



Featured Article

Development of pediatric surgical decision-making guidelines for COVID-19 in a New York City children's hospital[☆]



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ABSTRACT

Objective: During the COVID-19 pandemic, experience-based guidelines are needed in the pediatric population in order to deliver high quality care in a new way that keeps patients and healthcare workers safe and maximizes hospital resource utilization.

Background: The COVID-19 pandemic has created an unprecedented strain on national health care resources, particularly in New York City, the epicenter of the outbreak in the United States. Prudent allocation of surgical resources during the pandemic quickly became essential, and there is an unprecedented need to weigh the risks of operating versus delaying intervention in our pediatric patients.

Methods: Here we describe our experience in surgical decision-making in the pediatric surgical population at Morgan Stanley Children's Hospital of New York-Presbyterian (MSCHONY), which has served as a major urban catchment area for COVID-19 positive pediatric patients. We describe how we have adjusted our current treatment of multiple facets of pediatric surgery including oncology, trauma, minimally invasive procedures, and extracorporeal membrane oxygenation (ECMO).

Conclusions: Our pediatric surgery department had to creatively and expeditiously adjust our protocols, guidelines, and workforce to not only serve our pediatric population but merge ourselves with our adult hospital system during the COVID pandemic.

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In December 2019, an outbreak of the SARS-CoV2 virus, and the associated illness, COVID-19, first emerged in Wuhan, China [1]. The virus quickly spread around the globe and on February 11th, 2020, the WHO declared a worldwide pandemic. As of April 28th, more than 3 million cases have been confirmed worldwide and 200,000 worldwide deaths documented, increasing every day. New York City has seen a significant number of COVID-19 cases, representing almost 30% of the 1,000,000 cases and approximately 40% of the 60,000 recorded fatalities to-date in the United States [2–3]. Overall, approximately 5% of patients infected with COVID-19 require ICU-level care [4]. Recently, the outcomes of the first 1000 COVID-19 positive patients receiving care at our adult institution (ED, inpatient floor, ICU) were published: 23% of patients required ICU care, 32% developed acute kidney injury, and the mortality rate was 17% [5].

As a result, there has been an unprecedented need to increase hospital capacity and make changes to hospital resource utilization. As the influx of COVID-19 patients increased rapidly, New York City hospitals have been forced to establish new frameworks for surgical care resource allocation. As of April 30, 2020, close to 200 COVID-19 positive patients have been treated at the Morgan Stanley Children's Hospital of New York-Presbyterian (MSCHONY), which has also started to accommodate critically ill, ventilated adult patients to offload our adjacent overcapacity adult hospital ICU census. This has presented an unparalleled challenge to determine surgical priority and adequately increase hospital capacity while still maximizing the ability to provide life-saving medical care.

Given the considerable strain placed on health care systems, surgical priority guidelines have been developed to attempt to help inform COVID-19 surgical decision making. Recent evidence has called into question the safety of surgery during COVID-19 infection, which has further complicated this decision-making process. Retrospective observational data from Wuhan, China found the mortality rate to be 20.5% for adult patients who underwent elective procedures and are unknowingly COVID-19 positive, with approximately 45% of the patients

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requiring ICU-level care postoperatively [6]. While the numbers in this study were small ($n = 34$), the mortality rate is alarming. With the current paucity of clinical data on surgical outcomes of COVID-19 patients, it is paramount to continue to review each patient undergoing surgery on a case-by-case basis in order to minimize exposure to healthcare staff and prevent increased perioperative morbidity and mortality of COVID positive patients.

In the pediatric population, experience-based evidence is imperative for practitioners to make sound clinical judgments about the risks of delaying intervention for resource allocation purposes. Further complicating treatment algorithms in the pediatric population is the lack of clinical research and scientific evidence of how COVID-19 infection in children differs from that of adults. Preliminary data from a small study in China ($n = 10$) suggested that COVID-19 virus can persist in the gastrointestinal tract of pediatric patients for as long as 16 days after symptom onset, despite negative nasal and pharyngeal RT-PCR and resolution of symptoms [7]. Though no definitive recommendations have been released, these data suggest that there are distinct challenges to surgical intervention in COVID-19 pediatric patients that must be specifically addressed in developing treatment algorithms.

Taken together, these findings are of particular relevance to MSCHONY as a free-standing pediatric hospital caring for a significant number of COVID-19 patients. This article will describe our novel approach to pediatric surgical care while supporting our colleagues throughout the New York Presbyterian healthcare system during the COVID-19 pandemic, and may serve as a guideline for other institutions as COVID-19 sweeps from New York City to pediatric hospitals across the country.

1. General

As pediatric surgeons, we have always prioritized family-centered care for our patients. However, the pandemic has forced public health priorities to become apparent and has led to a change towards community-centered care [8]. The lessons learned within our department are broadly applicable to numerous surgical and clinical scenarios because our pediatric surgical service covers a broad range of procedures and surgical disciplines, including trauma, minimally invasive surgery, critical care/extracorporeal membrane oxygenation (ECMO), thoracic surgery, surgical oncology, transplant, and the broad scope of abdominal and general surgery. As such, our department may serve as a microcosm for other surgical departments across the country facing a possible COVID-19 surge crisis in their hospitals.

Many interdependent components must be carefully considered and prioritized when devising solutions for surgical care in a pandemic. First, along with most hospitals across the United States, we have canceled elective cases. We are following the guidelines put forth by the American College of Surgeons (ACS) for pediatric surgery and endorsed by the American Pediatric Surgical Association (APSA) [9–10]. This frees up crucial personal protective equipment and vital resources such as ventilators and medications that can be used for the critically ill. In addition, it aims to prevent spread of the virus through asymptomatic carriers and interactions within the hospital. Telemedicine has been widely embraced as a tool to keep our elective surgical patients and families engaged and closely followed throughout the length of the pandemic crisis. All patients have been offered video and/or telephone visits in lieu of outpatient clinic visits, and even multidisciplinary clinics have met virtually with patients for continuity of care. The needs of these families and continuity of care cannot be underestimated despite the elective nature of their conditions.

Current surgical management of children in our institution has been considered on a case-by-case basis. Severity of disease has been stratified, resource availability and management plan and goals of care have been discussed by multidisciplinary teams, and safe practices to minimize risk of infectious exposure have been instituted and strictly followed. A multidisciplinary committee was formed and tasked with

the review of urgent and semiurgent case requests, needed within 6–12 or within 48 h, respectively, to prevent further deterioration or morbidity in pediatric patients. In-patients who need urgent intervention to advance care and/or result in discharge receive an expedited review. Compared to other surgical specialties, our division has experienced a less drastic decrease in operative volume since the onset of the pandemic as we continue to see conditions, such as congenital neonatal anomalies, appendicitis, and need for ECMO, that require acute surgical intervention. The pediatric general surgery service has performed 67 emergent and urgent procedures in six weeks. Furthermore, during the COVID-19 pandemic our institution became the designated center for all pediatric inpatients in our multihospital network. We also expanded the age limits of patients evaluated and treated in our emergency department and inpatient wards, so that our system was able to free up beds and resources for the steady stream of incoming patients at our adult partner hospitals.

2. Staff protection

An important component of thoughtful community-centered care involves the protection of health-care providers. Multiple studies have confirmed that health-care providers represent an at-risk population in the setting of the COVID-19 pandemic. In Italy, another epicenter, as many as 20% of responding health care workers were infected with COVID-19 [11]. Our department typically consists of six attending surgeons, two surgical fellows, two to three rotating surgical residents, and two midlevel practitioners (physician assistants and nurse practitioners) on a typical service day. In an effort to protect as many of our staff as possible, our service was decreased to one attending surgeon, one fellow, and one resident or midlevel provider, similar to our weekend coverage prior to the pandemic. Several of our attending and midlevel staff were redeployed to the adult hospital, where personnel shortages were critical. Our administrative staff were placed on a staggered schedule and asked to limit on-site work to on average half a day per week.

3. Testing

The current gold-standard in testing for COVID-19 is real-time fluorescence quantitative reverse transcriptase polymerase chain reaction (RT-PCR) [12], which detects the presence of viral RNA from a nasopharyngeal swab. Studies in China have shown that patients with COVID-19 shed virus in a pattern that is similar to influenza [13]. Testing using a nasal swab is recommended, when possible, as it has been shown that a higher viral load is detected [14]. As these tests became available in the US, there have been supply chain challenges that have resulted in significant testing and processing delays [15].

Beginning in early April, all patients scheduled for nonemergent surgery or aerosol-producing procedures such as intubation, bronchoscopy, intestinal tract endoscopy, and transesophageal echocardiogram (TEE) underwent rapid COVID-19 testing with PCR. When patients had symptoms of COVID, tested positive or indeterminate, or the intervention was emergent without time for testing, COVID precautions were instituted. Endotracheal intubation and induction of anesthesia occurred in a negative pressure room and the patient would be transferred to a standard room for surgery. Standard contact and droplet precautions were implemented with the use of a gown, gloves, surgical mask, eye protection and N95 respirator. If COVID-19 test was negative, universal surgical face mask and standard precautions were followed.

4. Neonates

Neonates are a particularly vulnerable population served by pediatric surgeons. Despite having minimal symptoms from the disease itself, neonates pose unique challenges during the COVID-19 pandemic. The risk of vertical transmission from COVID positive mothers has not

been completely elucidated. Zeng et al. reported 3 symptomatic neonates out of 33 (9%) born to COVID positive mothers. All 3 of these patients retested negative by day of life 7 [16]. However, exposure of the fetus in COVID-positive mothers is cause for concern. Between March 13 and 27, 13.7% of asymptomatic pregnant women presenting to our hospital were found to be positive for COVID-19 [17]. Out of an abundance of caution, we have decided to treat these neonates of COVID positive mothers as patients under investigation (PUI) for 14 days. They are placed in negative pressure rooms and proper PPE is used for each interaction. They are tested 24 h after birth (to avoid false positives from maternal secretions) and on day of life fourteen. Regardless of COVID status, our policy is to only operate on urgent neonatal cases. These have included intestinal atresia, congenital diaphragmatic hernia, malrotation with midgut volvulus and esophageal atresia with tracheoesophageal fistula. Deferred cases include Hirschsprung's disease and anorectal malformations with adequate fistulas, which were able to be managed nonoperatively. The neonatal population also poses a unique challenge when applying high-efficiency particulate air (HEPA) filters to their ventilatory circuits. If applied directly to the endotracheal tube, the resistance through the filter can significantly impede ventilation and lead to severe respiratory acidosis. By placing the filter further from the patient (and closer to the ventilator), adequate ventilatory support for the neonate can be provided while protecting the anesthesia machine from contamination.

5. Endoscopy

Endoscopy is considered to be an aerosol-producing procedure and at high-risk for transmission of the COVID-19 virus. As the distance from patient to practitioner is less in rigid endoscopy, this form of endoscopy would be assumed to carry a higher risk of transmission than flexible endoscopy. Anecdotally, with more families staying at home, ingestion of foreign bodies seems to have increased. All patients requiring endoscopy were approached as a PUI for COVID, even with a negative COVID-19 test. As such, these procedures were performed in a dedicated negative pressure room with our previously described precautions for COVID-19. Since this is not a sterile procedure, this can be an OR, ICU or procedure room. Only essential personnel were present for these procedures to reduce exposure. Additional guidelines issued by the European Society for Pediatric Gastroenterology Hepatology and Nutrition (ESPGHAN) and North American Society for Pediatric Gastroenterology Hepatology and Nutrition (NASPGHAN) committees were followed. Their recommendations include adapting endoscopy technique to minimize exposure by minimizing the use of air/CO₂ during the procedure and proper sterilization of the equipment and procedure room [18].

6. Laparoscopy

The effect of surgery and laparoscopy on COVID particles is still poorly understood. Although prior research has shown that laparoscopy may lead to aerosolization of blood-borne viruses, including hepatitis and human immunodeficiency virus (HIV), there is no evidence that this effect is seen in COVID-19 [19–21]. Furthermore, the relative risk of laparoscopic versus open surgery is also unclear. A review of the literature on the safety of laparoscopy in COVID-19 infection has shown that there is substantial evidence that COVID-19 may be present in the gastrointestinal mucosa of infected patients [22]. As such, as put forth by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) and The European Association for Endoscopic Surgeons (EAES), "erring on the side of safety would warrant treating the coronavirus as exhibiting similar aerosolization properties" [23].

In order to minimize the escape of potential aerosolized particles from laparoscopy, we have implemented the use of closed-circuit devices that filter the released carbon dioxide, such as the ConMed Airseal® device with Smoke Evacuation and the Lexion Insufflow®

device with Smoke Evacuation. These devices are able to filter particles as small as 0.01 micron. COVID-19 particles measure on average 0.12 micron (0.06–0.14 micron). Indeed, some authors actually recommend laparoscopy over open surgery as the evacuation of smoke and aerosolized particles is more feasible with current laparoscopic smoke evacuating systems than open smoke evacuation systems, where containment of the surgical smoke is challenging, if not impossible. In open surgery, the smoke evacuator must ideally be within 2 cm of the source, with 50% loss of capture for every 1 cm from the source of the plume [24].

We also minimize the use of energy instruments and ultrasonic scalpel and decrease our flow rate to minimum prior to the end of the procedure. Upon completion, the flow is turned to off and the trocars are removed with theoretically very little if any unfiltered gas escaping into the atmosphere. For small patients and neonates in whom closed-circuit devices cannot be used, such as a laparoscopic pyloromyotomy, we perform minimally invasive procedures on low pressure insufflation and low flow. These conditions provide a favorable risk to benefit profile for the patient and healthcare staff, with no demonstrable increased risk to staff when compared to open pyloromyotomy. The decision to use laparoscopy over open surgery is determined by the benefit of quicker recovery and shorter hospital stay, hence lower use of hospital resources versus the upfront increased use of OR resources for a laparoscopic versus open procedure.

Although we suspect that the timing of presentation to the ED for appendicitis will have been affected by the pandemic, appendicitis is one of the most common pediatric conditions we treat and has continued to be throughout this period. We modified our practice based on the protocol submitted by the Children's Hospital of Colorado posted on the APSA QSC toolkit [10]. Briefly, all patients diagnosed with appendicitis in the emergency room had a rapid COVID-19 test performed. If positive they received a trial of antibiotics and were admitted to the hospital. Further intervention was determined based on their response to antibiotics. If the COVID test was negative they underwent laparoscopic appendectomy and were discharged home from the postoperative area. For complicated appendicitis, we administered IV antibiotics for a minimum of 48 h, followed by oral antibiotics and considered interventional radiology (IR)-guided percutaneous drainage of an intraabdominal abscess when possible.

7. Oncology

Approach and management of children with cancer during the COVID-19 pandemic has been challenging. Pediatric cancers often behave aggressively and require immediate treatment, including operative intervention. There are limited data on the clinical features and outcomes of COVID-19 in immunocompromised children with cancer thus far, although findings from Liang et al. suggest patients with cancer might have an increased risk of COVID-19 and experience from previous pandemics (e.g., influenza A and H1N1) suggests the vulnerability of immunosuppressed patients will be seen over time [25,26]. Considerations for prioritization of the oncologic cases include knowledge and understanding of the biology of each cancer, alternate treatment options, anticipated length of hospitalization, and resources required to care for the patient. During the COVID-19 pandemic, new oncologic diagnoses have required biopsy, access procedures for initiation of chemotherapy, bone marrow biopsy/aspiration, and lumbar puncture with intrathecal chemotherapy administration. Previously confirmed diagnoses, awaiting surgical intervention and planned to occur within a specified treatment window have been deemed approved cases for surgical resection. Case examples within the past month include a mediastinal germ cell tumor, lower extremity sarcoma, and femur osteosarcoma. Elective cases, such as removal of tunneled central lines, have been postponed for now. As more information becomes available, current policy and procedures will undoubtedly change, and guidelines will follow evidence-based consensus recommendations.

8. Trauma

While official trauma reporting agencies have not input their data yet, city-wide reports are consistent in the decreased number of trauma patients being evaluated in hospital systems throughout. Our number of trauma admissions has dropped by more than 40% for the months of March and April. At the beginning of the pandemic, we collaborated with the pediatric Emergency Department staff to determine the most effective way to continue providing reliable and timely trauma care while minimizing staff exposure and resource utilization. We did not alter our triage parameters, and essential personnel were required to continue to arrive in person and on time for the appropriate level activations as specified by the American College of Surgeons. However, we did implement the use of virtual consults for patients for whom a trauma consult was requested by Emergency Room staff in order to limit possible exposure of additional personnel. Request for in-person versus virtual visit was determined by the emergency room primary care team on a case-by-case basis. To assist our adult hospital partner, we also extended the age limit of patients evaluated in the ED to 35 years.

9. ECMO

The Extracorporeal Life Support Organization (ELSO) recently published guidelines for the use of extracorporeal membrane oxygenation (ECMO) support in the setting of COVID-19 illness [27]. While ECMO can be lifesaving for patients in respiratory failure, its benefits must be weighed against the significant resource utilization it enlists as well as the high number of healthcare providers who become exposed to the patient. Our department aimed to balance the need to provide high quality medical care while being mindful of resources and safety of healthcare workers. As a well-established ECMO center, we continued to offer ECMO support to children diagnosed with and without COVID-19. We continued to use our standard indications for initiation of ECMO support in the pediatric population throughout the pandemic and even at its peak. Discussion of candidacy for ECMO was initiated and documented for each patient newly admitted to the pediatric intensive care units, regardless of age. In addition, we supported our adult hospital partners by accepting adult patients on ECMO. Adult patients ranged in age from 24 to 52 years old. By extending our normal age parameters, the children's hospital was able to off load some of the most labor-intensive patients from our adult surgical colleagues and allow them to continue to provide high quality care to the surge capacity population of critically ill adult patients on our campus. As pediatric surgeons with significant experience of managing ECMO patients, we can be a unique resource to adult ECMO programs while continuing to support non-COVID-19 pediatric patients who may require ECMO.

10. Conclusion

The COVID-19 pandemic has been a type of systemic challenge the New York City hospital network has not yet experienced. Although children's hospitals overall have not been challenged as severely as our adult counterparts, the COVID-19 pandemic has tested our ability to quickly surge and ensure continued high-quality care to our youngest patients. Our department had to creatively and expeditiously adjust our protocols, guidelines, and workforce to not only serve our pediatric population but merge ourselves with our adult hospital system in this common fight. We learned how to deliver high quality care in a new way that keeps patients and healthcare workers safe and maximizes hospital resource utilization. To ease data sharing as things change and develop throughout the different phases of the pandemic and reopening, the APSA Quality and Safety committee created a data sharing spreadsheet so that pediatric surgeons across the country can easily

and quickly share their own experiences [10]. We hope that our experience can be useful to other children's hospitals that may face similar situations in the future with COVID-19 and other public health crises.

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