Patients With COVID-19 Undergoing Cesarean Deliveries: Adapting the OR Suite and Perioperative Care to Prevent Transmission

Kang Zou, MSN, RN; Hong Chen, MS, RN; Yang Liu, MSN, RN

ABSTRACT

The novel coronavirus SARS-CoV-2 first appeared in Wuhan, China, in December 2019 and led to the Coronavirus Disease 2019 (COVID-19), which quickly spread globally. Protocols for surgical patients with COVID-19 were lacking, particularly for pregnant women undergoing cesarean deliveries. Perioperative nurses at Tongji Hospital in Wuhan retrospectively analyzed the perioperative nursing process, including OR preparation, intraoperative care, and OR cleanup, for women with COVID-19 undergoing cesarean deliveries. Preparation involved altering the layout of the surgical suite, educating staff members, providing personal protective equipment, and creating new in-house guidelines to help protect personnel and patients. This article describes how perioperative personnel strategized to prevent the transmission of COVID-19 in the OR and presents a multiple-case summary of six pregnant patients with COVID-19 who underwent cesarean deliveries at Tongji Hospital in January and February 2020.

Key words: *Coronavirus Disease 2019 (COVID-19), cesarean delivery, isolation OR, cross-contamination, personal protective equipment (PPE).*

The novel coronavirus SARS-CoV-2, originally identified as 2019-nCoV,[1] initially emerged among a cluster of patients with pneumonia in Wuhan, China, in December 2019.[2-4] The virus quickly spread the resulting Coronavirus Disease 2019 (COVID-19) throughout China and other countries via sustained human-to-human transmission.[3-5] According to the World Health Organization, COVID-19 exhibits a strong infectious nature and can spread via the respiratory droplets and secretions of infected individuals.[6] Although it is unknown if pregnant women are at an increased risk of contracting COVID-19,[7] they are at a higher risk of progressing to severe illness and complications from the virus.[7,8]

Because of a lack of early awareness and insufficient management, COVID-19 rapidly spread within medical facilities in China. According to a retrospective report on 138 patients with COVID-19 at Zhongnan Hospital, Wuhan University, an estimated 41% of infections were transmitted from other patients with COVID-19 in the same facility.[9] Therefore, the prevention and control of health care–associated COVID-19 infections in surgical patients became an important aspect of perioperative care.[10] Tongji Hospital, located in the center of Wuhan, was one of the first hospitals to begin accepting patients infected with COVID-19; as the number of infected people in the area increased, we accepted an increasing number of infected patients into our ORs. Perioperative considerations related to the COVID-19 outbreak (eg, isolation, personal protection, personnel assignments, maternal and newborn care, medical waste disposal) were new challenges for us. In this article, we share our experiences providing infection prevention and control measures for pregnant women infected with COVID-19 undergoing cesarean deliveries at our hospital.

http://doi.org/10.1002/aorn.13145

PREGNANCY AND COVID-19

Pregnancy induces immunologic changes that increase the body's susceptibility to parasites, intracellular bacteria, and intracellular pathogens (eg, viruses).[11] Although it is unclear if pregnant women have a higher risk of contracting emerging infectious diseases, the severity of known infectious diseases (eg, influenza, varicella) often is more acute among pregnant women;[11] therefore, these patients may become sicker or experience more complications from COVID-19 than those who are not pregnant.[8] For a pregnant woman infected with COVID-19, factors such as increased tidal volume, uterine enlargement, diaphragmatic lift, and limited expansion of the lungs during the middle and late stages of pregnancy can threaten the mother and fetus.[12] If a natural birth is not safe or possible, a cesarean delivery is required.

PREOPERATIVE PREPARATION FOR PATIENTS WITH COVID-19 UNDERGOING CESAREAN DELIVERY

At our hospital, obstetricians perform cesarean deliveries in the main OR suite of the hospital. Pregnant women with COVID-19 stay in private rooms on an isolation unit by the labor and delivery unit that is specifically designated for pregnant patients with COVID-19. These patients need to be transferred between the isolation unit and the OR before and after surgery and many medical staff members (eg, obstetricians, perioperative nurses, surgical technologists, anesthesia professionals, midwives) come in contact with these patients during surgery. If personnel do not follow proper protocols, including adequate personal protection, cross-contamination can occur between patients with COVID-19 and staff members. To mitigate the risk of disease transmission, we temporarily altered the layout of the surgical suite to create two isolation ORs and developed new protocols to protect personnel and newborns from cross-contamination and infection.

Creating Isolation ORs

During the COVID-19 outbreak in China, infectious disease hospitals had limited resources and their health care personnel were unable to treat many patients with COVID-19 in a timely manner. Therefore, many infected patients came to general hospitals to be treated for the virus. In Wuhan, personnel at several general hospitals, including Tongji Hospital, temporarily modified the layout of their surgical suites to perform operative and other invasive procedures on patients with COVID-19. As a general hospital, we do not have negative-pressure ORs for patients with infectious diseases. When the COVID-19 outbreak occurred at the same time as the Chinese new year holiday, we did not have enough time, personnel, or material resources to construct new isolation ORs to meet the requirements of infectious disease hospitals (eg, negative-pressure airflow systems); therefore, we were only able to convert existing ORs into isolation ORs using physical space partitions.

Under the guidance of the hospital's infection control department, we selected an area of the surgical suite with an independent air-purification unit that services only two ORs so that we could turn off the air system in these ORs after a procedure without affecting the air conditioning in the other ORs. Because these were positive-pressure ORs, turning off the air after a procedure was the best method for containing potentially infectious air particulates to minimize the chance of cross-contamination and to allow for thorough terminal cleaning and disinfection of the room.

In accordance with China's national standards,[13] we divided the isolated section of the surgical suite into three separate areas: clean, semicontaminated, and contaminated (Figure 1). We created a clean route of passage to and from the isolation area for perioperative personnel and a contaminated route for transporting postoperative medical waste and patients infected with COVID-19. We designated anteroom I for staff members to don new head coverings and masks when entering or exiting the isolation area of the surgical suite. We placed personal protective equipment (PPE) in a clearly marked supply box in the clean area and an empty cart in the semicontaminated area to facilitate the transfer of items from the clean area to the contaminated area. We installed handheld radios in the clean area and contaminated corridors to facilitate communication. We used the first isolation OR (OR Z5) as the primary OR for patients with COVID-19 and kept the second isolation OR (OR Z1) ready as a backup. We designated anteroom II as a place for medical staff members to remove their PPE before leaving the contaminated area.

Isolation OR Equipment and Supplies

We ensured that each isolation OR had an OR bed, an electrosurgical unit, an anesthesia machine, an infant radiant warmer, a suction apparatus, and other necessary supplies (eg, syringes, radiopaque laparotomy sponges, dressings) to minimize the need for opening and closing the OR door.

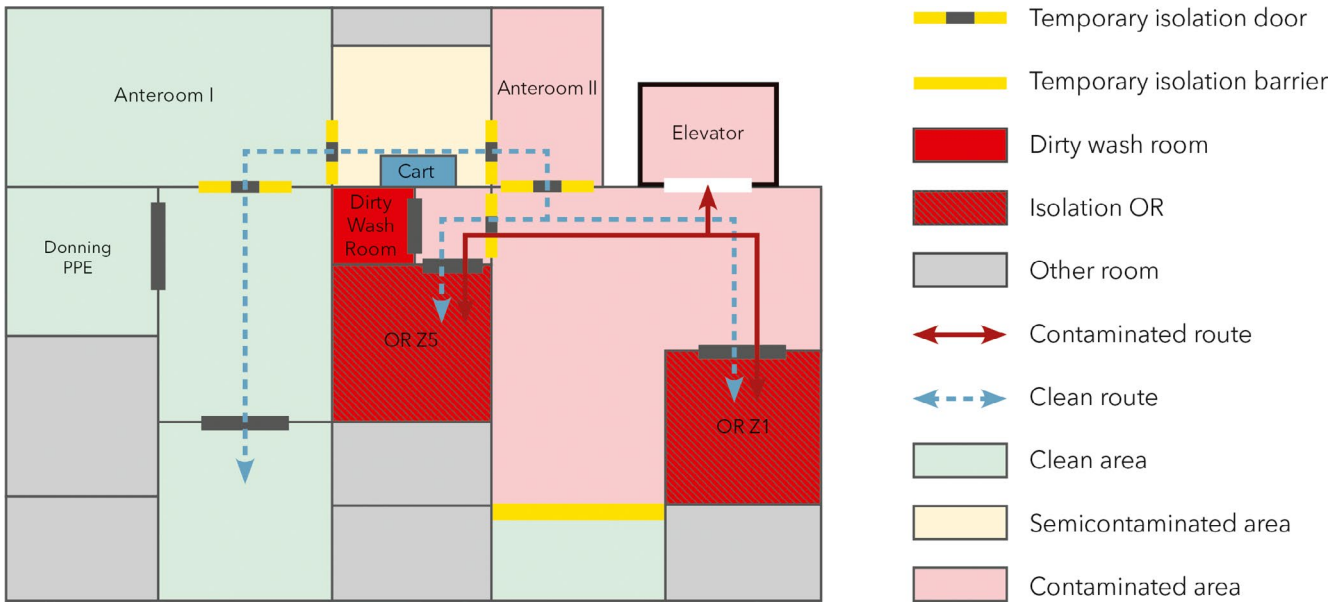

Figure 1. Diagram of the isolated area of the surgical suite created at Tongji Hospital, Wuhan, China, for patients infected with COVID-19 that includes a clean route of passage for perioperative personnel and a contaminated route for patients to and from two isolation ORs.

Personnel did not remove any items from the isolated OR during the procedure. Each OR also was equipped with a hydrogen peroxide vapor device, automatic alcohol-based hand-sanitizer dispensers, paper towels, and chlorine disinfectant to eliminate pathogens effectively. Nurses performed daily checks to ensure that there were enough supplies available for use.

Both ORs have centrally controlled suction that provides the negative pressure required for a suction device; however, because this negative-pressure pipeline cannot be disinfected, for procedures involving patients with COVID-19, we used an independent electric suction device that can be fully cleaned and disinfected postoperatively. We suctioned 20,000 mg/L chlorine solution into the disposable negative-pressure suction bag of the electric suction device before the procedure to facilitate cleaning the blood and other body fluids in the suction bag postoperatively.

Staff Member Education and Training

After changing the layout of the surgical suite to create the isolation area and two isolation ORs, we gathered all the staff members who would be involved in surgeries with patients with COVID-19 to conduct standardized isolation and protection training. We familiarized the staff members with the new partitions and layout of the isolated surgical area and taught them how to use PPE and isolation techniques to prevent the spread of infectious disease pathogens. We also taught them which routes to use when entering and exiting the isolation ORs. We video recorded the training content for staff members who could not participate in the onsite training to be able to access the content online. Finally, we conducted an assessment to ensure that each team member was proficient in donning and doffing PPE and performing infection control measures.

Personal Protective Equipment

We supplied PPE in one of the empty rooms in the clean area along with a pictorial for donning PPE. We also included a pictorial for doffing PPE in anteroom II for staff members to refer to at any time. We appointed a nurse supervisor to confirm that staff members were equipped with PPE in accordance with the required criteria and to guide them if necessary. Personnel used different levels of protection based on their job duties. The charge nurse and nurse supervisor in the clean area wore routine primary PPE (ie, surgical mask, head covering).

Personnel in the contaminated or semicontaminated areas wore secondary PPE (ie, head covering, protective medical coveralls, waterproof boot covers, N95 respirator, gloves, goggles or face shield) (Table 1). After donning the secondary PPE, the scrub person, RN circulator, midwife, surgeons, and anesthesia professional entered the

isolation OR through the anteroom and semicontaminated area. All personnel who scrubbed-in for the procedure were required to wear enhanced PPE, which included disposable sterile surgical gowns, sterile surgical gloves, and powered air-purifying respirators (PAPRs) in addition to secondary PPE.[14] After donning the PAPRs, they performed a positive-pressure seal check by exhaling into the facepiece. Finally, they performed surgical hand antisepsis using a surgical hand rub twice in sequence before donning the disposable sterile surgical gowns and gloves and beginning the procedure.

After the procedure, personnel doffed their PPE and placed it in a designated bucket lined with a yellow double-layered bag for medical waste—which includes infectious and pathogenic waste. When doffing PPE, personnel took care to prevent fomite dispersal during the removal process. They folded the used protective clothing inward and placed it in the bucket and then performed hand hygiene. Next, they removed their goggles and placed them in the same bucket and performed hand hygiene again. They then proceeded from anteroom II to the semicontaminated area to remove their N95 respirators and disposable head coverings, and then to anteroom I to don new head coverings and surgical masks. Finally, they proceeded through the clean area to the locker rooms to take a shower.

Preoperative Patient Transport

After the obstetrician decided that a patient with COVID-19 required a cesarean delivery, personnel placed the patient on a stretcher, covered her with a blanket and a waterproof bed covering, provided her with an N95 respirator to wear, and affixed a label on the stretcher indicating that the patient had COVID-19. Personnel transporting infected patients wore secondary PPE, including protective medical coveralls, waterproof boot covers, N95 respirators, goggles or face shields, and gloves. To reduce the likelihood of exposing others to the virus, the attendant transported the patient from the isolation unit to the OR using a specific route and designated elevator, avoided crowded areas, and did not make any stops. After the patient arrived in the isolation OR and moved to the OR bed, the stretcher was wiped down and temporarily stored in the OR for the duration of the procedure.

INTRAOPERATIVE CARE DURING CESAREAN DELIVERY INVOLVING PATIENTS WITH COVID-19

For each cesarean delivery, the OR team comprised an attending obstetrician, two experienced obstetric resident physicians, one anesthesia professional, one scrub person, one RN circulator inside the room, and a second RN circulator outside the room (ie, the supply nurse). The supply nurse was responsible for communicating with all personnel—both in the OR and outside the isolated surgical area—to assist with the preparation and delivery of surgical supplies. The RN circulator in the OR communicated any needs to the supply nurse and also monitored the surrounding environment; for example, if the patient's amniotic fluid or blood contaminated

Table 1. PPE Worn by Personnel During Cesarean Deliveries for Patients With COVID-19

Professional Role	Head Covering	Protective Medical Coveralls and Boot Covers	Sterile Surgical Gown	Goggles/Face Shield	N95 Respirator	PAPR	Gloves	Sterile Surgical Gloves
Surgeon	X	X	X	X	X	X		X
Anesthesia professional	X	X		X	X		X	
RN circulator	X	X		X	X		X	
Scrub person	X	X	X	X	X	X		X
Midwife	X	X	X	X	X			X
Neonatologist	X	X		X	X			X
Supply nurse[a]	X	X		X	X		X	

PPE = personal protective equipment; PAPR = powered air-purifying respirator.
[a]The supply nurse was a second RN circulator who remained outside the OR.

the area around the OR bed during the procedure, the RN circulator immediately cleaned it using 5,000 mg/L chlorine solution and absorbent paper towels.

The anesthesia professional administered spinal or epidural anesthesia so that patients were awake during the procedure (although some patients received mild sedatives). The patients wore the same N95 respirator they wore during transport to avoid spreading respiratory droplets during the procedure. The anesthesia professional monitored the patients' hemodynamic status and communicated with them if they were nervous or anxious during delivery. If patients required intraoperative intubation, the anesthesia professional added a disposable filter at the connection of the endotracheal tube and the internal ventilator tube to avoid contaminating the inside of the ventilator. A charge nurse in the clean area was responsible for coordinating the logistics of the procedure (eg, timing, scheduling and assigning personnel) and handling any emergency events that arose during the procedure.

Newborn Care

We placed the infant radiant warmer as far from the OR bed as possible to establish a relatively isolated area as the neonatal care area for the newborn after delivery. The RN circulator turned on the warmer 30 minutes before the procedure began to ensure the proper temperature in the neonatal care area to prevent hypothermia in the newborn. The RN circulator ensured that a suction apparatus and neonatal sputum suction tube were available to remove amniotic fluid from the newborn's mouth and nasal cavity and clear the respiratory tract after delivery. Appropriately sized intubation equipment and bag-valve-masks, epinephrine, and oxygen also were available in the event that emergency resuscitation of the newborn was necessary.[15]

The attending obstetrician or obstetric resident physician clamped and cut the umbilical cord as soon as possible to remove the newborn from the mother. We immediately separated the newborn from the mother to prevent transmission of COVID-19 from the mother to the newborn. To further prevent transmission, we made the difficult decision to isolate the infants for 14 days after delivery. Although in line with infection prevention protocols, this measure unfortunately interferes with maternal-infant bonding and early breastfeeding practices.

The midwife performed surgical hand antisepsis and donned a sterile surgical gown and gloves and was responsible for observing and treating the newborn after the delivery. If the newborn needed emergency resuscitation, the RN circulator called the neonatologist to the OR. After placing an identification band on the newborn and ensuring he or she was stable, the midwife removed her sterile surgical gown and gloves and immediately performed hand hygiene. After confirming the newborn's identification band information with the RN circulator, the midwife transferred the newborn to the isolated observation unit in the neonatology department, where the infant remained for 14 days.

POSTOPERATIVE CLEANING CONSIDERATIONS AFTER CESAREAN DELIVERY INVOLVING PATIENTS WITH COVID-19

After the procedure, personnel safely transferred the mother back to the isolation unit and the attendant brought the stretcher directly back to the isolation OR to be disinfected with the OR equipment. The RN circulator sealed the disposable suction bags and placed these and all other medical waste, including endotracheal tubes, into yellow double-layered medical waste bags. With the patient's consent, the RN circulator also placed the placenta in a yellow double-layered medical waste bag. He or she sealed each layer of the yellow bags separately and labeled them with "COVID-19." The supply nurse sprayed the outside of the bags with 1,000 mg/L chlorine solution and notified recipients that they would be receiving COVID-19 medical waste. The scrub person began disinfecting the dirty surgical instruments immediately after the procedure by immersing them in 5,000 mg/L chlorine solution and allowed them to soak for 60 minutes in the OR. The supply nurse then placed the instruments in sealed packages, labeled them with "COVID-19," and transported them to the central sterile supply department for routine decontamination and sterilization.

OR Disinfection

After cleaning with the electric aspirators, the RN circulator and scrub person cleaned any remaining visible contaminants on the floor and instrument table with 5,000 mg/L chlorine solution. Then they turned on the hydrogen peroxide vapor device, left the OR, closed the door, and let the machine run for 30 minutes to clean the room at a rate of 20 to 30 mL/m^3 according to the size of the

OR. After the disinfection was complete, nurses and environmental services personnel wearing secondary PPE used 1,000 mg/L chlorine solution to wipe down all OR equipment and surfaces (eg, instrument table, OR bed, door handles, cabinets). They also sprayed the floor with 2,000 mg/L chlorine solution. After another 30 minutes elapsed, they cleaned all surfaces, including the floor, with water. When the OR and anterooms were on standby, we used ultraviolet germicidal irradiation, which can decrease microbial contamination when used as an adjunct to manual cleaning,[16,17] for at least one hour twice a day to disinfect the rooms.

A MULTIPLE-CASE SUMMARY

From January 30, 2020, to February 6, 2020, we performed six cesarean deliveries at Tongji Hospital for patients infected with COVID-19. The six pregnant women were all living in Wuhan, China, and denied any history of exposure to another infected individual. Patient characteristics and the results of their computed tomography scans and reverse transcription polymerase chain reaction (RT-PCR) tests, which are diagnostic criteria for COVID-19,[18] are presented in Table 2. All patients were between 29 and 34 years old (average = 32 years) and were between 36 weeks five days' and 40 weeks four days' gestation (average = 38 weeks five days).

The patients' main presenting symptoms were cough (one patient) and fever (two patients); three patients showed no symptoms. The highest body temperature recorded was 39.5° C (103.1° F), and the overall duration of symptoms for all patients ranged from eight hours to 14 days. One patient had a history of hypothyroidism and another had hyperthyroidism. None of the other patients had any underlying diseases. All six patients displayed lesions indicating a respiratory infection on their computed tomography chest scans. The scans revealed a stripe-like lesion in the lower lobe of the right lung of one patient, multiple infectious lesions in the left lung of another patient, and bilateral lung infection in the other four patients. The routine laboratory blood tests of five patients showed an increased white blood cell count and a decreased lymphocyte count. One patient had normal blood test findings. The RT-PCR test results were positive for SARS-CoV-2 for all six patients before cesarean

Table 2. Characteristics of Six Patients With COVID-19 Undergoing Cesarean Deliveries in Wuhan, China, From January to February 2020

Patient No., Procedure Date	Age (y)	Gestational Age (wk+d)	GP History	Past Medical History	Symptoms	Chest CT	RT-PCR 1	RT-PCR 2	RT-PCR 3
1, 1/30/2020	31	36+5	G2, P2	None	None	Lesions in the left lower and right upper lobes	Positive	Negative	NA
2, 1/30/2020	34	38+2	G5, P2	None	Cough	Lesions in the right lung and left upper lobe	Positive	Negative	Negative
3, 1/31/2020	34	38+2	G2, P1	None	None	Lesions in bilateral lungs; suspected viral pneumonia	Positive	Negative	Positive
4, 2/2/2020	34	40	G2, P0	Hypothyroidism	Fever	Lesions in the left upper and lower lobes; suspected viral pneumonia	Positive	Negative	Negative
5, 2/3/2020	29	40+4	G1, P0	Hyperthyroidism	None	Stripe-like lesion in the right lower lobe	Positive	Negative	NA
6, 2/6/2020	34	38	G3, P1	None	Fever	Lesions in bilateral lungs	Positive	Negative	Negative

NOTE. RT-PCR tests were conducted approximately one week apart. GP = gravida para; CT = computed tomography; RT-PCR = reverse transcription polymerase chain reaction; NA = not applicable.

Key Takeaways

- The novel coronavirus SARS-CoV-2, originally identified as 2019-nCoV, initially emerged among a cluster of patients with pneumonia in Wuhan, China, in December 2019. The virus quickly spread the resulting Coronavirus Disease 2019 (COVID-19) throughout China and other countries via sustained human-to-human transmission.
- Tongji Hospital, located in the center of Wuhan, was one of the first hospitals to begin accepting patients infected with COVID-19. To prepare for patients with COVID-19 undergoing cesarean deliveries, perioperative personnel created two isolation ORs and implemented new protocols for OR preparation and disinfection, patient transport, personnel assignments, personal protective equipment use, and maternal and newborn care.
- Under the guidance of the hospital's infection control department, perioperative personnel selected an area of the surgical suite with an independent air-purification unit and used physical space partitions to transform existing ORs into isolation ORs. They placed personal protective equipment in the clean area and used two RN circulators during the procedure: one inside the OR in the traditional circulating role and one outside the OR to retrieve supplies and provide assistance if necessary.
- Six women with COVID-19 underwent cesarean deliveries in January and February 2020. In line with infection prevention protocols, personnel made the difficult decision to separate the newborns from the mothers immediately after delivery and keep the newborns in an isolation unit for 14 days. None of the infants or perioperative personnel became infected with COVID-19 after the procedures and all the patients eventually recovered.

delivery. We performed the RT-PCR test again approximately one week later and the results were negative for all six patients at that time.

The average operating time was 74 minutes (range, 60 to 90 minutes) and there were no intraoperative complications. The Apgar score for all six newborns was between 8 and 9 (out of 10). After the procedures, none of the medical staff members or newborns showed any signs of infection. All personnel involved in the procedures had negative RT-PCR test results and none of them reported any COVID-19–related symptoms. After the mothers recovered from the cesarean deliveries, we successfully treated them using a combined therapy of oxygen via nasal canula, antiviral and antibiotic medications, and traditional Chinese medicine. We conducted follow-up interviews via phone and none of the mothers reported fevers or any other COVID-19–related symptoms in their newborns, indicating that there was no direct vertical spread between the mothers and newborns.

CONCLUSION

The COVID-19 outbreak shows that the SARS-CoV-2 virus has strong infectivity. Medical staff members who participated in surgeries on patients with COVID-19 at our facility were therefore highly susceptible to contracting the infection because of contact with patients' respiratory tract secretions, blood, and other body fluids during both anesthesia administration and the operative procedure. To prepare for cesarean deliveries in patients with COVID-19, we used what we had available to transform two ordinary ORs into isolation ORs and implemented new protocols for OR preparation and disinfection, patient transport, personnel assignments, PPE use, and maternal and newborn care to prevent cross-contamination and infection transmission from mothers to their newborns or to perioperative personnel. We hope that this report will help other health care providers prepare for and manage cesarean deliveries for patients with COVID-19 at their facilities.

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