Objective: Adults with COVID-19 infection undergoing surgery have an increased risk of complications and mortality. However, literature mentioning the perioperative course and outcome of children with COVID-19 infection undergoing emergency surgery is still lacking. Therefore, we planned this study to observe the need for postoperative ventilation, oxygen requirements, and postoperative mortality in pediatric patients with COVID-19 infection scheduled for emergency surgery.

Methods: After ethical committee approval, all the COVID-19-infected pediatric patients who underwent an emergency surgery from April 2020 to May 2021 were included. Data collected included details of COVID-19 disease, American Society of Anesthesiology (ASA) grading, comorbidities, perioperative details such as tachycardia or bradycardia, any oxygen desaturation (SpO2<90), need for postoperative oxygen therapy, postoperative ventilation, and recovery/death.

Results: A total of 22 COVID-19-infected pediatric patients underwent emergency surgery in the study period. Fourteen (63.6%) were asymptomatic at the time of admission. Nineteen patients (86.4%) belonged to ASA grade IE and three (13.6%) patients belonged to ASA grade III E. Three patients (13.6%) had comorbidities. Only one patient had hypotension and tachycardia intraoperatively. The same patient needed postoperative ventilation and succumbed.

Conclusion: Our study shows that pediatric surgical patients with COVID-19 infection do not exhibit an increased need for oxygen or postoperative ventilation, postoperative pulmonary complications, or high mortality unless there is associated comorbidity.

Keywords: Child, COVID-19, morbidity, postoperative complication
children has become available. However, literature mentioning the perioperative course and outcome of infected children undergoing emergency surgery is still lacking. Therefore, we planned to study the intraoperative events, the need for postoperative ventilation, oxygen requirements, and postoperative mortality in pediatric patients with COVID-19 infection scheduled for emergency surgery in our institution. This was done with the aim of optimizing resource allocation in the postoperative period.

Materials and Methods

This retrospective and prospective observational study was conducted after approval by the Institutional Ethical Committee (LHMC/IEC/2020/102). All COVID-19-positive pediatric patients (<18 years) who underwent emergency surgery (under general/regional anesthesia) from April 2020 to May 2021 were included in the study. All the patients who had undergone an emergency surgery during the study period and were suspected to have COVID-19 infection and turned out to be positive in the postoperative period were also included. Patients requiring ventilation for the underlying surgical cause were excluded from the study.

Retrospective data were collected from the pediatric surgery COVID operation theater (OT) record register and case files of the patients. Prospective data were obtained from patients after taking consent. Data were entered into a structured proforma which included demographic data (age and weight), details of COVID-19 disease (duration, type, and severity of COVID-19 symptoms, stay in containment zone or not), comorbidities, type of COVID-19 sampling done, indication, and type of surgery. Preoperative investigations including complete blood count, kidney function tests, liver function tests, serum electrolytes, and coagulation profile. Details of American Society of Anesthesiology (ASA) physical status grading, anesthesia administered, and intraoperative events such as tachycardia (heart rate >150 beats per min), bradycardia (heart rate <60 beats per min), any oxygen desaturation (SpO2 <90%), need for postoperative oxygen therapy and postoperative ventilation (in patients where extubation criteria were not met, i.e., poor muscle tone, inadequate spontaneous breathing or tidal volume, and SpO2 <93%), duration of postoperative ventilation, postoperative complications, duration of hospital stay, and recovery/death were recorded.

Results

A total of 22 COVID-19-infected pediatric patients, confirmed by reverse transcriptase–polymerase chain reaction (RT-PCR) nasopharyngeal swab/oropharyngeal swab, underwent emergency surgery in the study period. Fourteen (63.63%) patients belonged to the containment zone. The youngest COVID-19-positive patient was a 1-day-old female child; the demographic data are shown in Table 1. Nineteen patients (86.4%) belonged to ASA grade IE and three (13.6%) patients belonged to ASA grade III E. Nine patients (40.9%) were diagnosed to be COVID-19 positive preoperatively while the majority of patients (59.1%) were diagnosed positive in the postoperative period, they were sampled preoperatively and taken up for surgery in view of the emergency nature of the surgery. Comorbidities included tuberculosis (4.5%) and prematurity (9.1%); most of the patients (86.3%) were without comorbidities. At the time of admission, 14 patients (63.6%) were asymptomatic. The rest developed COVID-19-related symptoms on day 2 (4.5%), day 3 (13.6%), day 4 (13.6%), and on day 5 (4.5%). The COVID-19-related symptoms during stay in hospital included fever (36.4%), cough (4.5%), fatigue (9.1%), dyspnea (9.1%), and nausea/vomiting (22.7%). The details of type and duration of surgery are shown in Table 2. Twelve patients (54.5%) received general anesthesia (GA) only, three of them received spinal anesthesia (for appendectomy), and rest of them received GA as well as a regional block.
None of the patients had any intraoperative fall in SpO₂ or bradycardia. Only one patient had hypotension and tachycardia intraoperatively. This COVID-19-positive patient had perforation peritonitis caused by intestinal tuberculosis, underwent an exploratory laparotomy with resection anastomosis, remained intubated and on mechanical ventilation with oxygen support in the postoperative period. Subsequently, the child developed sepsis with shock and multiorgan failure. Her postoperative investigations revealed pancytopenia and raised CRP and D-dimer values and expired on the 7th postoperative day. The rest of the patients had an uneventful postoperative course, a mortality rate of 4.5% was thus observed.

**Discussion**

This study, to the best of our knowledge, is the first from India reporting the outcome of pediatric patients with SARS-CoV-2 infection undergoing emergency surgery. All our 22 patients were diagnosed as being COVID-19 positive before or immediately after surgery. In spite of lockdown-imposed restrictions due to the pandemic, there was no delay in reaching the hospital after the presentation of disease symptoms. Nasopharyngeal/oropharyngeal samples of more than 50% of our patients were sent for RT-PCR, and without waiting for the report, they were taken for surgery in COVID-19 designated OT. This improved the outcome of our patients as there was no delay in surgical management. Many patients with a suspicion of COVID-19 disease who later became COVID-19 positive belonged to a containment zone. More than 50% of patients lacked COVID-19-related symptoms, which corroborates with the evolving literature suggesting a milder form of the disease in the pediatric age group.[2,4,7] The most common presenting symptom in our patients was fever, but fever could be a part of underlying infection related to surgical cause and cannot be solely attributed to COVID-19. Similarly, five patients presented with nausea and vomiting, and although gastrointestinal symptoms are part of COVID-19-related symptomatology, these symptoms could also be due to the underlying gastrointestinal obstruction.[6] In addition, most of the patients lacked respiratory symptoms such as dyspnea seen in COVID-19 disease. The preoperative laboratory investigations revealed no leukopenia or leukocytosis in our patients which is often seen in adult COVID-positive surgical patients.[9] Bari et al. have reported the same earlier.[10] Regarding preoperative chest imaging, it was recommended only if there were respiratory symptoms, therefore it was done only in one patient. Almost all patients lacked postoperative pulmonary complications (PPC); only one patient needed postoperative mechanical ventilation. This patient was a case of subacute intestinal obstruction due to abdominal tuberculosis with associated pulmonary tuberculosis. Although there was no intraoperative fall in SpO₂, her oxygen requirements continued to remain high. The pulmonary condition further deteriorated in the postoperative period and the hemodynamic status worsened requiring vasoppressor support. She succumbed in spite of appropriate treatment. None of the other patients developed COVID-19 pneumonia, unlike adult patients who have COVID-19 infection.[11] The incidence of PPC was reported to be only 13.6% in pediatric patients in the CovidSurg trial suggesting that children experience less PPC as compared to adults in whom the incidence is reported to be as high as 51.2%.[12,13]

Our mortality rate of 4.5% in pediatric surgical COVID-positive children is much higher than the mortality rate reported earlier. CovidSurg trial reported a 30-day postoperative mortality rate of 1.1% in children without specifying associated comorbidity.[13] Many previous studies in adult surgical COVID-19 patients have reported high mortality, particularly in patients with comorbidities.[11,14,15] It is highly likely that morbidity and mortality are higher in surgical COVID-19-positive children also who have an associated comorbidity. Lara S has emphasized that prehospital comorbidities appear as an important factor in the outcome.[16] The available literature, however, reports high mortality in pediatric nonsurgical patients who have severe disease or associated comorbidity and requiring intensive care unit (ICU) care.[17] None of our other patients, except those mentioned above, had prolonged stays due to COVID-19 or its complications. All were discharged within 7 days of admission, which is the usual time for discharging uncomplicated surgical patients. Our results were similar to a cohort study which found no difference in length of stay in operated pediatric patients with and without COVID-19.[18] There was no readmission of our patients.

Anticoagulation is now the mainstay of therapy in patients suffering from COVID-19 infection; however, the evidence in children is still lacking. In a study by SC Mehal, the criteria for starting prophylactic anticoagulation were risk factors such as obesity, decreased mobility, raised D-dimer, and raised inflammatory markers such as C-reactive protein and fibrinogen.[9] We initiated anticoagulation postoperatively in only one patient who had a deranged coagulation profile and raised D-dimer levels.

The limitation of our study was that it was an observational study, from a single center, and with a limited number of patients. Furthermore, the majority of...
our children were essentially healthy children, limiting generalizability to pediatric patients with significant comorbidities. Further studies are needed to extrapolate our results.

**CONCLUSION**

We have observed that pediatric surgical patients with COVID-19 infection do not exhibit an increased need for oxygen or postoperative ventilation, PPC, or high mortality unless there is some associated comorbidity. The length of hospital stay is also not increased in the absence of comorbidity. Surgery does not accelerate or exacerbate the disease progression of COVID-19 infection. This has a huge implication in resource-limited settings such as ours where there are a limited number of ICU beds, ventilators, monitors, and skilled professionals. Only patients with comorbidities need ICU care, the others can be managed inwards and sent home as usual pediatric surgery patients. This prioritization will help guide decision-making and streamlining the allocation of available resources to the patients who need it most in resource-constrained scenarios.

**What is known**

Children have less severe COVID-19 infection, and very low mortality has been observed when these children are hospitalized for nonsurgical causes.

**What is new**

COVID-19 infection is mild in children and there is no worsening of symptoms caused by anesthesia and/or surgery. Children without comorbidity do not need postoperative oxygen or postoperative ventilation. Mortality is low in the absence of comorbidity.

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**Conflicts of interest**

There are no conflicts of interest.

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