
THE ORTHOPAEDIC FORUM

Preparing to Perform Trauma and Orthopaedic Surgery on Patients with COVID-19

Ricardo Rodrigues-Pinto, MD, PhD, FEBOT, Ricardo Sousa, MD, PhD, and António Oliveira, MD, PhD

Investigation performed at the Department of Orthopaedics, Centro Hospitalar Universitário do Porto, and ICBAS-Instituto de Ciências Biomédicas Abel Salazar, Porto, Portugal

In December 2019, a pneumonia of unknown cause was recognized in Wuhan, the People's Republic of China¹. The outbreak was declared a Public Health Emergency of International Concern on January 30, 2020, and the World Health Organization (WHO) announced a name for this virus (SARS [severe acute respiratory syndrome]-CoV-2) and for the disease (COVID-19) on February 11, 2020, and formally declared it a pandemic 1 month later on March 11, 2020. The COVID-19 epidemic rapidly spread out of the People's Republic of China to the entire world with devastating consequences in many other countries such as Italy, Spain, Iran, France, the United States, and the United Kingdom, with >1,000 deaths in each country. Although authorities are still trying to contain the virus, on March 28, 2020, the WHO reported 575,444 cases and 26,654 deaths in 201 countries², and the numbers will continue to increase.

As doctors, it is our responsibility to ensure appropriate treatment to all patients. During these exceptional times, it is imperative to consider the possibility that surgical facilities become hampered by staff sickness, reduced supply of surgical materials, and the use of operating rooms (ORs), facilities, and even anesthesiologists for improvised intensive care unit (ICU) pods for patients with COVID-19. Several institutions have issued recommendations so that, during this pandemic, surgical procedures become restricted to urgent or emergency cases, such as trauma, infections, and malignant tumors³. With the spread of the virus within the community, it is likely that some of these patients will be COVID-19-positive.

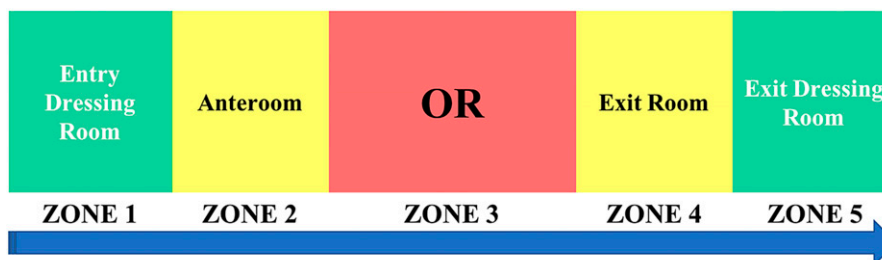
Recommendations have been issued as to the appropriate personal protective equipment (PPE) to use when diagnosing and treating patients with COVID-19 in wards and ICUs⁴. A recent study has also thoroughly described how the anesthesiology team should be equipped and prepared⁵. However, to date, there has been very little or no information as to how to assemble an OR for a patient with COVID-19 and how the surgical staff should be protected when performing surgical procedures on these patients.

Here, we detail the protocol that we have developed at our institution to treat these patients, with emphasis on the specifics required for trauma and orthopaedic surgical procedures.

Setting and Workflow within the Operating Room(s) for Patients Positive for COVID-19

There are several OR complexes at our institution, a central and larger one and several satellite smaller ones. It was decided that one of the satellite complexes (in this case, the orthopaedic one) would be exclusively dedicated to treat patients with COVID-19 for the duration of the epidemic to reduce the risk of contaminating other ORs and other patients. This satellite complex has a separate access and separate dressing rooms and 3 independent surgical rooms. Each room has an anteroom, usually used for anesthesia induction, which, in this case, will be used as a scrub room, and an exit room, leading to an outside corridor. This is usually designated as a dirty corridor, from which waste, biological materials, and surgical instruments are taken out of the OR

Disclosure: The authors indicated that no external funding was received for any aspect of this work. The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (<http://links.lww.com/JBJS/F830>).



Surgical Team Flow for Orthopaedic Surgery in a COVID19 dedicated OR

Fig. 1
OR diagram and workflow.

but, in this situation, will be used as an exit room for the surgical staff.

A negative-pressure OR environment would be ideal to reduce the dissemination of the virus beyond the OR^{5,6}. However, ORs are usually designed to have positive pressure to reduce intraoperative contamination, and it is not easy to reverse-engineer it. Given that coronaviruses are approximately 0.125 μm (125 nm) in diameter⁷ and that a very high proportion of particles (up to 100%) in this size range are captured by high-efficiency particulate air (HEPA) filters⁸, it is reasonable to assume that placing a portable HEPA filtration system with a high frequency of air changes rapidly reduces the viral load within the OR without increasing the risk of disseminating the virus.

For this specific scenario, the operative complex was divided into 5 zones (as detailed in Fig. 1):

- Zone 1: Entry dressing room, where the basic PPE is donned
- Zone 2: Anteroom, where the disinfection and surgical dressing take place
- Zone 3: OR (COVID-19 room)
- Zone 4: Exit room, where the PPE is removed
- Zone 5: Exit dressing room, where the staff showers

The entrance to all rooms should have specific signs alerting all hospital personnel that this is the COVID-19 dedicated OR, and each of the 5 created zones should have appropriate receptacles with the material to wear and with wastebaskets to discard the used garments (these should be



Fig. 2-A



Fig. 2-B

Figs. 2-A and 2-B PPE when exiting Zone 1. **Fig. 2-A** Front view. **Fig. 2-B** Lateral view.



Fig. 3-A



Fig. 3-B

Figs. 3-A and 3-B PPE when exiting the anteroom to perform a sterile procedure. **Fig. 3-A** Front view. **Fig. 3-B** Lateral view.

clearly marked with photographs and signage). The access to the OR should be reduced to the absolute minimum, and all of the staff should be thoroughly trained to avoid errors and unnecessary exposure.

In the entry dressing room (Zone 1), the surgical staff (surgeons, anesthesiologists, nurses, radiology technicians, and remaining operative staff) should don a surgical disposable scrub suit, surgical boots or shoes, waterproof boot or shoe covers, and a waterproof apron after which appropriate surgical hand preparation should be performed with water and chlorhexidine gluconate soap. The respirator should be placed at this time. As recommended by the U.S. Centers for Disease Control and Prevention (CDC) and by the U.S. National Center for Immunization and Respiratory Diseases (NCIRD), Division of Viral Diseases, on March 14, 2020, an FFP2 or N95 respirator should be used. These have been shown to be effective for particles within the size range of bacteria and viruses including the coronavirus^{4,9}. Although some centers may want to use surgical helmets (popular among arthroplasty surgeons), their efficiency for the filtration of submicrometer-sized particles is inadequate to use them as respirators and they should not be used alone for protection as they do not eliminate the need for a respirator. This is unlike powered air-purifying respirators (PAPRs), which draw ambient air through a HEPA filter¹⁰. After correct adjustment and sealing of the respirator, protective glasses (or a face shield) and a surgeon's hood

should be placed. Figures 2-A and 2-B illustrate how the staff should be dressed when exiting the dressing room to the anteroom.

In the anteroom (Zone 2), there are 2 options:

1. Sterile procedure (surgeon or scrub nurse): When appropriate, the first act should be to place a lead garment (apron, thyroid shield). Then either surgical space suits and helmets or a second layer of sterile protective garments can be used. In the latter case, a disposable surgical cap should be placed (over the hood), as well as a surgical mask with a shield. The surgical mask with a shield is an alternative to the face shield, which is not readily available at our institution. After this step, surgical hand scrubbing with an aqueous alcohol solution should be performed, and the first pair of surgical gloves should be put on. Finally, a sterile, disposable, reinforced surgical gown, followed by the second pair of gloves and by surgical sleeve protectors, should be put on. Figures 3-A and 3-B illustrate how the surgeon or scrub nurse should be dressed when exiting the anteroom to the OR.
2. Nonsterile procedure (e.g., for patient positioning or fracture traction and reduction): Most often, in trauma or orthopaedic surgical procedures, there is a need to position the patient prior to the surgical procedure and to place traction to reduce fractures (e.g., proximal hip fractures). For these procedures (as for the circulating nurse

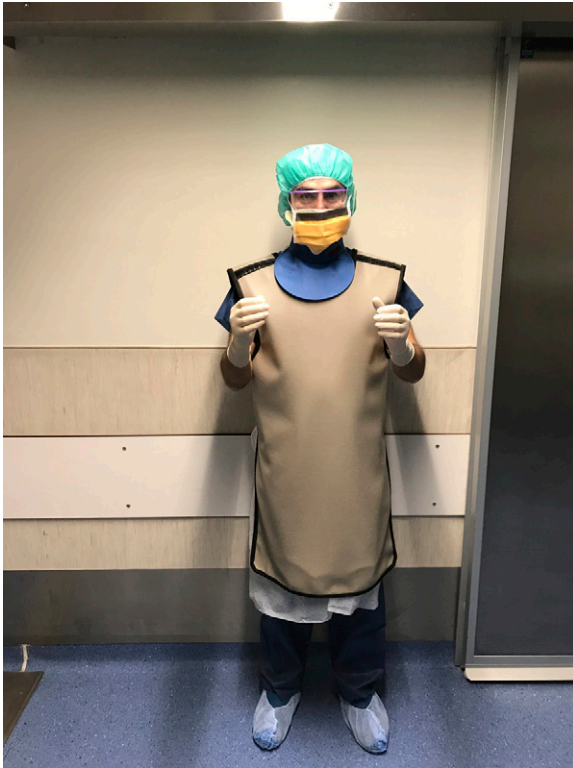


Fig. 4-A



Fig. 4-B

Figs. 4-A and 4-B PPE (before donning a nonsterile gown) to perform a nonsterile procedure. **Fig. 4-A** Front view. **Fig. 4-B** Lateral view.

and other nonsurgical staff in the OR), wearing proper PPE is also required, but the PPE does not need to be sterile. As such, after entering the anteroom, a lead garment should be donned (when required), followed by a disposable surgical cap and nonsterile gloves. Although long-sleeved gloves may be worn, this is not currently recommended by the CDC¹¹. Figures 4-A and 4-B illustrate how the surgeon or scrub nurse should be dressed at this stage. Then a nonsterile, disposable patient isolation gown (ANSI/AAMI [American National Standards Institute/Association for the Advancement of Medical Instrumentation] PB70 Level 3 or 4¹²) should be donned and the staff can then enter the OR. After a procedure such as helping to position the patient or reducing the fracture, if the surgeon needs to scrub in to a surgical procedure, he or she has to complete the exit process: remove the nonsterile surgical cap, gown, and gloves in the OR; and then exit through the exit room and return to the anteroom to complete the hand scrubbing and to put on sterile protective garments, as described previously for the sterile procedure.

After adequate disinfection and dressing, the surgeon enters the OR (Zone 3). Here, the patient should already be under anesthesia⁵, and the surgical staff performs the surgical procedure. For all procedures in the OR, donning an additional pair of gloves (sterile or nonsterile depending on the type of procedure) is recommended.

In trauma and orthopaedic surgical procedures, the use of power tools, such as electrocautery, bone saws, reamers, and drills, releases aerosols¹³, increasing the risk of virus spread. As such, their use should be reduced to the minimum and the power settings should be as low as possible. Suction devices to remove smoke and aerosols should be used during the surgical procedures¹⁴.

At the end of the surgical procedure, and while still in the OR, the surgeon should remove the second (and third, when using) pair of gloves, the sleeve protectors, and the gown and disinfect the first pair of gloves with an alcohol solution, before removing the surgical mask with the shield and the hair cap. Finally, the surgeon should remove the first pair of gloves and disinfect his or her hands with an alcohol solution and exit the room. When exiting the OR into Zone 4, the surgeon should be wearing the same basic PPE used for entering Zone 2 (i.e., disposable scrub suit, respirator, protection glasses, and hood).

As mentioned, the operative staff exits the room through a door that connects to an exit room (Zone 4) where several wastebaskets with appropriate designations should be placed, so that the PPE can be sequentially removed. PPE removal is performed in 4 steps: (1) the lead garment and the waterproof apron are removed and the hands are disinfected; (2) the surgical hood is removed and the hands are again disinfected; (3) protective glasses are removed, followed by shoe covers, and the hands are disinfected; and (4) finally, the FFP2 or N95 respirator is removed and the hands are

again disinfected before exiting into Zone 5, where a clean changing room with showers exists. In the exit dressing room (Zone 5), the surgical staff should remove the scrub suit and bathe.

Summary

In a time when the population is instructed to stay home, health workers are being asked to do the exact opposite. By early March 2020, 3,300 health workers had been infected in the People's Republic of China, and, by the end of February 2020, at least 22 health workers had died. At the time of this writing, it was estimated that at least 20% of responding health workers in Italy had been infected¹⁵. The protection of health workers and appropriate training are of paramount importance to minimize their infection and the stress associated with the physical and mental exhaustion in which they are being placed. The correct application of these procedures is expected to adequately protect health workers by using protective clothing

readily available at most ORs, minimizing the risks associated with the lack of PPE. ■

Ricardo Rodrigues-Pinto, MD, PhD, FEBOT^{1,2}
Ricardo Sousa, MD, PhD^{1,2}
António Oliveira, MD, PhD^{1,2}

¹Department of Orthopaedics, Centro Hospitalar Universitário do Porto, Porto, Portugal

²ICBAS-Instituto de Ciências Biomédicas Abel Salazar, Porto, Portugal

Email address for R. Rodrigues-Pinto: ric_pinto@hotmail.com

ORCID iD for R. Rodrigues-Pinto: [0000-0002-6903-348X](https://orcid.org/0000-0002-6903-348X)

ORCID iD for R. Sousa: [0000-0003-4293-7347](https://orcid.org/0000-0003-4293-7347)

ORCID iD for A. Oliveira: [0000-0001-6499-9552](https://orcid.org/0000-0001-6499-9552)

References

- Zhu N, Zhang D, Wang W, Li X, Yang B, Song J, Zhao X, Huang B, Shi W, Lu R, Niu P, Zhan F, Ma X, Wang D, Xu W, Wu G, Gao GF, Tan W; China Novel Coronavirus Investigating and Research Team. A novel coronavirus from patients with pneumonia in China, 2019. *N Engl J Med*. 2020 Feb 20;382(8):727-33. Epub 2020 Jan 24.
- World Health Organization. Coronavirus disease (COVID-19) outbreak. 2020. Accessed 2020 Mar 28. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019>
- NHS. Clinical guide for the management of trauma and orthopaedic patients during the coronavirus pandemic. 2020 Mar 16. Accessed 2020 Mar 31. <https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2020/03/specialty-guide-orthopaedic-trauma-and-coronavirus-v1-16-march-2020.pdf>
- U.S. Centers for Disease Control and Prevention (CDC). Coronavirus (COVID-19). 2020. Accessed 2020 Mar 25. <https://www.cdc.gov/coronavirus/2019-ncov/index.html>
- Wax RS, Christian MD. Practical recommendations for critical care and anesthesiology teams caring for novel coronavirus (2019-nCoV) patients. *Can J Anaesth*. 2020 Feb 12. [Epub ahead of print].
- Ti LK, Ang LS, Foong TW, Ng BSW. What we do when a COVID-19 patient needs an operation: operating room preparation and guidance. *Can J Anaesth*. 2020 Mar 6. [Epub ahead of print].
- Fehr AR, Perlman S. Coronaviruses: an overview of their replication and pathogenesis. *Methods Mol Biol*. 2015;1282:1-23.
- Perry JL, Agui JH, Vijayakumar R. Submicron and nanoparticulate matter removal by HEPA-rated media filters and packed beds of granular materials. NASA Technical Reports Server. 2016. Accessed 2020 Mar 31. <https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20170005166.pdf>
- Rengasamy S, Eimer BC. Nanoparticle penetration through filter media and leakage through face seal interface of N95 filtering facepiece respirators. *Ann Occup Hyg*. 2012 Jul;56(5):568-80. Epub 2012 Jan 31.
- Derrick JL, Gomersall CD. Surgical helmets and SARS infection. *Emerg Infect Dis*. 2004 Feb;10(2):277-9.
- U.S. Centers for Disease Control and Prevention (CDC). Interim infection prevention and control recommendations for patients with suspected or confirmed Coronavirus Disease 2019 (COVID-19) in healthcare settings. 2020. Accessed 2020 Apr 2. https://www.cdc.gov/coronavirus/2019-ncov/infection-control/control-recommendations.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fhcp%2Finfection-control.html
- ANSI/AAMI. PB70:2012 liquid barrier performance and classification of protective apparel and drapes intended for use in healthcare facilities. Arlington: Association for the Advancement of Medical Instrumentation; 2012.
- Yeh HC, Turner RS, Jones RK, Muggenburg BA, Lundgren DL, Smith JP. Characterization of aerosols produced during surgical procedures in hospitals. *Aerosol Sci Technol*. 1995;22(2):151-61.
- Zheng MH, Boni L, Fingerhut A. Minimally invasive surgery and the novel coronavirus outbreak: lessons learned in China and Italy. *Ann Surg*. 2020 Mar 6. [Epub ahead of print].
- Lo D; The Lancet. COVID-19: protecting health-care workers. *Lancet*. 2020 Mar 21;395(10228):922.