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Acute complex appendicitis during the COVID-19 epidemic: A single-institution retrospective analysis based on real-world data

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ARTICLE INFO

Article history:

Received 30 December 2020

Received in revised form 6 March 2021

Accepted 6 March 2021

Keywords:

Acute appendicitis

Acute complex appendicitis

COVID-19

ABSTRACT

Objectives: To investigate the influence of Coronavirus Disease 2019 on incidence of acute complex appendicitis and management of acute appendicitis.

Methods: Patients undergoing acute appendicitis surgery in a single center during the COVID-19 epidemic from January to September 2020 and patients from January to September 2019 were taken as the epidemic group and control group respectively. The clinical characteristics and surgical pathological information were compared between the two groups. The primary outcome measure was complex appendicitis.

Results: A total of 235 patients were included in the study, containing 106 in the epidemic group and 129 in the control group. The patients in the epidemic group had a significantly longer interval from the onset of symptoms to registration (37.92 h vs 24.57 h, $P = 0.028$), from registration to admission (18.69 h vs 8.04 h, $P < 0.001$), and from admission to surgery (7.23 h vs 6.52 h, $P = 0.016$). The epidemic group had a higher incidence of suppurative appendicitis (86.8% vs 76.0%, $P = 0.036$) and a higher incidence of complex appendicitis (35.8% vs 19.4%, $P = 0.005$).

Conclusion: Higher incidence of acute complex appendicitis seemed to occur during COVID-19 outbreak.

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1. Introduction

Since Coronavirus Disease 2019 (COVID-19) first broke out in Wuhan, China at the end of 2019, it has gradually spread all over the world. [1] Until 30 September 2019, the cumulative number of confirmed cases worldwide has exceeded 33.83 million, and the cumulative number of deaths has exceeded 1.01 million, according to the World Health Organization (WHO) statistics. COVID-19 has become a Public Health Emergency of International Concern (PHEIC), [2] that poses a serious threat to people's health and social economic development. At the same time, it has also caused a great impact on the field of medical and health care.

Acute appendicitis is one of the most common acute gastrointestinal inflammatory diseases in children and adults, [3,4] and it is also one of the most common general surgical emergencies worldwide. [5] Most patients can achieve good therapeutic effect by timely appendectomy, [6] but the public health crisis caused by COVID-19 is a barrier to timely surgical treatment. Such as, during the COVID-19 outbreak, many patients described a delay in seeking assessment for their symptoms due to fears of in-hospital COVID-19 infection; [7] some COVID-19 patients also shown gastrointestinal symptoms, [8] which might interfere with

doctors' timely and accurate diagnosis; hospitals would adopt more stringent epidemic prevention measures, [9] which also increased the time of each link from admission to discharge.

The purpose of this study is to investigate the effect of COVID-19 epidemic on acute appendicitis in order to provide reference for the diagnosis and treatment of this disease during the epidemic.

2. Methods

We reviewed records of patients treated for acute appendicitis undergoing acute appendicitis surgery in a single center, during the COVID-19 epidemic periods from January 1, 2020 to September 30, 2020. Patients from January 1, 2014 to September 30, 2019 were considered as control group. Inclusion criteria: acute appendicitis confirmed by postoperative pathology; exclusion criteria: 1. pregnant women; 2. combined with other surgeries; 3. accompanied by appendiceal tumor.

The patients' data were collected from electronic clinical records. Included clinical characteristics data such as age, sex, body mass index (BMI), history of antibiotic use before registration, body temperature at registration, white blood cell count and the proportion of neutrophils; diagnosis and treatment time information such as time interval from onset of symptoms to registration, time interval from registration to admission, time interval from admission to surgery, time of surgery, time interval from surgery to discharge; surgical pathological information

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such as whether the appendix is suppurative, perforated, gangrenous, and whether it is an acute complex appendicitis.

Acute complex appendicitis was defined as the presence of gangrenous appendicitis (assessed by pathological results) and/or perforated appendicitis (determined based on surgical results) [10].

SPSS version 26.0 software (IBM SPSS 26.0, Armonk, NY) was used for data analysis. Continuous variables were expressed as the mean (standard deviation) and categorical variables were expressed as n (%). Chi-square test or Fisher exact test was used for the comparison of categorical variables between groups, and Mann-Whitney test was used for the comparison of continuous variables between groups. Statistical significance was assumed at $P < 0.05$.

3. Results

During the epidemic of COVID-19 from January to September 2020, we identified 106 patients with acute appendicitis undergoing surgical appendectomy, less than 129 patients in the same period in 2019. According to quarterly analysis, the number of patients admitted in the first quarter of 2020 was only half of that in the first quarter of 2019 (23 vs 46), and there was no significant difference in the number of patients between the two groups in the second quarter (45 vs 46) and the third quarter (38 vs 37) (Fig. 1).

There were no significant differences in age, sex, BMI, body temperature at registration, white blood cell count and the proportion of neutrophils between the two groups ($P > 0.05$). However, more patients received pre-hospital antibiotics during the COVID-19 epidemic period (18.9% vs 7.8%, $P = 0.011$) (Table 1).

In terms of the related time of diagnosis and treatment during COVID-19, the time interval from onset of symptoms to registration was longer (37.92 vs 24.57 h, $P = 0.028$), from registration to admission was longer (18.69 h vs 8.04 h, $P < 0.001$), and from admission to surgery was longer (7.23 h vs 6.52 h, $P = 0.016$), but there was no significant difference between the two groups in surgery time and postoperative hospital stay ($P > 0.05$) (Table 2).

Indicated from the surgical pathology that during the epidemic of COVID-19, suppurative appendicitis was more common (86.8% vs 76.0%, $P = 0.036$), and the proportion of gangrenous appendicitis was also higher (17.9% vs 7.8%, $P = 0.018$). Although there was no significant difference in perforated appendicitis incidence between the two groups, the incidence was higher during the COVID-19 epidemic period (25.5% vs 17.8%, $P = 0.154$). Overall, during the epidemic of COVID-19, there was a higher incidence of acute complex appendicitis (35.8% vs 19.4%, $P = 0.005$), of which the incidence of acute complex appendicitis in the second quarter was mostly significantly different between the two groups (37.8% vs 13.0%, $P = 0.007$), although the difference in the

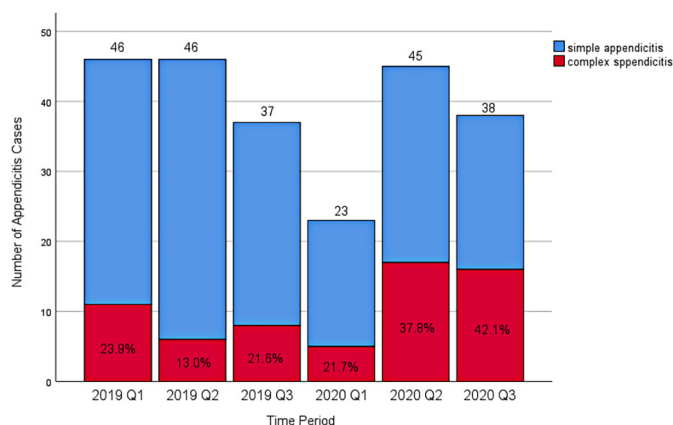


Fig. 1. Quarterly statistics on the number of acute appendicitis patients undergoing appendectomy, and the proportion of acute complex appendicitis by quarter.

Table 1

Comparison of clinical characteristics of patients with acute appendicitis before and after the epidemic period

| | Control period (n = 129) | COVID-19 period (n = 106) | P |
|--|-----------------------------|------------------------------|-------|
| Age (years), mean (SD) | 32.8(17.4) | 35.3(16.5) | 0.957 |
| Female, n (%) | 42(32.6) | 42(39.6) | 0.261 |
| BMI ≥ 24 , n (%) | 53(41.1) | 42(39.6) | 0.820 |
| History of antibiotic use before registration n (%) | 10(7.8) | 20(18.9) | 0.011 |
| Body temperature ≥ 37.3 °C, n (%) | 51(39.5) | 36(34) | 0.379 |
| WBC $\geq 10 \times 10^9$, n (%) | 100(77.5) | 87(82.1) | 0.389 |
| NEUT% ≥ 0.7 , n (%) | 114(88.4) | 96(90.6) | 0.587 |

BMI: body mass index; NEUT%: the proportion of neutrophils; SD: standard deviations; WBC: white blood cell count.

third quarter did not show statistical significance. The incidence of acute complex appendicitis also apparently increased (42.1% vs 21.6%, $P = 0.057$) (Table 3, Fig. 1).

4. Discussion

At present, the COVID-19 epidemic has spreaded all over the world, and all countries are actively taking various prevention and control measures. [11–13] It is gratifying that some achievements have been made, however, the cumulative number of infections all over the world continues rising, and there is even a second round of outbreaks in some areas. [14] Since the outbreak of the COVID-19 epidemic at the end of 2019, strict prevention and control measures have been taken in Chinese mainland area. At present, the epidemic has been basically brought under control and normal life has gradually resumed, but the prevention and control measures have not been relaxed. Our results showed that the number of surgeries for acute appendicitis varies with the development of the epidemic. On the whole, the number of surgeries during the epidemic was less than that of last year. Previous studies suggested that the incidence of appendicitis demonstrate seasonal variability, [15] we analyzed the number of surgery for acute appendicitis by quarter, and the results showed that the number of surgery in the first quarter of 2020, when the epidemic was most serious, was significantly less than that in the same period in 2019. However, in the second and third quarters, as the epidemic was basically brought under control, it gradually returned to the usual level. However, the incidence of acute complex appendicitis increased significantly in the second and third quarters, which also reflects that the diagnosis and treatment of patients with acute appendicitis is still affected by the epidemic, showing a trend of severity and complexity of the disease.

It has been reported that due to the impact of the epidemic, patients have reduced their visits to hospitals for fear of increased risks of COVID-19 infection. [7] The number of visits to the department of emergency surgery decreased, [16] as well as the number of patients in other disciplines, including the postponing of urinary surgical procedures, [17] decreased outpatient hemodialysis, [18] interruption of organ transplantation, [19] and so on. The incidence of acute appendicitis has also decreased, which is consistent with our findings. [20,21] However, patients' fear of going to the hospital leads to delayed treatment, unfortunately, acute complex appendicitis rates increasing linearly with duration of symptoms. [22,23] It is precisely in our study that during the epidemic period, the time interval from the onset of symptoms to medical treatment in patients with acute appendicitis was significantly prolonged, while the proportion of patients with suppurative appendicitis was higher, and the incidence of complex appendicitis was also higher. It has also been reported that the perforation rate of acute appendicitis in children increased during the epidemic, [7] and the incidence of complex appendicitis increased in the United States and other areas, [24,25] which is consistent with our research results.

Table 2
Comparison of diagnosis and treatment time information of patients with acute appendicitis before and after the epidemic period

| | Control period (n = 129) | COVID-19 period (n = 106) | P |
|--|--------------------------|---------------------------|--------|
| Time from onset of symptoms to registration (hours), mean (SD) | 24.57(24.122) | 37.92(28.767) | 0.028 |
| Time from registration to admission (hours), mean (SD) | 8.04(7.349) | 18.69(12.646) | <0.001 |
| Time from admission to surgery (hours), mean (SD) | 6.52(5.836) | 7.23(8.293) | 0.016 |
| Time of surgery (minutes), mean (SD) | 71.18(61.235) | 62.97(30.502) | 0.157 |
| Time from surgery to discharge (days), mean (SD) | 2.60(2.075) | 2.65(2.334) | 0.460 |

Table 3
Comparison of surgical pathology information of patients with acute appendicitis before and after the epidemic period

| | Control period (n = 129) | COVID-19 period (n = 106) | P |
|---------------------------------|--------------------------|---------------------------|-------|
| Suppurative appendicitis, n (%) | 98(76.0) | 92(86.8) | 0.036 |
| Gangrenous appendicitis, n (%) | 23(17.8) | 27(25.5) | 0.154 |
| Perforated appendicitis, n (%) | 10(7.8) | 19(17.9) | 0.018 |
| Complex appendicitis, n (%) | 25(19.4) | 38(35.8) | 0.005 |

Our study also suggests that there is a significant increase in the proportion of pre-hospital use of antibiotics during the epidemic, which also reflects that patients are more likely to choose their own experience treatment during the COVID-19 epidemic period, and reduce the number of medical counseling.

In our study, it was found that the time interval from registration to admission and from admission to surgery was prolonged during the epidemic period, which reflected the decreased efficiency of doctors and hospital in diagnosis and treatment of acute appendicitis during the epidemic period. There are several reasons for this phenomenon. First, fever is a common symptom of both acute appendicitis and COVID-19 infection, during the epidemic, COVID-19 infection should be excluded first in all patients with fever, [26] therefore the diagnosis and treatment time will inevitably increase due to the examination items not included in routine appendicitis diagnosis, such as Viral nucleic acid testing and pulmonary CT examination. [27] Second, COVID-19 can also present gastrointestinal symptoms, [8] which interferes with the doctor's timely and accurate diagnosis of acute appendicitis. Third, Some studies have suggested that when hospital resources are strained, surgeons should consider using antibiotics alone to manage appendicitis whenever possible, [28,29] and during the COVID-19 epidemic period, patients and doctors also tend to choose conservative treatment for acute appendicitis, instead of choosing surgical treatment directly, they choose surgical treatment only after the disease progresses and conservative treatment fails. In addition, as hospitals take measures such as reducing the number of beds in wards to reduce personnel density during the epidemic, this will increase in-patient waiting times; More stringent ventilation and disinfection measures have also increased the preparation time for the surgery. All of these have caused the delay in the time from registration to surgery, which may also result in the severity and complexity of acute appendicitis.

This study is a retrospective study with inevitable limitations. We only selected patients with acute appendicitis in the first three quarters of 2019 as the control group, the number of patients is limited, which affected the representative of the control group. In our study, we found that the COVID-19 epidemic group had a higher incidence of suppurative appendicitis and a higher incidence of complex appendicitis, but we only analyzed the causes of this phenomenon from the perspective of prolonged diagnosis and treatment time during the epidemic, without taking the effects of other factors into account.

5. Conclusions

Acute appendicitis has become more serious and complicated, and acute complex appendicitis has become more common, since the outbreak of COVID-19. The extended time interval between the onset of symptoms and the surgery during the epidemic period might be the main reason. We suggest that patients with acute appendicitis should seek medical treatment in time on the basis of personal protection. Surgeons should be alert to the high risk of acute complex appendicitis during the epidemic period, and hospitals should optimize the process from registration to surgery for patients with acute appendicitis.

Author contributions

Study concept and design: XH D; Acquisition, analysis, or interpretation of data: All authors; Statistical analysis: YX L, YY; Drafting of the manuscript: YY; Critical revision of the manuscript for important intellectual content: XH D; Study supervision: XH D.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Credit Author Statement

Each of the coauthors has seen and agrees with each of the changes made to this manuscript in the revision and to the way his or her name is listed.

Declaration of Competing Interest

The authors declared no conflicts of interest.

Acknowledgements

Thank you for all the patients included in this study for their contributions to scientific research.

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