

Original Scientific Article

THE IMPACT OF THE COVID-19 PANDEMIC ON PEDIATRIC APPENDICITIS MANAGEMENT AND OUTCOMES

Maja Zečević¹, Zoran Marjanović^{1,2}, Goran Janković¹, Danijela Djerić¹, Zorica Jovanović¹,
Vesna Marjanović^{2,3}, Jelena Lilić³, Danijel Mančić^{4,1}, Dragana Lazarević^{2,5}

¹Clinic for Pediatric Surgery, University Clinical Center Niš, Niš, Serbia

²Faculty of Medicine, University of Niš, Niš, Serbia

³Clinic for Anaesthesiology and Intensive Therapy, University Clinical Center Niš, Niš, Serbia

⁴Health Center Zaječar, Zaječar, Serbia

⁵Clinic of Pediatrics, University Clinical Center Niš, Niš, Serbia

Abstract. *The pandemic caused by the SARS-CoV-2 virus had a significant impact on providing health services the world over and is reflected in pediatric surgery also. The aim of this study was to determine the differences in the prevalence of forms of appendicitis among children during and prior to the pandemic, and to compare the demographic characteristics. A retrospective study which covered a period from September 1, 2018 until September 1, 2021 and all the patients who underwent surgery for acute appendicitis was carried out. Demographic and clinical data were collected and analysed. The study included a total of 267 patients. Prior to the pandemic a total of 160 children underwent surgical treatment, 61.9% boys and 38.1% girls, while during the pandemic a total of 107 underwent surgical treatment, mostly boys 68,2%, and to a lesser extent, girls 31.8%. The average age of the patients was 11.0±3.9 years. Even though there is a difference in the number of children who underwent surgical treatment for perforated appendicitis prior to and during the Covid-19 pandemic, 54:44 or 33.8:41.1%, the difference is not statistically significant. During the pandemic, two patients who tested positive for the SARS-CoV-2 virus received surgical treatment for a perforated appendicitis. The Covid-19 pandemic had an impact on the healthcare system worldwide. In most centers for pediatric surgery, there was an increased incidence of perforated appendicitis without significant deviations in the demographic characteristics, which correlates with the results of this study.*

Key words: *appendicitis, children, Covid-19 pandemic.*

Introduction

The pandemic caused by the SARS-CoV-2 had a significant impact on the healthcare provided worldwide and is reflected on all specialized fields, including pediatric surgery. The negative effects of the Covid-19 were especially noted on the health systems of low- or middle-level income countries [1]. An analysis of Anglo-Saxon literature provides insight into the trend of growth of complicated appendicitis (gangrenous and perforated appendicitis) during the pandemic caused by the SARS-CoV-2 virus, due to the possible fear of infection. As a result, there may potentially be a delay in diagnosis and an increased rate of complications [2]. However, the literature contains contradictory data which indicate that even though the routine in pediatric surgical centers during the pandemic changed significantly, and that there was a decrease in the number of admissions, this did not have an impact on the change in the diagnosis and treatment of acute appendicitis among children [3].

The Aim

The aim of this study is to determine whether there is a difference in the prevalence of clinical forms of appendicitis in the pediatric population during the pandemic compared to a control group from an identical period of time prior to the onset of the pandemic on the territory of the Republic of Serbia, and to compare the demographic characteristics of children who underwent appendectomies due to acute appendicitis.

Materials and Methods

By analysing the medical documents of the Clinic for Pediatric Surgery, University Clinical Center Niš, a retrospective study was conducted which included a three-year period, starting from September 1, 2018 to September 1, 2021. The study included all the patients who during that time underwent surgical treatment at the Clinic for Pediatric Surgery UCC Niš for acute forms of appendicitis. The study did not include any incidental appendectomies carried out during the surgical treatment of some other acute abdominal condition.

The study was performed in accordance with all the recommended guidelines, and the data were first entered into an Excel© table which was solely available to the

Correspondence to: Maja Zečević
Clinic for Pediatric Surgery, University Clinical Center Niš
81 Dr. Zorana Đinđića Blvd, 18000 Niš, Serbia
E-mail: maja.zecevicmd@gmail.com
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researchers, which ensured that the identity of the patients was kept anonymous. Data referring to age, gender, clinical forms of appendicitis, and place of living were collected. The statistical data analysis was carried out in the program package SPSS 16.0. The hypothesis was tested at the $p < 0,05$ level of significance. A period of 18 months prior to the pandemic caused by the virus on the SARS-CoV-2 territory of Serbia was compared to an identical period of time following the onset of the epidemic. A comparison of the continued values prior to and during the pandemic caused by the virus SARS-CoV-2 was carried out using the t-test, while the Chi-squared test was used to compare the categorical features between the groups.

Results

The study included a total of 267 patients who underwent surgical treatment for acute appendicitis in the aforementioned period. Prior to the pandemic caused by the SARS-CoV-2 virus, 160 children underwent surgical treatment, of which 61.9% were boys and 38.1% were girls. From the beginning of the pandemic, a smaller number of children underwent surgical treatment, 107 of them, mostly boys with 68.2%, and to a lesser extent, girls, 31.8%. There is no statistically significant difference in the frequency of occurrence of appendicitis in terms of gender ($p = 0.352$).

The average age of the studied population is 11.0 ± 3.9 yrs. The youngest patient to undergo surgical treatment was one year old, while the oldest was 17. The patients were divided into three age categories: the first one included children aged from birth to the age of four, the second included children aged from 5 to 10, and the third included children aged 11 to 17. The distribution of the age categories of children who underwent surgical treatment is shown in Fig. 1. Most patients treated during the pandemic were aged 11–17 years (64.5%, $p = 0.001$). Children who underwent surgical treatment for acute appendicitis during the pandemic caused by the SARS CoV2 virus are statistically significantly older ($p = 0.002$) than the children who underwent surgery prior to the pandemic.

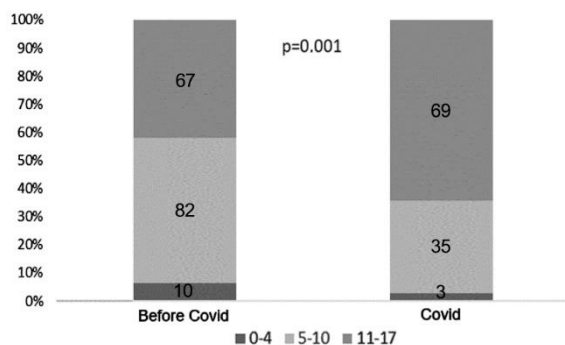


Fig. 1 Age categories prior and during the pandemic

Three-quarters of the patients prior to the pandemic caused by the SARS-CoV-2 (75.6%) were from urban

environments, followed by patients from rural environments (24.4%). The percentage of children from urban and rural environments who underwent surgical treatment during the pandemic is almost identical: 75.7% were children from urban environments, and 24.3% were children from rural areas. The prevalence of patients from Niš in percentages is 21.2% prior to the pandemic and 27.1% during the pandemic, whereby there is no statistical significance ($p = 0.339$). Place of residence was not statistically significantly connected with the number of patients who underwent surgical treatment due to appendicitis prior to and during the pandemic ($p = 0.989$).

The analysis also included the prevalence of clinical forms of appendicitis which correlate with the pathohistological forms prior and during the pandemic caused by the SARS-CoV-2 virus. The comparative results expressed in percentages for both periods of time are shown in Table 1. Even though there is a difference in the number of children who underwent surgical treatment for a perforated appendicitis prior to and during the pandemic caused by the SARS-CoV-2 virus, 54:44 or 33.8:41.1%, this difference is not statistically significant ($p = 0.583$). The other forms of appendicitis do not differ statistically significantly prior to and during the pandemic caused by the SARS-CoV-2 virus.

Table 1 The distribution of forms of acute appendicitis prior to and during the pandemic

	Prior to the pandemic Covid-19	During the pandemic Covid-19
Acute appendicitis	4.4%	2.8%
Phlegmonous appendicitis	22.5%	22.4%
Gangrenous appendicitis	39.4%	33.6%
Perforated appendicitis	33.8%	41.1%

During the pandemic, two female patients aged 4 to 11 underwent surgical treatment in our facility during the aforementioned period due to a perforated appendicitis, who at the time of the surgical treatment tested positive to the SARS-CoV-2. Both children underwent surgical treatment in an operating room meant solely for the care of patients who tested positive to the SARS-CoV-2, with the implementation of the complete protective equipment required by epidemiologists.

Discussion

Acute appendicitis is one of the most frequent types of surgical emergencies in the pediatric population [4]. The onset of the pandemic caused by the SARS-Cov-2 virus had a significant impact on the organization of work in the wards of the pediatric surgery departments, where mostly surgical emergencies are treated, including acute appendicitis. In order to reduce the possibility of spreading the Covid-19 infection, certain surgical centers also decided on the conservative treatment of acute appendi-

itis in children. Coldvin and associates published their results on the non-surgical treatment of appendicitis with a double parenteral antibiotic therapy (amoxiclav and gentamicin) during hospitalization, and the continued perioral antibiotic therapy during outpatient treatment during the pandemic caused by the SARS-Cov-2 virus. The aim was to decrease the exposure of the staff in the operating theatre during anaesthesia, considering the possibility that the patient might be Covid positive. The general success of the antibiotic therapy was 72%, 96% in the case of uncomplicated appendicitis, and 40% in the case of complications, whereby there were no patients who tested positive for the virus SARS-Cov-2 [5]. Other centers opted for the non-surgical treatment of appendicitis among children during the pandemic. Kvasnovsky stated that during the peak of the pandemic, in their facility they treated 45.5% of the children non-surgically, even though 78.2% of the children did not meet the previously published criteria for the non-surgical treatment of acute appendicitis [6].

During the pandemic, acute appendicitis was treated in our facility by relying on the prescribed protective measures against the SARS-CoV-2 virus. An increase in perforated appendicitis of 41.1% was noted, compared to 33.8%, which proved not to be statistically significant. An increase in the incidence of perforated appendicitis among children was noted in other centers worldwide.

Esparaz and associates determined a statistically significant increase in perforated appendicitis during the pandemic caused by the Covid-19 virus (45.6% vs 26.4%; $p < 0.001$) [7]. Similar reported increases in the incidence of perforated appendicitis were published by Schäfer, where the rate of perforation in 2020 was 27.8%, while during 2018–2019 it was 20.7%. The difference was that among younger patients (≤ 11.2 yrs) in 2020 the rate of perforated appendicitis was significantly greater, 37.6%, as opposed to 22.2% in 2018/2019. The age structure of the patients that underwent surgical treatment of 11.2 correlates with the average age of our patients, $11,0 \pm 3,9$ yrs [8]. An increased rate of complicated appendicitis (gangrenous and perforated histopathological forms) of 60.5% during the pandemic, compared to 30.4% during the same period of time the previous year, but without statistically significant demographic deviations was determined by Lee-Archer and associates [9].

The reason for the increased rate of perforated appendicitis among children could also be the prolonged duration of the symptoms prior to the first visit to the doctor. Prior to the pandemic, symptoms usually lasted for one day, while during the pandemic it was two days which proved to be statistically significant ($p = 0.003$) [10]. A multi-centric retrospective study from the USA compared the number of visits to the emergency room in 18 federal states of the USA from January to June 2020, and the number of visits from the same period of time for the previous calendar year. It was determined that the number of visits in the pediatric population initially fell by 74% among children under the age of 10 and by 67% among children aged 14–17, in order for that number to

decrease to 72% and 50% by the end of the studied period [11]. A significantly smaller number of cases of appendicitis among children during the same period of time, compared to the same period of time over a span of 4 years was also published by Hassoun and associates [12].

One of the aggravating factors which can affect the correct diagnosis of acute appendicitis among children during this pandemic is also the emergence of a systemic hyperinflammatory syndrome caused by the SARS-CoV-2 virus, known as MIS-C (Multisystem inflammatory syndrome in children). In such cases, gastrointestinal tract is affected in 92% cases, which could imitate the clinical image of inflammatory bowel disease as well as appendicitis. Jackson and associates published a case study of a nine-year-old girl who underwent surgical treatment on the suspicion of acute appendicitis diagnosed based on the clinical image, radiological findings, and pathohistological findings of the appendix, the clinical image of which differed from acute appendicitis in the sense of necrotic lymphadenitis and vasculitis, as well as Covid-19 antibodies which indicated MIS-C [13].

Anderson published two case studies, one of a girl who was diagnosed with perforated appendicitis and MIS-C, and the other of a patient diagnosed, based on the pathohistological review, with MIS-C even though the clinical image corresponded to acute appendicitis [14]. In our facility there were no cases where children diagnosed with MIS-C underwent surgical treatment due to suspicion of acute appendicitis.

For the duration of the study, two children infected by the Covid-19 virus underwent surgical treatment in our facility for perforated appendicitis. The girls were aged 11 and 4, and the diagnosis was made based on their clinical image, laboratory values, plane abdominal radiographies, and abdominal ultrasounds. Acevado and associates presented 3 cases of acute appendicitis among children with a concomitant Covid-19 infection. All three children were males, and one boy had perforated appendicitis. In two of the cases, an MSCT of the abdomen was also performed for diagnostic purposes [15].

Conclusion

The emergence of the pandemic caused by the SARS-Cov-2 virus had a significant impact on the way healthcare facilities work on a global level, both because of the new challenges in solving typical acute conditions such as appendicitis among children who are routinely tested prior to hospitalization, as well as the new challenges such as diagnosis and surgical treatment of acute appendicitis with a concomitant infection of the Covid-19, and the possibility of misdiagnosis of appendicitis among children with a diagnosis of MIS-C. In most of the centers of pediatric surgery, there is an increased incidence of perforated appendicitis without significant deviations in the demographic characteristics, which correlates with the results of this study.

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