



Recommendations of Prevention, Mitigation and Containment of COVID-19 in Pediatric Surgery Institution, Experience from China

Tianqi Zhu¹; Kuiran Dong²; Xufei Duan³; Jinfa Tou⁴; Zhibao Lv⁵; Yajun Chen⁶; Dawei He⁷; Bin Wang⁸; Jianghua Zhan⁹; Song Yu¹⁰; Shuo Gu¹¹; Xueqiang Yan¹²; Houfang Kuang¹³; Zhou Chen¹⁴; Jinfu Jia¹⁵; Xiang Zhao¹⁶; Chunlei Jiao¹⁶; Li Tian¹⁶; Ye Yin¹⁶; Hongyi Zhang¹⁶; Weibing Tang^{17*}; Feng Chen^{18*}; Jiexiong Feng¹⁹

¹Department of Pediatric surgery, Tongji Hospital, Huazhong University of science and technology, Wuhan, China.

²Department of Oncological Surgery, Children's Hospital, Fudan University, Shanghai, China.

³Wuhan Children's Hospital, Tongji Medical College, Huazhong University of Science & technology, Wuhan, China.

⁴Department of Neonatal Surgery, The Children's Hospital, Zhejiang University School of Medicine, National Clinical Research Center for Child Health, Hangzhou, China.

⁵Department of General Surgery, Shanghai Children's Hospital, Shanghai JiaoTong University, Shanghai, China.

⁶Department of General Surgery, Beijing Children's Hospital, Capital Medical University, National Center for Children's Health, Beijing, China.

⁷Department of Urology, National Clinical Research Center for Children Health and Disorders, Children's Hospital of Chongqing Medical University, Chongqing, China.

⁸Department of General Surgery, Shenzhen Children's Hospital, Shenzhen, China.

⁹Department of General Surgery, Tianjin Children's Hospital, Tianjin Medical college, Tianjin, China.

¹⁰Department of Pediatric Orthopedic Surgery, Zunyi Medical College Affiliated Hospital, Zunyi, China.

¹¹Department of Neurosurgery, Hainan Province Children's Hospital, Haikou, China.

¹²Wuhan Children's Hospital, Tongji Medical College, Huazhong University of Science & Technology, Wuhan, China.

¹³Wuhan Children's Hospital, Tongji Medical College, Huazhong University of Science & Technology, Wuhan, China.

¹⁴Department of General Surgery, Shanghai Children's Hospital, Shanghai JiaoTong University, Shanghai, China.

¹⁵Department of General surgery, Tianjin Children's Hospital, Tianjin Medical college, Tianjin, China.

¹⁶Department of Pediatric surgery, Tongji Hospital, Huazhong University of Science and Technology, Wuhan, China.

¹⁷Department of Pediatric Surgery, Children's Hospital of Nanjing Medical University, Nanjing, China.

¹⁸Department of Pediatric Surgery, Union hospital, Fujian Medical College, Fuzhou, China.

¹⁹Department of Pediatric surgery, Tongji Hospital, Huazhong University of Science & Technology, Wuhan, China.

***Corresponding Author(s): Weibing Tang**

Department of Pediatric Surgery, Children's Hospital of Nanjing Medical University, Nanjing, China.

Tel: 00862713986295423, Fax: 008683665364;

Mail: twbcn@163.com



Cite this article: Zhu T, Dong K, Duan X, Tou J, Tang W, et al. Recommendations of Prevention, Mitigation and Containment of COVID-19 in Pediatric Surgery Institution, experience from China. Ann Pediatr. 2020; 3(1): 1030.

Received: Aug 13, 2020

Accepted: Sep 16, 2020

Published Online: Sep 18, 2020

Journal: Annals of Pediatrics

Publisher: MedDocs Publishers LLC

Online edition: <http://meddocsonline.org/>

Copyright: © Tang W (2020). This Article is distributed under the terms of Creative Commons Attribution 4.0 International License

Keywords: Prevention and control strategy; COVID-19; Pediatric surgery; Expert consensus.

Introduction

Coronavirus disease 2019 (COVID-19), which is caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), is spreading across the world now. Infants and children can be infected by the virus-carrying caretaker, including family members, through respiratory droplets or direct contact [1]. Being exposed in hospital environment or other public spaces could also lead to COVID-19. Neonates and infants who need surgical intervention, especially those with immune dysfunction or with perioperative complications, are likely to infect COVID-19 and require more attention. In consideration of the vulnerability of these children, special medical care and support should be carried out.

Incorporation with the clinical characteristics of pediatric diseases and the experience from Chinese pediatric surgeons' clinical strategy, we draw up this Expert Consensus in order to give suggestion for medical staff in pediatric field worldwide, with reference from *Technical Guidelines for the Prevention and Control of Novel Coronavirus Infections in Medical Institutions (First Edition)* [2], *National Health Commission of China and the Pneumonia Diagnosis and Treatment Plan for Novel Coronavirus Infections (Seventh Trial Revision)* [3], and *Prevention and Control Plan for Novel Coronavirus Pneumonia (Sixth Edition)* [4].

Clinical characteristics of children patients

The incubation period of the COVID-19 is 1-14 days, mostly 3-7 days. According to the severity of symptoms, COVID-19 can be categorized as mild and severe type. Most children with COVID-19 presented with mild symptoms, and characterized by fever, dry cough, and fatigue [5]. Nevertheless, the clinical indicators of severe type in children include: (1) increased breathing

rate; (2) poor mental response and drowsiness; (3) progressively heightened Lactic acid; (4) radiological imaging shows bilateral or multi-lobe infiltration, pleural effusion, or shows rapidly progressing lesion in a short time. Although the incidence of critical ill is low, pediatricians still need to be vigilant, those with immune deficiency (e.g. long-term use of immunosuppressant) or other underlying diseases (such as congenital heart disease, bronchopulmonary dysplasia, deformity of respiratory tract, abnormal hemoglobin, and severe malnutrition etc.) are more like to develop severe type. In most critical ill patients, early symptoms of are atypical, but it aggravate quickly and cause multi-organs dysfunction syndrome [5]. Therefore, early identification and timely treatment would be very important.

Characteristics of biochemical and radiological abnormalities [6]

1. In the early phase of the disease, white blood cell count is normal or decreased, or with decreased lymphocyte count;
2. Respiratory tract or blood samples tested positive for SARS-CoV-2 nucleic acid using RT-PCR;
3. SARS-CoV-2 specific IgM antibody usually turns positive in 3-5 days after symptoms onset; while the titer of specific IgG antibody in the recovery period can be as higher as 4 times than that in the acute phase;
4. In the early phase of disease, pulmonary CT scan show multiple small plaques and interstitial changes, which are obvious in the lung periphery, further deteriorate to bilateral multiple ground-glass opacity and/or infiltrating shadows (Figure 1) [7].

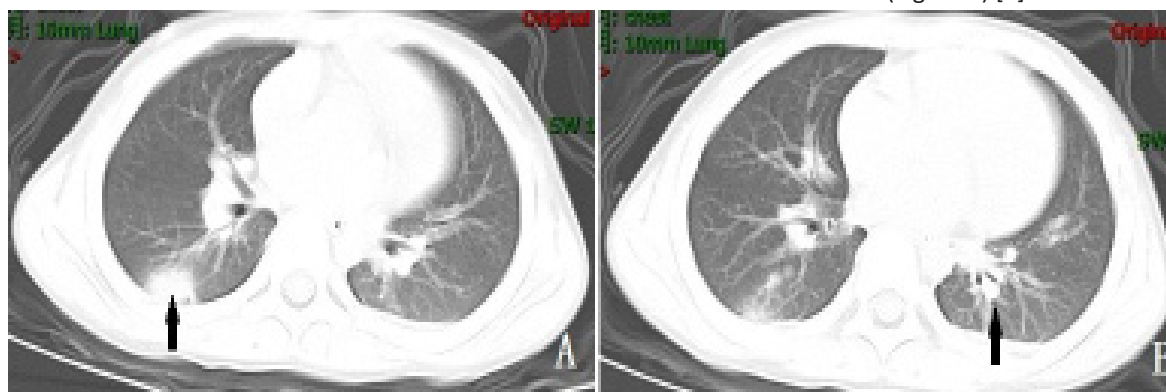


Figure 1: A case with 5 years and 7 months old, male, was admitted as emergency with “persistent right lower abdominal pain for 18 h”, and diagnosed as acute appendicitis complicated with COVID-19. A: nearly round ground-glass opacity shadow in the dorsal segment of the right lower pulmonary lobe; B: strip shape shadow in the left lower pulmonary lobe [7].

Outpatient management

Pediatric surgical diseases are always variety. The symptoms of many acute infectious diseases include fever, which need to be distinguished from COVID-19 by blood biochemical testing and pulmonary radiography. If above examinations show any abnormalities, nucleic acid test or serological test of SARS-CoV-2 should be performed immediately. Moreover, patients with COVID-19 need to be distinguished from common types of pneumonia, bronchitis and other non-surgical diseases. There are some digestive symptoms of COVID-19 patients, such as vomiting, anorexia and diarrhea and so on, which may be presented as only symptoms and needed to be distinguished from other gastroenterological diseases.

In outpatient clinics, most children are accompanied by their family, what increases the infective risk of COVID-19. It is recommended to limit only one parent staying with the patient. The epidemiological history of child and their parents or caregivers should be collected. For those patients who have exposure history with COVID-19 in recent two weeks, routine screening for COVID-19 (SARS-CoV-2 nucleic acid, SARS-CoV-2 specific antibody and pulmonary CT) is necessary.

Inpatient management

Inpatient ward is divided into general (non-isolation) unit and isolation unit. In the general unit, all medical staffs need Level I protection (Table 1). The working area and the resting area are strictly separated. Body temperature of the patients, caregivers, and ward cleaning staff is measured twice a day. If symptoms such as fever, cough or fatigue occur, it must be screened by COVID-19 testing timely. All the newly confirmed cases need to be reported to the Hospital-Acquired Infection Control Department (HAICD) immediately.

Patients as emergency admitting without COVID-19 testing, or who with suspected or confirmed COVID-19 should be admitted into the isolation unit, single-room management mode is for avoiding cross-infection, no more than 1 caregiver excluded COVID-19 is allowed to accompany. No less than Level II protection is needed in the isolation unit for all medical staffs. Level III protection is required when performing invasive procedures such as sputum aspiration, intravenous infusion, or colon enema etc. In normal situation, atomization inhalation is not adopted to avoid aerosol diffusion. When certain necessary out-ward examinations such as CT need to be taken, patients should be accompanied by doctor-in-charge with level II protection and transported through specific passageway.

Table 1: Requirements for personal protective equipment (PPE) of different protective levels.

levels	Level I protection	Level II protection	Level III protection
Medical Cap	✓	✓	✓
Normal medical mask	✓		
Medical protective mask (such as N95, KN95)		✓	✓
Safety goggles/ Face Shield		✓	
Isolation gown	✓	✓	✓
Protective clothing			✓
Full protective breathing mask			✓
Gloves	✓	✓	✓
Shoe covers			✓

Practice protocols for pediatric surgery

General Principles

Nearly all pediatric surgeries require general anesthesia and tracheal intubation, which need strictly follow surgical indications. Emergency surgery could be performed according to the normal operation procedures after excluding the COVID-19; otherwise, it should be performed under level III protection (in the details below). Selective surgery would better be suspended till the end of the epidemic. In principle, confine surgery could be postponed without affecting prognosis of the disease; but if the patient's condition aggravate rapidly, the operations need to be carried out according to the protocols of emergency operation.

Management strategy of emergency surgery

Since nearly all elective surgeries have been suspended or postponed during the COVID-19 epidemic, the challenges of pediatric emergency surgery have to be highlighted. For all patients admitted to the emergency department, their exposure history of COVID-19 should be known, and as far as possible, pulmonary CT, SARS-CoV-2 nucleic acid and hematological antibody tests should be completed, as well as other relevant tests.

All patients in need of emergency surgery should be transported to the negative pressure operating room through specific passageway. There are also several special notes: (1). Minimize surgical participants; (2). Schedule surgery time to avoid overlap; (3). Prevent cross-infection in the operating room, for example, use disposable equipment, remove non-disposable equipment unrelated to surgery away from the operating room, and cover the other equipment which could not be removed with protective film. During the operation, all medical staffs need to take no less than II levels of protection, while surgeons, instrument nurses and anesthesiologists need III levels of protection.

After the emergency operation, patients are transferred to the isolation unit. Pulmonary CT, SARS-CoV-2 nucleic acid and hematological antibody tests are re-tested 7 days later. If COVID-19 is definitely excluded, the patients can be transferred to the general unit.

A survey for emergency patients from single-center children's medical center in China found that, during January and

February 2020, there was a significant decrease of cases with traumatic injuries such as traffic accident injury, but no change of that with acute abdomen, or even there is slight increasing. Subsequently, an initial comparative analysis of patients with acute appendicitis between the last 3 years shows that, higher percentage of cases had symptoms lasting more than three days and more occurrence of appendicular perforation before admission, in this year. According to the medical history, a number of patients still chose to stay home until their early symptoms turned worse, which resulted to non-timely diagnosis and treatment for these children [8].

Recommendations for management of newborns

Although there is no evidence of vertical transmission yet [9], a few of newborns with COVID-19 have been reported [10]. In terms of newborns with suspected or confirmed COVID-19, we need to pay attention to the following issues:

1. When mother was diagnosed with suspected or confirmed COVID-19, the newborn should be regarded as suspected cases.
2. Cases with suspected or confirmed COVID-19 should be separated from the mother immediately after birth and undergo quarantine and medical observation. Meanwhile, breastfeeding should be stopped.
3. Nucleic acid testing of SARS-CoV-2 need to be completed at least three times (within 24 hours, during 5-7 days and 14 days after birth, respectively). Only when all the three tests are negative, the quarantine could be released.
4. Classification of neonatal surgery according to COVID-19.

-Emergency surgery: For certain cases with severe congenital malformation (such as gastroschisis, diaphragmatic hernia, and teratoma of neck or cyst hydrocele compressed airway etc.), a variety of neonatal acute abdomen (such as rapidly progressive neonatal necrotizing enterocolitis, intestinal volvulus, and gastrointestinal perforation etc.), and acute fatal diseases (such as intracranial hemorrhage et al), they must be corrected as soon as possible.

-Confine surgery: Some cases must be treated with surgical intervention within limited time, otherwise continuous or irreversible damages would be happened, such as congenital esophageal atresia, pyloric stenosis, and hydrocephalus et al.

-Elective operation: For some diseases, such as congenital cleft palate, hernia, hypospadias, and multi-finger and syndactyly deformity et al, operations are recommended to be scheduled until the epidemic is under control, since no serious damage would happen while waiting for operation.

Recommendations for management of solid tumors in children

Due to the invasion of tumor and influence of comprehensive treatment, including chemotherapy, radiotherapy and immunotherapy et al, patients with malignant solid tumors have lower immunity and may be more prone to COVID-19 infection. Therefore, ensuring the continuity and standardization of the comprehensive management is the key to improve the prognosis of children with malignant solid tumors.

-Emergency surgery: If the tumor progresses rapidly, and seriously affects organ function or threatens the life of patient, emergency surgery should be adopted immediately, regardless

it belongs to benign or malignant tumor (such as tumor rupture and hemorrhage, severe compression symptoms caused by huge tumor, ovarian tumor complicated with torsion, and spinal canal tumor complicated with severe neurological dysfunction or paraplegia et al).

-Confine surgery: For most malignant solid tumor, it is necessary to have operation within limited window, rather than postpone indefinitely. However, the operation timing and method still should be according to the actual situation of the hospital and clinic states of patients. Since most malignant solid tumors in children are sensitive to chemotherapy, biopsy approach is mostly chosen in preliminary surgery, and the timing of surgery is always compliant with adjuvant chemotherapy. Adjuvant chemotherapy is also recommended for certain newly developed tumors, after the diagnosis is confirmed and clinical staging and risk classification are systemically assessed.

-Elective surgery: For benign tumors with stable clinical manifestations and no severe compression of organ or airway, clinical observation can be carried out temporarily until the end of the epidemic.

Procedures for suspected or confirmed COVID-19 during operation (Figure 2)

Preparation

All surgical patients with suspected or confirmed COVID-19 should be treated in designated hospitals. Before the operation, the medical staff reports to the HAICD and Medical Administration Management Department (MAMD). Warning labels are attached to the medical documents. The doctor-in-charge under II level protection escorts the patient to negative pressure operating room.

All medical staffs, who involved in operation, should take no less than Level II protection during operation, the surgeons, instrument nurses and anesthesiologists need to take level III protection. At the same time, anesthetic catheters, laryngoscopes, tracheal tubes and other items must be disposable postoperatively, and anesthesia machines also need to be strictly disinfected.

Recommendations for anesthesia administration

1. To avoid droplets or aerosol diffusion during crying, patients could be adopted with tranquilizer through intravenous or sevoflurane by mask soon after entering the operating room;
2. During endotracheal intubation, spattering of respiratory secretions by choking cough should be avoided;
3. When operation is completed, sputum aspiration needs to be performed before patient awakening. Before the extubation, patient's mouth and nose need to be covered with pieces of warm and wet gauze, to avoid spillage of respiratory secretions by choking cough. Finally, the endotracheal tube is removed under deep sedation.
4. Improve postoperative multimodal analgesia, reduce crying and restlessness of patients after extubation.

Operation process

It is noticed that child with COVID-19 has worse cardiopulmonary function, so the surgical methods of children with suspected or confirmed COVID-19 should be especially carefully

chosen. Generally, staged operation and open approach are preferred during COVID-19 epidemic. For solid tumors, biopsy is more appropriate than radical procedure.

During the operation, attention should be paid to prevent splashing and spillage of blood, digestive juice and intestinal contents. At the same time, aerosol particles are produced when using electric knife, which can be suspended in the air and inhaled through the respiratory tract. So the power of the electric knife should be turned down to reduce intraoperative aerosol diffusion, and assistant surgeons extract smoke away at any time.

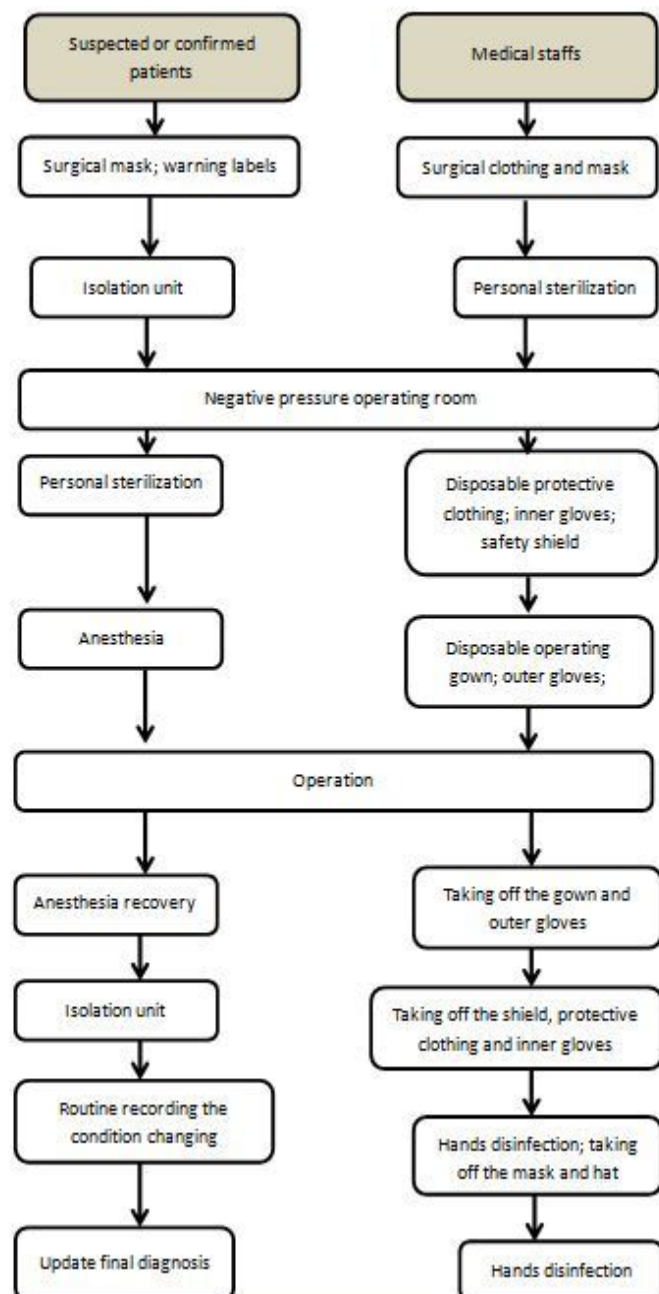


Figure 2: Flow chart of protection and control protocol for COVID-19 during operation.

Transportation

After the operation, the patient is transferred through specific passageway to the isolation unit for further treatment. For newborns, who are impractical for masks, should be transferred by particular transport incubator. Finally, the incubator and related medical supplies would be sterilized separately.

Record

The pathological specimens need to be packed with the label of “COVID-19” outside. In addition to the routine record of the patient’s information, the doctor-in-charge should also fill in the Infectious Disease Reporting Form in time.

Postoperative management

Postoperative management of patients without COVID-19

According to the individual condition, patients without COVID-19 could be transferred to the general unit. Postoperative fever and respiratory symptoms are monitored regularly.

Postoperative management of patients with suspected or confirmed COVID-19

Patients with suspected or confirmed COVID-19 should be transferred to a negative pressure isolation care unit after surgery. Adequate oxygen therapy could improve lung function. Enhanced recoveries after surgery (ERAS) protocols are also suitable for patients with COVID-19, including multi-modal analgesia management, decreasing of fasting time, earlier enteral feeding, and earlier mobilization after surgery. For some COVID-19 patients with gastrointestinal symptoms, it is feasible to balance intestinal microecology by the administration of probiotics and enteral nutrition.

Standards of discharge and releasing from quarantine

According to the *Diagnosis and Treatment Plan (Seventh Trial Revision)* [3], the standards of discharge and releasing from quarantine for those suspected and confirmed COVID-19 children should be: (1) Temperature has returned to normal for more than 3 days; (2) Respiratory symptoms have improved significantly; (3) Pulmonary imaging shows an obvious improvement in acute exudative lesions; (4) Two consecutive nucleic acid tests of respiratory tract specimens are negative (24 hour interval). When all the above criteria are achieved, and the clinical condition of surgical disease also improves, the patient could be discharged from the hospital. Due to a few patients have re-positive symptoms of COVID-19, all patients are recommended to be quarantined at home for 14 days after discharge.

References

1. Wei M, Yuan J, Liu Y, Fu T, Yu X, et al. Novel Coronavirus Infection in Hospitalized Infants Under 1 Year of Age in China. *JAMA*. 2020
2. National health commission of the People’s Republic of China. Notice on the first edition of technical guidelines on the prevention and control of novel coronavirus infection in medical institutions. [EB/OL]. 2020.
3. National health commission of the People’s Republic of China, National administration of traditional Chinese medicine. Diagnosis and treatment of novel coronavirus pneumonia (7th trial version). [EB/OL]. 2020.
4. National health commission of the People’s Republic of China. Prevention and Control Plan for New Coronavirus Pneumonia

-
- (6th Edition). [EB/OL]. 2020.
5. Lu X, Zhang L, Du H, Zhang J, Li YY, et al. SARS-CoV-2 Infection in Children. *N Engl J Med*. 2020.
 6. Shen K, Yang Y, Wang T, et al. Diagnosis, treatment, and prevention of 2019 novel coronavirus infection in children: experts' consensus statement[J]. *World J Pediatr*. 2020.
 7. Wang HB, Duan XF, Yan X, Sun R, Liu X, et al. A case of novel coronavirus pneumonia complicated with acute appendicitis in children [J]. *Chin J Pediatr Surg*. 2020; 41.
 8. Wang K, Zhang D, Pang WB, et al. Characteristics and response of pediatric surgical acute patients during the epidemic of COVID-19 at a children's specialist hospital in Beijing[J]. *J Clin Ped Sur*. 2020; 19: 89-92.
 9. Chen H, Guo J, Wang C, Luo F, Yu X, et al. Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records. *Lancet*. 2020; 395: 809-815.
 10. Yu N, Li W, Kang Q, Xiong Z, Wang S et al. Clinical features and obstetric and neonatal outcomes of pregnant patients with COVID-19 in Wuhan, China: a retrospective, single-centre, descriptive study [J]. *Lancet Infect Dis*. 2020.