive airway pressure; ICU, intensive care unit; OR, operating room; OR-ICU, operating room-intensive care unit (emergently constructed 78-bed unit).

the exposure and both tested negative for COVID-19 IgM/IgG more than 3 weeks after the exposure. Later, the patient was intubated during intrapartum cesarean delivery; the obstetric anesthesia fellow performing the intubation (with no N95 mask or face-shield, performing direct laryngoscopy and endotracheal tube suction) remained asymptomatic and tested negative for COVID-19 IgM/IgG 4 weeks later. Of 6 anesthesiologists present during the case, 5 remained asymptomatic and tested negative for IgG/IgM. The sixth anesthesiologist also worked on the COVID-intubation team on 2 occasions between March 20 and 30, and performed 18 intubations on COVID-19 patients, with appropriate airborne protection. This attending became symptomatic with loss of sense of smell on March 30, followed by fever, fatigue, and slight cough on April 3 which lasted 48 hours. On April 6, RT-PCR test was positive; on April 14, COVID-19 IgM/IgG test was negative but seroconversion (positive IgM/IgG) was observed on April 20.

Our findings suggest that anesthesiologists and affiliated intensive care providers do not appear to be at significant risk for severe COVID-19 illness, in the setting of available PPE and high preparedness, despite community transmission and repeated work-related exposures. The causal role of mass transit use, and NYC subway in particular, in SARS-CoV-2 transmission and exposure continues to be a controversial topic.[24] However, the impact of heightened social density within enclosed, poorly ventilated spaces continues to be suspected as a risk factor for viral transmission, and morning and evening commutes are associated with SARS-CoV-2 prevalence in NYC.[25]

With the implementation of universal testing for pregnant women admitted to labor and delivery on March 20, 2020, the incidence of COVID-19 infection, albeit asymptomatic in 88% of women on admission, was known to be in the order of 15% at the time of our study.[2] Therefore, we can determine that the low reported occurrence of fever (in the order of 10%) and other COVID-19–associated symptoms is similar to that found in our cohort of pregnant women. Of importance, none of the anesthesiologists or affiliated providers who were PUI or tested positive for COVID-19 infection with RT-PCR experienced severe symptoms; at most, they reported fever, myalgia, cough, or some shortness of breath.

We acknowledge a number of limitations. First, there has been much debate about the applicability of rapid point-of-care testing technologies in confirming an antibody response to COVID-19. In addition to the challenges posed by extrapolating results for asymptomatic and subclinical individuals, controversy remains about the appropriate "waiting period" after initial exposure and/or onset of clinical symptoms in establishing sensitivity and specificity indices for IgM and IgG specific to SARS-CoV-2. Further development of confirmatory diagnostic modalities (such as enzyme-linked immunosorbent assays [ELISA] methods) are awaited to validate our findings.

Second, since COVID-19 testing was not immediately available to symptomatic CUIMC HCPs, a majority of participants were not tested with RT-PCR, therefore we cannot determine the true infection rate or even attribute reported symptoms to COVID-19 infection. In addition, we did not collect the timeline between each work-related exposure and symptoms. Third, our cohort may have been tested too soon to capture community or work-related acquired immunity, although we estimate exposure to have begun in March, since no one was wearing PPE before early March; therefore testing 6–8 weeks later should have resulted in seroconversions if truly exposed. In a study from Germany, seroconversion occurred in

Table 4. Antibody Testing According to Work-Related Exposure

	All Respondents (N = 105)	Respondents Without Work-Related Exposure (N = 44)	Respondents With Work-Related Exposure (N = 61)
Number of respondents tested	91 (86.7%)	40 (90.9%)	51 (83.6%)
Test results			
IgM/IgG positive	11 (12.1%)	5 (12.5%)	6 (11.8%)
IgM/IgG negative	80 (87.9%)	35 (87.5%)	45 (88.2%)

Results are expressed as count (%).
Abbreviations: IgG, immunoglobulin G; IgM, immunoglobulin M.

Table 5. Comparison of Antibody-Positive and Antibody-Negative Respondents

	Antibody Negative (N = 80)	Antibody Positive (N = 11)	*P*
General characteristics			
Age (y)	31 (29–37)	31 (30–38)	.629
Female gender	34 (42.5%)	5 (45.5%)	>.99
History of asthma	10 (12.5%)	1 (9.1%)	.78
History of positive PPD skin test or tuberculosis	17 (21.2%)	1 (9.1%)	.585
BCG vaccine	23 (28.7%)	2 (18.2%)	.707
Anesthesia residents (PGY1-4; N = 53)	48 (90.1%)	5 (9.4%)	.006
Anesthesia fellows (PGY5; N = 6)	6 (100%)	0 (0%)	
Anesthesia attendings (N = 23)	20 (87%)	3 (13%)	
Maternal-fetal medicine/obstetrician attendings (N = 3)	0 (0%)	3 (100%)	
Affiliated intensive care providers (N = 6)	6 (100%)	0 (0%)	
Non–work-related exposure and symptom history			
History of air travel within the past 3 mo	35 (43.8%)	8 (72.7%)	.192
Contact with a friend, relative, or coworker with COVID-19–like symptoms	28 (35.0%)	6 (54.5%)	.355
NYC subway as transport mode (commuting)	33 (41.2%)	9 (81.8%)	.027
Cough, myalgia, fever, or shortness of breath within the last 10 d	14 (17.5%)	2 (18.2%)	>.99
Cough, myalgia, fever, or shortness of breath within the last 90 d	30 (37.5%)	8 (72.7%)	.047
Work-related exposure			
All type of exposures	45 (56.2%)	6 (54.5%)	>.99
High-risk exposures	37 (46.2%)	3 (27.3%)	.387
COVID-19 RT-PCR testing at the time of survey participation			
Not tested	71 (88.8%)	8 (72.7%)	.002
Tested negative	7 (8.8%)	0 (0.0%)	
Tested positive	1 (2.5%)	3 (27.3%)	

Respondents without antibody testing are excluded. Results are expressed as count (%) or median (IQR).
Abbreviations: BCG, Bacillus Calmette-Guérin; COVID-19, Coronavirus Disease 2019; IQR, interquartile range; PGY, postgraduate year; PPD, purified protein derivative; NYC, New York City; RT-PCR, reverse-transcription polymerase chain reaction.

50% of COVID-19 patients by day 7 after the onset of symptoms, and in all patients by day 14.[26] In addition, our sample is certainly too small to identify robust patterns of exposure, infection, and seroconversion. Finally, in the absence of evidence that detection of SARS-CoV-2 antibody on any serologic test actually demonstrates durable immunity, caution against its (mis)use and (mis)interpretation has been advised.[27]

In conclusion, despite significant community transmission in NYC since early March and multiple work-related exposures, only a small proportion of anesthesiologists and affiliated intensive care providers reported COVID-19–associated symptoms over the course of 6–8 weeks, and seroconversion occurred in <12.1% of our cohort. This is likely due to the availability of appropriate PPE in our institution, along with the introduction of universal testing that guided dynamic institutional policies as data became available. While further validation studies are needed for rapid SARS-CoV-2 antibody testing, our study establishes a first snapshot assessing the trajectory of COVID-19 exposure and infection among anesthesiologists and affiliated intensive care providers working in the epicenter of the outbreak. Studies using ELISA methods are underway to confirm our findings, and serial longitudinal testing should provide additional information while the COVID-19 outbreak unfolds to determine whether acquired immunity will occur both in NYC and more globally.

DISCLOSURES

Name: Miguel Morcuende, MD.
Contribution: This author helped design the study, collect and analyze the data, write the manuscript, and edit the critical content.
Name: Jean Guglielminotti, MD, PhD.
Contribution: This author helped analyze the data, write the manuscript, and edit the critical content.
Name: Ruth Landau, MD.
Contribution: This author helped design the study, collect and analyze the data, write the manuscript, and edit the critical content.
This manuscript was handled by: Jill M. Mhyre, MD.

REFERENCES

1. https://www1.nyc.gov/site/doh/covid/covid-19-data.page. Accessed April 31, 2020.
2. Sutton D, Fuchs K, D'Alton M, Goffman D. Universal screening for SARS-CoV-2 in women admitted for delivery. *N Engl J Med*. 2020;382:2163–2164.
3. Rational use of personal protective equipment for coronavirus disease 2019 (COVID-19). Available at: https://apps.who.int/iris/bitstream/handle/10665/331215/WHO-2019-nCov-IPCPPE_use-2020.1-eng.pdf.
4. Sanche S, Lin YT, Xu C, Romero-Severson E, Hengartner N, Ke R. High contagiousness and rapid spread of severe acute respiratory syndrome coronavirus 2. *Emerg Infect Dis*. 2020;26.
5. Tran K, Cimon K, Severn M, Pessoa-Silva CL, Conly J. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. *PLoS One*. 2012;7:e35797.
6. Zhong Q, Liu YY, Luo Q, et al. Spinal anaesthesia for patients with coronavirus disease 2019 and possible transmission rates in anaesthetists: retrospective, single-centre, observational cohort study. *Br J Anaesth*. 2020:124;670–675.
7. Smiley R. Spinal anaesthesia and COVID-19 transmission to anaesthetists. Response to Br J Anaesth. 2020: 124;670–675. *Br J Anaesth*. 2020. DOI: 10.1016/j.bja.2020.04.075.
8. Ip M, Chan PKS, Lee N, et al. Seroprevalence of antibody to severe acute respiratory syndrome (SARS)–associated coronavirus among health care workers in SARS and non-SARS medical wards. *Clin Infect Dis*. 2004;38:e116–e118.
9. Reynolds MG, Anh BH, Thu VH, et al. Factors associated with nosocomial SARS-CoV transmission among healthcare workers in Hanoi, Vietnam, 2003. *BMC Public Health*. 2006;6:207.
10. Lee HK, Tso EY, Chau TN, Tsang OT, Choi KW, Lai TS. Asymptomatic severe acute respiratory syndrome-associated coronavirus infection. *Emerg Infect Dis*. 2003;9:1491–1492.
11. Raboud J, Shigayeva A, McGeer A, et al. Risk factors for SARS transmission from patients requiring intubation: a multicentre investigation in Toronto, Canada. *PLoS One*. 2010;5:e10717.
12. Kim CJ, Choi WS, Jung Y, et al. Surveillance of the Middle East respiratory syndrome (MERS) coronavirus (CoV) infection in healthcare workers after contact with confirmed MERS patients: incidence and risk factors of MERS-CoV seropositivity. *Clin Microbiol Infect*. 2016;22:880–886.
13. Oboho IK, Tomczyk SM, Al-Asmari AM, et al. 2014 MERS-CoV outbreak in Jeddah–a link to health care facilities. *N Engl J Med*. 2015;372:846–854.
14. Hoffman T, Nissen K, Krambrich J, et al. Evaluation of a COVID-19 IgM and IgG rapid test; an efficient tool for assessment of past exposure to SARS-CoV-2. *Infect Ecol Epidemiol*. 2020;10:1754538.
15. Sommer P, Lukovic E, Fagley E, et al. Initial clinical impressions of the critical care of COVID-19 patients in Seattle, New York City, and Chicago. *Anesth Analg*. 2020.
16. Kumaraiah D, Yip N, Ivascu N, Hill L. Innovative ICU physician care models: COVID-19 pandemic at NewYork-Presbyterian. *Catalyst*. 1.
17. https://www.osha.gov/laws-regs/regulations/standardnumber/1910. Accessed May 30, 2020.
18. https://www.cdc.gov/coronavirus/2019-ncov/hcp/using-ppe.html. Accessed May 30, 2020.
19. Breslin N, Baptiste C, Gyamfi-Bannerman C, et al. COVID-19 infection among asymptomatic and symptomatic pregnant women: two weeks of confirmed presentations to an affiliated pair of New York City hospitals. *Am J Obstet Gynecol MFM*. 2020;2:100118.
20. Landau R, Bernstein K, Mhyre J. Lessons learned from first COVID-19 cases in the United States. *Anesth Analg*. 2020.
21. Chow EJ, Schwartz NG, Tobolowsky FA, et al. Symptom screening at illness onset of health care personnel with SARS-CoV-2 infection in King County, Washington. *JAMA*. 2020;323:2087–2089.
22. https://www.fda.gov/medical-devices/emergency-situations-medical-devices/eua-authorized-serology-test-performance. Accessed June 1, 2020.
23. https://www.confirmbiosciences.com/knowledge/blog/confirm-biosciences-healgen-scientifics-largest-distributor-north-america-announces-u-s-fda-emergency-use-authorization-covid-19-igg-igm-rapid-test-kit/. Accessed May 31, 2020.
24. Zheng R, Xu Y, Wang W, Ning G, Bi Y. Spatial transmission of COVID-19 via public and private transportation in China. *Travel Med Infect Dis*. 2020;34:101626.
25. https://dash.harvard.edu/handle/1/42665370. Accessed May 30, 2020.
26. Wolfel R, Corman VM, Guggemos W, et al. Virological assessment of hospitalized patients with COVID-2019. *Nature*. 2020;581:465–469.
27. https://www1.nyc.gov/assets/doh/downloads/pdf/han/alert/2020/covid-19-status-of-serologic-testing.pdf. Accessed April 25, 2020.