ORIGINAL CLINICAL RESEARCH REPORT

Adaptation of an Obstetric Anesthesia Service for the Severe Acute Respiratory Syndrome Coronavirus-2 Pandemic: Description of Checklists, Workflows, and Development Tools

Yunping Li, MD,* Erin J. Ciampa, MD, PhD,* Liana Zucco, MBBS,* Nadav Levy, MD,* Meredith Colella, MD,* Toni Golen, MD,† Scott A. Shainker, DO,† J. Mark Lunderberg, MD, PhD,* Satya Krishna Ramachandran, MD,* and Philip E. Hess, MD*

BACKGROUND: Care of the pregnant patient during the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) pandemic presents many challenges, including creating parallel workflows for infected and noninfected patients, minimizing waste of materials, and ensuring that clinicians can seamlessly transition between types of anesthesia. The exponential community spread of disease limited the time for development and training.
METHODS: The goals of our workflow and process development were to maximize safety for staff and patients, minimize the risk of contamination, and reduce the waste of unused supplies and materials. We used a cyclical improvement system and the plus/delta debriefing method to rapidly develop workflows consisting of sequential checklists and procedure-specific packs.
RESULTS: We designed independent workflows for labor analgesia, neuraxial anesthesia for cesarean delivery, conversion of labor analgesia to cesarean anesthesia, and general anesthesia. In addition, we created procedure-specific material packs to optimize supplies and prevent wastage. Finally, we generated sequential checklists to allow staff to perform standard operating procedures without extensive training.
CONCLUSIONS: Collectively, these workflows and tools allowed our staff to urgently care for patients in high-risk situations without prior experience. Over time, we refined the workflows using a cyclical improvement system. We present our checklists and workflows as well as the system we used for their development, so that others may use them to their benefit. (Anesth Analg XXX;XXX:00–00)

KEY POINTS

- **Question:** What tools can be used to rapidly adapt an obstetric anesthesia service to provide safe and efficient care to pregnant patients during the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) pandemic?
- **Findings:** Our workflow development process used cyclical improvement and plus/delta debriefing format to develop sequential checklists and procedure-specific packs.
- **Meaning:** Our development process and the resultant workflows and checklists can be used for others to adapt to their center or rapid adaptation in future crises.

GLOSSARY

Ambu = xxx; **BMI** = body mass index; **BP** = xxx; **COVID-19** = coronavirus disease 2019; **CSE** = combined spinal-epidural; **EKG** = xxx; **HME** = xxx; **ICU** = intensive care unit; **L&D** = labor and delivery; **LR** = xxx; **OAA** = Obstetric Anaesthetists' Association; **OB** = xxx; **PE** = xxx; **PEEP** = xxx; **PPE** = personal protective equipment; **SARS-CoV-2** = severe acute respiratory syndrome coronavirus-2; **SOAP** = Society for Obstetric Anesthesia and Perinatology; **SQUIRE** = Standards for Quality Improvement Reporting Excellence; **TB** = xxx

From the Departments of *Anesthesia, Critical Care and Pain Medicine and †Gynecology and Reproductive Medicine, Beth Israel Deaconess Medical Center, Boston, Massachusetts.

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Address correspondence to Philip E. Hess, MD, Department of Anesthesia, Critical Care and Pain Medicine, Beth Israel Deaconess Medical Center, 330 Brookline Ave, Boston, MA 02215. Address e-mail to phess@bidmc.harvard.edu.

Similar to previous coronavirus epidemics, the novel severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) virus is spread primarily by droplets or contact from symptomatic individuals; however, SARS-CoV-2 appears to also be transmissible from individuals who have not yet displayed symptoms.[1] The virus replicates to high titers in the upper airway with high degrees of shedding during the first week of symptoms.[2] Additionally, aerosolization of the virus can occur with certain procedures, such as endotracheal intubation or extubation. The high rate of transmission poses significant risks to all health care workers, other patients, and bystanders without appropriate preparation.[3,4] The first case of coronavirus disease 2019 (COVID-19), the disease caused by the SARS-CoV-2 virus, was identified in Massachusetts on February 1, 2020. But it was not apparent how the virus would affect the Commonwealth until a month later when a cluster of 70 cases was identified among attendees of a scientific conference in Boston. This was approximately the same time that the World Health Organization declared a global pandemic on March 11, 2020.[5]

In preparation for the pandemic, we reviewed relevant literature and recommendations specific to anesthetic care, which appropriately focused on operating room preparation[6] and patient management during airway manipulation and transport,[4,7,8] with a notable paucity of literature detailing preparation tailored to obstetric anesthesia.[4,9] The delivery of anesthesia on the labor and delivery (L&D) unit is distinct from the care in the intensive care unit (ICU) or in the operating room. In many cases, the method of delivery is unknown until the end and may emergently change with little notice. Clinicians must also prepare for unexpected operative and nonoperative procedures such as management of postpartum hemorrhage or emergent cesarean delivery. Thus, the impact of SARS-CoV-2 in obstetric anesthesia required the creation of parallel workflows to simultaneously deliver high-level care to pregnant patients with and without COVID-19 for labor analgesia, cesarean anesthesia, and other procedures.

While we appreciated that the rapid spread of this virus would expedite the time to the presentation of the first patient in our L&D unit, the first patient with COVID-19 was admitted to our unit overnight for observation before planned preparedness steps had been completed. This unexpected admission resulted in a significant waste of material supplies, because our infection control consultants recommended all disposable supplies in the patient's room to be discarded following their stay. This report describes the processes we subsequently used to rapidly adapt our obstetric anesthesia service and the solutions to reduce waste, maintain safety, and support effective care of patients with confirmed or suspected SARS-CoV-2 infection. Because the SARS-CoV-2 virus will not likely disappear until effective vaccines are developed, the disease will continue to spread to locations that are not currently heavily affected and maybe ill-prepared to care for the patient while keeping health care workers safe. Our goal is to provide materials that may assist others in improving their units and discuss a system that can be used for rapid preparation during a future crisis.[10]

METHODS

This article reports all appropriate components of the Revised Standards for Quality Improvement Reporting Excellence (SQUIRE 2.0), published on September 15, 2015. This was classified as a quality improvement study and was determined to be exempt from institutional review board review and did not require informed consent. The study was performed in a tertiary care facility and teaching hospital for Harvard Medical School serving an urban area with a metropolitan population of 4.6 million. The medical center is the regional referral center for the Beth Israel Lahey Health network which delivers 15,000 pregnant patients, annually.

Our intent was to develop a system of care that would satisfy several aims:

- Provide full and simultaneous services for both infected and noninfected patients
- Rapidly adapt to new workflows
- Maximize safety for staff and patients through standard practices
- Minimize risk of contamination during procedures
- Optimize supplies and materials

The development of these critical adaptations was performed using cyclical improvement methodology in combination with plus-delta debriefing. These tools were used to create workflows consisting of sequential checklists and procedure-specific packs. Workflows were distributed via e-mail to all clinicians, recorded on video and made widely available, posted as laminated pages in appropriate locations, and published on the hospital intranets. Each of these was updated with each change in a workflow.

Cyclical Improvement

We used a cyclical improvement methodology to design each new workflow. Cyclical improvement is based on the Plan-Do-Study-Act methodology introduced by W. Edwards Deming for learning and improvement.[11] The initial step was the creation of a process map detailing each step of the workflow, including donning and doffing personal protective equipment (PPE), detailing every step a clinician may take during a procedure.

We also defined possible deviations of expected outcomes, for example, when additional materials may be needed, or a change in anesthetic plan.

After the creation of the initial process map, we performed small-group in situ simulations using a clinician, an observer, and an event recorder. The clinician simulated performing each step read to them by the recorder, including the use of equipment and medications. The observer's role was to (a) confirm that all steps were completed, and (b) identify where breaches in protocol could result in substandard outcomes. Based on simulation findings, the workflow was revised, and the cycle was repeated. After achieving a workflow that was stable, the process was presented to clinicians for use in patient care. After each case, a debriefing was conducted, and the workflow was updated based on these findings.

Debriefing Methodology

Based on previous experience at our center, we modified the plus/delta format for debriefings of our processes and workflows after each real-time test. This method is commonly used and well described in aviation training.[12] Our experience is that this exercise lends itself well for rapid cycle improvement. The debriefing team leader begins the session by directing focus on the events and processes (the System) as opposed to any individual actions. Participants are notified that commentary or concerns with individual clinical performance will be addressed separately. Participants are prompted to discuss what went well in the System (plus); this strategy is intended to ensure that the strengths of the System are identified and are not changed in future iterations. The debriefing leader then focuses the discussion on processes that could be improved or changed (delta). This may resemble a short, focused brainstorming session where clinicians recommend alternate workflows or ideas for improvement. The debriefing ends with a request that additional ideas for improvement be brought forward at any time.

Debriefings following neuraxial labor analgesia procedures with COVID-19 patients were performed with the director of obstetric anesthesia and frontline clinicians. Debriefings after each operative procedure on COVID-19 patients involved frontline clinicians, plus leadership personnel from the Divisions of Obstetric Anesthesia and Quality and Safety, L&D Nursing, the Department of Obstetrics and Gynecology, and the Department of Neonatology.

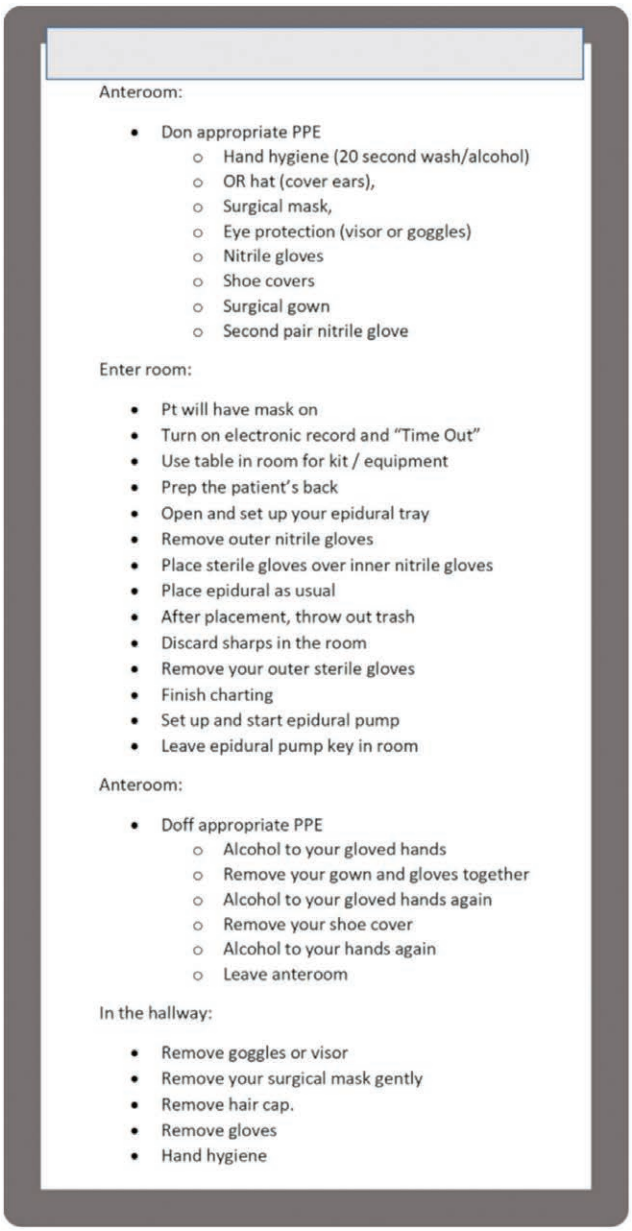
RESULTS

Labor Analgesia Workflow

The labor analgesia workflow consisting of the checklist, procedure-specific packs, and guidance graphics underwent 2 cycles of small-group simulation. Before any opportunity for further refinement, the workflow was then urgently required to be used for clinical care. After each use, the workflow underwent redesign using the cyclical improvement process. Within a week, opportunities for refinement were no longer being identified during debriefings. The sequential checklist is presented in Figure 1.

Perioperative Workflow

Preparation for operative procedures represented greater complexity due to the range of distinct modes


Anteroom:

- Don appropriate PPE
  - Hand hygiene (20 second wash/alcohol)
  - OR hat (cover ears),
  - Surgical mask,
  - Eye protection (visor or goggles)
  - Nitrile gloves
  - Shoe covers
  - Surgical gown
  - Second pair nitrile glove

Enter room:

- Pt will have mask on
- Turn on electronic record and "Time Out"
- Use table in room for kit / equipment
- Prep the patient's back
- Open and set up your epidural tray
- Remove outer nitrile gloves
- Place sterile gloves over inner nitrile gloves
- Place epidural as usual
- After placement, throw out trash
- Discard sharps in the room
- Remove your outer sterile gloves
- Finish charting
- Set up and start epidural pump
- Leave epidural pump key in room

Anteroom:

- Doff appropriate PPE
  - Alcohol to your gloved hands
  - Remove your gown and gloves together
  - Alcohol to your gloved hands again
  - Remove your shoe cover
  - Alcohol to your hands again
  - Leave anteroom

In the hallway:

- Remove goggles or visor
- Remove your surgical mask gently
- Remove hair cap.
- Remove gloves
- Hand hygiene

Figure 1. Sequential checklist for placement of neuraxial analgesia. The items of this checklist are ordered to allow a clinician to follow sequential steps for donning PPE, performing a neuraxial analgesic procedure, and doffing their PPE. This checklist can be used in conjunction with a procedure-specific pack to maximize safety and minimize supplies. OR indicates operating room; PPE, personal protective equipment.

of anesthesia that can be required, the number of collaborative services involved, and the need to redesign the procedural space for COVID-19 patients. Our L&D operating room preparation process drew from the perioperative COVID-19 pathways under development for the general operating rooms at our institution by the Division of Quality, Safety, and Innovation of the Anesthesia Department, and in consultation with Infection Control.

Preparation for operative procedures in patients with COVID-19 included dividing isolation space for infected patients into distinct work zones (clean area, transition anteroom, and contaminated procedure room) that minimized the risk of contamination. The unit was separated such that 1 operating room and 4 labor rooms were sealed from approach to the rest of the unit, with the hallway representing a transition anteroom (Supplemental Digital Content, Figure 1, http://links.lww.com/AA/D222). Each labor room was stocked with the minimal necessary equipment while operating room preparation was based on reports from previous epidemics. We removed all nonessential materials and supplies from the operating room and wrapped remaining surfaces in plastic covering (Supplemental Digital Content, Figure 2A, http://links.lww.com/AA/D222).

The perioperative case workflow was distributed to a multidisciplinary group including representatives from obstetrics, maternal-fetal medicine, obstetric anesthesia, neonatology, and the anesthesia division of quality and safety. The group was able to perform 1 cycle of cognitive review. Unfortunately, before attempting in situ simulations to refine the workflow or disseminate and train frontline staff, the process was urgently needed for clinical care. Each use of the workflow was followed by the cyclical improvement process, including thorough team debriefing and redesign, until achieving a final form, which took approximately 11 cycles (Figure 2).

Major Changes After Initial Implementation

We initially expected the team leader to be a physician but found that the anteroom nurse had the greatest situational awareness and was best suited to this task. While the identification of the clinicians who enter the operating room with a patient was clear, defining the order of caregivers leaving the room was challenging. Especially with the emergence of general anesthesia, we wanted to minimize the number of individuals in the operating room while still having resources to deal with emergencies. Additional supplies are frequently needed during procedures; thus, we designated a "runner" for both nursing and anesthesia who waited in the anteroom and would be contacted by the nurse inside the procedure room via hands-free communication headset. Because of the expected low

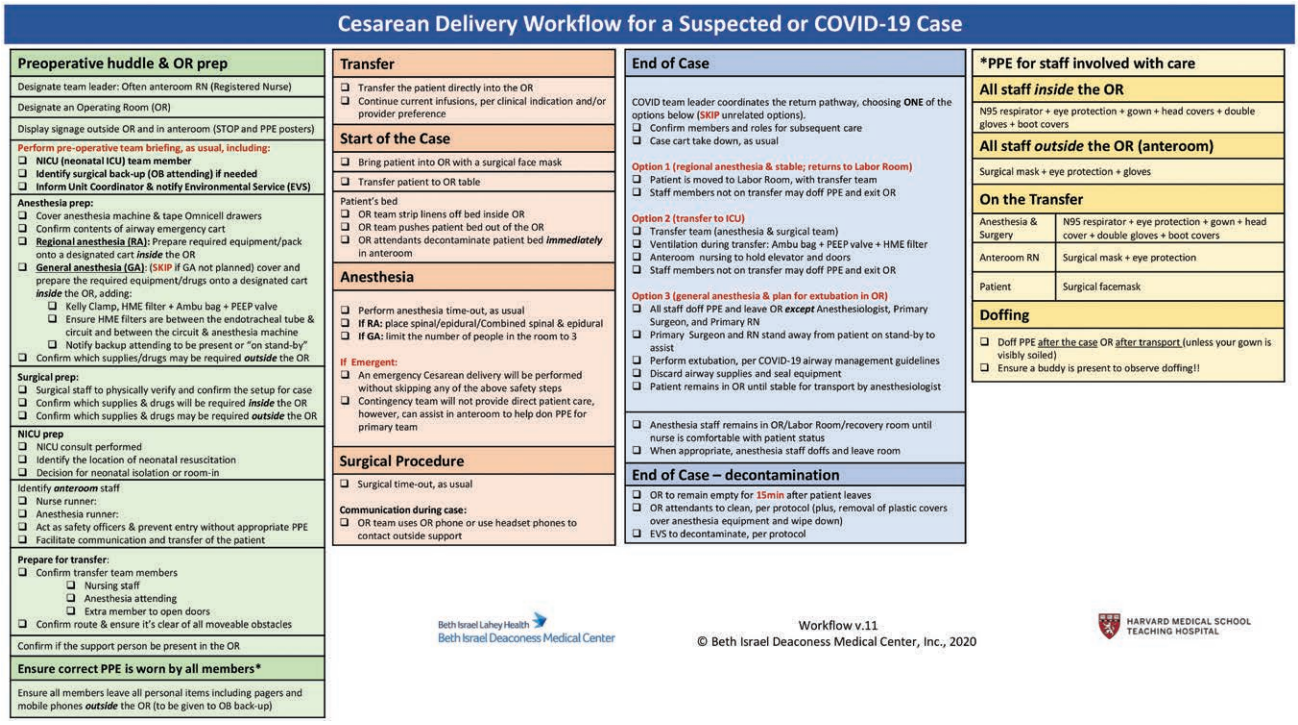


Figure 2. Checklist for operative procedures. This multidisciplinary checklist is used for any invasive procedure requiring the use of the operating room. The key feature of this checklist is the designation of a team leader, who then sequentially reads the checklist to all participants. Reprinted with permission. Ambu indicates xxx; COVID-19, coronavirus disease 2019; HME, xxx; ICU, intensive care unit; OB, xxx; PEEP, xxx; PPE, personal protective equipment.

frequency of both general anesthesia and postpartum hemorrhage among our patients, we enclosed supplies for these contingencies in a cart housed in the pared-down operating room that would be sealed to prevent contamination but easily accessed when required (Supplemental Digital Content, Figure 2B, http://links.lww.com/AA/D222). When there was a need to perform these procedures, the cart would be unsealed; unused supplies would be discarded, and the cart and reusable supplies would be decontaminated. We found this to be far superior to a plastic bag, especially for heavy and bulky supplies. Finally, we used an easily decontaminated metal cart as a work surface when a debrief identified that the anesthesiologist had no place to organize supplies (Supplemental Digital Content, Figure 2C, http://links.lww.com/AA/D222).

Procedure-Specific Packs

To avoid wasting supplies and to minimize the time required for decontamination, we decided not to use the neuraxial supply cart that we normally bring into the room for procedures. Instead, we composed a list of minimum supplies to be stored in procedure-specific packs. Plastic bags containing the necessary supplies were assembled and labeled for various clinical scenarios. To accompany each pack, we developed a list of just-in-time items that would need to be obtained immediately before the procedure, such as medications and ancillary supplies that could not be stockpiled. These were printed on a paper and affixed to each pack to minimize the need for clinicians to call out requests for additional materials during a procedure. Individualized procedure packs were developed for:

- Neuraxial for labor (Figure 3)
- Spinal or combined spinal-epidural anesthesia (Figure 4)
- Conversion of labor epidural to cesarean anesthesia
- General anesthesia

DISCUSSION

The SARS-CoV-2 virus and associated COVID-19 pandemic place significant pressure on the obstetric anesthesia care provider to simultaneously care for infected and noninfected patients. Multiple parallel plans must be made for labor analgesia, cesarean anesthesia, emergent conversion from labor to cesarean, and the management of acute complications such as postpartum hemorrhage. In addition, these plans must be coordinated with the obstetric, nursing, and neonatology services in a way that does not increase risk to patients or clinicians.

In translating recommendations from governmental organizations and the major societies into clinical guidelines, we realized that variability in individual interpretation could lead to deviation from best

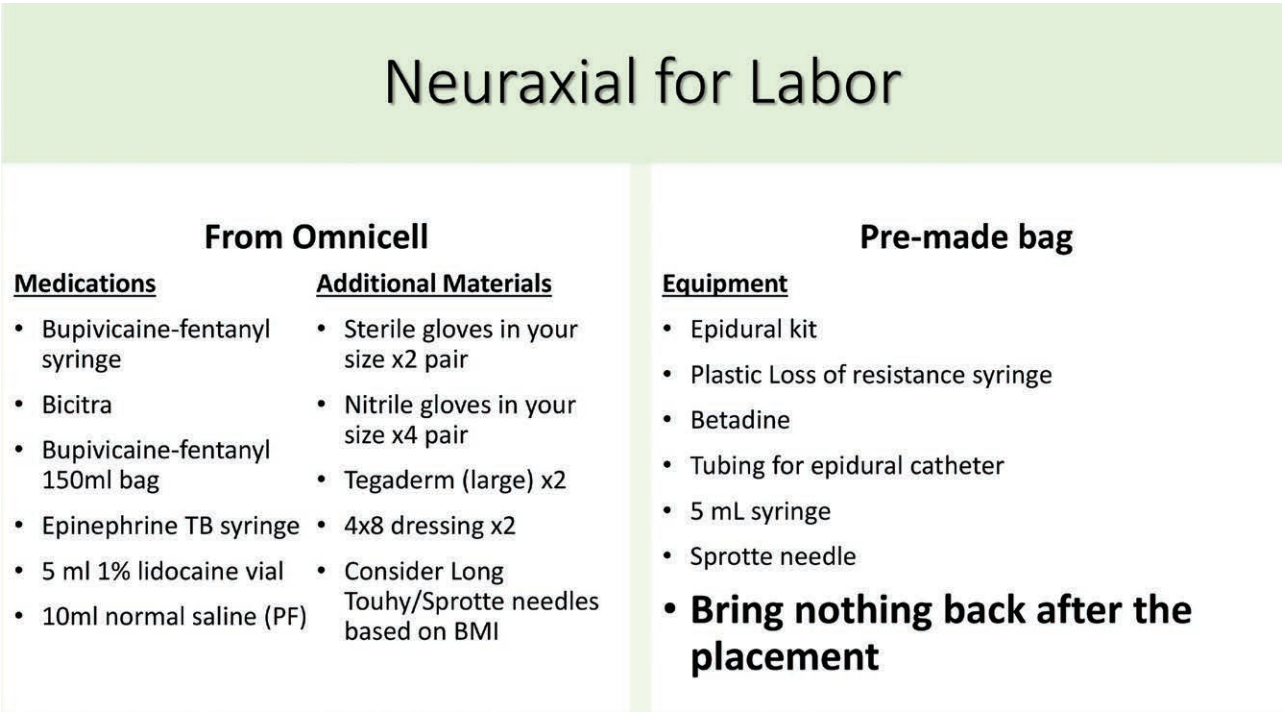


Figure 3. The procedure-specific card for neuraxial procedures for labor analgesia. This card details the contents of the preassembled pack, and also the items that the clinician collects immediately before a procedure, including medications and additional materials. This paper is attached to the pack. BMI indicates body mass index; PF, xxx; TB, xxx.

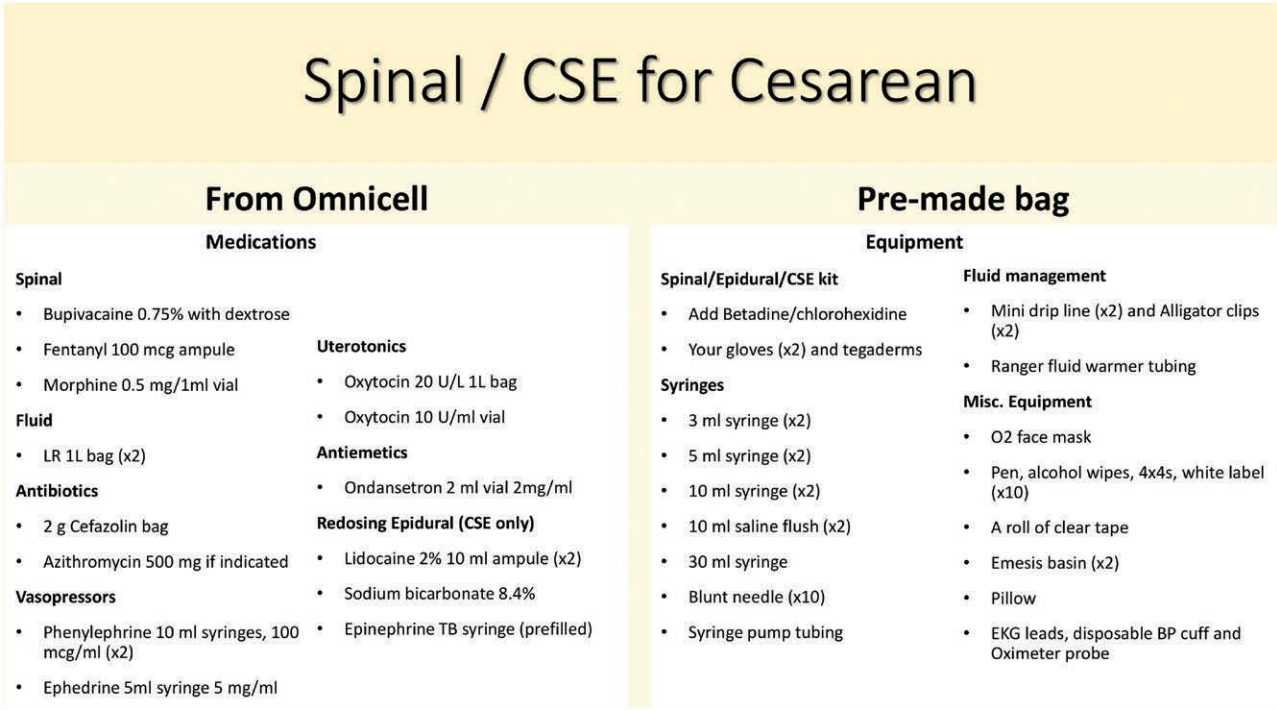


Figure 4. Procedure-specific pack contents for neuraxial anesthesia (spinal or CSE) cesarean delivery. The right side of the card identifies the contents of the preassembled procedure bag that a clinician will pick when performing a spinal or CSE for cesarean delivery. The left side of the card identifies the medications that are needed to be removed immediately before placement. BP indicates xxx; CSE, combined spinal-epidural; EKG, xxx; LR, xxx; TB, xxx.

practices that carries higher risk of accidental contamination.[13,14] This is especially critical during donning and doffing PPE.[15] We chose to define standard operating procedures in the form of checklists to ensure the completion of critical steps for clinical care; however, as we simulated performance of a neuraxial labor analgesia procedure, we came to appreciate that it would be easy for clinicians to become contaminated if individual steps were performed out of sequence. We changed from a traditional checklist to one that explicitly defined the temporal sequence of steps. The sequential checklist minimizes deviation from a standard operating procedure and ensures the necessary steps to always provide a "clean" layer of gloves and coverings. Additionally, having an observer who ensures that each step is followed is crucial to protecting ourselves and our colleagues.[13] That both the first labor analgesic and the first cesarean were performed by clinicians who were not engaged in the development of our COVID-19 workflows suggests that this method can be used to enforce a standard operating procedure in a novice population. Clearly, these checklists do not take the place of education and training of a skilled workforce but can be used in an emergency to reduce the risk of error.

Using a cyclical improvement approach allowed us to rapidly design and iteratively refine our workflows after each live case, and to achieve final products very quickly. We see important advantages to the inclusion of frontline clinicians in the cyclical redesign process: stakeholders gain the expectation that the processes will continue to evolve over time, thus reducing the frustration of a constantly changing protocol, and related gains are tied to the sense of buy-in created among clinicians who feel that their input will play a part in the evolution of workflow.

Recent difficulties with the medical supply chain nationally were reflected in our hospital and left us acutely aware that the wastage of supplies would impact our ability to care for patients. Before this pandemic, the usual method of obtaining materials was to either stockpile supplies in cabinets inside the operating room, or to carry them in a specialized cart. Because of the risk of contamination, unused supplies in the patient location need to either be decontaminated or wasted after use by a COVID-19 patient. Our procedure packs specific for each anticipated type of anesthesia encounter simplified, standardized, and minimized clinical supplies. We are unaware of a case when the wrong pack was chosen for a procedure, but this is likely to happen at some point. Our designation of a "runner" to deliver supplies to the procedure room would allow the correction of this error.

Our workflows and checklists, as well as the redesign of our procedural areas, reflect institutional needs and practices. In a broader view, we believe that the methods we used for adaptation can be used to refine practices at other institutions and in other situations

that require rapid practice changes. In addition to what we present, the Society for Obstetric Anesthesia and Perinatology (SOAP),[9] Obstetric Anaesthetists' Association (OAA),[16] and Anesthesia Patient Safety Foundation[17] have published a number of resources to consider when preparing an obstetric anesthesia service. Both obstetric organizations recommend early epidural placement during labor, avoidance of general anesthesia, and training and simulation of critical tasks, such as donning/doffing and patient transport. Video laryngoscopy is suggested if general anesthesia is required. SOAP recommendations include the screening of all patients admitted for scheduled/elective procedures and the use of teleconferencing to minimize contact with patients. The OAA resources include additional checklists, which might be useful for adaptation.

In conclusion, we share here our obstetric anesthesia pathways for dissemination, because they may be of assistance to other centers experiencing similar challenges related to the COVID-19 pandemic. We also describe the tools that we used to develop these workflows, because they comprise a system that can be generalized to any crisis where a rapid change in processes is needed. ■

DISCLOSURES

Name: Yunping Li, MD.
Contribution: This author helped design the program of development and assist manuscript preparation.
Name: Erin J. Ciampa, MD, PhD.
Contribution: This author helped design the program of development and assist manuscript revision.
Name: Liana Zucco, MBBS.
Contribution: This author helped design the program of development and assist manuscript revision.
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Name: Scott A. Shainker, DO.
Contribution: This author helped design the program of development and assist manuscript revision.
Name: J. Mark Lunderberg, MD, PhD.
Contribution: This author helped design the program of development and assist manuscript revision.
Name: Satya Krishna Ramachandran, MD.
Contribution: This author helped design the program of development and assist manuscript revision.
Name: Philip E. Hess, MD.
Contribution: This author helped design the program of development and write the manuscript.
This manuscript was handled by: Jill M. Mhyre, MD.

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