Pediatric Surgery during the COVID-19 Pandemic: An International Survey of Current Practice

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Abstract

Introduction Understanding the challenges experienced by pediatric surgeons in the early phases of the pandemic may help identify key issues and focus research.

Materials and Methods Two pediatric surgeons from each of the 10 countries most affected by COVID-19 were surveyed over a 10-day period. Data were obtained regarding service provision, infection control, specific surgical conditions, and the surgical workforce.

Results Twenty pediatric surgeons responded. All centers had postponed non-emergency surgery and clinics for nonurgent conditions with virtual consultations being undertaken in 90% of centers. A majority (65%) of centers had not yet knowingly operated on a positive patient. Minimal access surgery was performed in 75% centers but a further 75% had reduced or stopped upper gastrointestinal endoscopy. The management of simple appendicitis was unchanged in 70% centers, patients with intussusception were being referred for radiological reduction in all centers and definitive pull-through surgery for Hirschsprung patients was performed by 95% where washouts were successful. Timing of surgery for reducible neonatal inguinal hernias had changed in 55% of centers and the management of urgent feeding gastrostomy referrals and of inflammatory bowel disease patients failing with biological therapy varied considerably.

Conclusion Service provision has been severely affected by COVID-19 leading to an inevitable increase in untreated surgical pathology. Better understanding of extrapulmonary infectivity, the risk of asymptomatic carriage in children, and the reliability of testing for surgical scenarios may allow appropriate use of conventional surgery, including laparoscopy and endoscopy, and rational development of the novel care pathways needed during the pandemic.

Keywords
- COVID-19
- pediatric surgery
- infectivity
- asymptomatic carriage
- testing

Introduction

Challenges to pediatric surgery caused by the COVID-19 pandemic have meant that individual institutions and health care systems have necessarily based decisions affecting patient care and healthcare worker safety on the best available current knowledge, which is itself limited. Available guidance has changed with time, perhaps adding uncertainty among clinicians and affecting implementation of guidance. Clear and accurate guidance will be necessary to allow safe resumption of services following the peak.

The experience of surgeons in different centers may help identify common challenges or knowledge gaps where further research could be directed. Health care centers around the

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world are at different phases and have approached care using differing recommendations. Comparison may identify effective solutions to problems or indicate likely future challenges.

The aim of the study was to survey pediatric surgical practice in the countries most affected by COVID-19.

Materials and Methods

An online questionnaire was constructed to gather information related to service provision, infection control, medical workforce, and the management of specific pediatric surgical conditions (►**Supplementary Appendix A**, available in the online version). It was administered in the English language using a web-based survey model offered by Google Forms.[1] Centers providing care to both adults and children as well as standalone children's hospitals were approached. The questionnaire was piloted by three independent U.K. pediatric surgeons (R.E., B.E., G.M.) to identify ambiguity and estimate the time required to complete the survey.

The 10 most affected countries by the pandemic based on number of positive cases were identified on April 14, 2020 using Worldometer.[2] Senior pediatric surgeons from two different institutions per country were identified. Surgeons received a first email inviting them to take part in the survey. Following a positive response, a second email with the survey web link was sent to the responders. Non-responders were sent a first reminder and if no response following that, a new clinician was identified and emailed following the same process.

Once two completed surveys per country were obtained, no further reminders were sent. To keep the responses contemporaneous with each other, surveys were completed within a 10-day window (April 15 and 25, 2020). Completed questionnaires were collated and analyzed.

Results

Characteristics of Contributing Centers

Responses from all the 10 identified countries were obtained. In each affected country, two geographically different centers completed the survey. Responses were obtained from Belgium (Brussels, Ghent), China (Nanjing, Wuhan), France (Paris, Rennes), Germany (Leipzig, Munich), Iran (Shiraz, Teheran), Italy (Padua, Rome), Spain (Barcelona, Madrid), Turkey (Ankara, Istanbul), United Kingdom (Bristol, Nottingham), and the United States of America (Boston, Massachusetts, Columbus, Ohio).

Table 1 Number of pediatric surgeons per institution

Number of pediatric surgeons	*N* (%)
< 5	3 (15)
5–10	11 (5)
10–15	0 (0)
15–20	3 (15)
> 20	3 (15)

There was an even split between children's hospitals and centers that provide both pediatric and adult services. The number of pediatric surgery consultants/attendings indicated a range of sizes of centers (►**Table 1**).

Pediatric Surgical Service Provision

All centers had cancelled or postponed non-emergency surgery and clinics for non-urgent conditions. Virtual consultations via teleconference or telephone were being delivered in 18 of 20 centers. Fifteen of 20 centers had not reduced or changed their usual provision of neonatal surgery.

At least some minimally invasive surgery (MAS) in the form of either laparoscopic, thoracoscopic, or robotic procedures was performed in 15 of 20 centers. Elective upper gastrointestinal endoscopy was performed in only 5 of 20 centers. Three centers had reduced smoke-generating standard electrosurgery and smoke extractors were used by 8 of 20 centers.

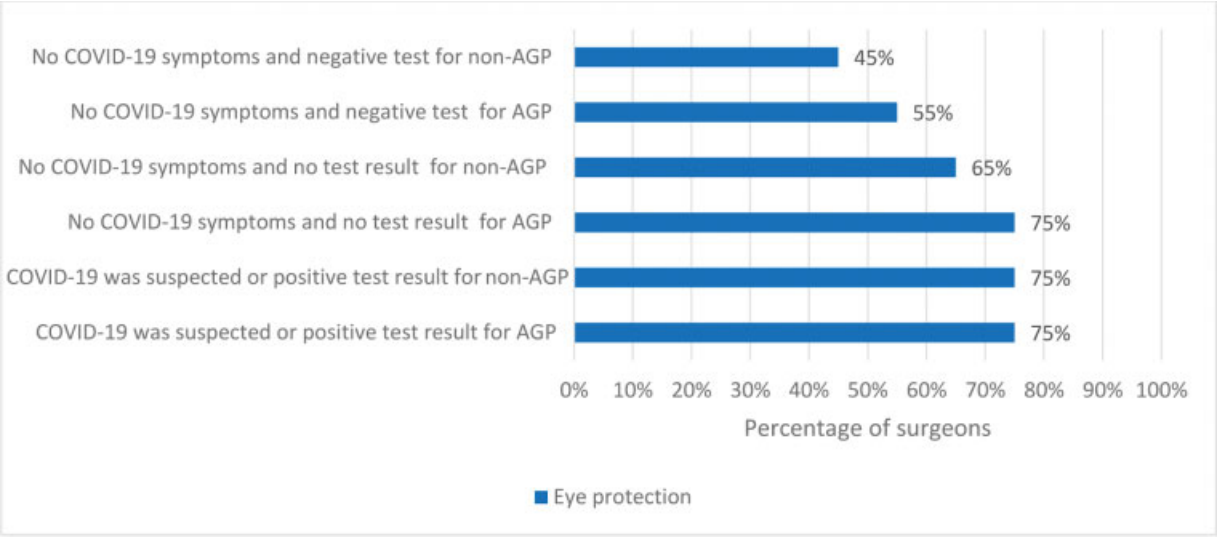

Fig. 1 Eye protection in operating theater/room.

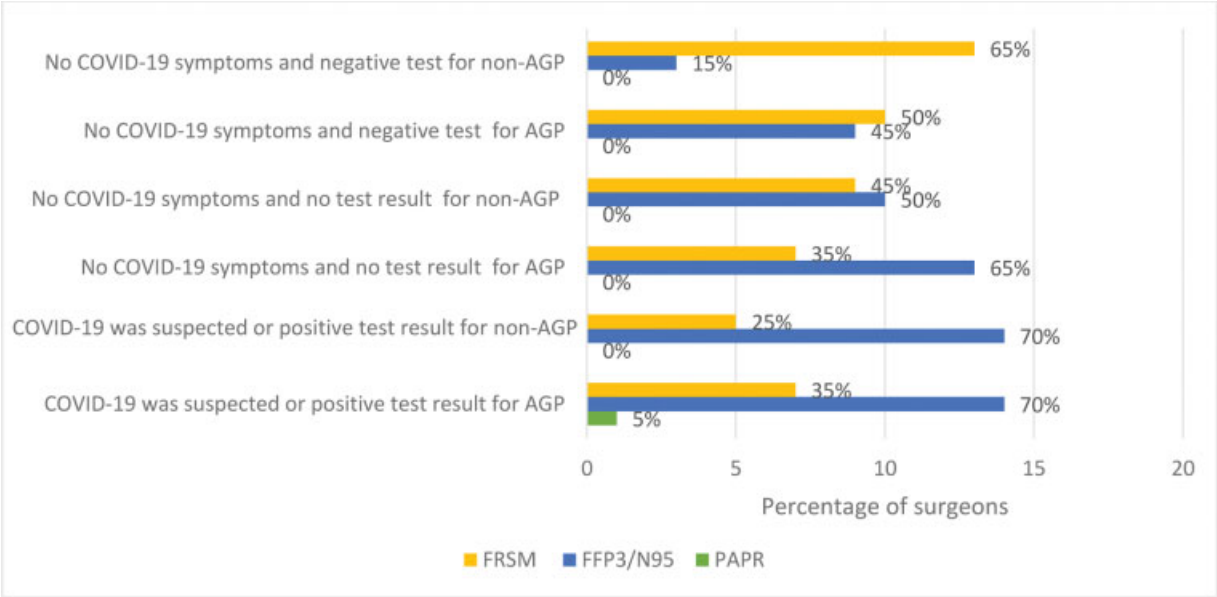

Fig. 2 Use of masks by surgeons for face protection in operating theater/room. FFP, filtering facepiece; FRSM, fluid-resistant surgical mask; PARP, powered air-purifying respirator. Note that for some scenarios, surgeons wore more than one mask.

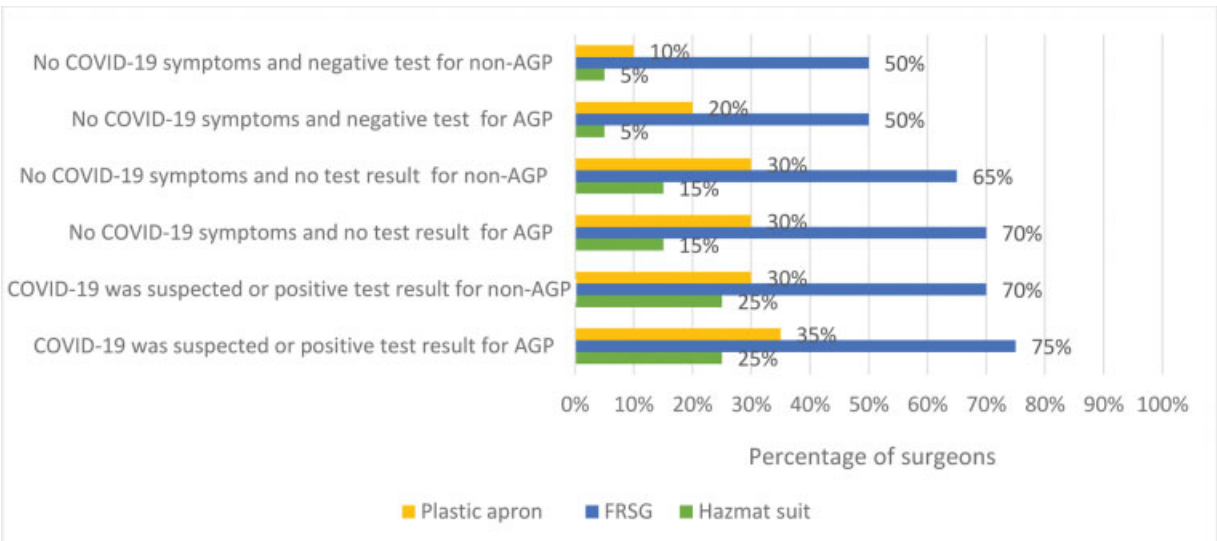

Fig. 3 Use of body protections in operating theater/room. FRSG, fluid-resistant surgical gown. Note that surgeons wore more than one type of protection in some scenarios (for example, plastic apron in addition to a FRSG or hazmat suit).

Infection Control

Asymptomatic patients were at least sometimes treated as potentially positive for COVID-19 unless proven otherwise in 80% of centers and 15 of 20 centers routinely tested patients preoperatively irrespective of the presence of COVID-19 symptoms. Suspected patients were treated as positive even without a test result in 13 of 18 centers. Patients who had previously tested positive were retested until negative, at least sometimes, by 9 of 16 respondents.

Use of Personal Protective Equipment

Respondents were asked about which eye, face, body, and hand protection is used in theater for three scenarios; when there were no COVID-19 symptoms and a negative test; when there were no COVID-19 symptoms but no test result; and when COVID-19 was suspected or positive test result. For each scenario, respondents were asked if the presence or absence of an aerosol-generating procedure (AGP) made a difference. Results are recorded as the percentage of surgeons who responded (►Figs. 1–4). Additionally, one surgeon responded "I don't know" for each scenario.

Is a Laparotomy Itself Seen as a Risk Factor?

Centers were asked if they would consider a laparotomy to be an AGP if the intestinal lumen was not opened, and whether

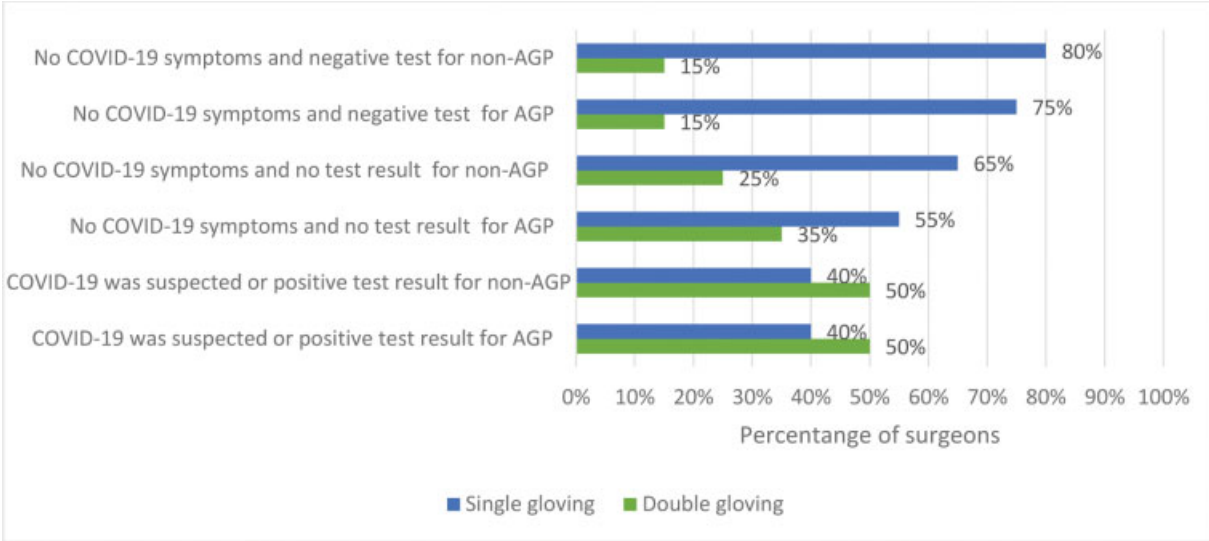

Fig. 4 Use of hand protection in operating theater/room. One surgeon did not respond to every scenario. It is possible, but unlikely, that no gloves were worn.

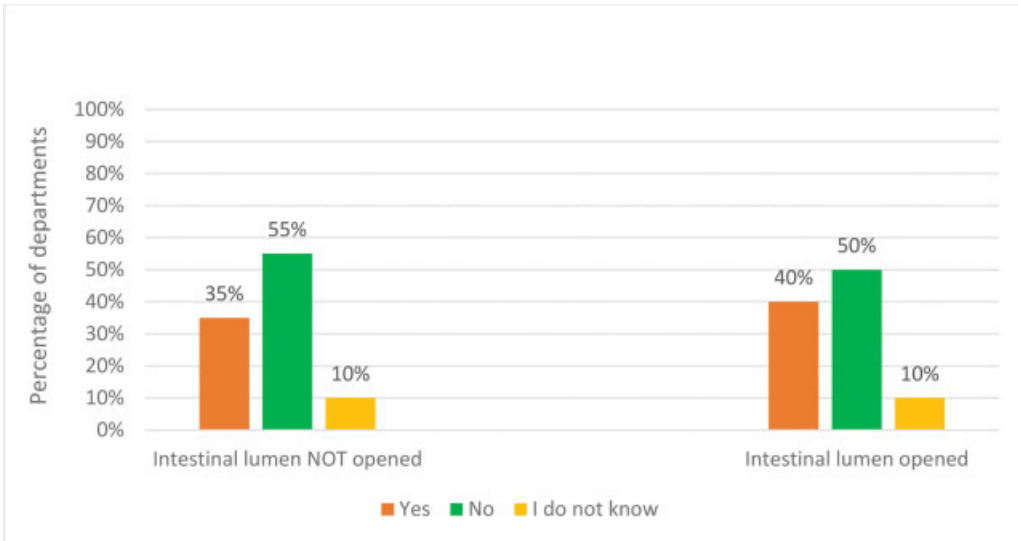

Fig. 5 Is a laparotomy seen as an aerosol-generating procedure (AGP).

this view would change if the lumen was opened (►Fig. 5). Most of the respondents (13/20) had not operated on a known positive patient.

Pediatric Surgical Conditions

Respondents were asked if they had changed their practice when treating specific surgical conditions during the pandemic. Only 4 of 20 centers had begun to use non-operative management of appendicitis during the pandemic with 14 of 20 reporting no change in practice and 2 of 20 clinicians stating that their department was already undertaking this. Most centers (11/20) had changed the timing of surgery for reducible neonatal inguinal hernia. All centers were still attempting radiological reduction of intussusception first rather than performing surgical (laparoscopic or open) reduction primarily. Almost all centers (19/20) were performing pull-through surgery for Hirschsprung patients who are managing well with rectal washouts, rather than using a defunctioning stoma to defer definitive surgery.

There was a wide variation in practice for patients referred for an urgent feeding gastrostomy (►Fig. 6). Most surgeons (9/20) would perform a laparoscopic procedure for inflammatory bowel disease (IBD) patients whose symptoms were poorly controlled with biological treatment, with 6 of 20 performing an open procedure, and 4 of 20 continuing with medical treatment. One clinician stated they did not know.

Surgical Workforce

Thirteen of the 20 centres had routinely performed COVID-19 tests on staff members if they or their family had symptoms and 14 of 20 had not had staff members test positive for

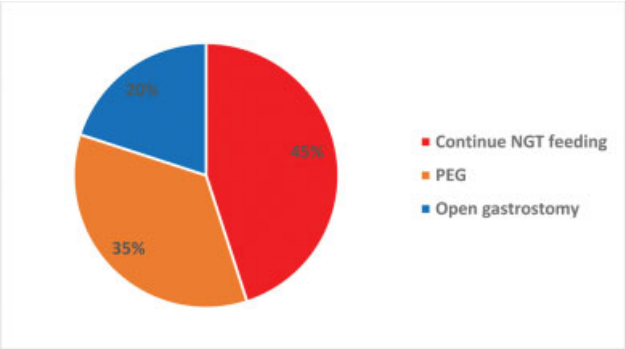

Fig. 6 Percentage of pediatric surgeons continuing with nasogastric tube (NGT) feeds, placing a percutaneous endoscopic gastrostomy (PEG), or performing an open gastrostomy for children referred for an urgent open gastrostomy.

COVID-19. A majority of centers (14/20) had not have members of staff redeployed to other clinical areas. Half of the institutions had arranged formal training prior to redeploying the staff members with 5 of 10 delivering this even though no redeployment had happened. Eighteen of 20 surgeons stated that training opportunities for trainees/residents/fellows had been reduced during the pandemic.

Discussion

We present the first international survey of pediatric surgeons during the COVID-19 pandemic. Responses have been provided by surgeons from different cities within all 10 of most affected countries. Information from countries with significant experience and with a range of incomes and healthcare systems has therefore been obtained. Centers include those affected very early in the pandemic, notably Wuhan. The contributing centers had a range of sizes and different configurations (i.e. from hospitals providing care for both adults and children, or for children only).

Pediatric surgical service provision has been severely affected by COVID-19. All centers had suspended or postponed non-emergency surgery, although 75% were maintaining neonatal surgery. There is likely to be a consequent build-up of pathology in non-neonatal groups. The ability to deliver treatment was further affected particularly for endoscopy but also for MAS and the use of electrocautery.

Based on available evidence, surgeons had altered their approach to common pediatric surgical pathologies. There was some increase in the number of centers undertaking non-operative management of acute simple appendicitis, and the timing of surgery for neonatal inguinal hernia was affected in a majority. While there was little change in the management of Hirschsprung disease and intussusception, there was significant variability in decision making for patients referred for an urgent feeding gastrostomy or for IBD where medical management was failing.

The risk of interventions (e.g. washouts, radiological reduction of intussusception, or endoscopy) would be informed by data for viral transmission from the gastrointestinal tract. The risk of laparoscopy and laparotomy additionally requires data for viral transmission from peritoneal fluid. The evidence base describing extrapulmonary viral transmission risk is however limited. In one study,[3] serum, nasopharyngeal, and oropharyngeal swabs, urine, stool, and tissues from 73 COVID-19 patients (both adults and children) were examined. SARS-CoV-2 ribonucleic acid (RNA) was identified in the stool of 53% of patients. Esophageal, gastric, duodenal, and rectal tissues obtained endoscopically from one patient demonstrated inflammation, with polymerase chain reaction (PCR) evidence of the virus at all sites. The same study highlighted the potential for fecal carriage in "post-symptomatic" patients; ongoing evidence of the virus in stool was found in 23% after clearance from the respiratory tract. Other data are emerging confirming the presence of the virus in stool of children who are asymptomatic, symptomatic, and "post-symptomatic."[4–8] Other body fluids have been examined: in a paper now accepted for publication by the *Annals of Surgery*, the presence of SARS-CoV-2 was identified in the peritoneal fluid of a COVID-19 patient using reverse transcription-PCR. The concentration in peritoneal fluid was higher than in the respiratory tract. If confirmed in a larger group of patients, this is of importance when considering the risks of both open and laparoscopic surgery,[9] and potentially in the pathophysiology of children with COVID-19 presenting with abdominal pain. Conversely, it has been stated that "extrapulmonary detection of viral RNA does not necessarily mean that the infectious virus is present and the clinical significance of the detection of viral RNA outside the respiratory tract is unknown."[10]

Asymptomatic carriage of the SARS-CoV-2 virus has been described in adults[5,11] and children.[12] Understanding the nature of asymptomatic carriage in children and the reliability of testing to exclude infectivity in asymptomatic children would improve the safety of health care workers and may simplify treatment for some pathways.

Testing was used to a variable extent; 80% centers at least sometimes treated asymptomatic patients as potentially positive until a test was obtained. Testing of surgical patients, including asymptomatic ones occurred in 75% centers at least sometimes. Retesting following a previous positive COVID-19 test result occurred at least sometimes in 56% of centers.

The accuracy of tests is known to be imperfect; a recent study in adult patients demonstrated that PCR testing for COVID-19 had an inferior sensitivity (83.3%) compared with computed tomography imaging (97.2%).[13] Variables that may affect accuracy have been set out in a way that could inform our interpretation of, or improve, the reliability of testing.[14] Research prioritization focusing on testing would benefit from understanding clinical need which would in turn allow key clinical questions to be addressed.

The range of PPE used by centers in different scenarios varied. Our focus was eye protection, the use of masks, body protection, and the use of gloves. We did not ask about other protection (e.g. for hair or feet), or other areas of the hospital where transmission of infection is possible (e.g. wards, communal areas, lifts, handrails, and computers). PPE availability, confidence of staff and patients, and the implementation of recommendations are further considerations. Development and implementation of

PPE recommendations would benefit from better understanding of the risks associated with each intervention.

Understanding how the virus may produce symptoms in each system in children, and the associated risks of infectivity and the ability to test would require a range of skill sets and collaboration between centers. Such information may improve the nature of clinical recommendations, patient care, staff protection, the use of resource such as PPE, and the ability to safely "open up" services. The pandemic and its consequences are likely to persist for some time, and now may be as good a time as any to develop this evidence base.

Although delivery of routine care had been significantly curtailed, most centers did not have surgeons who had tested positive for the virus and had not experienced a high redeployment rate. Our workforce seems therefore largely to be in place at present. An impact of the pandemic on surgical training was identified in 90% of centers and the consequences of this must be addressed. It is possible, however, that the pandemic itself will enhance other aspects of training, in particular through the need to reappraise established clinical pathways and develop innovative approaches to service provision. At present, it would seem that capacity exists to find time for teaching and service development if social distancing can be achieved.

At the beginning of this project, we recognized the need to accept "good-enough" methodology to obtain information at pace and given the current critical phase of the pandemic in many countries. There were therefore limitations in this study. First, the authors themselves designed the questionnaires without involving other staff groups (including nursing and medical colleagues) or service users leading to potential bias in the selection of topics. Nevertheless, we have attempted to cover items relevant for clinicians as far as possible using a survey designed to take less than 15 minutes per participant. We wanted to capture more than one center per country and chose to survey two centers from each to complete the survey in a timely manner.

Responders may not represent the range of practice of all the centers in the country they belong to, since variations of clinical practice occur in every country. We did not sample adult surgeons who deliver care to children. We selected countries by identifying those "most affected" by COVID-19 and did not capture data from countries with different population densities, testing capacity, health care infrastructure, or gross domestic product. We recognize particularly the different challenges that may be experienced by low- and middle-income countries.

The term AGP was not defined. We do not know if each center viewed AGPs in the same way as each other.

We recognized that survey results do not constitute clinical evidence but instead illustrated shared experience and practice. We hope the data are nonetheless useful to demonstrate the challenges and common themes across the pediatric surgical units approached.

We would advocate a formal scoping project designed to define the priorities to clinicians, patients, and their families, and those who run health care systems. Involvement of the correct range of experts, with suitable support (e.g. data scientists) would be more likely to allow identification of effective approaches to care than a "piecemeal" approach at the level of individual centers. Many knowledge gaps will be identified. Without addressing these using focused research, safe progress will be limited. With collaboration, some research questions may be answered, perhaps at pace.

Recommendations made will need to be altered as new evidence emerges and new scenarios arise. Defining what outcomes are important for individual patient care, the protection of the workforce and public health would allow prospective measurement and help direct focus. Involvement of organizations responsible for the coordination of health care for each country would professionalize a response making it more likely to be effective and in keeping with what our populations require of us.

Conclusion

During the COVID-19 pandemic, pediatric surgical teams in different parts of the world and their patients have faced similar challenges. There has been a profound impact on clinical practice especially with regard to service provision for non-neonatal patients. Testing strategies differed and PPE use has varied between institutions. There have been significant effects on specific patient pathways, particularly for those involving minimal access or endoscopic approaches. While the workforce has been preserved, surgical training has been significantly affected. Variation between centers in the delivery of care may be linked to the knowledge gaps that have existed in the early phase of the pandemic and the consequent limitations in recommendations.

Since this crisis is unlikely to be fully resolved in the near future, "getting ahead of the curve" will require a clear understanding of basic principles, particularly pulmonary and extrapulmonary viral transmissibility and how best to use testing in surgically relevant scenarios. Knowledge gaps will require targeted research, formulation of evidence-based recommendations, and considered implementation. International cooperation between clinicians, scientists, and families, perhaps using established networks, will clearly be essential in the immediate future.

Conflict of Interest

None declared.

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