

Anesthetic concerns for pediatric patients in the era of COVID-19

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Abstract

After a novel human coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was reported in China in December 2019, the disease quickly reached pandemic level. On January 30, 2020, the World Health Organization (WHO) declared that the SARS-CoV-2 outbreak constituted a Public Health Emergency of International Concern. The caseload has increased exponentially, with WHO reporting 182 000 global cases by March 17, 2020, and over 2.6 million by 23 April. The clinical situation is complex, with children presenting different clinical features compared to adults. Several articles with recommendations on the anesthetic management of adult patients with COVID-19 have been published, but no specific recommendations for pediatric anesthesiologists have been made yet. This article addresses specific concerns for the anesthetic management of the pediatric population with COVID-19.

KEYWORDS

anesthesia, COVID-19, pediatrics, SARS-CoV-2

1 | INTRODUCTION

Since its discovery in China in late 2019, the SARS-CoV-2 virus has spread to nearly all of the world's countries in a matter of weeks.^{1,2} The consensus transmission mode is via droplet exposure to conjunctival, nasal, or oral mucosa, with some indication that airborne transmission is possible but not predominant. Transmission may also occur via direct contact with virus-laden oral fluids, nasal secretions, or other patient materials. Indirect contact with contaminated instruments and/or environmental surfaces could also lead to transmission; the virus may remain viable for up to 3 days on steel and plastic.³ Many guidelines for the protection of healthcare workers have been issued, but due to increased disease severity and mortality among the older adult population, few available guidelines focus on those caring for pediatric patients. Specific recommendations tailored to physicians caring for pediatric patients are necessary because pediatric patients with COVID-19 are likely to exhibit milder symptoms relative to adults, or even no symptoms at all. Further, anesthesiologists face particular risks beyond those of most

physicians. We present below some recommendations for pediatric anesthesiologists caring for pediatric patients during this pandemic.

2 | NEED FOR PEDIATRIC-SPECIFIC COVID GUIDELINES IN ANESTHESIA

The classical clinical presentation of COVID-19 in adults includes fever, dry cough, and myalgia or fatigue with abnormal chest CT, though symptoms may also be mild.⁴ Seriously affected adults often develop a viral pneumonia and cardiac complications, and older patients are more susceptible to respiratory failure and death.⁵ Less common symptoms include sputum production, headache, hemoptysis, and diarrhea.⁴ The symptomatology of COVID-19 in the pediatric population, however, is less clear. Especially early in the outbreak, pediatric cases remained rare. On February 9, 2020, out of about 35 000 cases reported in China, only about 2000 were children.⁶ The delayed and reduced involvement of pediatric patients was confusing. The pediatric population

is usually more susceptible to viral respiratory diseases due to their incompletely developed immune systems, with immature T helper cytokine response as well as immature specialized memory T and B lymphocytes producing antibodies directed against pathogens.⁷ Viruses typically target both juvenile and elderly patients, but COVID-19 is more likely to be severe (and appears to be more prevalent) among older patients.

The first retrospective epidemiologic analysis of disease spread and severity examined 2143 confirmed or possible pediatric COVID-19 cases reported to the Chinese Center for Disease Control and Prevention (China CDC) from January 16 to February 8, 2020.⁶ While prevalence varied only slightly among pediatric age-groups, the study did indicate that the proportion of severe/critical cases may decrease with pediatric patients' age.

A systematic review by Castagnoli et al indicates that children with SARS-CoV-2 infection typically exhibit mild or no symptoms.⁸ While fever and cough are common in affected children, they are not pathognomonic. Of note, all three of the pediatric case series cited by Zimmermann and Curtis⁹ include asymptomatic cases, at rates up to 20%. Given that the typical criteria for testing by public health departments have emphasized fever, cough, and shortness of breath, these findings suggest that the incidence of asymptomatic infection in the pediatric population is likely to be high. Pediatric patients may thus be an important source of undetected transmission, as asymptomatic or undiagnosed carriers.

Most experienced pediatric anesthesiologists would probably proceed with an anesthetic in a child with a recent mild URI (runny nose, cough, and even recent resolved fever). Those without symptoms are not yet routinely tested at every institution, despite asymptomatic transmission being documented in literature.^{1,10} The incubation period is thought to be 1-14 days in most patients, but may be longer.² If symptoms appear, distinguishing COVID-19 from other common respiratory tract infections in symptomatic pediatric patients is difficult. Confusion may also be created by coinfection with other pathogens such as common cold viruses or influenza, possibly leading to unexpected constellations of symptoms and incomplete diagnosis. Further, chest X-rays may not be diagnostic in mild cases,² such as often occur among children. Confusion may also be created by coinfection with other pathogens such as common cold viruses or influenza, possibly leading to unexpected constellations of symptoms and incomplete diagnosis.

Given the sparse data and apparent lack of signs/symptoms with high sensitivity or specificity, it might be quite difficult for a pediatric anesthesiologist to either diagnose or exclude COVID-19 in a given pediatric patient. Estimates of RT-PCR testing sensitivity for SARS-CoV-2 RNA unfortunately vary, and false negatives appear to be a common problem. Some authors have reported positive virus RNA detection in known COVID-19 patients as low as 32% with pharyngeal swab.¹¹ Adding to the difficulty, there is some indication that the false-negative rate varies with time since exposure¹² and conversely, that positive virus RNA detection does not automatically indicate viable virus presence.¹³ Other factors, including swab technique and the patient's viral load and current anatomical site of

replication, may further compromise sensitivity. Also, a case series reports 4 HCWs who had recovered from COVID-19, with two consecutive negative RT-PCR tests by throat swab, but later returned to positive test results.¹⁴ For these reasons, sequential tests on a given patient are likely to improve sensitivity, but by an amount that is difficult to quantify. At present, serologic (antibody) testing is still in development, and at least one major health department has advised against its use for diagnosis of acute or prior infection.¹⁵ Case-by-case decisions on PPE usage and/or other precautions may therefore be inadvisable while community transmission is still occurring.

3 | PROTECTING PEDIATRIC ANESTHESIOLOGISTS AND THE HEALTHCARE WORKFORCE

At least 3300 healthcare workers (HCW) have been infected with SARS-CoV-2 in China¹⁶; another study of 25 000 COVID-19 patients there found substantial HCW overrepresentation at 5.1% of the total cases.¹⁷ In Italy, 8.3% of reported cases have involved HCW.¹⁸ In Spain, HCW have represented 38% of positive tests, and 11.6% of hospital workers have tested positive.¹⁹ Anesthesiologists in particular are likely to be at increased risk of contracting COVID-19 during airway management, due to the required proximity to the patient's airway and exposure to aerosolized viral droplets, especially during airway manipulation, including intubation, extubation, and positive-pressure ventilation via mask. There is also additional risk of exposure to sputum and other body fluids during anesthetic management, which could also potentially transmit the disease. Additionally, endonasal endoscopic surgery has been associated with high rates of viral transmission, likely to be due to extremely high viral shedding from the nasopharynx.²⁰ A review of data from the 2003 SARS outbreak can be used to illustrate the risk. When compared to healthcare workers who did not perform airway or ventilator management, those who performed tracheal intubation had 6.6-fold increased odds of contracting disease in the 2003 SARS-CoV outbreak.²¹ Anesthesiologists are therefore well advised to exercise particular caution, as there is no evidence that the 2019 SARS-CoV-2 virus behaves differently in this respect.

Anesthesiologists should begin with rigorous hand hygiene for all patients, regardless of health status. Proper hand washing should occur before patient examination, after touching the patient, after touching the surroundings (bed rails, etc), and before and after donning or doffing the PPE. Anesthesiologists should avoid touching their own faces, especially the eyes, mouth, and nose, and N95 masks should be used routinely.²² The N95 can be covered with a regular surgical/procedure mask to avoid soiling, to preserve supply during shortages, and to allow for reprocessing and reuse, which some institutions are already doing. Besides N95 or PAPR/CAPR (powered air-purifying respirator/controlled air-purifying respirator) in case of failed N95 fit test, the anesthesia provider should also wear goggles and a face shield during intubation, extubation, and any other aerosol-generating procedures.

Hair should be covered, preferably with a hat that also covers the neck and shoulders. Waterproof gown and shoe covers should be worn.

In a study from 4 hospitals in close proximity to Wuhan, China, between 23 and 31 January, 2020, a low infection rate among operating room staff was demonstrated after adoption of strict infection control procedures.²³ Their guidelines recommended use of scrubs or surgical gowns, protective masks and disposable skull caps, disposable biological-proof protective suits in the outer layer, disposable gloves and disposable shoe covers, and a combination of face shields or goggles with masks, or respirators and positive-pressure exhaust helmets (whole-skull protection). The specified sequence for PPE donning at those institutions was as follows: hand disinfection → cap → medical protective mask → goggles/face screens/eye protective surgical masks → isolation gowns/protective suits → shoe covers → gloves.

PPE doffing followed another sequence: remove shoe covers → gloves → hand disinfection → isolation gowns/protective suits → hand disinfection → goggles/face screens → hand disinfection → medical protective masks → hand disinfection → disposable skull caps → hand disinfection/hand washing → change personal clothing.

Thorough disinfection and sterilization of the OR was conducted at the end of every day, and immediately after surgery in confirmed or suspected COVID-19 cases. The sterilization included routine disinfection of the anesthesia machine, whole-OR ultraviolet radiation, disinfectant spray, and mopping.

4 | MANAGING INCOMING PEDIATRIC SURGERY PATIENTS

The United States Surgeon General advised cancelation of elective surgeries on March 14, 2020.²⁴ At present, many hospitals in the United States are following this advice to reduce the likelihood and severity of shortages in staffing and supplies. Other institutions may still proceed with urgent elective surgical cases. Regardless, stringent airborne and contact precautions are sometimes enacted only for known COVID-19 patients, due to concern for unnecessarily exhausting limited supplies of personal protection equipment (PPE). Given that reality, clear guidelines for pediatric patients' evaluation and postponing of elective cases in case of concern are needed. We recommend telephone screening for all surgical procedures, following a questionnaire such as the one we offer in Table 1. We developed this questionnaire based on both current literature and informal communications with several pediatric institutions. In the case of a parent responding YES to any question, consider postponing the procedure and repeat the screening in 14 days. The patient and parent should be instructed to self-quarantine at home and report symptoms to the local health department. If a patient's parent replies NO to all the screening questions, surgery may proceed. It is vitally important to note, however, that patients not exhibiting any symptoms can still have the virus and be contagious.

TABLE 1 Telephone screening questionnaire

1. Has the patient been diagnosed with COVID-19?
2. Has the patient been in contact with a person diagnosed with COVID-19 in the past 14 d?
3. Has the patient traveled in areas with high incidence of the disease?
4. Has the patient travelled by plane or ship in any area for the past 14 d?
5. Has the patient had a fever of 37.3°C or higher in the past 14 d?¹²
6. Has anyone in the patient's home had a fever of 37.3°C or higher in the past 14 d?
7. Has the patient had any recent onset of respiratory problems, such as a cough or difficulty breathing within the past 14 d?
8. Has the patient had any recent cough in the past 14 d?
9. Has the patient had any recent diarrhea in the past 14 d?
10. Has the patient had any myalgias, rhinorrhea, malaise, headache, nausea or vomiting in the past 14 d?
11. Has the patient been in contact with people with fever or respiratory problems within the last 14 d?
12. Has the patient been recently participated in any large gatherings, meetings, or had close contact with many unacquainted people?
13. Has the patient or anyone in the family or close contacts lost their ability to smell?³⁰

5 | PATIENT-DIRECTED PREPARATION CONSIDERATIONS

One publication in the field of dentistry suggests that mouth rinse with 1% hydrogen peroxide or 0.2% povidone (but not chlorhexidine) might decrease the viral load in the oral cavity.²⁵ To our knowledge, this is not part of anesthesia practice at any institution. While its use would be limited to older pediatric patients, and it would have no effect on secretions arising from lungs or trachea, it may be a strategy to consider in oral procedures, or in situations where respiratory secretions are expected to be minimal.

In anxious patients, consider the benefits of premedication to decrease crying and resulting viral aerosolization. Avoid nasal premedication since it can cause aerosolization. If a child presents for anesthesia without intravenous access, assess for cooperation with intravenous (IV) catheter placement versus inhalation induction. If IV access is present, rapid sequence induction (unless contraindicated) will avoid mask ventilation, and complete muscle relaxation will prevent coughing, further decreasing aerosolization of virus particles.

If available, video laryngoscopy may allow the anesthesiologist to intubate with greater personal distance from the patient's face. Improvised clear barriers between patient and anesthesiologist may also decrease virus transmission.^{26,27} When listening for a leak, the anesthesiologist should not place their face close to the patient. If available, consider a wireless stethoscope.²⁷ Also consider closed suction to avoid aerosolization. Protect the anesthesia machine with viral filters, placed on the patient side of the Y-piece. The viral filters should be used for transport of intubated patients.²⁷ For known or

TABLE 2 ASA recommendations for healthcare professionals caring for known or suspected COVID-19 patients

- Place patients in an airborne infection isolation room
 - Healthcare professionals entering the room should use airborne and contact precautions, including eye protection.
 - Personal protective equipment (PPE) to be worn includes:
 - a. Either an N95 mask, for which one has been fit-tested, or a powered air-purifying respirator (PAPR)
 - b. A face shield or goggles
 - c. A gown
 - d. Gloves
 - Hand hygiene is essential before donning and after doffing PPE. Hand hygiene can be performed using alcohol-based hand rubs or hand washing with soap and water. Wash hands with soap and water if hands are visibly soiled. It might be reasonable to add for a period of 20 seconds to ASA recommendations.
 - Use extreme caution when removing and disposing of PPE to minimize the risk of self-contamination. Strongly consider observing the correct procedures for donning and doffing PPE and then rehearsing these procedures prior to direct patient care.
 - For further details, refer to the CDC guidance.
- When considering a procedure for a patient with known or suspected COVID-19 infection:
- Postpone nonurgent surgical procedures until the patient is determined to be noninfectious or not infected.
 - If respiratory support is indicated, then planning ahead may avoid the need for rescue interventions (eg, crash intubations), which have greater potential for infectious transmission due to mishaps during the use of barrier protections.
 - In patients with acute respiratory failure, it may be prudent to proceed directly to endotracheal intubation, because noninvasive ventilation (eg, CPAP or biPAP) may increase the risk of infectious transmission.
 - When possible, perform procedures in an airborne infection isolation room rather than in an operating room. An airborne isolation room has a negative pressure relative to the surrounding area. In contrast, a typical operating room is designed to provide positive pressure relative to the surrounding area and incoming air is often flow-directed, filtered, and temperature and humidity controlled.
 - If a procedure cannot be postponed or done at the bedside, then schedule the patient when a minimum number of healthcare workers and other patients are present in the surgical suite.
 - Seek collaboration with local infection control expertise.
- When patients with known or suspected COVID-19 infection need to be transported:
- Transport patients only for procedures and studies deemed essential for patient care.
 - Consult local infection control expertise prior to transport.
 - Intubated patients should have a HEPA filter inserted between the bag-valve-mask breathing device and the patient.
 - Patients who are not ventilated should wear a surgical mask.
 - Healthcare professionals transporting the patient should not routinely wear gowns and gloves, unless direct contact with the patient or contaminated equipment is anticipated during transport. In this case, one person should wear the appropriate PPE per CDC COVID-19 guidance, and, ideally, be accompanied by an additional member of the transport team who is not wearing a gown and gloves. The person without gloves and gown can interact with the environment. Prior to transport, the PPE clad person should perform hand hygiene and don a fresh gown and gloves to reduce potential contamination of environmental surfaces.
- When performing procedures on patients with known or suspected COVID-19 infection:
- Do not bring the patient to the holding or PACU areas. A designated OR should be allocated and signs posted on the doors to minimize staff exposure.
 - If general anesthesia is not required, the patient should continue to wear the surgical mask.
 - If general anesthesia is used:
 - a. Place a HEPA filter between the Y-piece of the breathing circuit and the patient's mask, endotracheal tube or laryngeal mask airway.
 - b. Alternatively, for pediatric patients or other patients in whom the additional dead space or weight of the filter may be problematic, the HEPA filter should be placed on the expiratory end of the corrugated breathing circuit before expired gas enters the anesthesia machine.
 - c. The gas sampling tubing should also be protected by a HEPA filter, and gases exiting the gas analyzer should be scavenged and not allowed to return to the room air.
 - During laryngoscopy and intubation:
 - a. Double gloves will enable one to shed the outer gloves after intubation and minimize subsequent environmental contamination.
 - b. Designate the most experienced anesthesia professional available to perform intubation, if possible.
 - c. Avoid awake fiberoptic intubation unless specifically indicated. Droplets containing viral pathogens may become aerosolized during this procedure. Aerosolization generates smaller liquid particles that may become suspended in air currents, traverse filtration barriers, and inspired.
 - d. Consider a rapid sequence induction (RSI) in order to avoid manual ventilation of patient's lungs and potential aerosolization. If manual ventilation is required, apply small tidal volumes.
 - e. After removing protective equipment, avoid touching your hair or face and perform hand hygiene.

(Continues)

TABLE 2 (Continued)

- If available, use a closed suction system during airway suctioning. Closed suctioning systems may only be available in the critical care setting.
- Consider disposable covers (eg, plastic sheets for surfaces, long ultrasound probe sheath covers) to reduce droplet and contact contamination of equipment and other environmental surfaces.
- The patient should be recovered in the operating room or transferred to an airborne infection isolation room.
- After the patient has left the operating room, leave as much time as possible before subsequent patient care (for the removal of airborne infectious contamination). The length of time depends on the number of air exchanges per hour in the specific room or space. See this CDC reference for more detailed guidance.
- After the case, clean and disinfect high-touch surfaces on the anesthesia machine and anesthesia work area with an EPA-approved hospital disinfectant.
- If devices such as point-of-care ultrasound are used:
 - a. A long sheath cover of the ultrasound unit and cable should be used to minimize contamination of the equipment.
 - b. Nonessential parts of the ultrasound cart may best be covered with drapes to minimize droplet exposure.

suspected COVID-19 patients, consider performing all intubation and extubation in negative-pressure rooms if available.

6 | PROFESSIONAL SOCIETY RECOMMENDATIONS

Since testing remains inconsistent across the country, we recommend that anesthesiologists institute airborne precautions for all patients, asymptomatic or symptomatic, for the duration of the pandemic. This is consistent with guidance from the Anesthesia Patient Safety Foundation²⁸ and American Association of Nurse Anesthetists (AANA),²⁹ which quickly recommended PPE usage for any open airway case, even with asymptomatic patients. The American Society of Anesthesiologists' (ASA) Committee on Occupational Health has also issued recommendations for healthcare professionals caring for patients with known or suspected COVID-19 infection, as listed in Table 2.²² The Anesthesia Patient Safety Foundation states that a PAPR may be warranted for airway procedures, given prior cases of infection transmission of SARS-CoV-2 when N95 masks were used.^{21,28}

The Pediatric Anesthesia's Pediatric Difficult Intubation Collaborative and the Canadian Pediatric Anesthesia Society have also recommended PPE for all aerosol-generating procedures, including intubation and extubation.²⁷

7 | CONCLUSION

The data and recommendations in this article are compiled from the emerging literature on COVID-19 to date and from guidance promulgated by relevant professional associations as noted. The situation with COVID-19 is serious and ever-changing as the pandemic matures and our knowledge of the pathogen and its behavior improves. Pediatric anesthesiologists appear to face a specific set of risks that are not identical to those confronting other physicians, and should exercise particular caution for the duration of the pandemic. This caution should include both careful patient screening and personal protection measures. Minimization of infection risk for all physicians,

but especially those who face higher risk, will help to reduce disease transmission and losses to the healthcare workforce.

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