Review Article

What a pediatric anesthesiologist should know about COVID-19

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Abstract

The COVID-19 pandemic has posed unprecedented challenges and has unique implications for pediatric anesthesiologists. While children have a less severe clinical course compared to adults, they might be an important component in the transmission link by being asymptomatic carriers. Thus, it is essential to have practice guidelines for pediatric health care providers to limit transmission while providing safe and optimum care to our patients. Here we provide a brief review of the unique epidemiology and clinical characteristics of COVID-19 inflicted children. We have also reviewed various pediatric anesthesia guidelines and summarized the same to provide insight into the goals of management. We share the protocols that have been formulated and adopted in the pediatric anesthesia wing of our tertiary care hospital. This article lays special emphasis on the preparation of specialized protocols, designated areas, and training of personnel expected to be involved in patient care. The operating room should be well equipped with weight and age-appropriate equipment and drugs. Special attention should be paid to minimize aerosol generation via premedication and physical barriers. Induction and airway handling should be performed rapidly and securely with minimum personnel present. Disconnections should be avoided during maintenance. Extubation and transfer of children should be smooth. These protocols and guidelines are being constantly reviewed and updated as new evidence emerges. Our goal as pediatric anesthesiologists is to provide anesthesia that is safe for the child while preventing and minimizing the risk of infection to health care workers.

Keywords: Children, COVID-19, protocols

Introduction

The World Health Organization (WHO) declared Corona Virus Disease 2019 (COVID-19) as a worldwide pandemic in March 2020. The virus causing the COVID-19 infection is extremely contagious as has been evidenced by its trajectory around the world. As of 1st May 2020, this disease has inflicted over three million people worldwide and more than 50,000 people in India.

Although the adult population bears the major burden of the disease, the pediatric population can also be inflicted with this viral infection. The attack rate of infection is highest for adults of the age group 50–59 years (22%) vs. children (age <18 years; 3.8%–7.2%).[1] The incidence in children has been estimated to be in the range of 0.8% (<18 years) in Spain to 1% (1–10 years) in early reports from China.[2,3] There is no published data for pediatric patients yet available from India. The case mortality rate has been cited to be around 4% in adults. The data for pediatric patients is much less with 2 deaths reported in China and none in Italy until March 2020.[4] The Centre for Disease Control (CDC) reported 3 deaths in the United States of America until early April.[5]

Transmission

The disease transmission occurs via respiratory droplets, contact with respiratory secretions, and by fomites via contaminated surfaces. Also, evidence shows that children continue to shed virus in stool up to 30 days after infection and therefore may be a potential source of children-to-adult virus dissemination.[6,7]

In a health facility, the risk of transmission is higher owing to the treatment of potential virus-positive patients compounded by the limited availability of personal protective equipment (PPE). Inappropriate and insufficient care while doffing the PPE is an additional factor in increased transmission to health care providers (HCPs) as well as patients.

Symptomatology

Children tend to show milder symptoms of COVID-19 as compared to adults. An epidemiological study of 2143 Chinese pediatric patients described only 4% amongst them to be asymptomatic.[8] This number is likely to be an underestimate due to limited testing in the asymptomatic population.

The primary symptoms with which children can present include pneumonia, fever, dry cough, and tachypnea.[9] Those who have severe respiratory distress commonly have some other underlying comorbidities. Some children can also present with gastrointestinal symptoms such as diarrhea and vomiting. A case series of infants presenting to a pediatric hospital in Spain reported that 4 infants presented with fever and neurological symptoms.[10] A vast number of them are also reported as asymptomatic carriers detected as contacts of known COVID-19 positive patients. Children have been thought to have lower susceptibility to infection and also show better tolerance and rapid improvement. This may be because the immune system in children has certain mechanisms, which interact in specific ways with the respiratory machinery leading to a milder disease.[9] Asymptomatic children, may however still have a large viral load and contribute to viral transmission as was evidenced by an asymptomatic 6-month-old infant whose nasopharyngeal swab showed pathogens till day 16 of his admission.[11] This highlights the fact that children may be an important link in the transmission of infection despite not being severely symptomatic themselves. It also suggests that current clinical screening tools may need broader definitions for the pediatric age group.

Amongst children, infants have been identified as a vulnerable age group.[8] However, there is limited data regarding the disease profile for the neonatal age group. In a study done in 33 neonates born to COVID positive mothers, 3 were found to be symptomatic and tested positive for the same on day 2 of life. They all had shortness of breath, lethargy, and fever.[12] Vertical transmission remains a questionable form of transmission, as samples from cord blood and amniotic fluid tested negative for the infection.[13] Although most

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Access this article online

Quick Response Code:

Website: www.joacp.org

DOI: 10.4103/joacp.JOACP_237_20

How to cite this article: Jain A, Bhardwaj N, Yaddanapudi S. What a pediatric anesthesiologist should know about COVID-19. J Anaesthesiol Clin Pharmacol 2020;36:S85-91.
Submitted: 10-May-2020 **Accepted:** 15-May-2020 **Published:** 24-Jul-2020

neonates have mild symptoms, a case report from Texas, USA identified COVID-19 as the cause of late-onset neonatal sepsis, which needed both ventilator and inotropic support.[14] This demonstrates the spectrum of symptoms, which neonates can present with. Further literature is needed in this cohort for a better understanding.

Testing for COVID

Real-time reverse-transcription–polymerase chain-reaction (RT-PCR) testing of nose and throat swab for detection of the virus is recommended as the confirmatory test for COVID-19. Other alternative samples include bronchoalveolar lavage or endotracheal aspirate. The Government of India has now advised the use of antibody tests in patients with symptomatic influenza-like illness (ILI).[15]

Biochemistry

The laboratory findings in various studies have been variable. In a review of 66 patients performed across 12 studies, it was found that most of the cases (69.6%) had a normal leukocyte count, with 15.2% having leukocytosis and 15.2% leukopenia as per the locally defined reference limits. Only 2 infants were found to have lymphopenia. The inflammatory markers C-reactive protein (CRP) and procalcitonin (PCT) were elevated in 13.6% and 10.6% of cases, respectively.[16]

Radiology findings

Although chest X-ray and CT scan are more commonly normal in children, they may show unilateral or bilateral ground-glass opacities. The most common finding was bilateral ground-glass opacity in 32.7% of children.[17]

Hospital response to the pandemic

With the rapid spread and increasing infectivity of this infection, there is an urgent need for anesthesiologists to assemble protocols that help guide them in providing anesthesia for emergency pediatric surgeries providing a safe environment for the health care workers, without compromising the safety of the patients. We acknowledge that due to the rapidly evolving and the changing course of the pandemic there is no high-level evidence and most recommendations are made on consensus statements and retrospective reviews. As more evidence comes to light, these might require modifications.

Anesthesia management

Preoperative preparation

As per recommendations, the entire team of doctors, nurses, and technicians should perform a "huddle" to designate roles, expectations, and management plans.[1] The operation theatre should have minimum personnel at the time of airway manipulation. A designated "runner" should be available outside the contaminated area to help the team in case of trouble. As far as possible, single-use equipment should be used. The weight and age of the child should be confirmed and appropriate-sized airway equipment should be used. Preloaded syringes with required drugs in weight-based doses should be available and labeled in bold font as it may be difficult to read through the PPE. The anesthesia machine should be checked and covered with a transparent physical barrier and high-efficiency particulate air (HEPA) filters should be attached to the expiratory limb and the patient end of the circuit keeping in mind they may increase dead space significantly in small infants and neonates. Warming blankets should be covered with a plastic drape and forced air warmers are discouraged.[18]

Premedication

While premedication may not be desirable in certain emergency conditions due to the risk of apnea and aspiration in children, this should be balanced against having a crying, uncooperative child during induction as this can increase the aerosol spread. Premedication facilitates smoother inhalational induction as well as the placement of intravenous (IV) line. Appropriate time should be given for its peak action to facilitate smooth separation from parents. The nasal route should be avoided as it can lead to unwanted sneezing and coughing.[1] Parental presence is not recommended as minimum personnel should be present at the time of induction; however, if their presence is deemed essential they should leave the contaminated zone postinduction and preintubation of the child.

Induction and airway management

The primary airway plan along with backup plan should be decided in advance and roles designated. The airway should be handled by an experienced anesthesiologist as the pediatric airway is different from the adult and may prove to be difficult for the inexperienced worker. Although intravenous induction is preferable, inhalational induction might be carried out if the child is struggling vigorously. Desirable airway management in COVID has been described as "SAS"- safe, accurate, and swift.[19] Preoxygenation is challenging in children. It should be performed with a tight seal using low oxygen flows. High-flow nasal oxygen is contraindicated as the risk of virus transmission is not known. The evidence surrounding low- flow oxygen to increase safe apnea time is equivocal as per airway guidelines and undesirable according to the Pediatric Difficult Intubation Collaborative (Pedi-C group).[19,20] Rapid sequence induction should be carried out ensuring adequate muscle relaxation to avoid bucking during airway manipulation. Use of a video laryngoscope and physical barriers are recommended as they increase the distance between provider and patient.[18] Cuffed endotracheal tubes with in-line suction catheters are recommended. In younger infants and neonates Microcuff tube should be used. The cuff should be inflated before the

beginning of positive pressure ventilation. The endotracheal tube should be clamped after induction before connection to the circuit and released when the connection is secure. In case of a failure to intubate, a second-generation supraglottic airway device (SGAD) may be used in place of bag-mask ventilation as it forms a tight seal and reduces aerosol spread. Spontaneous supported ventilation is preferable over positive pressure while using an SGAD.

During airway procedures, minimum personnel should be present in the operation theater and those without PPE in nonproven suspect patients should enter 20 min after the procedure.

Maintenance

All circuit connections should be tightened and disconnections avoided. Disconnections are more common in pediatric anesthesia and special care should be given while attaching various components of the circuit and during patient positioning. Physical barriers may be kept around head-end throughout surgery if they do not interfere with the surgical field [Figure 1].

Extubation

The postoperative period may be stormier than induction in children. This is due to the higher incidence of accidental extubations and laryngospasm in children as compared to adults. Extubation should not be done in an intermediate plane of anesthesia. Prophylaxis should be given in time to prevent unwanted postoperative vomiting. Suctioning should be done in a deep plane of anesthesia. Coughing should be kept to a minimum in the postoperative period. The child's face may be covered with a mask if he/she permits, during transport.

Transfer

In cases where the child is to be transferred to the intensive care unit for further ventilation, it is desirable to do so on a transport ventilator. During transport, the filter attached to the patient end of the circuit should also be shifted alongside the child. Additional sedation and muscular blockade may help prevent bucking and accidental extubation and should be considered.

Care of children at PGIMER

The authors present their institutional protocols for pediatric anesthesia management and summary of reviewed literature for the same, intended to help serve as guidance.

Elective versus emergency surgery

Postgraduate Institute of Medical Education and Research (PGIMER) is a COVID designated hospital. It was decided by the institute that elective surgeries will be put on hold to reduce strain on the health care system as well as to decrease the risk of spread of the disease to both patients and health care workers, decrease the viral load in the hospital, and for optimum and preferential allocation and utilization of available medical resources to combat the surge of positive cases.

The flow pattern of patients coming to the Advanced Pediatric Center (APC)

In APC, all patients coming to "Pediatric Emergency" as well as their caregiver are screened for COVID-19, based on symptoms of acute respiratory illness (high-grade fever, cough, respiratory distress/severe acute respiratory illness). The history of travel and whether the patient is coming from a designated hotspot area is also taken. Suspected cases are taken to a specially demarcated COVID-19 area for testing and further management. In case the test is positive, the patient is shifted to designated COVID-19 building.[21]

At the time of writing this report, in the Advanced Pediatric Centre (APC) of our institute, a total of 170 children have been screened for COVID-19 using RT-PCR, based on symptomology and contact history as per institutional guidelines.[21] Of these, one child who was a referred case with congenital cardiac disease tested positive for this infection and subsequently died. Also, eleven children were found to be positive through contact tracing and directly admitted to the COVID designated wing of the hospital. Out of all these children, only one child required oxygen and ventilator support. All the other children were comfortable in room air.

Infrastructure and planning

It is recommended that a designated operating room (OR) should preferably be kept for COVID proven or suspected patients. A dedicated OR located in the designated COVID-19 hospital has been created for COVID positive patients. Till date, no COVID-19 positive child has been operated for any kind of emergency surgery in our setup.

Creation of an OR for suspect patients

Children coming for emergency surgery are stratified into emergency and urgent cases by a multidisciplinary team involving the surgeons and anesthesiologists [Table 1]. In the period from March 20th to May 1st our pediatric anesthesia team has facilitated 120 surgeries, 72 of which were done in infants.

In the initial part of the pandemic, all emergency pediatric patients were operated in a common operating room (OR). However, now when community spread is a possibility, a suspect OR has been created in APC.

Proper donning and doffing areas should be made even for suspect OR to minimize the risk of cross-infection. Checklists

Figure 1: Photograph showing use of plastic drape on the anesthesia circuits

and buddy-systems can help act as cognitive aids to minimize error. Protocols for shifting the patients from testing regions to operation theatres involve minimizing exposure to personnel by having designated elevators and corridors and telephonic handovers before initiation of shifting to ensure the receiving team is ready.

Testing for COVID 19 in children coming for emergency surgery

Testing is required for appropriate risk stratification. In suspected cases, based on the urgency of surgery, the patients either need to be tested first before surgery or taken without testing in a designated suspect OR. The reasons for testing include the following:

A large proportion of infected children are asymptomatic and therefore will not be detected by screening based on history alone. However, these children can transmit the disease to a large team of health care workers with whom they will come in contact during surgery

The disease is usually less severe in children. Also, they may have nonrespiratory/atypical symptoms, due to which it may be missed during screening

The outcome following surgery in patients with COVID-19 is poor. The time sensitive procedures may be deferred until the child recovers from the infection, provided there is no threat to life due to this delay

Congenital anomalies are common in children coming for emergency surgery. Presence of COVID-19 infection in addition to certain congenital anomalies such as heart diseases is likely to result in a poor outcome.

Standard Operating Protocols (SOPs)

Nearly all anesthesia societies including the pediatric societies have published guidelines and protocols to be followed in managing COVID-19 positive patients.[18,20] Institutes need to develop their own SOPs based on the availability of resources, testing kits, and PPEs.

In unprecedented times, certain new practices and techniques may need to be used to minimize spread and contamination. Hence to familiarize oneself with newer equipment such as working with physical barriers and in full gear, full in-situ simulation scenarios should be carried out.[19] The Pedi-C group have further emphasized context-specific simulation in which each provider practices his/her particular role.[20] Other than the institutional and departmental drills of donning and doffing, our pediatric anesthesia team practiced intubation using the aerosol box and other plastic barriers [Figure2]. Troubleshooting problems such as a need to increase the height of the mattress inside a standard adult-sized aerosol box for better laryngoscopy and intubating conditions in small children helped us prepare better for our cases.

Health care worker protection

All personnel dealing with the airway of children should wear appropriate personal protective equipment (PPE). They should be well acquainted with their PPE kit and have adequate practice for donning as well as doffing. Institutional infection control protocols and protective gear should be applied and used for all airway handling even if the child is asymptomatic.

At our institute, the personnel working in the designated COVID and suspect OTs don complete hazmat suits along with eye protection visors, N-95 masks, shoe covers, and double gloves. For the conduct of anesthesia in children coming for nonsuspected emergency surgery we wear a plastic, water-resistant apron over the surgical scrubs followed by a surgical gown, eye protection with goggles, double surgical masks or FFP2 mask, visors, double gloves, and shoe protection. Hand hygiene at various steps and proper cleaning of reusable equipment before doffing is meticulously practiced.

Conclusion

As more literature and research is carried out in pediatric patients afflicted with COVID-19, our understanding of its pathophysiology, course, and management will improve with time. There are several unresolved issues with ethical and

Table 1: Stratification of pediatric surgery patients

Emergency cases - Delay is life threatening	Urgent cases - Delays of days to weeks may be detrimental
Acute intestinal obstruction	Most pediatric cancer surgery
Abnormalities of intestinal rotation	Solid tumors (initial biopsy, resection following neoadjuvant therapy; consideration should be given for continuing chemotherapy in patients who will require postoperative intensive care or ventilation especially with curative intent)
Incarcerated inguinal hernia	Portoenterostomy for biliary atresia with jaundice
Pyloromyotomy for hypertrophic pyloric stenosis	Pyeloplasty/Ureterostomy for solitary kidney
Intussusception reduction not amenable to radiographic reduction	Posterior Urethral valves in solitary kidney
Intestinal perforation	PD Catheter insertion
Band/Meckel's/others	Abscess incision and drainage
Necrotizing enterocolitis with perforation	Vascular access device insertion
Trauma with uncontrolled hemorrhage or penetration	Repair of symptomatic inguinal hernia
Ischemia	Tracheostomy/Gastrostomy/Feeding Jejunostomy if required for discharge
Testicular torsion	
Ovarian torsion	
Limb ischemia from trauma or iatrogenic	
Congenital anomalies	
Esophageal atresia with tracheoesophageal fistula	
Symptomatic congenital diaphragmatic hernia	
Intestinal atresia	
Intestinal diversion for anorectal anomalies	
Intestinal diversion for Hirschsprung disease not improved with irrigations	
Appendectomy for acute appendicitis	
Esophageal or tracheal foreign body ingestion (special note should be made of higher risk of COVID-19 for endoscopic procedures)	

legal implications including testing of all emergency surgery cases and allocation of PPEs in hospital areas with a higher risk of infection. Our goal as pediatric anesthesiologists is to provide anesthesia that is safe for the child while preventing and minimizing the risk of infection to health care workers.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Figure 2: Use of intubation box

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