


# COVID-19 in the Perioperative Setting: Applying a Hierarchy of Controls to Prevent Transmission

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Rebecca T. Alvino, MS, RN, CNS, CIC, CNOR; Carolyn M. Caughell, MSN, RN, CIC

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## OUTCOME

The learner will have knowledge of best practices for the perioperative care of patients with coronavirus disease 2019 (COVID-19) and will translate that knowledge into practice.

## OBJECTIVES

1. Identify symptoms and manifestations of COVID-19.
2. Discuss perioperative considerations for patients with COVID-19 and preventing the transmission of SARS-CoV-2.
3. Describe the Centers for Disease Control and Prevention's Hierarchy of Controls model.

## ACCREDITATION

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Rebecca T. Alvino, MS, RN, CNS, CIC, CNOR, and Carolyn M. Caughell, MSN, RN, CIC, have no declared affiliations that could be perceived as posing potential conflicts of interest in the publication of this article.

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## ABSTRACT

The evolution of SARS-CoV-2 from a zoonotic virus to a novel human pathogen resulted in the coronavirus disease 2019 (COVID-19) global pandemic. Health care delivery and infection prevention and control recommendations continue to evolve to protect the safety of health care personnel, patients, and visitors while researchers and policymakers learn more about SARS-CoV-2 and COVID-19. The perioperative setting is unique in that it exposes clinicians and personnel to increased risks through the invasive nature of surgical care. Using the Centers for Disease Control and Prevention's Hierarchy of Controls as a model, this article presents risk mitigation strategies for preventing the transmission of COVID-19 in the perioperative environment. The goals are to identify and eliminate potential exposure to SARS-CoV-2 when surgery is necessary for patients who are suspected or confirmed to have COVID-19 or who have an unknown infection status.

**Key words:** *coronavirus disease 2019 (COVID-19), SARS-CoV-2, hierarchy of controls, aerosol-generating procedure (AGP), personal protective equipment (PPE).*

In December 2019, a cluster of patients presented with pneumonia of unknown etiology in Wuhan City, Hubei Province, China.<sup>1,2</sup> The etiology was later identified as a novel coronavirus (SARS-CoV-2) causing severe acute respiratory syndrome (SARS),<sup>3</sup> and the World Health Organization named the resulting illness *coronavirus disease 2019 (COVID-19)*.<sup>4</sup> By January 20, 2020, there were confirmed cases of COVID-19 in four countries (China, Thailand, Japan, and the Republic of Korea).<sup>5</sup> On March 11, 2020, the World Health Organization declared COVID-19 a pandemic after identifying thousands of additional cases around the world.<sup>6</sup>

The novel coronavirus SARS-CoV-2 belongs to the same *Betacoronavirus* genus as other coronaviruses linked to previous disease outbreaks: SARS in 2002 and Middle East respiratory syndrome in 2012.<sup>7</sup> Unlike SARS, in which the highest viral loads and shedding occurred approximately 10 days after symptom onset, the highest viral loads for

COVID-19 are evident at the time of symptom onset and progressively decrease within days. The timing of this peak viral load may facilitate community spread of SARS-CoV-2, even if the initial symptoms of COVID-19 are mild or absent.<sup>7</sup>

## COVID-19 EPIDEMIOLOGY, SYMPTOMS, AND DIAGNOSIS

As of October 23, 2020, the COVID-19 dashboard that is maintained by the Center for Systems Science and Engineering at Johns Hopkins University and updated on a daily basis reported 42,070,215 confirmed cases of COVID-19 and 1,141,724 deaths attributed to COVID-19 globally, and 8,479,652 cases of COVID-19 and 223,845 deaths attributed to COVID-19 in the United States.<sup>8</sup> According to the dashboard, the case-fatality rate for COVID-19 in the United States was 2.6% as of October 23, 2020.

Patients with COVID-19 can present with several flu-like symptoms, including fever, cough, shortness of breath, sore throat, rhinorrhea, chills, headache, fatigue, and muscle pain.<sup>9</sup> Some patients may have gastrointestinal symptoms, including vomiting and diarrhea, or experience a new loss of taste or smell. For those who become symptomatic, the onset of symptoms may occur from 2 to 14 days after exposure to SARS-CoV-2.<sup>9</sup> According to the Centers for Disease Control and Prevention (CDC),<sup>10</sup> for patients who developed severe disease, the median time from symptom onset to dyspnea was five to eight days; the median time from symptom onset to acute respiratory distress syndrome was 8 to 12 days; and the median time from symptom onset to intensive care unit admission was 10 to 12 days. Likely routes of transmission include exposure to respiratory droplets and close-range aerosol particles carrying the virus.<sup>11</sup> Older age appears to be a strong risk factor for illness severity, complications, and death,<sup>12</sup> which may explain the typically mild course of illness reported among most pediatric patients.<sup>13</sup>

## Pediatric Patients

Of the 6,520,820 cases with age group reported by the end of October 2020, 8.8% were children 0 to 17 years of age.<sup>14</sup> Published data show some differences in clinical presentation among pediatric patients compared with adult patients.<sup>15-17</sup> The main difference in symptom presentation is severity. In pediatric patients, COVID-19 tends to be mild—cough and fever are the most common symptoms. Gastrointestinal manifestations also can develop, including diarrhea, nausea, vomiting, difficulty feeding, or poor appetite.<sup>18</sup> Children with COVID-19 also may be asymptomatic.<sup>16,18-21</sup>

It is important for health care workers (HCWs) to be aware that the presentation of COVID-19 in children may be similar to other common viral respiratory infections and to maintain an index of suspicion. Because pediatric patients seem to develop less severe COVID-19 illness, they are less likely to be tested, which may result in underreporting. A rare and serious complication associated with COVID-19 that affects the pediatric population is multisystem inflammatory syndrome.<sup>18</sup> Pediatric patients with this condition tend to have a history of past SARS-CoV-2 infection or contact with someone with COVID-19.<sup>17</sup> The CDC issued a health advisory about the

correlation between multisystem inflammatory syndrome in children and COVID-19.<sup>22</sup>

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## Diagnostic Testing

Diagnostic testing collection methods are the same for adults and children: the tester swabs the nasopharynx, oropharynx, nasal midturbinate, or anterior nares and places the swab into viral or Amies transport media.<sup>23</sup> Nasal wash or nasopharyngeal aspirate also can be tested for SARS-CoV-2 using nonbacteriostatic saline collected in a sterile transport tube. Sputum testing also is available, for which the tester should use a dry, sterile collection container.<sup>23</sup> Antibody testing is not an appropriate diagnostic method for active infection, but instead can provide evidence of previous infection, including in asymptomatic individuals.<sup>24</sup>

The CDC no longer recommends the use of diagnostic testing as a strategy to discontinue isolation for patients who are positive for SARS-CoV-2 because it may prolong isolation for patients who continue to test positive but are likely no longer infectious.<sup>25</sup> Exceptions include severely ill or immunocompromised patients for whom there are concerns regarding a prolonged period of infectivity; providers should consult with local infectious disease experts for assistance with evaluating the role of diagnostic testing in these patients.<sup>25</sup>

## SARS-CoV-2 IN THE PERIOPERATIVE ENVIRONMENT

The perioperative team provides specialized and often complex treatment in a unique environment of care, requiring infection prevention strategies designed specifically for surgical patients and HCWs in the OR. Team members have a responsibility to provide safe care for patients undergoing operative and other invasive procedures.<sup>26</sup>

The invasive and technical nature of surgical care presents infection-related exposure risks (eg, to pathogens) as well as other harmful exposure risks (eg, to radiation). It is important to mitigate the risk of SARS-CoV-2 transmission among both surgical patients and perioperative personnel by using real-time bedside interventions in addition to system-wide strategies.

## Exposure Risk

The COVID-19 pandemic has forced HCWs to assess infection exposure risks critically in the perioperative environment and to determine suitable interventions and mitigation strategies. As health care system and facility subject matter experts and key partners gather more information about SARS-CoV-2 transmission and exposure risk, they will make frequent changes to recommendations to help create a safe, evidence-based clinical practice environment. Although these frequent changes are necessary because of the novelty of the virus and the evolving science, the fluctuating recommendations can be confusing to HCWs and the public at-large, thereby undermining rapid and complete adherence.

Because aerosols that originate in the respiratory tract pose a significant transmission risk to HCWs,<sup>11</sup> one concern in the perioperative environment is identifying aerosol-generating procedures (AGPs) and sufficiently mitigating HCWs' risk of exposure to SARS-CoV-2 during these procedures. According to the CDC, AGPs "are more likely to generate higher concentrations of infectious respiratory aerosols than coughing, sneezing, talking, or breathing."<sup>27</sup> However, defining which procedures generate infectious aerosols that can increase exposure risk to SARS-CoV-2 is difficult. The CDC<sup>27</sup> categorizes the following as AGPs based on their ability to create uncontrolled respiratory secretions:

- open suctioning of airways,
- cardiopulmonary resuscitation,
- endotracheal intubation and extubation,
- manual ventilation, and
- bronchoscopy.

These procedures are common in the perioperative setting and place HCWs at increased risk for exposure to infectious aerosols.<sup>27</sup> Additionally, the American College

of Surgeons<sup>28,29</sup> identifies laparoscopic surgery as aerosol-generating given the proximity of the surgical site to the aerodigestive tract, the creation of a pneumoperitoneum, and the use of a number of devices that create surgical smoke that may disperse pathogens.<sup>30</sup> The American Academy of Otolaryngology–Head and Neck Surgery<sup>31</sup> indicates that procedures that induce coughing or sneezing in a patient may become AGPs. A lack of consensus remains regarding which procedures across specialties qualify as AGPs because of the limitations in data and unanswered questions about SARS-CoV-2 transmission.<sup>27,28,31</sup>

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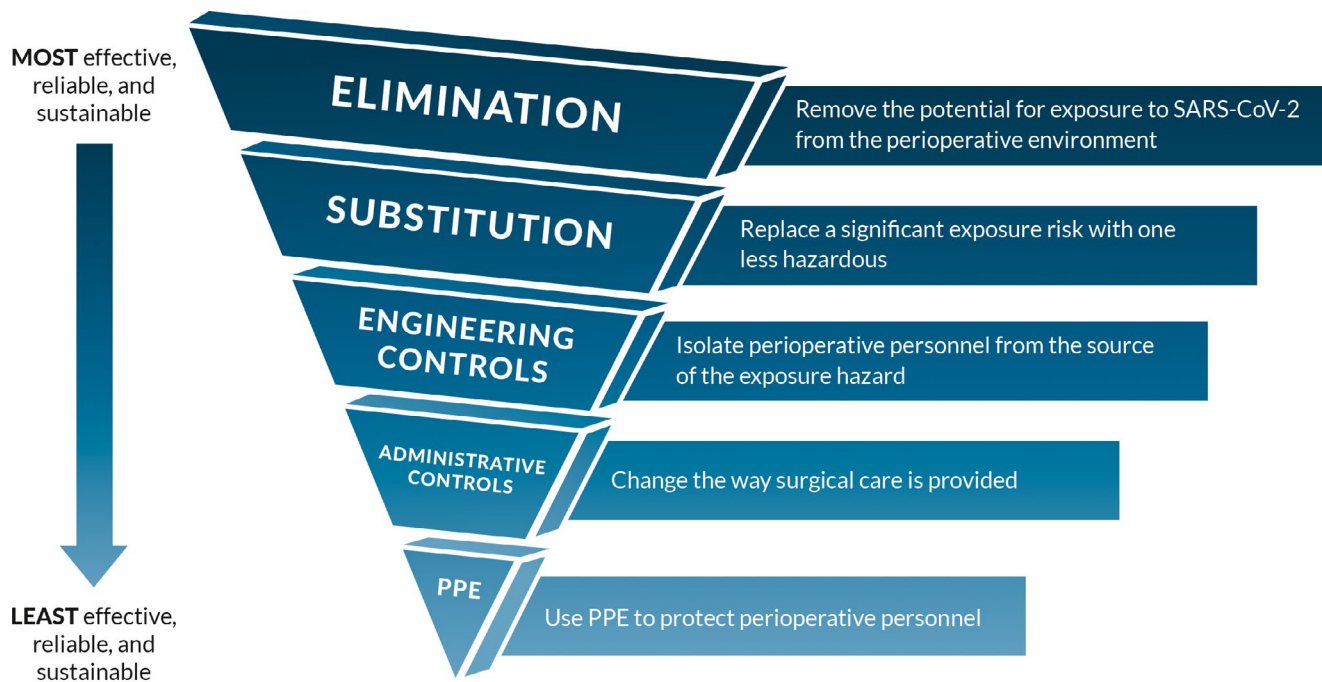
**The American Academy of Otolaryngology–Head and Neck Surgery indicates that procedures that induce coughing or sneezing in a patient may become aerosol-generating procedures.**

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## Infection Prevention Using the Hierarchy of Controls

During the early surges of the COVID-19 pandemic, the US Surgeon General and multiple professional organizations called for the cancellation of elective surgical procedures as part of an effort to conserve the resources necessary to manage COVID-19 patients.<sup>32–36</sup> As elective surgical care resumes, perioperative leaders, HCWs, support teams, and key stakeholders must continue to monitor community transmission to inform the decisions related to elective surgeries and develop a dynamic approach to managing care in the perioperative setting safely during the pandemic.<sup>37,38</sup>

Perioperative leaders, key partners, and facility experts (eg, infection preventionists) should consider state and local orders or advisories, community transmission, and available HCW and supply resources when developing COVID-19 infection prevention and control strategies. They also should maintain flexibility and provide a nimble response to accommodate changing conditions, evolving recommendations, and local resource availability. Key stakeholders (eg, facility leaders; infection prevention, engineering, occupational health and safety, and supply chain personnel) should form a strong partnership and engage in ongoing communication to design a comprehensive and



**Figure 1.** Hierarchy of control strategies to protect surgical patients and perioperative personnel from SARS-CoV-2. PPE = personal protective equipment. Adapted from *Hierarchy of Controls*. Centers for Disease Control and Prevention. <https://www.cdc.gov/niosh/topics/hierarchy/default.html>. Reviewed January 13, 2015. Accessed September 30, 2020.

sustainable plan for managing COVID-19 in the perioperative environment. The CDC's Hierarchy of Controls model,<sup>39</sup> which categorizes occupational hazard control solutions (ie, elimination, substitution, engineering controls, administrative controls, personal protective equipment [PPE]) and prioritizes them from most to least effective, is a useful tool that facility leaders can adapt to manage patient and personnel safety in the perioperative environment (Figure 1).

### Elimination

Elimination is the physical removal of the hazard from the environment and is the most effective way to prevent exposure.<sup>39</sup> In this case, it is the removal of sources of SARS-CoV-2 from the perioperative environment. To eliminate sources of SARS-CoV-2, one must first identify those sources; in the perioperative area, these are patients and personnel. Identification of source patients requires presurgical screenings of as many patients as possible<sup>8</sup> (some patients' condition or health status may preclude testing) using reliable testing methods within a defined time frame.<sup>40</sup> Both presymptomatic transmission (ie, before the onset of associated symptoms) and asymptomatic transmission of SARS-CoV-2 are possible.<sup>10</sup>

The *Joint Statement: Roadmap for Resuming Elective Surgery After COVID-19 Pandemic*<sup>40</sup> details several considerations for personnel developing policies and procedures for patient testing. Conducting patient testing within a limited time period before surgery can identify asymptomatic or presymptomatic patients. If the time gap between patient testing and the surgical procedure is too long, the patient could contract the virus during that time period but not present with symptoms: in this case, a negative test result would provide false reassurance to HCWs.

Presurgical testing of patients can allow for assessment of the surgical risk versus benefit for an identified source patient and the possible delay of surgical care for low-acuity patients with COVID-19 until they are no longer a source of potential transmission. However, delaying a procedure may not be possible if a patient's condition warrants urgent or emergent surgical care. If such a patient has COVID-19 or his or her status is pending or unknown, the surgical team must then implement risk mitigation strategies to prevent transmission.

At the beginning of each shift, any HCW entering the perioperative environment should be screened for associated symptoms and any known work with or community

exposures to individuals with COVID-19 during which they did not don proper PPE; the CDC currently recommends temperature screening as part of this assessment. Staff members reporting symptoms that could be consistent with COVID-19 or positive viral testing for SARS-CoV-2 should not go to work while ill.<sup>41</sup>

### Substitution

According to the Hierarchy of Controls, replacing the hazard is the second best way to control exposure to occupational hazards.<sup>39</sup> When a source patient needs surgical care (in either an asymptomatic, presymptomatic, or symptomatic state), one way to replace the hazard is to substitute one surgical technique or approach for another that reduces the exposure risk for HCWs. For example, some critically ill patients with COVID-19 may be considered for a tracheostomy after prolonged intubation. Because tracheostomies require direct access to the airway where viral loads may be high, some medical centers have developed strategies to substitute percutaneous tracheostomy for an open surgical technique, when deemed safe and necessary for the patient, in an attempt to reduce aerosolization and exposure potential.<sup>42,43</sup>

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### Staff members reporting symptoms that could be consistent with COVID-19 or positive viral testing for SARS-CoV-2 should not go to work while ill.

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When surgery is indicated as an intervention (eg, for patients with certain cancer diagnoses), the treatment team can carefully assess and evaluate the risks and benefits of delaying surgery and proceeding with alternative treatments first, especially if resources are limited.<sup>44</sup> Perioperative HCWs should be aware of these considerations so that they can advocate for their patients; however, the evaluation of risks, benefits, potential complications, and feasibility of substitutions for surgical care are led and determined by the patient's treatment team.

### Engineering controls

In the perioperative setting, engineering controls may include management of heating, ventilating, and air-conditioning

(HVAC) systems for the ORs and other sterile areas (eg, sterile processing department). The use of engineering controls is critical to reducing the risk of transmitting respiratory viruses, including SARS-CoV-2. AORN<sup>45</sup> and the Facility Guidelines Institute<sup>46</sup> provide evidence-based recommendations for the planning, design, and construction of the perioperative environment. Operating room engineers should design HVAC systems to minimize airborne contaminants that can compromise patient outcomes and jeopardize the safety of HCWs. Providing filtered supplied air, preventing entry of contaminated outside air, and diluting contaminated air from the patient can help protect patients and personnel in the OR by reducing infections in surgical patients and HCW exposure to hazardous particles.<sup>46</sup> Both AORN<sup>45</sup> and the Facility Guidelines Institute<sup>46</sup> recommend a minimum of 20 air changes per hour (ACH) for renovated HVAC systems and newly constructed ORs.

The use of calculated ACH has become a central tenet for protecting HCWs from SARS-CoV-2 in the OR, especially when the surgical team is performing AGPs. The CDC<sup>47</sup> provides guidance for the time required to clear 99% of airborne contaminants based on the number of ACH in a space. Questions may arise from facility engineers, perioperative personnel, infection preventionists, or other stakeholders regarding the calculation of these values in an empty room without an AGP source present and their applicability to clinical care; however, the CDC<sup>47</sup> maintains that the current guidelines related to ACH are an effective engineering control strategy for clearing airborne contaminants. Perioperative leaders should consult with infection preventionists, engineering personnel, and other key stakeholders about applying the CDC's calculations to each individual OR to ensure that the HVAC system and OR are designed to achieve these thresholds for safety.

Typically, ORs should maintain positive pressure with respect to adjoining spaces to protect patients, supplies, and equipment inside the room from airborne contaminants outside the room.<sup>45,46</sup> However, negative-pressure rooms (eg, airborne infection isolation rooms [AIIRs]) are designed to prevent airborne contaminants that originate inside one space from drifting to adjacent areas, thereby protecting the outside environment from contaminants, including infectious pathogens.<sup>46,48</sup> Negative air pressurization in an OR can help protect individuals, supplies, and equipment outside the room from a SARS-CoV-2 source (eg, a patient with COVID-19 undergoing surgery) inside the room. It is critical to note that not all negative-pressure

spaces necessarily qualify as AIIRs, which are characterized by distinct features (eg, direct exhaust to the outside) and should have a minimum of 6 to 12 ACH.<sup>41</sup>

Providing surgical care to patients who are suspected or confirmed to have COVID-19 in an AIIR or negative-pressure OR is a viable strategy for decreasing the risk of transmission. However, in one study that investigated the causes of a polymicrobial outbreak of surgical site infections (SSIs) among cardiac surgery patients at a single hospital, the investigators found that the air pressure in the OR was lower than the pressure outside the OR (ie, negative pressure), which may have attributed to SSI development.<sup>49</sup> Perioperative leaders and staff members should discuss the risks and benefits of negative-pressure rooms with infection preventionists, engineering personnel, and other key partners, because altering HVAC systems to create a negative-pressure space could adversely affect surgical patients (eg, by increasing their risk for SSIs) or other areas served by the same HVAC system.<sup>50</sup>

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### **Providing surgical care to patients who are suspected or confirmed to have COVID-19 in an airborne infection isolation room or negative-pressure OR is a viable strategy for decreasing the risk of transmission.**

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When performing an operative or other invasive procedure on a patient who is suspected or confirmed to have COVID-19 in a negative-pressure OR is not feasible, personnel may consider using an AIIR or other negative-pressure space outside the OR for certain AGPs (eg, intubation, extubation), even if it is not the location where the surgery will be performed.<sup>29,42</sup> Constructing a negative-pressure anteroom provides a dedicated space to direct potentially infectious aerosols generated during a procedure in the OR and helps protect adjacent environments outside the OR by keeping the contaminated air in the anteroom.<sup>51</sup> The anteroom can be constructed at one entrance to the OR as the sole entry and exit; it also can serve as an intermediary space for personnel to drop off supplies or pick up specimens during a procedure.<sup>29</sup>

Perioperative personnel may consider using portable high-efficiency particulate air filtration, but should

consult with infection preventionists and engineering personnel first because correct placement of the filter is critical to maximize efficacy and avoid inadvertently altering air balances to the HVAC system or in the OR.<sup>29,52</sup> To help maintain normothermia in patients who are suspected or confirmed to have COVID-19, perioperative personnel may continue to use forced-air warming devices; however, they should determine the timing of device activation and frequency of filter changes through a multidisciplinary risk assessment involving infection preventionists, physician partners, and the equipment manufacturer.<sup>50</sup> Additionally, all OR doors should remain closed as much as possible to achieve maximum efficacy of these engineering controls.<sup>45</sup>

Perioperative personnel may consider using negative-pressure barrier enclosures (known as aerosol boxes or intubation boxes) or drapes during intubation to minimize the dispersal of aerosols and protect themselves from SARS-CoV-2; however, the Anesthesia Patient Safety Foundation<sup>32</sup> does not take a position on these barriers because there currently is no evidence of their effectiveness; further, their use may create unintended risks if they are constructed or implemented incorrectly.<sup>53</sup> Anesthesia professionals should attach a single-use high-efficiency particulate air or viral filter to the Y-piece of the breathing circuit where it connects to the ventilation mask, endotracheal tube, or laryngeal mask airway to protect the immediate environment from contaminated aerosols if the airway becomes disconnected from the circuit.<sup>54</sup> For pediatric patients or in circumstances in which additional dead space or filter weight may create complications, placing a viral filter on the expiratory limb of the circuit will protect the anesthesia machine from infectious aerosols in the inspired gas that enters the machine.<sup>55</sup>

The Society of American Gastrointestinal and Endoscopic Surgeons<sup>56</sup> recommends that laparoscopic trocar ports remain closed when using insufflators without desufflation features because increased intra-abdominal pressure can cause contaminated carbon dioxide from the peritoneum to be pushed back into the insufflator when the flow is turned off. Creating a closed ultrafiltration system for surgical smoke and pneumoperitoneum evacuation with trocars in place and ports closed before disconnecting tubing can minimize dispersal of contaminated smoke and gases.<sup>57</sup>

Effective cleaning and disinfection of surfaces is critical to maintaining a safe OR environment for patients and HCWs. Personnel should physically remove gross soil and fomites and then apply an Environmental Protection Agency (EPA)-registered, hospital-grade disinfectant (or use wipes that clean and disinfect in one step) after each surgical procedure.<sup>47</sup> According to the EPA, products used to clean and disinfect surfaces and equipment after performing a procedure on a patient who is suspected or confirmed to have COVID-19 should be effective against emerging viral pathogens and must be used according to the manufacturer's instructions, including adhering to the recommended surface contact time. The EPA maintains a current list of disinfectants that are effective against SARS-CoV-2.<sup>58</sup> To further reduce exposure opportunities to aerosolized SARS-CoV-2, personnel should not clean and disinfect the OR and its contents until after the predetermined time for air turnover based on ACH.<sup>52</sup> A multidisciplinary team, including environmental services, occupational health and safety, and infection prevention personnel, should evaluate the use of disinfection technologies (eg, ultraviolet germicidal irradiation units).

Postanesthesia care for patients who are suspected or confirmed to have COVID-19 is similar to that for patients with other airborne-transmissible diseases (eg, pulmonary tuberculosis, disseminated varicella). AORN<sup>52</sup> recommends using an AIIR for the postanesthesia recovery of these patients; however, if an AIIR is not available, patients who are suspected or confirmed to have COVID-19 should remain in the OR for their postanesthesia recovery.<sup>29,59,60</sup>

### Administrative controls

Administrative controls change the way that work is performed and can be developed to help prevent exposure to and transmission of SARS-CoV-2 in the perioperative environment. These controls require employer or worker action and may originate as policies or procedures to reduce exposures. Administrative controls may not be as effective as the first three controls in the hierarchy (ie, elimination, substitution, engineering controls).<sup>39</sup> Although administrative controls can be seemingly easy and inexpensive to establish, sustainability can be costly and challenging, especially if there are resource constraints. A multidisciplinary team of perioperative leaders, infection preventionists, and other key partners may consider several strategies to design and implement such controls, but

these require clear communication, advanced planning, and collaboration when possible.

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## Administrative controls change the way that work is performed and can be developed to help prevent exposure to and transmission of SARS-CoV-2 in the perioperative environment.

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To minimize HCW exposure to patients with COVID-19, perioperative leaders should encourage physical distancing, which is a key strategy to prevent SARS-CoV-2 transmission.<sup>41</sup> One specific strategy would be to reduce the total number of personnel present in the OR as much as possible while still ensuring patient safety.<sup>28</sup> It is important to identify ways that perioperative personnel can maintain physical distancing without eliminating necessary communication or educational opportunities. Perioperative leaders should review current staffing models for opportunities to reduce or stagger the number of HCWs in the department at the same time. Informed by current local recommendations or public health orders, in-person meetings should remain in small, physically distanced groups or be moved to virtual or phone platforms.<sup>61</sup> Leaders should assess break rooms, charting areas, and changing rooms for maximum capacity and provide visual indicators to help maintain adherence to capacity limitations. Perioperative leaders may adjust the surgical schedule to take advantage of underused block times to manage surgeries for patients who are suspected or confirmed to have COVID-19. Performing these surgeries on the weekend or at the end of the day, as permitted by patient condition, can help minimize exposure risk.<sup>52</sup>

A preoperative huddle provides the opportunity for the surgical team to identify key roles clearly, outline the plan of care, clarify anticipated needs, and provide an opportunity to ask questions before proceeding. If it is necessary to perform AGPs in a positive-pressure OR, only the minimum number of staff members necessary for patient care should assist, and it is critical that they don the appropriate PPE. The team should dedicate a staff member to remain outside the OR to retrieve additional supplies and equipment.<sup>62</sup> The RN circulator should document all personnel



present in the OR during the procedure in the patient's record. Additionally, tracking anyone else who enters the OR during the procedure (eg, charge nurse, vendor) can help facilitate contact tracing, if necessary. Designating a specific surgical suite, ideally away from other ORs and without shared spaces, can allow perioperative personnel and leaders to employ additional control measures. Personnel will become familiar with the dedicated perioperative environment and its immediately available resources. Minimal supplies and dedicated equipment should be present to reduce the risk of cross-contamination and waste.<sup>29</sup> Perioperative leaders and key partners (eg, infection preventionists) should outline a clearly defined path of travel for staff members to follow to reduce opportunities for cross-contamination.<sup>54,60,62</sup>

Hand hygiene is a cornerstone of infection prevention; therefore, a robust hand hygiene program with frequent observations and feedback is important to breaking the chain of transmission for several pathogens, including SARS-CoV-2. Stakeholders and leaders of the facility's hand hygiene program (eg, infection preventionists) should post visual reminders throughout the facility for both HCWs and patients. Handwashing with soap and water for at least 20 seconds or using an alcohol-based hand sanitizer containing at least 60% alcohol is necessary for HCW and patient safety.<sup>41</sup>

### Personal protective equipment

The least effective control in the hierarchy is PPE. The use of PPE is minimally effective unless used correctly and in combination with other control strategies.<sup>39</sup> It is an individual control measure that is more useful as part of a larger program,<sup>27</sup> and health care leaders should prioritize the protective measures with the broadest effect. Because close proximity to the patient is required to deliver care in the OR, strategies such as physical distancing may impede necessary care delivery; therefore, the correct use of PPE is vital to maintain HCW safety.

The CDC<sup>27</sup> recommends a tiered approach to inform local decisions regarding universal PPE and source control strategies based on community transmission. Personnel can use standard precautions for patients who have been effectively ruled out for COVID-19 through symptom screening, careful clinical assessment, and high-quality testing programs; however, HCWs still may be apprehensive and uncertain about using lower-level respiratory protection.

Some HCWs may be concerned about test accuracy and continue to use higher levels of PPE than instructed. This can create challenges with preserving PPE resources for procedures involving high exposure risk, such as caring for patients who are suspected or confirmed to have COVID-19 or patients with non-COVID-19 aerosol-transmissible diseases and performing AGPs for patients who are suspected or confirmed to have COVID-19 or other aerosol-transmitted infections.

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### The use of PPE is minimally effective unless used correctly and in combination with other control strategies.

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Communicable illnesses necessitate transmission-based precautions, including the use of PPE. The route(s) of disease transmission and anticipated tasks to be performed by the wearer, including the risk of exposure to blood or other potentially infectious materials, inform PPE use.<sup>52</sup> The CDC<sup>41</sup> currently recommends implementing universal source control measures for everyone who enters a health care facility. For HCWs caring for patients who are suspected or confirmed to have COVID-19, the CDC<sup>63</sup> recommends the following PPE:

- gloves,
- a long-sleeved isolation gown,
- respiratory protection that is at least as protective as a fit-tested National Institute for Occupational Safety and Health–approved N95 respirator, and
- eye protection that protects the front and sides of the eyes (eg, goggles, face shield).

If N95-level respiratory protection is not available, HCWs may wear a surgical mask for encounters during which AGPs are not being performed to prioritize N95 respirators for high-risk procedures and AGPs.<sup>64</sup>

A multidisciplinary team, including infection preventionists, perioperative leaders and staff members, occupational health and safety personnel, and other stakeholders, should assess the use of powered air-purifying respirators (PAPRs) in the OR. A PAPR filters inspired air for the wearer but does not filter exhaled

## Key Takeaways

- ◆ In December 2019, a cluster of patients presented with pneumonia of unknown etiology in Wuhan City, Hubei Province, China. The virus was later identified as the novel coronavirus SARS-CoV-2 and the resulting illness, coronavirus disease 2019 (COVID-19), was declared a global pandemic in March 2020.
- ◆ Patients with COVID-19 can present with several flu-like and gastrointestinal symptoms and a new loss of taste or smell. For those who become symptomatic, the onset of symptoms may occur from 2 to 14 days after exposure to SARS-CoV-2.
- ◆ The invasive nature of surgical care presents exposure risks for perioperative personnel. Procedures that generate aerosols originating in the patient's respiratory tract pose a significant transmission risk, and it is important to mitigate the risk of exposure to SARS-CoV-2 during these and other surgical procedures.
- ◆ Perioperative leaders should consider federal, state, and local orders and the available health care worker and supply resources when developing COVID-19 infection prevention and control strategies. The Centers for Disease Control and Prevention's Hierarchy of Controls model, which categorizes and prioritizes occupational hazard control solutions, is a useful tool that facility leaders can adapt to manage patient and personnel safety in the perioperative environment during a pandemic.

air, which can increase the air contamination inside the OR.<sup>52</sup> The multidisciplinary team should evaluate each type of PAPR for the risks to patient safety versus the benefits to HCW safety and consider their use in conjunction with other control strategies, such as performing AGPs outside the OR in an AIIR when possible. It is best to avoid using N95 respirators or PAPRs with exhalation valves because exhaled air is not filtered and can compromise source control and the sterility of the surgical field.<sup>52,65</sup>

Evidence of the effectiveness of different types and combinations of PPE is inconsistent and lacking, which may create confusion regarding routes of transmission<sup>66</sup> and subsequently compound risk assessments when balancing available resources. Additionally, there have been multiple barriers to personnel using PPE, including decreased availability, difficulty donning and doffing, and inconsistent guidance for required PPE, producing variability in adherence to transmission-based precautions.<sup>66,67</sup> These factors contribute to the ineffectiveness of PPE as a sole method of protection for HCWs who encounter COVID-19 in the perioperative environment. Given the invasive nature of the clinical care they provide, perioperative personnel are likely at a higher risk of infection than the general population during any pandemic. Further, PPE is only as protective as it is intended to be when used properly. Self-contamination is a high risk when doffing PPE.<sup>68</sup> Focused education, frequent practicing of these processes away

from the patient care environment, the use of a “buddy system” to monitor safe donning and doffing of PPE, and correcting breaches immediately can reduce self-contamination, maximize PPE efficacy, and help maintain HCW safety.

Employers are mandated to protect their workers against exposure hazards.<sup>69</sup> The challenges that health care facilities have faced to maintain PPE supplies during the pandemic are well recognized in the United States, and many facility leaders have reported shortages in the PPE needed to protect HCWs from exposure to COVID-19.<sup>68</sup> The shortage of available PPE has had a ripple effect across the US health care system. Examples of these repercussions include

- requests for donations,<sup>70</sup>
- national guidance and local policy development for reuse and extended use of PPE,<sup>71</sup>
- deployment of PPE that has exceeded its manufacturer-designated shelf life,<sup>72</sup>
- calls to invoke the Defense Production Act,<sup>73-75</sup>
- identification of methods for the safe decontamination of PPE for reuse,<sup>76</sup>
- use of homemade PPE,<sup>77</sup>
- accelerated production of medical supplies,<sup>78</sup> and
- a shift in the recommended level of PPE.<sup>79,80</sup>

Reuse and extended use of PPE may not be aligned with manufacturer guidelines, leaving many HCWs lacking confidence in the PPE provided. Strategic allocation to the HCWs who are most likely to be exposed is necessary to preserve resources and maintain required safety standards; knowledge of current published guidance and frequent multidisciplinary risk assessments are critical.

## CONCLUSION

Scientists and clinicians continue to learn more about the transmission of SARS-CoV-2 and subsequent development of COVID-19 across populations. As more evidence emerges regarding transmission, illness, and effects on local communities, health care leaders and personnel must remain flexible and prepared for changes in guidance from federal, state, and local authorities. Surges in patient admissions are anticipated and likely to continue putting stress on health care systems. Resource constraints involving PPE, surface disinfectants, and other supplies challenge safe patient care. As HCWs become infected through community or occupational exposure, it is reasonable to expect strains on HCW staffing.

To sustain safe surgical care for patients and reduce perioperative personnel's risk of occupational exposure to COVID-19, health care facility leaders must take a comprehensive and multidisciplinary approach to developing sustainable and dynamic risk-mitigation strategies while navigating changing conditions and evolving recommendations. The Hierarchy of Controls model can be used as a framework to identify, organize, and plan tactics for sustaining surgical care in a safe perioperative environment during a pandemic.

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**Rebecca T. Alvino**, MS, RN, CNS, CIC, CNOR, is an infection preventionist in the Department of Hospital Epidemiology and Infection Prevention at UCSF Health, San Francisco, CA. *Ms Alvino has no declared affiliation that could be perceived as posing a potential conflict of interest in the publication of this article.*

**Carolyn M. Caughell**, MSN, RN, CIC, is an infection preventionist in the Department of Hospital Epidemiology and Infection Prevention at UCSF Health, San Francisco, CA. *Ms Caughell has no declared affiliation that could be perceived as posing a potential conflict of interest in the publication of this article.*

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## Continuing Education

# COVID-19 in the Perioperative Setting: Applying a Hierarchy of Controls to Prevent Transmission

2.3  [www.aornjournal.org/content/cme](http://www.aornjournal.org/content/cme)

## OUTCOME

The learner will have knowledge of best practices for the perioperative care of patients with coronavirus disease 2019 (COVID-19) and will translate that knowledge into practice.

## OBJECTIVES

1. Identify symptoms and manifestations of COVID-19.
2. Discuss perioperative considerations for patients with COVID-19 and preventing the transmission of SARS-CoV-2.
3. Describe the Centers for Disease Control and Prevention's Hierarchy of Controls model.

The Examination and Learner Evaluation are printed here for your convenience. To receive continuing education credit, you must complete the online Examination and Learner Evaluation at <http://www.aornjournal.org/content/cme>.

## QUESTIONS

1. Patients with COVID-19 can present with several symptoms, including
  1. polyuria.
  2. shortness of breath.
  3. headache.
  4. fever.
    - a. 1 and 2
    - b. 2 and 3
    - c. 2, 3, and 4
    - d. 1, 2, 3, and 4
2. For those who become symptomatic, the onset of COVID-19 symptoms may occur from \_\_\_ to \_\_\_ days after exposure to SARS-CoV-2.
  - a. 2; 14
  - b. 5; 15
  - c. 3; 7
  - d. 6; 12
3. A rare and serious complication associated with COVID-19 that affects the pediatric population is multisystem \_\_\_\_\_ syndrome.
  - a. adrenal
  - b. neurologic
  - c. dysmorphic
  - d. inflammatory
4. Procedures that the Centers for Disease Control and Prevention categorizes as aerosol-generating include
  1. colonoscopy.
  2. bronchoscopy.
  3. marsupialization.
  4. endotracheal intubation.
    - a. 1 and 2
    - b. 2 and 4
    - c. 1, 2, and 3
    - d. 1, 2, 3, and 4
5. According to the Centers for Disease Control and Prevention's Hierarchy of Controls model, occupational hazard control solutions listed from most to least effective include
  - a. personal protective equipment, prioritization, and administrative controls.
  - b. engineering controls, substitution, and personal protective equipment.





## Continuing Education

# COVID-19 in the Perioperative Setting: Applying a Hierarchy of Controls to Prevent Transmission

2.3  [www.aornjournal.org/content/cme](http://www.aornjournal.org/content/cme)

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## OUTCOME

The learner will have knowledge of best practices for the perioperative care of patients with coronavirus disease 2019 (COVID-19) and will translate that knowledge into practice.

## OBJECTIVES

To what extent were the following objectives of this continuing education program achieved?

1. Identify symptoms and manifestations of COVID-19.  
*Low 1. 2. 3. 4. 5. High*
2. Discuss perioperative considerations for patients with COVID-19 and preventing the transmission of SARS-CoV-2.  
*Low 1. 2. 3. 4. 5. High*
3. Describe the Centers for Disease Control and Prevention's Hierarchy of Controls model.  
*Low 1. 2. 3. 4. 5. High*

## CONTENT

4. To what extent did this article increase your knowledge of the subject matter?  
*Low 1 2. 3. 4. 5. High*

5. To what extent will you translate the knowledge of the subject matter into practice?  
*Low 1. 2. 3. 4. 5. High*
6. To what extent were your individual objectives met?  
*Low 1. 2. 3. 4. 5. High*
7. Will you be able to use the information from this article in your work setting?  
1. Yes    2. No
8. Will you change your practice as a result of reading this article? (If yes, answer question #8A. If no, answer question #8B.)
- 8A. How will you change your practice? (*Select all that apply.*)
  1. I will provide education to my team regarding why change is needed.
  2. I will work with management to change/implement a policy and procedure.
  3. I will plan an informational meeting with physicians to seek their input and acceptance of the need for change.
  4. I will implement change and evaluate the effect of the change at regular intervals until the change is incorporated as best practice.
  5. Other: \_\_\_\_\_
- 8B. If you will not change your practice as a result of reading this article, why not? (*Select all that apply.*)
  1. The content of the article is not relevant to my practice.
  2. I do not have enough time to teach others about the purpose of the needed change.
  3. I do not have management support to make a change.
  4. Other: \_\_\_\_\_