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Research Paper

Appendicitis tends to be complicated during the COVID-19 epidemic: A multicentre retrospective study

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HIGHLIGHTS

- A multi-centre large sample size retrospective study
- COVID-19 Epidemic Alters Age Composition of Acute Appendicitis
- COVID-19 Epidemic Promotes Complexity of Acute Appendicitis

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ABSTRACT

Background: In past studies, non-medical factors in the social-healthcare-patient triad associated with the prevalence of COVID-19 have led to delays in the presentation of patients with acute appendicitis and an increase in complications. However, as research progresses, there is increasing evidence of a clinical association between COVID-19 and the development of acute appendicitis.
Methods: The effect of COVID-19 prevalence and associated factors on acute appendicitis in the control (2016–2019) and exposed (2020−2023) groups was derived from a retrospective study of 3070 patients with acute appendicitis from 2016 to 2023.
Results: After the implementation of the restrictions, the rate of acute appendicitis visits in the exposed group compared to the control group dropped sharply in the initial period ($P = 0.047$) and recovered gradually with the relaxation of the restrictions. Similar changes occurred in the number of acute complicated appendicitis visits. In addition, after the lifting of restrictions and the COVID-19 outbreak, the proportion of acute complicated appendicitis in the exposed group increased significantly ($P < 0.001$) and an increase in the number of complicated appendicitis visits was observed ($P < 0.001$) compared with the control group. In addition, the age distribution of acute appendicitis during this period showed an ageing trend ($P = 0.001$).
Conclusion: COVID-19 infections may be more likely to progress to complicated appendicitis after an episode of appendicitis, even if they have been cured for the same period of time. In addition, the proportion of elderly patients with appendicitis increased after the COVID-19 epidemic.

Introduction

The novel coronavirus, SARS-CoV-2 (COVID-19), has circulated globally for over three years since the outbreak. Measures such as tightened restrictions, social distancing, reduced mobility, and avoidance of large gatherings to combat the outbreak. Initial studies showed that these restrictive measures and tendentious propaganda, while reducing the transmission of viral contacts, induced delays in patient attendance and decreased willingness to attend, as well as leading to delays in the attendance of patients with other types of illnesses and even critically ill patients [1–8].

Acute appendicitis, a common acute abdominal condition (11 cases

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per 100,000 people per year) [6], has also been impacted. Studies conducted after the SARS-CoV-2 outbreak suggest a decrease in the number of patients seeking care and an increase in complicated appendicitis [3,7–11]. In addition, the impact of these measures and campaigns is not limited to the patient population, as the psychological stress of healthcare workers is much higher than usual in the context of pandemics and healthcare system collapse, which is exacerbated by the chronic overburdening of the healthcare system [9,10]. The lack of personnel and supplies, in turn, has prompted hospitals to ask surgical departments to perform fewer surgeries in order to save more of their modest healthcare resources to cope with critically ill patients, which, on the other hand, delays the treatment of patients who should be operated on [11].

Acute appendicitis is one of the most common acute abdominal conditions, occurring in 11 out of every 100,000 people per year [12]. Some early studies showed an increase in the proportion of delayed visits and progression of acute appendicitis following the SARS-COV-2 outbreak [3,13–17]. In more recent studies, some authors have further pointed out the structural changes in the epidemiology of acute appendicitis during the pandemic caused by changes in hospital protocols, patient concerns, and timing of surgery, among other factors [18–20]. A significant increase in the number and proportion of complicated appendicitis was found in a large number of studies after the SARS-COV-2 outbreak [21–23]. Some researchers have also suggested that SARS-COV-2 may directly attack appendiceal tissue causing the development and progression of acute appendicitis [18]. However, the number of patients included in these studies was limited.

In this study, we collected data from multiple medical centres located in Wuxi, Jiangsu Province, China, and counted 3070 cases of all surgical treatments for acute appendicitis during the specified time period of 2016–2023. The aim was to explore the possible clinical association between appendicitis and SARS-COV-2 infection.

Methods and materials

Ethical approval

Research Ethics Committee of Wuxi People's Hospital (Reference: EC-20240126-1002) confirms that the study fully complies with the principles of the Helsinki Declaration on Good Clinical Practice (GCP) and approves its implementation (Approval Date: 2023-09-13; Number: KY23118).

Participants and data collection

This is a retrospective cohort study of acute appendicitis involving a total of four large comprehensive medical centres (Wuxi People's Hospital, Wuxi No. 2 People's Hospital, the former Wuxi No. 3 People's Hospital, and Wuxi No. 5 People's Hospital) covering a population of 7,400,000 people in Wuxi, Jiangsu Province, China.

All patients who were diagnosed with acute appendicitis according to the International Classification of Diseases diagnostic code ICD-10 (Appendix. 1) and underwent surgical treatment during January–July in the period of 2016–2023, totalling 3070 patients, were selected from the case database and included in the study.

The number of acute appendicitis episodes, the number of acute complicated appendicitis episodes and the proportion of complicated appendicitis were used as primary outcome indicators. Secondary outcome indicators included gender, age, Body Mass Index (BMI), comorbidities, The American Society of Anesthesiologists (ASA) Score, delay from symptom onset to clinic visit, preoperative vital signs, preoperative laboratory findings, and postoperative hospital stay. In addition, the number of pneumonia and fever (Appendix. 2) cases during the same period was counted as the local area population prevalence status of the SARS-COV-2.

Study design

The 1390 acute appendicitis surgery patients admitted during the period of 2020.1.1–2023.7.31, the period of the novel coronavirus epidemic, were taken as the exposure group; the 1680 acute appendicitis surgery patients during the same time period (2016.1.1–2019.12.31) before the novel coronavirus epidemic were selected as the control group. The differences in the indicators of the exposed and control groups were compared separately.

Statistical analysis

For secondary outcome indicators, frequencies (percentages) were used to describe categorical variables and to compare differences using the chi-square test, and means (95 % Confidence interval, 95 % CI) were used to characterise continuous variables (rank variables) and to compare differences using ANOVA.

For the main outcome indicators, comparability was tested by normality test (Shapiro-Wilk test), and if the test was not passed, it was corrected using removal of outliers or BOX-COX transformation. Statistical differences were compared by *t*-test.

Missing data were supplemented with telephone and mail follow-ups, and data were deleted if they could not be contacted.

$P < 0.05$ is considered a statistically significant difference.

We used Statistical Product and Service Solutions (SPSS, IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp) and Graphad Prism 8.3.0 (GraphPad Prism version 8.3.0 for Windows, GraphPad Software, Boston, Massachusetts USA) for data statistics and analysis.

Results

We included all patients who came to our institution for surgery for acute appendicitis during the period January–July from 2016 to 2023. A total of 3070 patients were included in the study, of which the control group 2016–2019 accounted for 1680 patients (54.72 %), of the exposure group, those in the restrictive measures group included 253 (8.24 %) in 2020, 334 (10.88 %) in 2021 and 364 (11.86 %) in 2022; and those in the group lifted from the restrictive measures 439 in 2023 people (14.3 %). We also collected data on hospital admissions with a diagnosis of "pneumonia and fever" from 2016 to 2023, and included a total of 17,958 patients in the study. Data from 2016 to 2019 were used as a control to briefly determine the prevalence of SARS-COV-2 in the study area from 2020 to 2023 onwards for each time period.

Table 1 presents demographic and clinical characteristics, showing no statistical differences in Sex, BMI, ASA Score, Duration of symptoms, Temperature, Heart Rate, Respiratory Rate, O2 saturations, Hypertension, Arrhythmia, COPD, Diabetes, Drainage tube placement, and Postoperative hospitalization days. Notably, there was a significant shift in surgical modality choice over time ($p < 0.001$), with a decrease in laparoscopic procedures in 2020–2021 and a gradual rebound thereafter. There was a clear change in the age structure($P = 0.001$), which mainly occurred post-derestriction in 2023(Table S1. 2023:$P = 0.002$). In contrast, there was no significant difference in the age of patients with complicated appendicitis (Table S2. 2020–2023: $P > 0.05$). Age segmentation revealed a significant increase in elderly patients and a decrease in the younger group in 2023 after restriction lifting (Table S3). Further analyses indicated a persistent trend toward acute appendicitis complications throughout the post-epidemic era, most pronounced in 2023 after restrictions were lifted (Table 2).

To ensure comparability of the data, we performed normality tests on the data from the control group (Tables S4, S5, S6). Significant variation could be found in the data for May 2016 ($P = 0.003$), so the data for that month were excluded. *Re*-verification revealed that the data of the control group were comparable (Table S7).

The number of episodes of acute appendicitis for each year during

Table 1
Demographic and clinical characteristics.#

Variables	2016–2019	2020	2021	2022	2023	Total	P value
n (%)	1680 (54.72 %)	253 (8.24 %)	334 (10.88 %)	364 (11.86 %)	439 (14.3 %)	3070 (100 %)	
******Patient Characteristics***	***	***	***	***	***		
Age(years),mean(sd)	41.14 (16.4)	40.85 (16.63)	42.15 (16.77)	40.98 (15.44)	44.78 (16.35)	41.73 (16.38)	0.001
Sex							
Female,n(%)	785 (46.73 %)	119 (47.04 %)	137 (41.02 %)	172 (47.25 %)	209 (47.61 %)	1422 (46.32 %)	0.359
Male,n(%)	895 (53.27 %)	134 (52.96 %)	197 (58.98 %)	192 (52.75 %)	230 (52.39 %)	1648 (53.68 %)	
BMI, mean(sd)	22.25 (2.97)	22.17 (2.72)	22.06 (2.66)	22.48 (2.69)	22.21 (2.86)	22.25 (2.87)	0.412
***Perioperative Characteristics**	***	***	***	***	***		
ASA Score, mean(sd)	1.12 (0.4)	1.11 (0.38)	1.14 (0.45)	1.1 (0.36)	1.15 (0.46)	1.13 (0.41)	0.393
Duration of symptoms prior to ED(Hours),mean(sd)	20.56 (17.73)	21.49 (18.11)	21.74 (18.24)	21.2 (18.73)	20.72 (17.36)	20.87 (17.88)	0.785
WBC	12.99 (3.97)	12.73 (3.94)	13.02 (4.02)	12.75 (3.83)	12.98 (4.12)	12.94 (3.98)	0.742
CRP	40.49 (42.5)	35.62 (38.25)	37.37 (39.3)	40.06 (43.33)	40.03 (42.51)	39.63 (41.93)	0.397
***Preoperative Vitals**	***	***	***	***	***		
Temperature,mean(sd)	37.75 (0.9)	37.72 (0.9)	37.76 (0.9)	37.81 (0.88)	37.79 (0.86)	37.76 (0.89)	0.659
Heart Rate,mean(sd)	91.66 (20.43)	90.97 (20.43)	92.58 (20.52)	90.98 (20.22)	91.95 (20.42)	91.67 (20.4)	0.835
respiratory rate,mean(sd)	16.06 (2.62)	16.06 (2.54)	16.15 (2.51)	15.98 (2.7)	15.83 (2.61)	16.03 (2.61)	0.469
O2 saturations,mean(sd)	97.9 (2.4)	97.82 (2.28)	97.82 (2.49)	97.96 (2.18)	97.79 (2.39)	97.88 (2.37)	0.823
***Operative Vitals**	***	***	***	***	***		
Surgical procedure							
Open,n(%)	221 (13.15 %)	75 (29.64 %)	89 (26.65 %)	29 (7.97 %)	21 (4.78 %)	435 (14.17 %)	<0.001
Laparoscopy,n(%)	1459 (86.85 %)	178 (70.36 %)	245 (73.35 %)	335 (92.03 %)	418 (95.22 %)	2635 (85.83 %)	
Drainage tube placement,n(%)	442 (26.31 %)	66 (26.09 %)	97 (29.04 %)	90 (24.73 %)	139 (31.66 %)	834 (27.17 %)	0.139
***Comorbidities**	***	***	***	***	***		
Hypertension,n(%)	649 (38.63 %)	94 (37.15 %)	123 (36.83 %)	133 (36.54 %)	187 (42.6 %)	1186 (38.63 %)	0.37
Arrhythmia,n(%)	32 (1.9 %)	7 (2.77 %)	10 (2.99 %)	8 (2.2 %)	8 (1.82 %)	65 (2.12 %)	0.678
COPD,n(%)	224 (13.33 %)	34 (13.44 %)	48 (14.37 %)	42 (11.54 %)	57 (12.98 %)	405 (13.19 %)	0.856
diabetes,n(%)	350 (20.83 %)	51 (20.16 %)	71 (21.26 %)	80 (21.98 %)	100 (22.78 %)	652 (21.24 %)	0.897
***Postoperative Characteristics**	***	***	***	***	***		
Post-operative hospitalization days,mean(sd)	4.95 (2.73)	4.94 (3.11)	5.15 (3.19)	4.99 (3.49)	4.86 (3.12)	4.96 (2.97)	0.736

BMI: Body Mass Index; ASA Score: The American Society of Anesthesiologists Score; WBC: white blood cell; CRP: C-reactive protein; COPD: chronic obstructive pulmoriary disease.

Table 2
OR of the percentage of complex appendicitis in the exposed group compared to the percentage in the control group by age 2016–2019.

	Age		Total	<20	20–29	30–39	40–49	50–59	60–69	70–79	≥80
2020	**OR**		**1.546**	**1.359**	**1.414**	**1.359**	**2.089**	**0.893**	**3.306**	**2.700**	**1.375**
	95%CI	Lower	1.120	0.410	0.647	0.698	0.875	0.391	1.270	0.616	0.218
		Upper	2.135	4.502	3.091	2.644	4.986	2.041	8.607	11.835	8.669
2021	**OR**		**1.409**	**1.073**	**2.019**	**1.114**	**2.564**	**1.215**	**1.403**	**0.415**	**1.375**
	95%CI	Lower	1.050	0.331	1.031	0.600	1.175	0.608	0.587	0.086	0.218
		Upper	1.892	3.475	3.957	2.069	5.598	2.431	3.349	2.006	8.669
2022	**OR**		**1.243**	**1.199**	**2.719**	**0.898**	**1.554**	**0.681**	**0.771**	**2.314**	**2.375**
	95%CI	Lower	0.928	0.366	1.485	0.479	0.717	0.326	0.252	0.694	1.402
		Upper	1.667	3.923	4.977	1.683	3.369	1.426	2.359	7.723	4.024
2023	**OR**		**2.023**	**2.779**	**1.531**	**2.154**	**2.055**	**1.295**	**4.666**	**1.296**	**1.727**
	95%CI	Lower	1.580	0.926	0.778	1.294	1.075	0.709	2.406	0.549	1.177
		Upper	2.589	8.343	3.016	3.585	3.929	2.365	9.047	3.058	2.535

#OR: Odds Ratio.

2020–2023 was compared with the control group respectively (Table. 3). The results suggested that there was a significant decrease in the number of acute appendicitis in 2020 compared to the control group ($P = 0.047$); whereas, acute complicated appendicitis likewise had a significant decrease in 2020 ($P = 0.038$) and by a significant increase in 2023 ($P < 0.001$).

Table 3
The number of cases of acute appendicitis and acute complicated appendicitis in each year in the exposed group was compared with the control group in an independent samples t-test.

	Year	P value	Mean difference
Total	2020	**0.047**	−167.000
	2021	0.191	−86.000
	2022	0.354	−56.000
	2023	0.735	19.000
Complicated	2020	**0.038**	−9.500
	2021	0.280	3.500
	2022	0.417	2.500
	2023	**<0.001**	54.500

#'Total': Number of acute appendicitis; 'Complicated': Number of acute complicated appendicitis.

Changes in the number of appendicitis episodes in each month of the year in the exposed group were analyzed by independent samples *t*-test (Table. 4). Considered quantitatively, a relatively long-term stable decline in acute appendicitis occurred only in 2020 for a period of 5 months (Feb: $P = 0.036$; Mar: $P = 0.059$; Apr: $P = 0.075$; May: $P = 0.004$; Jun: $P = 0.053$), whereas no stable change lasting >2 months occurred at any other time. For complex appendicitis, on the other hand, two relatively stable increases (Jan: $P = 0.051$; Feb: $P = 0.008$; May: $P = 0.099$; Jun: P = 0.008) occurred in 2023 only in January–February and May–June, and were most significant in February and June, respectively.

Analysis of the proportion of complicated appendicitis revealed significant changes in appendicitis incidence by time period (Table. 5). In terms of annual incidence rates, the proportion of complicated appendicitis increased significantly in 2020, recovered gradually in the

Table 4
An independent samples t-test was performed on the number of monthly episodes of acute appendicitis in the exposed group, as well as the number of monthly episodes of complicated appendicitis.

P value(Mean Difference)		Jan	Feb	Mar	Apr	May	Jun	Jul
Total	2020	0.738 (−4.000)	**0.036 (−33.250)**	0.059 (−45.250)	0.075 (−31.250)	**0.004 (−19.000)**	0.053 (−31.500)	0.152 (−8.250)
	2021	0.164 (−20.000)	0.104 (−21.250)	0.625 (−8.250)	0.337 (−13.250)	0.122 (−3.000)	0.067 (−28.500)	0.569 (2.750)
	2022	0.866 (−2.000)	0.308 (−11.250)	0.645 (7.750)	0.405 (−11.250)	**0.005 (−16.000)**	0.821 (−2.500)	**0.009 (−26.250)**
	2023	0.738 (−4.000)	0.516 (6.750)	0.964 (0.750)	0.890 (1.750)	**0.049 (5.000)**	0.274 (13.500)	0.098 (−10.250)
Complicated	2020	0.920 (0.250)	0.145 (−3.250)	0.103 (−7.750)	0.762 (−1.750)	0.467 (3.250)	0.187 (3.250)	0.415 (−3.500)
	2021	0.920 (0.250)	0.373 (1.750)	0.470 (−2.750)	0.965 (0.250)	0.209 (6.250)	0.245 (−2.750)	0.901 (0.500)
	2022	0.162 (4.250)	0.272 (−2.250)	0.733 (1.250)	0.638 (−2.750)	0.467 (3.250)	0.559 (1.250)	0.548 (−2.500)
	2023	0.051 (7.250)	**0.008 (10.750)**	0.402 (3.250)	0.216 (8.250)	0.099 (9.250)	**0.008 (12.250)**	0.415 (3.500)

#'Total': Number of acute appendicitis; 'Complicated': Number of acute complicated appendicitis.

Table 5
A chi-square test was used to compare the proportion of complicated appendicitis per month in the exposed group with the control group.

Year		Jan	Feb	Mar	Apr	May	Jun	Jul	Total
2016–2019	Complicated(%)	27 (14.36)	33 (17.83)	39 (17.97)	43 (16.73)	27 (13.43)	47 (15.56)	46 (16.14)	262 (16.02)
2020	Complicated(%)	7 (16.27)	5 (38.46)	2 (22.22)	9 (27.27)	11 (22.91)	15 (34.09)	8 (12.69)	57 (22.52)
	P value	0.812	0.135	0.668	0.15	0.118	**0.005**	0.569	**0.015**
2021	Complicated(%)	7 (25.92)	10 (40)	7 (15.21)	11 (21.56)	14 (21.87)	9 (19.14)	12 (16.21)	70 (20.95)
	P value	0.155	0.016	0.831	0.422	0.144	0.524	1	**0.03**
2022	Complicated(%)	11 (24.44)	6 (17.14)	11 (17.74)	8 (15.09)	11 (21.56)	13 (17.80)	9 (20)	69 (18.95)
	P value	0.081	1	1	1	0.187	0.599	0.521	**0.185**
2023	Complicated(%)	14 (32.55)	19 (35.84)	13 (23.63)	19 (28.78)	17 (23.61)	24 (26.96)	15 (24.59)	121 (27.56)
	P value	**0.008**	**0.008**	0.342	**0.035**	**0.026**	**0.019**	0.138	**<0.001**

following two years, but increased more significantly again in 2023 (2020: $P = 0.015$; 2021: $P = 0.03$; 2022: $P = 0.185$; 2023: $P < 0.001$). And further breakdown to monthly data shows that only in 2023 was there an increase in the proportion of long term stable complicated appendicitis (Significant differences (Jan: $P = 0.008$; Feb: P = 0.008; Apr: $P = 0.035$; May: $P = 0.026$; Jun: $P = 0.019$) were observed in January–February and April–June). In addition, the statistical results of the data on "Pneumonia and fever" show a significant decrease in the number of patients in January–June 2020 (Table.S7, Jan-Jun: $P < 0.05$) and a significant increase in January–February and April–June 2023 (Table.S7, Jan: $P < 0.001$; Feb: $P = 0.001$; Apr: $P = 0.007$; May: $P = 0.008$; Jun: $P = 0.034$), and a significant decrease in the number of patients in January–February and April–June (Table.S7; Jan: P < 0.001; Feb: P = 0.001; April: P = 0.007; May: P = 0.008; Jun: P = 0.034).

Discussion

The socially induced phenomena of delayed patient visits, medical depletion and healthcare overwhelm, which have led to a decline in visits, delayed treatment and increased rates of non-operative care for all types of surgical conditions, including appendicitis, have been a recurring theme since the SARS-COV-2 outbreak [4,5,15,17]. This likewise explains the precipitous drop in the volume of acute appendicitis surgeries in the initial period of this study.

Delays in treatment inevitably cause disease progression, and several retrospective studies have noted an increase in complicated appendicitis caused by delays in consultation following SARS-COV-2 outbreaks [13–15,22]. However, due to overly complex and strong social factors, these studies have not been able to explore the clinical association between SARS-COV-2 and acute appendicitis in greater depth. In the present study, we similarly found an increase in complicated appendicitis under the SARS-COV-2 epidemic. Surprisingly, there was an explosive increase in the number and proportion of complicated appendicitis after the lifting of restrictions in 2023. In line with this, the number of cases of patients with "fever and pneumonia", which is the reference for the SARS-COV-2 epidemic, increased dramatically at the same time. This suggests that SARS-COV-2 infection is an important factor in the progression of complications in acute appendicitis. One of the possible explanations for this phenomenon is the excessive immune response induced by the new crown; SARS-COV-2 may directly attack the appendiceal tissues, thus exacerbating the immune response to acute appendicitis, which in turn contributes to the progression of acute appendicitis and the development of complications [18,24].In addition, from our results, it can be found that there seems to be a delay of about one month in the emergence of the peaks of both stable increases in complicated appendicitis in 2023 compared to the increase in SARS-COV-2 infection (Table S8). This suggests that even though the symptoms of SARS-COV-2-infected individuals have subsided, the high titres of antibodies in the body, as well as the high inflammatory response state, still promote the progression of acute appendicitis and the development of complications [25,26].

Despite a large number of studies pointing to an increase in patients with progressive acute appendicitis caused by factors such as delay in consultation [21–23], in this study, complex appendicitis was maintained at a relatively stable level after an initial decline without a significant increase during the period of 2020–2022, when the restriction was imposed. A possible reason for this is that, thanks to the abundant lower hospital healthcare resources in the region, more patients with acute appendicitis may be more inclined to attend local lower hospitals rather than general medical centres as usual due to the long-term publicity, and thus the increase that should have occurred was masked.

In the analysis of patient characteristics, we found that the mean age of patients with appendicitis in the area included in the study underwent a phased and significant increase after the lifting of the restriction. The age composition of both appendicitis as well as complicated appendicitis changed, with a decrease in the proportion of the younger age group (<30 years) and an increase in the middle-aged and older age group, especially the older age group (>60 years). Age is one of the major risk factors for complications of SARS-COV-2 [27–29], and the expression of the classical receptor for SARS-COV-2, ACE2, is influenced by age, with younger people expressing less in their bodies, whereas older people tend to express more ACE2 receptors in appendiceal tissue and thus exacerbate the systemic inflammatory response associated with SARS-COV-2 [26,30]. This explains the preference for older age groups for acute appendicitis following the SARS-COV-2 epidemic. Older people are more affected in patients with appendicitis following SARS-COV-2 infection due to the expression of more ACE2 receptors. This coincides with our view that SARS-COV-2 infection promotes the progression of acute appendicitis.

It is worth noting that we similarly found a change in surgical practices during SARS-COV-2, with the sudden SARS-COV-2 outbreak causing physicians to favour open surgery with relatively safe lumbar anaesthesia [31], which explains the turnaround increase in the proportion of open surgeries from 2020 to 2021. However, at the time of the SARS-COV-2 population epidemic in 2023, the proportion of laparoscopic procedures did not decline again, perhaps at a time when relatively more sophisticated management strategies increased the confidence of medical staff in performing laparoscopic procedures [32].

Of course, this study has some limitations. Data from four tertiary general medical centres were included in this study, and missing data from community hospitals and other lower-level hospitals may have caused bias. In addition, the number of cases of control group 2016 acute appendicitis in May went to other values were significantly different, and the analyses performed after deletion may have had some impact on the results. The association of acute appendicitis characteristics with SARS-COV-2 infection also requires more intuitive statistical and pathological evidence. As a definitive diagnosis of acute appendicitis requires pathological evidence, data from patients who chose safer non-surgical treatment with antibiotics due to less severe and unspecified symptoms may not have been included due to the diagnosis of "abdominal pain to be investigated" [33,34].

In conclusion, we conducted a multicentre retrospective study in an international city in Asia and included clinical data from four integrated medical centres covering a population of >7,400,000 in almost the entire region. Our study suggests that the SARS-COV-2 epidemic still has an impact on acute appendicitis after excluding new crown-associated social factors such as restrictive measures. Our results found that the rate of progression of acute appendicitis increased after SARS-COV-2 infection in the population, and the proportion of elderly patients increased. However, the specific mechanism causing this phenomenon still requires further study.

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Ethics approval statement

This study was approved by the Research Ethics Committee of Wuxi People's Hospital (Reference: EC-20240126-1002; Approval Date: 2023-09-13; Number: KY23118).

CRediT authorship contribution statement

Macheng Lu: Writing – review & editing, Writing – original draft, Visualization, Formal analysis, Conceptualization. **Xiangpeng Kong:** Writing – review & editing, Writing – original draft, Visualization, Formal analysis. **Cong Cheng:** Writing – original draft, Data curation. **Mengmeng Liu:** Writing – original draft, Validation, Data curation. **Yuan Zhang:** Writing – original draft, Validation. **Qiuhua Zhang:** Writing – review & editing, Resources, Funding acquisition. **Tong Wang:** Writing – review & editing, Resources. **Ye Zhang:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization. **Huiqiang Dou:** Writing – review & editing, Supervision, Project administration, Conceptualization.

Declaration of competing interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data availability statement

The data of our included study patients were uploaded to Mendeley Data after removing the privacy information (*https://data.mendeley.com/datasets/2rfdr835fz/draft?a=2653c5e7-6306-460b-9e9f-23637b499091*), if you need the full detailed data, please request it from the Bureau of Statistics of Wuxi City, China, or the four research organizations mentioned above.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sopen.2024.06.009.

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