ORIGINAL ARTICLE

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Reduced number of admissions with acute appendicitis but not severe acute appendicitis at two Sydney hospitals during the first COVID-19 lockdown period

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Abstract

Background: This study investigated whether there was a change in acute appendicitis, appendicectomy admissions or disease severity during the 2020 lockdown period in NSW.
Methods: A retrospective before-and-after study was undertaken of patients admitted to two Sydney hospitals (St. Vincent's and Liverpool Hospitals) who had appendicectomy for presumed acute appendicitis and patients who had confirmed appendicitis but did not undergo surgery. Study periods were the 2020 lockdown period (15 March–15 May 2020), the corresponding period in the previous year, and the 1-month after these periods. Patients were classified as having no, mild or severe appendicitis using operation and histopathological reports.
Results: (Thirty-six percent) fewer patients were admitted with acute appendicitis during the lockdown period compared with the previous year with a substantial reduction in normal/mild appendicitis presentations (OR 0.56, 95% CI 0.34–0.93, $P = 0.03$). There were 46% fewer patients with mild appendicitis during lockdown (56) compared with the previous year (103); numbers of patients with severe appendicitis were very similar (46 vs. 51). There was no increase in number of admissions with severe appendicitis, or in the time from onset of symptoms to admission, in the month following lockdown.
Conclusion: Compared with the previous year, there were markedly fewer admissions with appendicitis during lockdown, with no evidence of a shift to more cases of severe appendicitis nor delayed presentation in the post-lockdown period. It is plausible that some patients with mild appendicitis may have recovered without hospitalization, supporting the importance of implementing trials on non-surgical management of appendicitis.

Introduction

The novel coronavirus, SARS-CoV-2, and the COVID-19 disease it causes, were first detected in Wuhan, China, in December 2019. While the official number of COVID-19 related deaths globally is 5.2 million, using excess deaths data, it has been estimated that between 7 and 13 million people have died since the initial outbreak.[1–3]

The first Australian case of COVID-19 was reported on 25 January 2020, in Melbourne, Victoria. Australian public health measures to prevent the spread of SARS-CoV-2 included closing international borders and mandatory 14 day quarantine in supervised hotels for all arrivals. The state of New South Wales (NSW), population 7.95 million, initiated strict lockdown measures from 15 March until 15 May 2020 (first lockdown period). These measures included stay at home orders for non-essential workers,

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avoidance of non-essential travel, social distancing, hand washing and the compulsory wearing of face masks indoors. These measures were effective in achieving a very low COVID infection and mortality rate in NSW.[4]

Management protocols for patients with acute abdominal pain during this lockdown period included prompt clinical assessment and either early operative intervention or discharge with close follow-up by the surgical team. The goal was conservation of hospital resources and avoidance of unnecessary time in healthcare environments, without compromising patient safety.

We subjectively observed an apparent reduction in acute surgical admissions at the two study hospitals during the COVID-19 lockdown period. The aim of this study was to determine whether the initial COVID-19 outbreak and subsequent containment measures were associated with a change in the rate of admission for acute appendicitis or appendicectomy, and the severity of appendicitis, at two Sydney hospitals.

Methods

We conducted a retrospective before-and-after study of admissions for acute appendicitis at two tertiary level hospitals in NSW, Australia (St. Vincent's Hospital and Liverpool Hospital, located in the east and west of Sydney, respectively). The study period was the 2020 lockdown period (15 March–15 May). The same period in 2019 (15 March–15 May) was the control period. Data for the 1 month following lockdown and the same period in 2019 were also recorded to investigate whether patients may have presented late due to reluctance to attend hospital during the state-wide lockdown. Surgical admission to these hospitals during the study lockdown period was not restricted as there were relatively few COVID-19 cases in the general population. Human Research Ethics Committee approval was obtained for both sites (2020/ETH01863).

Study subjects were those who had appendicectomy for presumed acute appendicitis and patients who did not have appendicectomy but had radiologically confirmed acute appendicitis. Patients were classified as having no appendicitis, mild (also termed simple) appendicitis, or severe (also termed complex) appendicitis, with the histopathology diagnosis selected over the operative diagnosis.[5] The classification of Bhangu *et al.* was used, with modifications, to classify appendicitis, as shown in Table 1.

Table 1 Classification of acute appendicitis†

Category	Macroscopic appearance	Microscopic appearance
Normal appendix	Normal OR mildly inflamed or injected or increased diameter	Normal OR luminal, mucosal or submucosal neutrophils only
Mild (simple) appendicitis	Inflamed or injected or congested or increased diameter +/− serous fluid No perforation, abscess, mass, disseminated purulent fluid	Transmural inflammation
Severe (complex) appendicitis	Inflamed or congested or phlegmonous or gangrenous OR Perforation or abscess or mass or disseminated purulent fluid	Necrosis Transmural inflammation or necrosis

†Modified from the classification system of Bhangu et al.[5]

Statistical analysis

We summarized patient gender, age, clinical characteristics at time of presentation (symptom duration, abdominal tenderness, pre-operative imaging modality, pre-operative white cell-count), treatment (surgery, antibiotic therapy) and length of hospital stay for all included patients. We compared the number of acute appendicitis diagnoses in the 2020 lockdown period to the number of diagnoses during the same period during the previous year, with the difference between these periods expressed as a proportion of the 2019 figure. We also used this approach to compare the 2020 post lockdown period with the same period in 2019. To assess the impact of the 2020 lockdown period on the presentation, severity and management of acute appendicitis, we compared the median duration of symptoms and length of stay between the two study periods using a Mann–Whitney *U*-test; and the proportions of patients managed by surgery, having normal histology; and of those with appendicitis, the proportion classified as having mild versus severe appendicitis using a Pearson chi-squared test or a Fisher's exact test if cell size was less than five. We compared the odds of presenting with normal/mild versus severe appendicitis between the study periods as an odds ratio with a 95% confidence interval (CI). All analyses were conducted using SPSS software (IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp.). A P-value <0.05 was regarded as statistically significant for null hypothesis testing.

Results

A total of 360 patients were included in the study. Of these, 344 patients were included because they underwent appendicectomy for suspected acute appendicitis and 16 patients were included because they had radiological confirmation (CT in all cases) of acute appendicitis (all severe appendicitis) but did not undergo appendicectomy during the study periods. Table 2 shows demographic and clinicopathological data for all patients.

As shown in Table 3, fewer patients were admitted with acute appendicitis during the 2020 COVID lockdown study period compared with the 2109 control period (107 patients versus 168 patients, a 36% reduction). The odds of presenting with normal or mild appendicitis during the lockdown period was lower than the previous year (odds ratio 0.56, 95% CI 0.34–0.93, $P = 0.03$). Of the 256 patients with a final diagnosis of appendicitis, there was a 46% decrease in the number of patients with mild appendicitis between the study and control periods (56 during 2020 lockdown compared with 103 during the 2019 control period). The number of patients with severe appendicitis was similar in both periods (46 patients compared with 51 patients).

Table 2 Patient clinicopathological characteristics and treatment

Characteristic	Study period 2020	Control period 2019
	n (%)	
All	152	208
Time period		
Lockdown/control period, 15 March–15 May, 63 days	106 (70)	169 (81)
Post-lockdown/control period, 16 May–15 June 31 days	46 (30)	39 (19)
Hospital		
Liverpool	91 (60)	126 (61)
St. Vincent's	61 (40)	82 (39)
Sex		
Male	92 (61)	121 (58)
Female	60 (39)	87 (42)
Age, years	36 (18)	36 (16)
Mean (*SD*) (range)	(9–92)	(12–84)
Symptom duration, hours	24 (18–48)	24 (24–48)
Median (IQR) (range)	(3 h–14 days)	(3 h−21 days)
Abdominal tenderness		
Nil	2 (1)	6 (3)
Localized	145 (95)	195 (94)
Generalized	5 (3)	7 (3)
Pre-operative imaging		
Nil	24 (16)	24 (12)
Ultrasound	38 (25)	47 (23)
CT	89 (59)	135 (65)
MRI	0 (0)	2 (1)
Missing	1	
Pre-operative white cell count		
Normal range	40 (29)	87 (43)
Elevated (>11.0 × 10^6/L)	100 (71)	113 (57)
Missing	12	8
Treatment		
Laparoscopic appendicectomy	138 (91)	189 (91)
Appendicectomy via McBurney's incision	0 (0)	4 (2)
Appendicectomy via midline laparotomy	5 (3)	7 (3)
Radiologically guided percutaneous drain	1 (1)	0 (0)
No surgery	8 (5)	8 (4)
Antibiotic therapy		
Yes	134 (88)	198 (95)
No	2 (1)	5 (2)
Missing	16	5

The proportion of patients who underwent operative management was very similar in the 2020 lockdown and the 2019 control periods (94–95%), as was the proportion who had a laparoscopic appendicectomy (90–91%).

Discussion

This study found that admissions with acute appendicitis during the NSW lockdown period of 15 March–15 May 2020 were reduced by approximately one third compared with the same period in 2019. This is consistent with reports of decreased acute healthcare presentations in Australia and globally during the pandemic[6–10] and confirms the general impression of the surgeons at our institutions who were providing acute surgery services during the lockdown period.

Fewer appendicectomies have been performed each year as shown by Australian Institute of Health and Wellbeing data.[11] From July 2013 to June 2014 a total of 40,898 appendicectomies were performed in Australia across all public and private hospitals, equivalent to 174.1/100000 using estimated population data from the Australian Bureau of Statistics. The number of appendicectomies declined by ∼2/100000 population each year after that until July 2018–June 2019 when it was 164.9/100000 population. This small decline is clearly not the explanation for the very marked difference observed between 2019 and 2020 in our study. We acknowledge however that a progressively declining appendicectomy rate is an interesting finding and worthy of further study.

It was thought at the time of the 2020 lockdown that patients may be avoiding hospitalization due to the widely publicized risk of contracting SARS-Cov-2 in hospital and that as a result there may be an increase in delayed presentations with more severe pathology after lockdown ended. Our study shows that this did not occur; the number of patients with severe appendicitis was the same in the month after the lockdown period and in the same month in the previous year, with major changes in the size of the source population for each hospital considered unlikely. There was also no significant difference in the median duration of symptoms prior to presentation during the lockdown period compared with the same period in 2019 or in the month after lockdown versus the same month in 2019. These findings make it unlikely that patients with acute appendicitis requiring appendicectomy simply delayed their hospital presentation until easing of restrictions.

We found that the reduced number of admissions for acute appendicitis during lockdown was mostly due to a reduction in admissions for mild (simple) appendicitis rather than severe (complex) appendicitis. There was a 46% decrease in the number of patients with simple appendicitis (56 during 2020 lockdown compared with 103 during the 2019 control period), whereas the number of patients with severe appendicitis was similar in both periods (46 patients compared with 51 patients). This result suggests that many patients with mild appendicitis may have avoided admission to hospital, presumably to avoid the risk of contracting COVID-19 there.

We do not know if these patients received medical care elsewhere, for example with oral antibiotic therapy from their general practitioner, and we cannot be certain that they were not admitted to other hospitals. Travel restrictions were in place during lockdown that limited movements around Sydney, so it is possible that some patients who would ordinarily have attended either of the relatively large study hospitals chose to attend smaller or private hospitals and underwent appendicectomy at those hospitals. The likelihood that this explains our results is limited, however, as there were no restrictions on travel distance for medical care. The only hospitals with emergency departments near to the study hospitals were other large public hospitals dealing with COVID-19 (Prince of Wales, Royal Prince Alfred, Royal North Shore, St. George, Bankstown and Fairfield Hospitals). There are no private hospitals with emergency departments within 20 km of the study hospitals. We thus consider that although some patients may have undergone appendicectomy elsewhere during the 2020 periods, it seems unlikely that the number of patients doing so would account for the very large (46%) reduction in admissions with mild appendicitis at our hospitals during the 2020 lockdown period. We also note that the observed reduction was only in patients with mild appendicitis, whereas if referral or

Table 3 Clinical characteristics during the 2020 COVID-19 lockdown period and during the 1 month after lockdown compared with the same periods in 2019

Characteristic	Lockdown period $N = 275$			Post-lockdown period $N = 85$		
	2020 lockdown period	2019 control period	*P*-value	2020 1 month period post-lockdown	2019 control month	*P*-value
	n (%)			*n* (%)		
N	106	169		46	39	
Duration of symptoms, hours median (IQR)	24 (17–48)	24 (24–48)	0.20†	24 (19–48)	24 (18–48)	0.70†
Missing values		1		2		
Pathology¶						
Normal appendix	4 (4)	15 (9)		5 (10)	4 (10)	
Appendicitis	102 (96)	154 (91)	0.14‡	41 (90)	35 (90)	1.00‡
Appendicitis severity¶						
Mild	56 (55)	103 (67)		23 (56)	17 (49)	
Severe	46 (45)	51 (33)	0.05‡	18 (44)	18 (51)	0.52‡
Length of stay median (IQR)¶	48 (24–72)	48 (48–96)	0.008†	48 (24–48)	72 (48–120)	0.001†
Missing values		3				

†Mann–Whitney *U*-test. ‡Fisher's exact test. ¶Pathology, appendicitis severity, and length of stay results include both operated and unoperated patients with acute appendicitis (all unoperated patients had severe acute appendicitis on CT scan). IQR, interquartile range.

presentation patterns had changed significantly, we would expect a reduction in admissions with both mild and severe appendicitis.

The general surgeons at both study hospitals were asked to manage patients in accordance with the guidelines from the Royal Australasian College of Surgeons and General Surgeons Australia that followed the guidelines entitled *Intercollegiate General Surgery Guidance on COVID-19* (from the four Royal Surgical Colleges, the Association of Surgeons of Great Britain & Ireland, the Association of Coloproctology of Great Britain & Ireland and the Association of Upper Gastrointestinal Surgeons). The guidelines state 'Where non-operative management is possible (such as for early appendicitis and acute cholecystitis) this should be implemented. Appropriate non-operative treatment of appendicitis and open appendicectomy offer alternatives'. The reason that open appendicectomy was encouraged was that 'Laparoscopy is considered to carry some risks of aerosol-type formation and infection and considerable caution is advised…. Consider laparoscopy only in selected individual cases where clinical benefit to the patient substantially exceeds the risk of potential viral transmission in that particular situation'. In this retrospective study we are unable to assess the extent to which the guidelines were followed and it is possible that some patients were reviewed but not admitted for intravenous antibiotic therapy in an effort to follow the guidelines. Our discussions with consultants and registrars suggest; however, that were no major changes in the management of appendicitis at our hospitals and simply discharging patients with clinical appendicitis would have been unlikely. Contrary to the guidelines, open appendicectomies were not performed instead of laparoscopic and we note that 91% of all appendicectomies during lockdown and the control period the year before were laparoscopic rather than open.

We therefore consider it reasonably likely that during the 2020 lockdown period some, and perhaps many, patients with mild appendicitis recovered without appendicectomy. This suggests that some patients with mild appendicitis will recover without appendicectomy, and furthermore that we may be operating unnecessarily on many patients with mild appendicitis.

Noting that the principle of operative therapy as the standard of care for acute appendicitis was established prior to the discovery of antibiotics and medical imaging methods such as CT scanning, non-operative treatment has been investigated in numerous trials. Suitable patients for safe non operative management have been identified as those with imaging confirmed uncomplicated/simple/mild appendicitis as well as demonstrated absence of appendiceal faecolith by CT or high quality ultrasound, absence of major comorbidities, not pregnant, and able and willing to comply with the full duration of antibiotic treatment.

In a meta-analysis of data from six randomized studies, Findlay *et al.* found an initial failure rate from antibiotic therapy alone of 10.2%.[12] Longer term follow-up studies have demonstrated the five-year failure rate of non-operative management of appendicitis to be 39.1%.[12] From these RCTs we surmise that some of the patients who were not admitted for acute appendicitis during the 2020 lockdown period will require appendicectomy in the future.

A notable public health benefit of lockdown was the reduction in communicable diseases in general due to reduced movement within communities, improved hand hygiene and reduced close contact with others. Cases numbers and deaths from influenza infection during the 2020 winter, for example, were at an historic low.[13] Lockdown provided a unique natural experiment to inform debate on the issue of whether communicable infection may be a causal agent for appendicitis in some cases.[14–16] No change in incidence of appendicitis in population-based studies (which this report is not) would have provided strong evidence against the communicable aetiology hypothesis.

Our interpretation of published studies is that evidence for a communicable disease component has not been convincing. An epidemiological study by Alder *et al.* using U.S. National Hospital Discharge Survey (NHDS) data for 1970 to 2006 (~300 000 discharges per year) showed a similar pattern for annual incidence rates of influenza and non-perforated appendicitis over time, declining before 1995 then increasing (Trace test for co-integration 0.01). However, influenza is primarily a disease of older individuals whereas appendicitis is more often a disease of younger individuals and the study findings that the seasonal variation for influenza (winter) differed from that for appendicitis (throughout the year and summer) does not support influenza as a proximate cause.[14] Furthermore, there is a general lack

of reports or observations of temporospatial clustering of appendicitis cases (including among family members), or observations of outbreaks of appendicitis.[17] A microbiome study of appendicitis in children also reported that changes in the microbiome did not seem to be the primary aetiological event in the vast majority of cases.[16] While we regard a communicable infection as a less likely explanation for our findings given the lack of supportive evidence, we cannot exclude this possibility.

Conclusion

Markedly fewer patients with mild appendicitis were admitted with acute appendicitis during the 2020 lockdown period at the two study hospitals. In contrast, the number of patients with severe appendicitis remained constant despite lockdown. This study is limited to only two hospitals and the results should therefore be interpreted with caution. Even so, it is plausible that some patients with mild appendicitis may have recovered without hospitalization, supporting the importance of implementing clinical trials on strategies for the non-surgical management of appendicitis. A suitable trial design to further investigate management of mild (simple or uncomplicated) appendicitis would include the factors that seem to be associated with successful non-operative treatment, such as CT imaging showing mild appendicitis without a faecolith. As one of the most common surgical presentations, ongoing uncertainty about the pathogenic basis for appendicitis is a major knowledge gap and highlights the importance of further research.

Author contributions

Meryem Al-Abid: Data curation; investigation; writing – original draft. **Ryan Petrucci:** Data curation; investigation; methodology; writing – original draft. **Tamara C. Preda:** Conceptualization; data curation; methodology; project administration; supervision; writing – original draft; writing – review and editing. **Sally J. Lord:** Formal analysis; methodology; supervision; validation; writing – review and editing. **Reginald V. Lord:** Conceptualization; methodology; project administration; supervision; validation; writing – review and editing.

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Conflict of interest

None declared.

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