

Acute appendicitis during the COVID-19 pandemic—changes in incidence and clinical presentation but not in patients' outcome

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Abstract

Background: The coronavirus disease 2019 (COVID-19) pandemic is an ongoing severe issue.

Objective: The aim of this study was to compare the incidence, severity and treatment of acute appendicitis (AA) before and during the COVID-19 pandemic.

Methods: A retrospective cohort analysis was conducted between January 2019 and April 2020 in one high-volume center. A comparison was performed between two groups (Group A: patients admitted with AA before the COVID-19 pandemic; Group B: patients admitted with AA at the beginning of the pandemic) in terms of the incidence of AA and clinical and pathological outcomes. The incidence of AA was also analyzed in six surrounding peripheral hospitals.

Results: A total of 94 patients were identified, 54 in Group A and 40 in Group B (57% vs. 43%). Demographic data were comparable between groups. AA in Group B showed a significant higher rate of histological advanced cases (10 (18.5%) Group A vs. 20 (50%) Group B, $P = 0.001$) and the need for postoperative antibiotic treatment (6 (11.1%) Group A vs. 11 (27.5%) Group B, $P = 0.045$). During the pandemic, a higher percentage of patients were treated at peripheral hospitals (Group A: 54/111 vs. 40/126).

Conclusion: During the onset of the COVID-19 pandemic there was a significant decrease of patients with AA in a high-volume center, which showed more advanced disease of AA. This significant decrease in the high-volume center correlates with an increase in patients with AA in peripheral hospitals and represents a change in patient flow during the onset of the pandemic.

Key words: COVID-19, SARS-CoV-2 infections, appendicitis, pandemic, laparoscopic

Introduction

First diagnosed in Wuhan, China, in December 2019, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections and coronavirus disease 2019 (COVID-19) showed exponential growth and worldwide spread, leading to a global pandemic. Although a lot has been learned about the SARS-CoV-2 infection and vaccination is being expedited, the disease is a severe ongoing issue not yet solved. This affects health-care systems all over the world, resulting in a shortage of critical care capacity and health-care workers due to the need of COVID-19 treatment. Thus, elective as well as urgent operations have had to be postponed to spare resources.

In Italy, one of the countries most affected by COVID-19 in Europe, a significant decrease in visits to the pediatric emergency department from 73% to 88% during the acute

pandemic period compared with the same period in previous years was noted [1]. A significant percentage of these patients also required management in the intensive care unit, with higher rates of morbidity and mortality due to delayed care. Others also described this phenomenon. During the lockdown, access and admissions to emergency departments and hospital wards decreased. Fear of contagion may have discouraged access also for pressing health needs. This may result in some patients suffering reduced health or increased risk of death as a result of this decision [2].

Acute abdominal pain accounts for 7–10% of all emergency department visits. In addition to nonsurgical causes of abdominal pain, acute appendicitis (AA) represents one of the most common causes for abdominal pain requiring surgical treatment, accounting for 4.5% [3]. Around 135,000 patients

undergo appendectomy in Germany every year [4]. Therefore, AA is a valid tool to describe surgical admissions to the emergency department. If the diagnosis and treatment of AA is delayed, severe disease with perforation of the appendix and peritonitis may occur. This can significantly increase in the morbidity of AA, which can usually be treated safely.

With rising number of COVID-19 cases, we noticed a significant decline in the number of AA presenting to our institution. A significant decrease in emergency department admissions was also noted during outbreak of the Middle East respiratory syndrome in Korea, although the incidence of acute diseases such as AA should not be affected by respiratory infections itself [5]. In Germany, a pandemic situation as the COVID-19 outbreak is a totally new situation. Thus, the aim of this analysis was to determine the impact of COVID-19 on the incidence of AA in our department and to investigate demographics and outcomes of these patients compared to a setting without COVID-19.

Methods

This single-center retrospective cohort analysis was undertaken at the high-volume University hospital Augsburg (UKA), Germany, that provides a tertiary center healthcare to the entire metropolitan region of Augsburg and surrounding area. The hospital was primarily involved in the treatment of COVID-19 patients in the region. Approval for this study was granted by the ethics committee of the UKA. The requirement for informed consent was waived in the light of the retrospective and anonymous nature of the study. Health diagnostic codes K35 based on the International Statistical Classification of Diseases and Related Health Problems (ICD-9) codes for appendicitis and operation codes 5–470, 5–471 and 5–479 for appendectomy were used to detect patients with AA. All consecutive patients between 01 March and 30 April 2019 as well as 01 March and 30 April 2020 were identified from the institutional electronic database. To detect a potential shift of patients with AA from the high-volume University hospital, which was treating patients with COVID-19 at the beginning of the pandemic, to smaller rural hospitals, data of patients with AA of six nearby hospitals were collected via the same pathway. These hospitals cover the surrounding area of Augsburg and had to deal with fewer patients with SARS-CoV-2 infection in this period (Wertach Clinic Schwabmuenchen, Donau-Ries-Clinics Donauwoerth, Friedberg and Aichach Hospital, Guenzburg Hospital and St. Elisabeth Hospital Dillingen).

Identified patients were verified according to the following inclusion criteria: Patients had to have presented emergently via the emergency department, have either a radiologically or intraoperatively diagnosed AA and have electronic medical records available. With regard to treatment, patients were included if they were treated surgically with laparoscopic or open appendectomy. Patients who underwent surgery for suspected AA and who were subsequently found to have a grossly normal appendix were also included in the study. Children under the age of 16 were excluded.

Demographics of patients were evaluated at admission to the emergency department including age, sex, duration of symptoms, leukocyte count (normal reference range 3.0–10.0/nl) and C-reactive protein (CRP, normal reference range 0–0.5 mg/dl). Furthermore, operation technique and

peri- and postoperative parameters such as length of hospital stay, macroscopic grade of appendicitis (normal appendix, acute but not perforated or perforated appendicitis) and peritonitis (local or generalized), histologic grading, postoperative need for antibiotic treatment and complications (according to the Clavien–Dindo classification [6]) were analyzed. The macroscopic grade of appendicitis and the extent of peritonitis were subjectively assessed by the surgeon. To compare the severity of AA, histologic results were divided into two groups (no/mild/phlegmonous AA vs. severe phlegmonous/necrotic/gangrenous/perforated AA).

The primary goal of the study was to compare the incidence of AA before and during the onset of COVID-19. Secondly, the study tried to analyze whether there was a change in the characteristics or severity of patients diagnosed with AA during the COVID-19 period compared to beforehand.

In order to assess these outcomes, the cohort was split into two groups. Group A represented patients with AA before the COVID-19 pandemic. Recruitment period was defined as 1 March until 30 April 2019. Group B represented patients with AA during the onset of the COVID-19 pandemic in Germany, which started with the first SARS-CoV-2 positive patient in the UKA on 9 March 2020. The corresponding Group B therefore included patients with AA admitted from 1 March until 30 April 2020.

All statistical analysis was performed using SPSS, version 21 (IBM SPSS Statistics for Windows, version 21.0. Released 2012. Armonk, NY: IBM Corp). Continuous variables were compared using *t*-test or Wilcoxon rank-sum test depending on the distribution and are shown as mean and range. Categorical variables are reported as number (*n*) and percentage and compared using Fisher's exact or chi-squared test. A two-sided *P*-value of <0.05 was considered significant.

Results

Demographics

In our institution a total of 94 patients with AA were identified and included for further analysis with 54 patients assigned to Group A and 40 patients to Group B. Demographics between groups were similar with respect to sex and age (Table 1). There was also no difference in patients' condition at the time of presentation in the emergency department. Duration of symptoms until hospital admission (1.6 (±1.2) vs. 2.1 (±1.9) days, *P* = 0.434), total leukocyte count (13.2 (±4.2) vs. 13.6 (±4.3) g/l, *P* = 0.968) and CRP (4.1 (±7.7) vs. 4.9 (±6.8) mg/dl, *P* = 0.225) were similar between Group A and Group B (Table 1).

Peri- and postoperative outcomes

There was a general trend toward more advanced cases of AA in Group B on both intraoperative and histologic evaluation. Nearly all patients underwent a laparoscopic appendectomy, only two patients in Group B required a conversion to open appendectomy due to severe intraabdominal inflammation (*P* = 0.097). Although not significant, intraabdominal findings showed more cases of perforated AA (13% Group A vs. 25% Group B, *P* = 0.134) and local as well as generalized peritonitis (20.4% vs. 32.5%, *P* = 0.182) in Group B. This was confirmed by histological examination. There were significantly more advanced cases of AA in Group B (18.5% vs. 50%, *P* = 0.001). Hence more patients in Group

Table 1 Demographics of patients with AA, mean values

Variable	Total N = 94	Group A N = 54	Group B N = 40	P-value
Age	37.4 (±16.6)	37.2 (±15.6)	37.8 (±17.8)	0.976
Sex				
Male	46 (48.9%)	27 (50%)	19 (47.5%)	0.811
Female	48 (51.1%)	27 (50%)	21 (52.5%)	
Duration of symptoms (days)	1.8 (±1.6)	1.6 (±1.2)	2.1 (±1.9)	0.434
Leukocytes on admission (g/l)	13.4 (±4.2)	13.2 (±4.2)	13.6 (±4.3)	0.968
CRP on admission (mg/dl)	4.5 (±7.3)	4.1 (±7.7)	4.9 (±6.8)	0.225

Table 2 Peri- and postoperative outcomes of patients with AA, mean values

Variable	Total N = 94	Group A N = 54	Group B N = 40	P-value
Length of hospital stay (days)	3.1 (±1.7)	3.0 (±1.6)	3.2 (± 1.8)	0.591
Operation technique				
Laparoscopic appendectomy	92 (97.9%)	54 (100%)	38 (95%)	0.097
Conversion to open appendectomy	2 (2.1%)	0 (0%)	2 (5%)	
Need for postoperative antibiotics	17 (18.1%)	6 (11.1%)	11 (27.5%)	0.041
Peritonitis (local/generalized)	24 (25.5%)	11 (20.4%)	13 (32.5%)	0.182
Grade of appendicitis				
Normal appendix	8 (8.5%)	6 (11.1)	2 (5%)	0.254
Perforated appendicitis	17 (18.1%)	7 (13.0%)	10 (25%)	0.134
Postoperative complications (Clavien–Dindo ≥ 3)	4 (4.3%)	1 (1.9%)	3 (7.5%)	0.205
Histologic result				
No/mild/phlegmonous appendicitis	64 (68.1%)	44 (81.5%)	20 (50%)	0.001
Severe phlegmonous/necrotic appendicitis	30 (31.9%)	10 (18.5%)	20 (50%)	
SARS-CoV-2 infection (pre- and postoperative)	0	0	0	0

B required postoperative antibiotic treatment (11.1% vs. 27.5%, $P = 0.041$). Nevertheless, there was no difference in patient outcomes between groups with similar rates of postoperative complications (Clavien–Dindo ≥ 3) and length of hospital admission. No patient had a SARS-CoV-2 infection preoperative and none acquired an infection during hospitalization (Table 2).

Incidence of AA compared between hospitals

To attribute the reduced number of AA at this high-volume center (total bed capacity 1530) to maybe different numbers of AA cases in surrounding hospitals, we analyzed the total numbers of AA cases of six surrounding peripheral hospitals (radius 40 km, administrative district Swabia, hospital beds ranging from 100 to 250). Despite our institution, these hospitals had to deal less with COVID-19 patients at the beginning of the pandemic. These patients were primarily allocated to the analyzed high-volume University hospital. The number of AA cases in those six hospitals showed an increase in Group B, which is an opposite trend to the numbers of AA at our institution (peripheral hospitals: $n = 111$ Group A/ $n = 126$ Group B; University hospital: $n = 54/n = 40$) (Figure 1). This represents an increase of 15 (14%) patients with AA in peripheral hospitals in pandemic times compared to the previous year, whereas there was a decrease of 14 (26%) patients in our institution.

Discussion

Statement of principal findings

This study could show significantly decreased numbers of patients presenting with AA to the emergency department

in a high-volume hospital with the onset of the COVID-19 pandemic compared to the same period in the previous year. Even though patients' demographics were similar between the pandemic and non-pandemic period, the cases of AA in the COVID-19 period showed a more severe phenotype with significantly more patients requiring postoperative antibiotic treatment because of perforated AA or peritonitis. All these patients could be treated safely without any nosocomial SARS-CoV-2 transmission. The significant decrease in the high-volume center correlated with an increase in patients with AA in peripheral hospitals and represents a change in patient flow during the onset of the pandemic.

Interpretation within the context of the wider literature

Decreased numbers of AA have been reported by other authors. The reduction of both elective surgery and surgical emergencies during the pandemic has been reported worldwide. An Italian multicenter study reported a 45% reduction of hospital admissions due to surgical emergencies during the lockdown period [7]. Although there was no increase in severity of cases, a large retrospective analysis from Israel including 378 patients noticed a reduced incidence of AA from 62.7% to 37.3% in the COVID-19 pandemic [8]. This trend was explained by a possible successful cure of mild appendicitis treated symptomatically by patients at home.

We analyzed the 'first wave' of the COVID-19 pandemic in Germany. With the first admission of a COVID-19 patient on 9 March 2020 to our hospital, we defined the period from March until April 2020 as the 'pandemic' Group B and as Group A corresponding months from the previous year. The

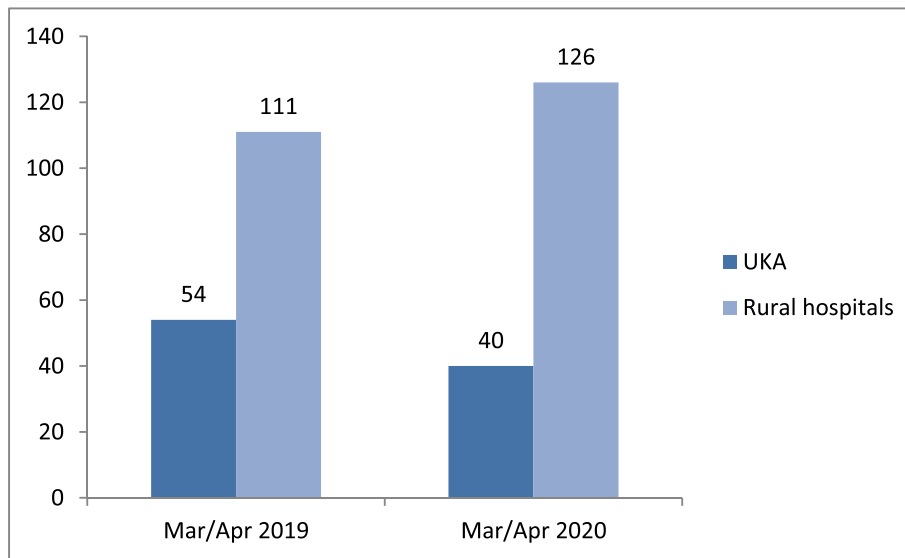


Figure 1 Total numbers of patients with AA admitted to main high-volume center (UKA) and six surrounding rural hospitals. Group A: March/April 2019, Group B: March/April 2020.

fact that there might be seasonal differences in the incidence of AA with more cases found in summer [9] can therefore be disregarded in this study. At the beginning of the COVID pandemic in Germany, restrictions were made with a total ‘lockdown’, which was achieved by closure of stores of the retail sector and also limitations in meeting other persons with the call of reducing personal contacts to a minimum. People were also called upon to go only to an emergency department if really necessary in order to relieve pressure on health-care institutions. It is widely known that epidemic situations can lead to fear and a mental health burden. This can now be observed as well in the COVID-19 outbreak, which has a new global scale [10–12].

Results from a study evaluating computerized tomography (CT) scans of patients with AA during the pandemic period support our observed increase of severity of AA. The proportion of AA diagnosed by abdominal CT as well as the severity of the diagnosed AA was higher during the acute pandemic period (92% vs. 57.1%, $P = 0.003$) [13]. Several other studies also reported a sharp decrease in patients who underwent appendectomy with a higher proportion of complicated AA during COVID-19 pandemic [14–16]. An analysis from Italy with 532 patients found a significant reduction of both admissions for noncomplicated AA and negative appendectomy rate during the pandemic period [17]. Antibiotic treatment as an alternative for surgery of mild AA is well known and now in discussion among surgeons for a long time [18]. Therefore, in the COVID period, many patients with mild symptoms of AA could have received a nonoperative out-hospital treatment with antibiotics or mild AA could have resolved spontaneously. This hypothesis and as outlined above, the fear of contact with to COVID patients in high-volume hospitals could explain fewer admissions to emergency departments. This finding must be viewed in light of the critical role of these high-volume medical centers, which were the first to be involved in the medical care and treatment of COVID-19 patients. Therefore, only anguished patients will find their way to the hospital, which reflects in the higher

severity of cases with AA in our data. Also, the obligatory confinement (lockdown) could have had an effect on the number of appendectomies as shown by registry data [19].

Although there were more severe cases of AA with a higher proportion of peritonitis and patients needing postoperative treatment, these patients were treated safely. There was no difference in the duration of patients’ hospital stay and postoperative complications between the pandemic and the previous year period. Moreover, no patient was infected with SARS-CoV-2 during hospital stay. Minimization of nosocomial transmission is critical to the safe delivery of surgical care. Data from a global survey highlighted a significant risk for pulmonary complications and increased risk of mortality if there is a perioperative COVID-19 infection [20]. A national survey undertaken across academic centers in Ireland in late April and early May 2020 indicated a nosocomial transmission rate of SARS-CoV-2 of less than 5%. Procedural complexity and emergency surgery were significantly associated with the risk of perioperative SARS-CoV-2 (both $P < 0.001$). Against this, laparoscopic surgery showed a protective effect for SARS-CoV-2 transmission [21]. Therefore, patients with AA should not be at risk to get infected with SARS-CoV-2 if treated in hospital.

In order to get a better understanding of patients with AA in the area of Augsburg, Germany, we also analyzed numbers of patients with AA in six surrounding hospitals. Whereas our high-volume center treated 26% less patients with AA in the pandemic period as usual, the other hospitals had to deal with raised numbers (14% more). Thus, the decreased total numbers of patients with AA in our hospitals almost exactly correspond to raised numbers in peripheral hospitals (UKA: decline 15 patients, peripheral hospitals: increase 16 patients). In the non-pandemic period, our hospital normally serves not only the population of the city of Augsburg but also people from different surrounding rural areas. The hospital serves almost 600,000 inhabitants of the city and county of Augsburg [22]. Because of pandemic restrictions, many people were limited in their ability to travel, so they may have

visited hospitals closer to their places of residence instead. Furthermore, pandemic fear maybe led patients to present first to peripheral hospitals, which had less exposure to COVID-19 patients, rather than visiting high-volume centers.

Implications for policy, practice and research

As highlighted above, the totally ‘new’ experience of a pandemic situation in Germany, not only involved massive restrictions on public life but also led to a rapid reorganization of hospital structure. Beside possibilities for treatment of COVID-19 patients, a good COVID-19 management in hospitals with safety precautions for health-care workers and patients and separated pathways and wards for COVID- and non-COVID-patients is crucial to reduce nosocomial transmissions of SARS-CoV-2. Our data highlight that although at the beginning of the ‘new’ pandemic situation, these measures were already effective and safe for patients. Nevertheless, political statements and public regulations have to be made while taking into account that pandemic fear can lead to aggravation of diseases and to redirection of patient flows. Further epidemiologic analyses have to be made to get a wider picture of the distribution of emergency patients to the different types of hospitals during the pandemic.

Strengths and limitations

This study illustrates for the first time the impact of a pandemic situation on the health-care system in Germany, shown exemplary on the cases of AA admitted to hospital as outlined above.

In our institution, patients with perforated AA or peritonitis receive a standardized postoperative antibiotic treatment. Nevertheless, the results on postoperative antibiotic treatment might be biased as it is conceivable that the application of antibiotics could depend on the treating physician.

The principal limitation of this study is that we only evaluated specific patient data from one institution, and we cannot extrapolate these findings to other settings. Data of the analyzed rural hospitals only reflect the total numbers of AA. These data also reflect only the first pandemic wave in Germany. With the evolving nature and growing understanding of the pathogenesis and health-care impact of COVID-19, the evidence base surrounding the conclusions made here may well change in the future. Further long-term assessment of data from patients with AA also during the following ‘second’ and ‘third’ COVID waves in Germany is mandatory.

Conclusion

The onset of the COVID pandemic led to significantly decreased numbers of patients admitted with AA. This possibly represents a shift of patients to less COVID-affected hospitals closer to patients’ residence and maybe a successful resolution of mild appendicitis treated symptomatically by patients at home. Although health-care systems are challenged by the pandemic, these advanced cases of AA, compared to the non-COVID period, could still be treated safely with a minimum risk of nosocomial SARS-CoV-2 infection.

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Data availability

Data are only available for authors.

Code availability

Not applicable.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Because of the retrospective character of this study, no informed consent could be obtained from all individual participants included in the study.

Contribution to the paper

F. S., S. W., D. V., C. S., F. E., P. P. and R. P. acquired the data.

F. S., S. W. and M. A. participated in the research design.

S. W. and M. S. performed statistics.

F. S. and S. W. wrote the manuscript.

All authors contributed to careful review of the paper and approved its submission.

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