Physiologic changes during pregnancy may increase the risk of coronavirus disease 2019 (COVID-19) infection. Limited data show serious complications of COVID-19 infection and pregnancy. Severe adverse maternal and perinatal outcomes such as preterm delivery, intensive care unit admission, and neonatal and intrauterine death have been reported. Our knowledge of the epidemiology, pathogenesis, disease progression, and clinical course of COVID-19 is continually changing as more information and evidence emerge. The present case adds further insights on COVID-19 and anesthesia considerations for patients undergoing cesarean delivery. In this case report, we describe a successful spinal anesthetic in a pregnant woman with confirmed COVID-19. To prepare for the likelihood of caring for women during labor and cesarean delivery, anesthesia professionals must know how to provide safe, patient-centered care and how to protect every member of the obstetric team from exposure to the virus. In addition, it is paramount that our profession shares our experiences and practices to help guide our multidisciplinary approach in delivering the best care possible to these women.

Keywords: Anesthesia, cesarean delivery, COVID-19, pregnancy, spinal anesthetic.

The outbreak of the novel coronavirus disease 2019 (COVID-19) infection has become a global health crisis. Exposure to this pathogen predisposes both the mother and fetus to an increased risk of infection and severe adverse maternal and perinatal outcomes.¹ The physiologic and immunologic changes during pregnancy increase maternal morbidity and mortality.² Because current data on COVID-19 and its impact on pregnancy are not entirely understood, researchers draw on experiences from previous coronavirus outbreaks as a guide to infer the severity of COVID-19 to pregnant women. For instance, during the 2009 influenza A virus subtype H1N1 pandemic, infected pregnant women experienced more severe complications compared with the general population.³ Similarly, the case fatality rates for severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS) were significantly higher in pregnant women compared with nonpregnant women.² Severe sequelae such as preterm deliveries, stillbirths, respiratory complications, and maternal mortality were common during the SARS and MERS epidemics.²

Case reports show serious complications of COVID-19 infection and pregnancy. Mullins and colleagues⁴ analyzed 23 case reports or case series and reported adverse morbidity to include intensive care unit (ICU) admissions. In the same narrative review, 47% of pregnant women admitted to the hospital had preterm delivery. Similar findings were described in a systematic review and meta-analysis of 19 studies showing that 41% of the pregnant women infected with COVID-19 deliver prematurely at less than 37 weeks.⁵

There is variability in the rate of cesarean delivery in COVID-19–infected patients. An analysis of 108 pregnancies shows that 91% delivered via cesarean delivery.⁶ In addition, most women undergoing cesarean delivery have thrombocytopenia and elevated C-reactive protein, which may increase the severity of COVID-19 and neurologic complications.⁷⁻⁹ There are known maternal deaths of patients with COVID-19 due to respiratory complications after delivery.¹⁰ Neonatal and intrauterine death have been reported in reviews of numerous studies.⁵,¹¹

Our knowledge of the epidemiology, pathogenesis, disease progression, and clinical course of COVID-19 is continually changing as more information and evidence emerge. The limited knowledge of the impact of COVID-19 on pregnant women and the limited clinical experience in managing COVID-19 in pregnant women pose a potential anesthetic challenge during labor and delivery. Professional societies have issued interim guidance regarding the evaluation and management of pregnant women with COVID-19.¹²⁻¹⁹

The purpose of this case report is to present additional information on COVID-19 and anesthesia considerations for patients undergoing cesarean delivery. In this case report, we describe a successful spinal anesthetic in a pregnant woman with confirmed COVID-19.
Case Summary
A 34-year-old woman, gravida 2, para 1, presented to the clinic for a scheduled nonstress test because of her gestational diabetes and increased body mass index (BMI). At a gestation of 38 weeks and 5 days, the patient was 147 cm tall and weighed 105 kg, with a BMI of 48 kg/m². The patient had gestational diabetes, and her blood glucose level was controlled with an oral hypoglycemic drug. The patient had preeclampsia in a previous pregnancy (also delivered by Cesarean delivery) but had only a few isolated elevated blood pressures (BPs) with this pregnancy. She had a history of a positive tuberculosis blood test (Quantiferon-TB Gold Plus, Qiagen) with a normal chest radiograph in 2019.

During this admission, her chest radiograph showed probable atelectasis. The patient had no known drug allergies. Her electrocardiogram (ECG) showed sinus tachycardia with a rate of 100/min. She had a hematocrit of 39% and a platelet count of 156 × 10⁹/µL. At this scheduled appointment, the patient arrived wearing a facial mask, and she reported a dry cough with occasional green sputum, nasal congestion, body aches, and mild headache. All symptoms started 2 days before this appointment. Her temperature was 37.4 °C, and it was recommended to send her to the emergency department (ED) for COVID-19 testing. There, the patient’s nasal cavity was swabbed to test for the COVID-19 virus. In the ED, her vital signs were as follows: heart rate (HR) of 100/min, BP of 158/83 mm Hg, respiratory rate of 23/min, oxygen saturation measured by pulse oximetry (SpO₂) of 97% on room air, and a temperature of 36.1 °C. She was transferred back to the labor and delivery unit for observation in case she had more elevated BPs that would negate delivery.

Eight hours after testing, a positive COVID-19 test result was reported. Within 4 hours after confirmation of the positive result, she began contracting uncomfortably, and assessment of the cervical os showed a 4-cm dilation. The obstetric team decided to proceed with a cesarean delivery with bilateral tubal ligation.

After the patient signed an informed consent form, azithromycin (500 mg) was administered intravenously, and acetaminophen (1 g) was given orally. At the same time, the anesthesia machine was prepared with a heat moisture exchange filter (HMEF) between the breathing circuit and the patient’s airway. The patient was assisted into a wheelchair, a surgical mask was applied, and she was transported to the operating room (OR). Both Certified Registered Nurse Anesthetists (CRNAs) and the labor nurse each donned a yellow isolation gown, regular gloves (double-gloved), and a standard bouffant cap. The CRNAs also wore splash shields, N95 respirator masks, and goggles in the event of airway manipulation.

Standard noninvasive monitors were applied on the patient’s arrival to the OR. Baseline vital signs were as follows: BP of 153/79 mm Hg, HR of 76/min, and SpO₂ of 95% on room air. Supplemental oxygen at 2 L/min was delivered via a nasal cannula under the patient’s surgical mask. A liter of Ringer’s lactate was infused through an 18-gauge access catheter in the patient’s right hand. The patient was prepared and draped in the usual fashion, and the skin was localized with 3 mL of 1% lidocaine at the L3-L4 interspace after landmarks were identified. The 24-gauge spinal anesthesia needle (Pencan, B Braun Medical Inc) was placed via an introducer after the return of cerebrospinal fluid, with good barbotage. A 1.6-mL solution of 0.75% hyperbaric bupivacaine with fentanyl (15 µg) and preservative-free morphine sulfate (Duramorph, 150 µg) was injected intrathecally. The patient was placed in a supine position with left uterine displacement. The sensory block was assessed using pinprick testing. The surgical incision was started when the sensory level reached the T4 level and a Bromage scale of 3.

A lower segment cesarean delivery with bilateral tubal ligation via the Pomeroy technique was performed. The patient had an estimated blood loss of 700 mL and urine output of 40 mL, and total intravenous fluids administered were 1,600 mL. Her high BP was treated with ephedrine and phenylephrine as necessary.

The patient delivered a viable infant with Apgar scores of 8 and 9 at 1 and 5 minutes, respectively. After delivery, oxytocin (40 units) was added to 1 L of lactated Ringer’s solution.

The infant was immediately taken to the neonatal ICU and was to be quarantined from her parents for 14 days. The mother was transferred to a negative pressure room. The OR was disinfected after the procedure, and all anesthesia machine breathing circuits were discarded.

Postoperative analgesia was achieved using a standard morphine (Duramorph) order set, which included up to 6 mg of morphine intravenously each hour. These orders were in place for 12 hours after the preservative-free morphine was given intrathecally in the OR. Oxygen saturation was 96% with 2 L by nasal cannula. She was started on hydroxychloroquine therapy at 400 mg twice daily for 1 day and then 200 mg twice daily for 4 days. She had serial ECGs to monitor QT intervals during hydroxychloroquine treatment.

Her postoperative course was uneventful until postoperative day four, when she became febrile and desaturated to the low 80% level, with new midlung to lower lung opacities. The patient was eventually placed on mechanical ventilation support and admitted to the ICU with the diagnosis of COVID-19–related pneumonia. In the ICU, the patient was given a 10-day remdesivir regimen with convalescent plasma and tocilizumab. The patient was extubated 16 days after the ICU admission.

Discussion

- State of the Art. The SARS coronavirus 2 (SARS-CoV-2)
that causes COVID-19 has been found to be highly virulent and can be transmitted through droplets from normal breathing, sneezing, and coughing, and by aerosolization of bodily fluid discharge.\textsuperscript{20} Some of the clinical features associated with COVID-19 include lower respiratory tract infection with fever, dry cough, shortness of breath, and malaise.\textsuperscript{20} As the COVID-19 outbreak continues, it is essential to evaluate the effects of the disease on special populations, including the parturient.

To date, the case fatality rate for COVID-19 is rapidly changing. Information from a small number of case reports or series indicates that the clinical findings of pregnant women with COVID-19 are similar to those in nonpregnant women.\textsuperscript{21} Furthermore, the severity of the disease in pregnant women is similar to that in other adults.\textsuperscript{22} However, reviews of COVID-19 cases in pregnant women reported severe and critical illness requiring hospitalization and ICU admission.\textsuperscript{4,23} Although the exact mechanism of COVID-19 transmission has not been entirely determined, reputable agencies report that the virus is spread through droplets.\textsuperscript{24,25} Hence, there is a growing concern that pregnant mothers are at risk because of physiologic changes occurring during pregnancy. Atelectasis due to the growing fetus and constriction of the diaphragm, reduced functional residual capacity, and increased oxygen consumption are likely to affect pulmonary reserve and can result in adverse patient outcomes.\textsuperscript{26} Intrauterine transmission is a reasonable concern; however, current evidence suggests vertical transmission is unlikely.\textsuperscript{27,28}

The anesthesia management of the patient with a suspected or confirmed COVID-19 infection presents a major challenge for anesthesia professionals because of the pathophysiologic and confirmed rapid human-to-human transmission of the virus through symptomatic and asymptomatic carriers. As with SARS and MERS, the most critical goal in the OR is to prevent cross-contamination by implementing stringent anesthesia guidelines and infection control strategies in the perioperative setting (Table). The American Association of Nurse Anesthetists (AANA) published an infographic highlighting anesthesia considerations in managing patients with COVID-19 infection.\textsuperscript{29}

Pregnant women with suspected or confirmed COVID-19 should be triaged and their condition categorized as mild, severe, or critical. Liang and Acharya\textsuperscript{7} classified a symptomatic patient with stable vital signs as having a mild case of COVID-19. Pregnant patients with tachypnea and hypoxemia expressed as a partial pressure of arterial blood oxygen/oxygen concentration ratio less than or equal to 300 mm Hg are considered to have severe cases. Moreover, pregnant women presenting with shock and multiorgan system failure requiring mechanical ventilation have critical cases.

In our case, we employed rigorous contact and airborne precautions because of the high transmissibility of COVID-19. In our department, we allocated an observer to guide proper donning and doffing of personal protective equipment (PPE). Sequential steps for donning and doffing PPE are presented by the Centers for Disease and Prevention (CDC; https://www.cdc.gov/niosh/nptl/pdfs/PPE-Sequence-508.pdf). Consistent with strict anesthesia management in cesarean delivery is the effective use of personnel. Regardless of the type of cesarean delivery, the current recommendation outlines the use of the most experienced provider performing procedures such as subarachnoid blocks or intubations. Furthermore, the Society for Obstetric Anesthesia and Perinatology suggests that the anesthesia department minimize the use of trainees in the room of a patient with COVID-19.\textsuperscript{14} In our case, we used 2 CRNAs for 2 reasons. First, one of the CRNAs was a new hire to the anesthesia department and was in his second week of orientation as a new graduate of a nurse anesthesia program. The newly hired CRNA had less experience than the other provider; however, he was confident in his neuraxial technique and asked to be part of the case as a valuable learning experience. The institution in which this case is presented is a teaching hospital, and thus the culture of education is highly prioritized. Second, the safety of clinicians was enhanced through a “buddy system” in the donning and doffing of PPE. This case was the inaugural COVID-19 case in the operating suite at this particular institution, so to proceed as safely as possible, the providers believed that working together was in the best interest of the patient and all healthcare workers involved.

The diagnosis of COVID-19 in itself is not a contraindication to neuraxial anesthesia.\textsuperscript{12-19} The safety of neuraxial techniques in suspected or confirmed cases of COVID-19 has been documented. The decision to use a particular anesthetic technique for cesarean delivery is based on a variety of factors, including risks to the parturient or fetus and the skill set of the provider.\textsuperscript{30} Spinal anesthesia was preferred to general anesthesia because the benefits outweigh the risk.\textsuperscript{31} It is well documented that regional anesthesia aids in the reduction of pain scores and opioid consumption, postoperative nausea and vomiting, and the risk of aspiration and difficult airway associated with general anesthesia.\textsuperscript{32} During tracheal intubation, the risk of transmission of upper respiratory tract infection to healthcare providers is known to be 6.6 times greater than those not exposed to intubation.\textsuperscript{33} Regional anesthesia offers the benefit of avoiding airway manipulation and instrumentation; this decreases the chance of coughing and viral aerosolization during intubation and extubation.\textsuperscript{34} Besides, the maintenance of pulmonary function may reduce postoperative complications in a patient with COVID-19 and associated pneumonia or acute respiratory distress syndrome.\textsuperscript{33}

As the number of COVID-19 cases continues to rise
The table outlines current clinical obstetric anesthesia practice and preparedness recommendations for cesarean delivery.

### Perioperative phase

<table>
<thead>
<tr>
<th>Phase</th>
<th>Clinical considerations/management of obstetric patients with COVID-19</th>
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<tbody>
<tr>
<td>Prehospital admission</td>
<td>- Conduct phone screening before appointment.</td>
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<td>- If patient is asymptomatic for COVID-19, proceed with routine prenatal care.</td>
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<td>- Perform severity assessment if patient presents in clinic with symptoms.</td>
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<td>- For COVID-19 testing, prioritize patients with suspected COVID-19 or those who have signs and symptoms suggestive of COVID-19.</td>
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<td>Preoperative</td>
<td>- Isolate patient in negative pressure room.</td>
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<td>- All healthcare providers involved in care should wear gown, gloves, N95 mask, and face shield (per hospital protocol).</td>
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<td>- Patient should wear a surgical mask.</td>
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<td>- Use hospital’s adopted checklist for donning appropriate PPE. If possible, obtain an observer.</td>
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<td>- Order routine laboratory studies and encourage neuraxial anesthesia in absence of thrombocytopenia.</td>
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<td>- Avoid general anesthesia to mitigate the risks involved in aerosol-generating procedure.</td>
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<td>- Prepare COVID-19 OR kit to avoid contaminating medication station (uterotonic agents, vasopressors, narcotics for intrathecal administration, and antiemetics).</td>
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<td>- Dedicate an OR for patients with COVID-19, to minimize contaminating surfaces.</td>
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<td>- Alert necessary staff for backup coverage and assign a runner to retrieve supplies or help if needed.</td>
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<tr>
<td>Intraoperative</td>
<td>- Use of spinal anesthesia is not contraindicated for patients with COVID-19 and should be the preferred method of anesthesia for these patients.</td>
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<td>- Follow standard precautions when placing neuraxial anesthetic.</td>
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<td>- Avoid excessive or deep sedation to reduce need for any airway manipulation or instrumentation.</td>
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<td>- Patient should wear a surgical mask at all times throughout procedure to minimize viral spread.</td>
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<td>- If general anesthesia is indicated, all personnel in OR at time of intubation should wear PPE for airborne precautions.</td>
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<td>- Minimize OR to only essential personnel during intubation.</td>
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<td>- Preoxygenation should occur with a breathing circuit extension and high-quality filter at the patient side of the circuit.</td>
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<td>- Maximize chance of first-pass intubation by having experienced providers manage airway.</td>
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<td>- Use video laryngoscopy if able.</td>
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<td>- During extubation, which has a high risk of aerosolization of the virus, minimize personnel in OR and be sure every healthcare worker is protected with proper PPE.</td>
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<td>- The patient should be monitored in OR until safe and before transfer to a COVID-19–designated room following hospital guidelines.</td>
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<tr>
<td>Postoperative</td>
<td>- Use of NSAIDs in the intraoperative and postoperative periods lacks sufficient evidence. It is unknown if the treatment of postpartum pain with NSAIDs will worsen the trajectory of patients with COVID-19.</td>
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<td>- Administer antiemetics to prevent vomiting in patients undergoing cesarean delivery because gagging and vomiting are considered aerosolization events.</td>
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<td>- Because of potential risks of immunosuppression with corticosteroid use, avoid use of dexamethasone in this patient population for PONV prophylaxis and treatment.</td>
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<td>- Healthcare facilities providing inpatient obstetric care should limit visitors to those essential for the pregnant woman’s care.</td>
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<td>- Encourage use of communication techniques that avoid person-to-person contact, such as phone calls and videoconference calls.</td>
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Table. Current Clinical Obstetric Anesthesia Practice and Preparedness Recommendations for Cesarean Delivery

Abbreviations: COVID-19, coronavirus disease 2019; HEPA, high-efficiency particulate air; NSAIDs, nonsteroidal anti-inflammatory drugs; OR, operating room; PONV, postoperative nausea and vomiting; PPE, personal protective equipment

and as the knowledge of the pathogenicity of the virus continues to evolve, anesthesia professionals face challenges in the care of laboring mothers and those who will undergo a cesarean delivery. A coordinated team response is necessary to optimize and provide high-quality patient care and to prevent virus transmission in perioperative settings. Professional organizations have outlined recommendations and guidelines in the delivery of care.
to pregnant patients.\textsuperscript{12-19} We highlight here the evidence-based precautionary steps that are vital during the care of a pregnant and laboring patient with COVID-19.

\textbf{Recommendations for Anesthesia Care.} Preadmission screening for potential COVID-19 exposure is conducted over the phone, and a preanesthesia assessment is done through video devices. According to the CDC, the clinical presentation of COVID-19 includes fever, dry cough, and shortness of breath.\textsuperscript{24} Other common clinical manifestations of COVID-19 infection are anosmia, hyposmia, and dysgeusia. In fact, the American Academy of Otolaryngology-Head and Neck Surgery recommends the screening of patients who report the loss or reduction of taste and/or smell.\textsuperscript{35}

Once admitted to the labor and delivery department, the patient with COVID-19 is placed in a negative pressure room and must be provided a face mask. All personnel with direct contact with the patient must have PPE, which include gloves, gown, mask, and face shield during the first and second stages of labor. Visitation of family members during labor and delivery is limited and, in most cases, prohibited. Signage for airborne, contact, and droplet precautions is adequately posted in specified locations in the labor and delivery unit.

A dedicated PPE cart is placed outside the patient’s room for easy access to supplies for labor and delivery to avoid unnecessary traffic and reduce contamination of supplies and equipment. A coordinated and multidisciplinary approach to maternal and fetal monitoring ensures patient safety and reduces virus transmission. Early placement of an epidural block for laboring patients with active COVID-19 infection is recommended to mitigate labor pain-induced respiratory sequela and reduce the likelihood of emergency cesarean delivery. Labor anesthesia supplies must be easily accessible and stationed near the labor room to minimize traffic. Anesthesia professionals and personnel assisting during placement of a labor epidural anesthetic must wear necessary PPE for contact and droplet precaution. It is also essential that the patient wear a surgical mask to limit droplet spread. Vaginal delivery is recommended in stable patients because viral shedding during vaginal delivery and vertical transmission have not been reported.

If cesarean delivery is necessary, surgery must be performed in a designated negative pressure OR, and regional anesthesia is highly recommended. Routine assessment of platelet count must be conducted before neuraxial anesthetic placement. In a recent cohort study of 1,099 patients, Guan and colleagues\textsuperscript{36} found that 36% of the patients had thrombocytopenia. In another study, Lippi et al\textsuperscript{38} reported a decrease in platelet counts in patients with severe COVID-19 symptoms. However, no neurologic sequelae were observed in studies with the use of the neuraxial technique for cesarean delivery.\textsuperscript{37,38}

In an emergency cesarean delivery that requires general anesthesia, the staff should implement the appropriate infection control procedures.\textsuperscript{38,39} The anesthesia machine is prepared with an HMEF between the circuit and the patient’s airway to avoid the virus from entering the internal parts of the machine and to subsequently prevent pathogen transmission to other patients.\textsuperscript{29} Two additional high-quality filters can be used on both the expiratory and inspiratory limbs if supplies of filters are not limited.\textsuperscript{29,40} To prepare for these emergency scenarios, we recommend creating an emergency PPE kit that can expedite the donning process of the providers. These kits would contain the gowns, face shields, and N95 masks. It is essential to have a variety of styles and types of N95 masks available in these kits for each provider’s preference. The use of a donning and doffing checklist is useful in these emergent situations. All the OR personnel present for induction should don the appropriate PPE.\textsuperscript{2,38} If possible, every attempt to minimize personnel in the OR is recommended.

The most experienced anesthesia provider should be dedicated to the intubation of a patient with COVID-19. It might be necessary to have a colleague available for assistance, whether inside the OR or immediately available outside the room.\textsuperscript{40} The preoxygenation process should include an HMEF between the patient and the anesthesia circuit. A rapid-sequence induction should be performed, avoiding positive pressure bag-mask ventilation. Video laryngoscopy is recommended, but it is ultimately the provider’s decision on which method would take the least amount of time and would ensure the best possibility for first-pass success.

Extubation in the OR should be done with limited personnel present. This process presents increased risk of viral transmission to others. Placing a face mask on the patient immediately following the extubation is preferred. Adequate time must be spent in the OR before transport to ensure the patient is exchanging air without distress and has respiratory stability. Every effort of obtaining a PPE observer in the recovery area should be made. The risk of transmission is highest during the doffing of PPE.\textsuperscript{41} After surgery, the AANA suggests discarding disposable items such as the breathing circuit, reservoir bag, gas sampling tubing, and mask.\textsuperscript{29} Cleaning of internal parts of the machine is not necessary if appropriate high-quality filters were used based on the design of the anesthesia machine.\textsuperscript{29,40} Furthermore, the AANA endorses wiping all exposed areas after the procedure using the anesthesia machine manufacturer’s cleaning and disinfecting recommendations.\textsuperscript{29}

So far, no data suggest transplacental transmission of SARS-CoV-2 since no virus has been detected in the amniotic fluid, cord blood, placenta, breast milk, and nasal secretions of the neonate. However, there have been confirmed cases of neonatal infection.\textsuperscript{2,10,38,42-44} Hence, newborns are separated from the infected
mother for at least 2 weeks to reduce transmission.

Findings from COVID-19 cases in pregnant women are emerging, and recommendations change as new information is appraised. To prepare for the likelihood of caring for pregnant women in labor and cesarean delivery, anesthesia professionals must be equipped with the knowledge to provide safe, patient-centered care and to protect every member of the obstetric team from exposure to the virus.

Conclusion
The number of positive COVID-19 cases has now surpassed 2.5 million worldwide. As we continue to care for these patients, we will be faced with more challenging obstetric cases. There are still limited data on the care and management of the parturient with COVID-19. It is paramount that our profession shares our experiences and practices to help guide our multidisciplinary approach in delivering the best care possible to these women. Every health care institution across the world has been working diligently to educate its employees on the current recommendations that comply with the CDC and other national organizations that we reference for our practice. Not only is the care of patients with COVID-19 continually changing, but also so are the safety precautions that the anesthesia provider must take. Our national societies have done an excellent job of educating us with the most recent updates, such as on PPE, to ensure that we are providing safe anesthesia care as well as keeping ourselves safe.

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DISCLOSURES
The authors have declared no financial relationships with any commercial entity related to the content of this article. The authors did not discuss unapproved off-label use within the article.