

# Pediatric surgical activity during the SARS-CoV-2 pandemic: experience at a tertiary hospital

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## ABSTRACT

**Objectives.** The primary objective was to describe the characteristics and demographics of the surgical procedures carried out at a tertiary hospital during the SARS-CoV-2 pandemic. The secondary objective was to study the impact of the pandemic on the acute appendicitis cases treated at our healthcare facility and to compare them with a pre- SARS-CoV-2 period.

**Materials and methods.** A retrospective study of all patients undergoing surgery at the pediatric surgery department in the pandemic period, from the beginning of the state of emergency in Spain until the first restrictions were removed, was conducted.

**Results.** A total of 61 patients underwent surgery in 58 days vs. 406 patients in the same 2019 period ( $p < 0.00001$ ). 59.01% of surgeries were urgent. 5.1% of patients had a positive SARS-CoV-2 diagnostic test. 30 different procedures were carried out, with appendectomy being the most frequent one ( $n = 13$ , 19.6% of patients). 61.5% of appendicitis cases were complicated vs. 42.4% in the non-COVID period ( $p = 0.17$ ). Surgical approach was open in 46.1% of patients vs. 6.1% in the non-COVID period ( $p = 0.004$ ). No statistically significant differences were found in terms of complication rate or hospital stay.

**Conclusions.** During the SARS-CoV-2 pandemic, a significant decrease in the number of daily procedures was noted, with more than half being urgent. Appendicular pathologies were in a more advanced stage than usual, with a clear trend towards open surgery vs. laparoscopy.

**KEY WORDS:** SARS-CoV-2; COVID-19; Pediatric surgery.

## CIRUGÍA PEDIÁTRICA DURANTE LA PANDEMIA DE SARS-CoV-2. EXPERIENCIA EN UN HOSPITAL DE TERCER NIVEL

### RESUMEN

**Objetivos.** Describir las características y demografía de los procedimientos quirúrgicos realizados en un hospital de tercer nivel durante la pandemia del SARS-CoV-2. Como objetivo secundario se estudia el impacto de la pandemia en las apendicitis agudas tratadas en nuestro centro y su comparación con un periodo previo al SARS-CoV-2.

**Material y métodos.** Estudio retrospectivo incluyendo a todos los pacientes intervenidos por parte del Servicio de Cirugía Pediátrica durante el periodo de pandemia. Abarca desde el primer día del estado de alarma hasta la desescalada de las restricciones.

**Resultados.** Se intervinieron un total de 61 pacientes en 58 días frente a 406 pacientes durante el mismo periodo de 2019 ( $p < 0.00001$ ). El 59,01% de las intervenciones eran de carácter urgente. Un 5,1% de los pacientes tuvieron un test diagnóstico de SARS-CoV-2 positivo. Se realizaron 30 procedimientos distintos, siendo el más frecuente la apendicectomía ( $n = 13$ , 19,6% de los pacientes). El 61,5% de las apendicitis fueron complicadas frente a un 42,4% en periodo no COVID ( $p = 0,17$ ). El abordaje quirúrgico fue abierto en un 46,1% de los pacientes frente al 6,1% no COVID ( $p = 0,004$ ). No hubo diferencias estadísticamente significativas en la tasa de complicaciones o la estancia hospitalaria.

**Conclusiones.** Durante la pandemia por SARS-CoV-2 se ha producido una importante disminución del número de procedimientos diarios, pasando a ser más de la mitad de carácter urgente. La patología apendicular se ha presentado más evolucionada de lo habitual, habiendo una clara tendencia a la cirugía abierta frente a la laparoscopia.

**PALABRAS CLAVE:** SARS-CoV-2; COVID-19; Cirugía pediátrica.

## INTRODUCTION AND OBJECTIVE

Since the first new coronavirus (SARS-CoV-2) cases were detected in December 2019, expansion was quick worldwide, with the WHO officially declaring it a pandemic on March 11, 2020<sup>(1)</sup>. In Spain, the state of emergency was declared on March 13. With the reorganization

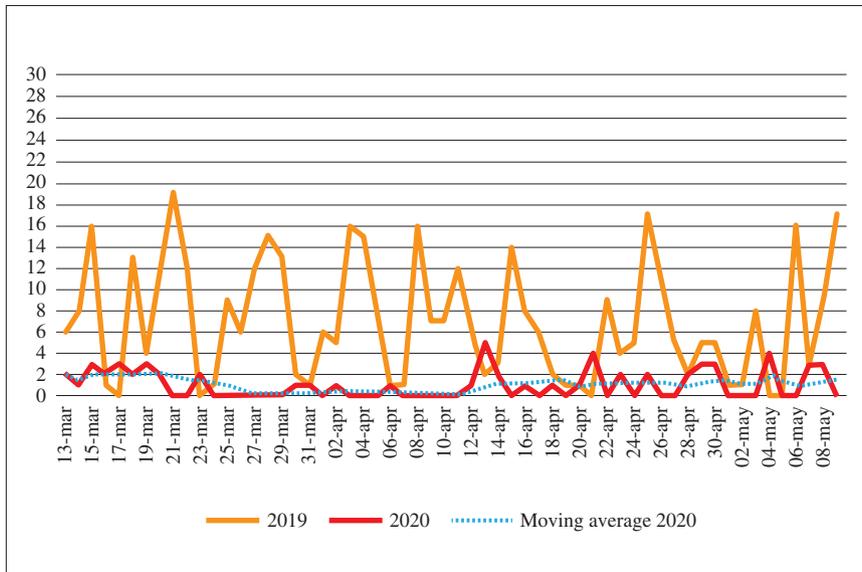
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Date of submission: May 2020

Date of acceptance: September 2020



**Figure 1.** Evolution in the number of procedures over time. The number of procedures is represented on the ordinate axis, and the date (day-month) is represented on the abscissa axis. The dark, solid line represents the evolution of the number of procedures in 2020. The dotted line represents the moving average of the number of procedures in the previous 7 days. The light, solid line represents the number of daily procedures in the same period in 2019. Political changes: 03/14 beginning of the state of emergency in Spain; 03/21 reorganization of pediatric departments in Madrid; 03/31 activity limited to essential departments; 04/13 activity resumed in non-essential departments; 04/26 citizens under 14 years of age allowed to go out 1 hour per day; 05/2 beginning of phase 0, with the whole population being allowed to go out at certain time slots according to age.

of pediatric care in the region of Madrid on March 21, our healthcare facility's emergency department was no longer considered a reference center – it regained its status on May 7. On-call pediatricians and pediatric surgeons were still available for urgent, non-deferrable pathologies, for chronic patients under regular follow-up at our healthcare facility, and for newborns. Hospital rooms remained open in spite of low occupancy as a result of decreased admissions from the emergency department. The Pediatric Intensive Care Unit (PICU) had the number of beds reduced from 11 to 7. The Neonatal Care Department remained open at usual levels owing to increased activity as a result of obstetric care reorganization in the region, with childbirths mainly taking place at our healthcare facility and two further hospitals.

Following such reorganization, pediatric surgical activity at our healthcare facility significantly changed both from a qualitative and a quantitative standpoint.

The primary objective of this study was to describe the characteristics and demographics of the surgical procedures carried out during the pandemic. The secondary objective was to study the impact of the pandemic on the acute appendicitis cases treated at our healthcare facility and to compare them with a pre-SARS-CoV-2 period.

## MATERIALS AND METHODS

A retrospective study of all patients undergoing surgery at the pediatric surgery department in the SARS-CoV-2 pandemic period, from the beginning of the state of emergency in Spain (March 13, 2020) until the first restrictions were removed, was conducted. Activity resumed with the reopening of the external consultations and the pediatric emergency departments in our healthcare area on May 9, 2020.

In this period, three types of surgeries were performed: urgent surgeries in patients coming directly from home, urgent surgeries in patients already in hospital, and scheduled surgeries. Only preferential patients with a potentially worsening prognosis or clinical situation if not operated on within 1 month were scheduled.

In addition, a comparative analysis of the main characteristics of patients undergoing appendectomy in this period vs. a control group was carried out. The control group was made up of patients undergoing surgery in the same period in 2019.

The following data were collected for all patients: demographic variables, type of surgery (scheduled or urgent), presence or absence of SARS-CoV-2 test and test result, pathology, and surgical procedure. The indication for SARS-CoV-2 test (polymerase chain reaction (PCR) of a nasopharyngeal swab sample) request was compliant with the protocol in force at our healthcare facility at the time of surgery. These data were collected from patients' clinical history.

Statistical analysis was performed using the IBM SPSS Statistics software, version 22. Comparison between variables was carried out using the Chi square test while applying Fisher's exact test and Student's t-test as required. Statistical significance was established at  $p \leq 0.05$ .

## RESULTS

The study covered a 58-day period, with 61 patients undergoing surgery, a total of 76 procedures, and a mean of 1.05 daily patients. In the same 2019 period, 406 patients underwent surgery, with a mean of 7 daily patients ( $p < 0.00001$ ). The evolution in the number of procedures over time is featured in figure 1. 59.01% of surgeries were urgent, whereas 40.99% were scheduled (76.1% in 2019,

**Table I. Procedures carried out.**

<i>Procedure</i>	<i>n</i>	<i>Procedure</i>	<i>n</i>	<i>Procedure</i>	<i>n</i>
Appendectomy	13	Bronchoalveolar lavage	2	Anorectal malformation colostomy	1
Permanent catheter placement	8	Intestinal resection	2	Urethral dilation	1
Esophageal dilation	6	Double J stent removal	2	Open duodenoduodenostomy	1
Abscess drainage	6	Muscular biopsy	1	Laparoscopic gastrostomy	1
Endoscopic explorations under anesthesia	6	Renal biopsy	1	Laparoscopic inguinal hernia repair	1
Permanent catheter removal	5	Anal calibration	1	Laparoscopic oophorectomy	1
Esophageal foreign body removal	3	Tracheoesophageal fistula closure	1	Open diaphragmatic plication	1
Testicular detorsion and orchiopexy	2	Omphalocele primary closure	1	Wound suture	1
Esophageal corticoid injection	2	Abdominal drainage placement	1	Thoracoscopic posterior tracheopexy	1
Urinary substance injection	2	Thoracic drainage placement	1	Laparoscopic-assisted jejunostomy	1

$p < 0.01$ ). 55.2% of patients were male. Mean age was 5.8 years (4.32-7.26), with a median of 3 years (range: 0 days-17 years).

According to the protocols in force at our healthcare facility, a total of 40 PCR tests (69% of patients) were carried out in the 24 hours prior to surgery, 3 of which (5.1%) were positive: a 6-year-old male patient with acute appendicitis and a 14-year-old male patient with mediastinal lymphoma who underwent two surgeries – one for removal of an infected Port-a-Cath (PAC), and one for placement of a new PAC. In addition, two further study patients had a positive PCR result pre- or post-surgery, but not in the previous 24 hours. The first was a 3-month-old male patient undergoing two surgeries, one for removal of an infected PAC, and one for placement of a new PAC and a Hickman catheter. This patient had a PCR positive result on postoperative day 3 following the second surgery. The second was a 13-month old female patient with recurrent tracheoesophageal fistula who underwent surgery for fistula closure. She had a PCR positive result one month prior to surgery, two further subsequent positive results, and then three negative results.

30 different procedures were carried out, with appendectomy being the most frequent one ( $n = 13$ , 19.6% of patients). The remaining procedures are featured in table I. 5 neonatal surgeries were carried out: intestinal resection and intestinal perforation ileostomy, omphalocele primary closure, abdominal drainage placement, anorectal malformation colostomy, and duodenal atresia duodenoduodenostomy.

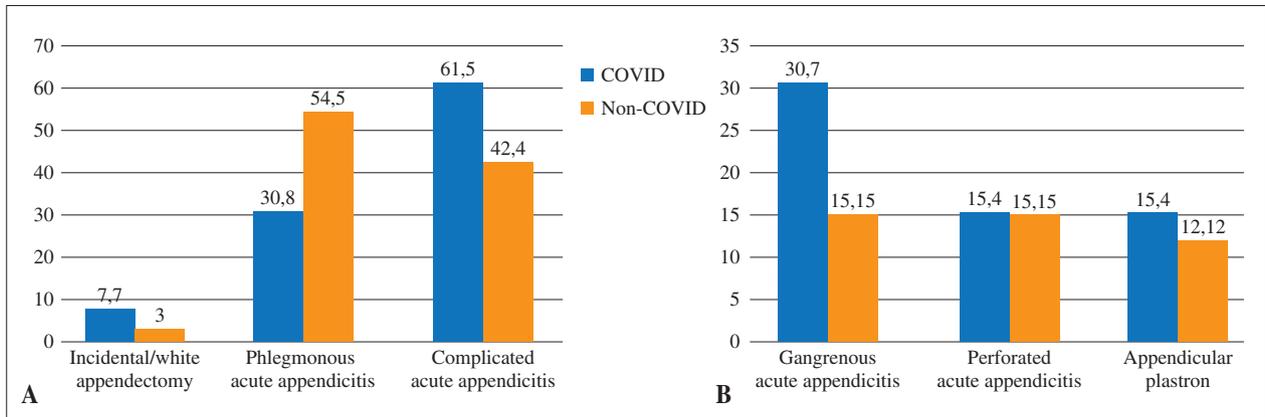
Regarding the most frequent procedure, appendectomy was performed in 13 patients, 53.8% of whom were female. Mean age was 9.77 years (7.55-11.99), with a range of 3-15 years. 30.8% (4/13) of appendicitis cases were simple, 61.5% (8/13) were complicated, and 7.7% (1/13) were normal (incidental appendectomy). Complicated appendicitis cases included gangrenous cases (4/13, 30.7%), perforated cases (2/13, 15.4%), and appendicular plastrons (2/13, 15.4%). The surgical approach was open in

**Table II. Comparison of appendectomies between periods.**

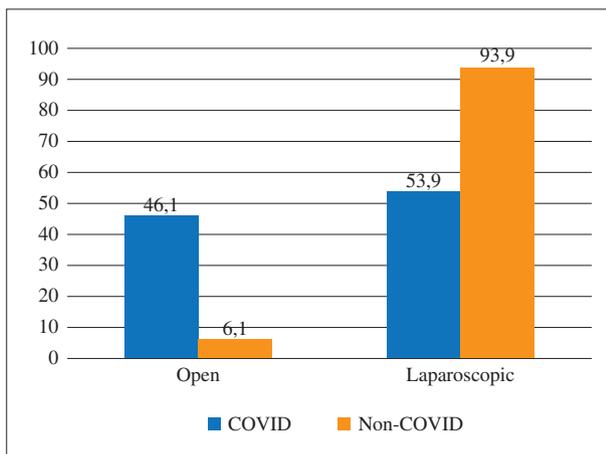
	<i>COVID period</i>	<i>Non-COVID period</i>	<i>p</i>
N	13	33	
Age	9.77 years (7.55-11.99)	11-51 years (10.65-12.38)	0.17
Sex	Male: 46.2% Female: 53.8%	Male: 63.6% Female: 36.4%	0.28
Uncomplicated acute appendicitis	30.8% (4)	54.5% (18)	0.17
Complicated acute appendicitis	61.5% (8)	42.4% (14)	
Gangrenous appendicitis	30.7% (4)	15.15% (5)	
Perforated appendicitis	15.4% (2)	15.15% (5)	
Appendicular plastron	15.4% (2)	12.12% (4)	
Open approach	46.1% (6)	6.1% (2)	0.004
Laparoscopic approach	53.9% (7)	93.9% (31)	
PICU admission	23.1% (3)	9.1% (3)	0.21
Complications	23.1% (3)	12.1% (4)	0.385
Mean hospital stay	4.23 days (1.86-6.6)	3 days (2.04-3.96)	0.192

6 cases (46.2%) and laparoscopic in 7 cases (53.8%). Three patients required postoperative PICU admission (23.1%). 3 patients developed postoperative intra-abdominal collections (23.1% complication rate). Mean hospital stay was 4.23 days (1.86-6.6), with 30.8% of patients staying in hospital for 24 hours or less.

The appendectomy control group in the non-pandemic period was made up of 21 male patients (63.6%) and 12 female patients (36.4%), with a mean age of 11.51 years (10.65-12.38) (range: 5-15 years). The comparison with the pandemic patient group is featured in table II and figures 2



**Figure 2.** A) Comparative bar chart of appendicitis types: the percentage of patients is represented on the ordinate axis, and the type of appendicitis is represented on the abscissa axis. B) Comparative bar chart of complicated appendicitis types: the percentage of patients is represented on the ordinate axis, and the type of complicated appendicitis is represented on the abscissa axis.



**Figure 3.** Comparative bar chart of appendectomy approach: the percentage of patients is represented on the ordinate axis, and the type of approach is represented on the abscissa axis.

and 3. No statistically significant differences were found between patients from both periods in terms of sex distribution ( $p = 0.28$ ) or age ( $p = 0.17$ ). Regarding appendicitis type in the non-pandemic period, 3% (1/33) of procedures were normal appendix cases (white appendectomy), 54.5% (18/33) were simple appendicitis cases, and 42.4% (14/33) were complicated appendicitis cases. Complicated appendicitis cases included gangrenous cases (5/33, 15.15%), perforated cases (5/33, 15.15%), and appendicular plastrons (4/33, 12.12%). No statistically significant differences were found between the two periods ( $p = 0.17$ ). The surgical approach was open in 6.1% (2/33) of cases and laparoscopic in 93.9% (31/33) of cases, with the difference between periods being statistically significant ( $p = 0.004$ ). Three patients required postoperative PICU admission (9.1%,  $p = 0.21$ ). 4 complications (12.1%) were recorded,

all of which were postoperative intra-abdominal abscesses. No statistically significant differences were found in terms of complication rate between both periods ( $p = 0.385$ ). Mean hospital stay was 3 days (2.04-3.96) ( $p = 0.261$ ). 48.5% of patients stayed in hospital for 24 hours or less.

## DISCUSSION

Surgical activity at our healthcare facility's pediatric surgery department was hugely impacted by the SARS-CoV-2 pandemic epidemiological situation. Scheduled activity was reduced to a minimum, with more than half of procedures carried out being urgent. Our organization followed the guidelines established by most surgical associations, both adult and pediatric<sup>(2-7)</sup>, thus cancelling elective surgeries. Separate patient pathways were established for suspicious or confirmed patients vs. non-suspicious patients or negative test patients at the emergency department, at the operating rooms, and at hospital rooms.

In spite of the pediatric activity redistribution carried out in the region of Madrid, patients undergoing surgery were considered ineligible for referral for various reasons. In some cases, referral would have caused a therapeutic delay which could have compromised prognosis, such as in esophageal foreign body removal, testicular torsion, or acute appendicitis with a poor general condition. Other cases included hospitalized patients not eligible for referral as the physician in charge was not present at our healthcare facility, as it was the case with all oncological patients with permanent catheter removal and placement, bronchoalveolar lavage, abscess drainage, muscular and renal biopsies, diaphragmatic plication, double J stent removal, and all neonatal surgeries. Finally, there were some patients with chronic pathologies followed up at our healthcare facility where long-term management made referral unreason-

able, such as esophageal and urethral dilations, digestive endoscopies, tracheoesophageal fistula closure, posterior tracheopexy, and jejunostomy with gastrostomy.

The differences in terms of the procedures carried out in this period *vs.* regular practice were a result of cancelling all elective procedures and delaying preferential procedures due to the lack of operating rooms. Cancellations and delays caused an increase in certain emergencies, such as esophageal stenosis in patients with esophageal atresia. 2 esophageal disimpactions with esophageal dilation and 4 urgent esophageal dilations as a result of poor oral tolerance in patients on a waiting list for scheduled esophageal dilation were required.

The evolution in the number of procedures over time (Fig. 1) had three stages. The first stage was characterized by a moderate decrease as compared to regular practice and went from the beginning of the period to pediatric department reorganization (mean of 2.12 daily patients). The second stage went from pediatric department reorganization to non-essential activity resumption, with activity being almost fully cancelled and a mean of 0.3 daily patients. The third stage started following non-essential activity resumption, with a partial return to normality and a certain increase in activity and patients at the emergency department, but without returning to pre-pediatric department reorganization levels (1.37 daily patients).

In terms of SARS-CoV-2 prevalence in our surgical population, incidence was 5.1%. These data are consistent with those reported in other studies performed in the pediatric population outside Spain, with prevalence ranging between 2-5%<sup>(2)</sup>. In a recent article on pediatric patients from our environment, a growing prevalence of 5.8% was reported in the first lockdown week *vs.* 11.2% in the second lockdown week<sup>(8)</sup>. It should be highlighted that, according to the protocols in force at our healthcare facility, preoperative PCR was not mandatory in the first month, which means there were no reliable data available regarding the first 30 patients. This may explain why various members of the surgical personnel got infected, which occurred at the beginning of the pandemic only. The first positive patient had undergone a preoperative PCR test in the first month as a result of being admitted at the adolescent hemato-oncology unit, where various cases had been recorded. The second patient belonged to the mandatory preoperative PCR period.

Regarding appendectomies, a clear trend towards more advanced clinical sign presentation was noted, but without statistically significant results (increase in complicated appendicitis cases, need for postoperative PICU admission, hospital stay, and postoperative complications). Recommendations not to attend healthcare facilities whenever possible as well as the fear of getting infected when attending the emergency department most likely account for this. Patients had been experiencing clinical signs for various days (sometimes more than one week) *vs.* less than

24 hours in regular practice. Indeed, in the first lockdown week, no acute appendicitis cases were operated on at our healthcare facility, which had never occurred in regular practice.

Although various publications discuss conservative treatment of acute appendicitis<sup>(9-11)</sup>, conservative management has never been considered at our healthcare facility given the absence of a standardized protocol and the lack of experience. Appendectomy as a first-line treatment often reduces hospital stay and symptom duration, and it also prevents the need for surgery in case of conservative treatment failure – which occurs in 5-20% of cases. Therefore, it was considered the treatment of choice during the pandemic.

In addition, surgeons now seem to have a new mindset in terms of surgical approach. Although the laparoscopic approach was largely predominant, a significant rise in the number of open procedures was noted. Speculation around the possibility of minimally invasive surgery in SARS-CoV-2 patients increasing the risk of contagion for operating room personnel may account for this<sup>(5,10-12)</sup>. Indeed, various reports of hepatitis B and human papilloma viral aerosolization at laparoscopic surgeries have been published<sup>(4,6)</sup>. However, there is no clear scientific evidence demonstrating the presence of SARS-CoV-2 particles in the air inside the operating room following a laparoscopic procedure<sup>(4,11)</sup>. Minimally invasive surgery proponents argue that it creates a physical barrier that reduces fluid contagion and operating field cauterization aerosols. Postoperatively speaking, the advantages of laparoscopy are widely known, with shorter postoperative hospital stay being an important parameter when facing a lack of hospital beds, as it was the case. On the other hand, the incision required for open appendectomy in pediatric patients exposes a very small operating field, which means fluid exposure is minimal. Most surgical societies have issued their own recommendations in this respect, but there is no consensus. The Spanish Association of Surgeons and the Spanish Pediatric Surgery Society<sup>(5-7)</sup> agree in that the epidemiological situation should not play a role when choosing the most adequate surgical approach.

## CONCLUSIONS

The SARS-CoV-2 pandemic brought about significant changes in surgical care. Changes were quantitative, with a notable decrease in the number of daily procedures, but also qualitative, with more than half of the procedures being urgent. Elective procedure cancellation caused urgent surgeries in patients waiting for elective surgery to spike. A clear trend towards more advanced pathologies than usual was noted, with acute appendicitis standing out. Owing to aerosolization fears in minimally invasive procedures, more open appendectomies were carried out than usual.

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