

Impact of COVID-19 on appendicitis presentations in children in Australia and New Zealand

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Key words

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Introduction

A secondary effect of the COVID-19 pandemic on public health systems worldwide has been delayed or altered presentations of other medical and surgical conditions. As a common emergency surgical condition, where delayed presentation may result in increased morbidity, presentations of appendicitis have been reviewed. A number of studies from Spain,¹ Germany,² Israel³ and the USA^{4,5} have demonstrated delayed presentations and higher rates of complicated appendicitis. Consistent with these findings was a study of UK paediatric emergency attendances.⁶ Several adult studies have also noted increased rates of delayed presentations and complicated appendicitis.^{7–13} Interestingly, despite low rates of COVID-19 and short lockdowns in Australia, one paediatric centre in Australia did report higher rates of complicated appendicitis.¹⁴ This was not, however, universally observed. In Italy, one of the earliest and most

Abstract

Background: In contrast to many countries, the prevalence of COVID-19 in Australia and New Zealand has been low. We hypothesised, however, that a potential secondary effect of the COVID-19 pandemic would be delayed presentation of paediatric appendicitis, with resultant higher rates of complicated appendicitis. This study was an initiative of the Australian and New Zealand Surgery in Children Registrars' Association for Trials collaborative, a trainee-led research group based in Australia and New Zealand.

Methods: A binational multicentre, retrospective review was undertaken of paediatric patients with appendicitis early in the COVID-19 pandemic (20 March–30 April 2020), compared with previous years (2018, 2019). Primary outcomes were the duration of symptoms prior to presentation and the severity of disease.

Results: A total of 400 patients from six centres were included. Duration of symptoms prior to presentation, sepsis at presentation, complicated disease and presence of complications did not differ significantly between time periods. Duration of intravenous antibiotic treatment and overall antibiotic treatment were both significantly shorter during 2020 (2.4 days versus 3.5 in 2018 and 3.0 in 2019 [$P = 0.0038$] and 3.7 days versus 5.2 in 2018 and 4.6 in 2019 [$P = 0.04$], respectively). Management approach did not differ, with the majority of patients managed operatively.

Conclusions: We did not demonstrate any difference in duration of symptoms prior to presentation or other markers of disease severity early in the pandemic. Duration of antibiotic treatment was shorter during this period compared with previous years. Management of children with appendicitis, both simple and complicated, did not appear to change as a result of COVID-19.

affected countries,¹⁵ there was no difference in delayed presentation or rates of complicated appendicitis.¹⁶ One centre in Spain reported similar outcomes.¹⁷ In the USA and Germany, there was no increase in the number of patients with complicated appendicitis, but a decrease in uncomplicated appendicitis.^{18,19}

Australian and New Zealand Surgery in Children Registrars' Association for Trials (ANZSCRAFT) is a trainee-led research collaborative uniquely placed to answer such questions that concern practice across both countries. As an ANZSCRAFT initiative, we aimed to determine the presentation and management of paediatric appendicitis in Australia and New Zealand early in the COVID-19 pandemic.

Methods

A retrospective review was conducted of paediatric patients with a diagnosis of acute appendicitis over three time periods (20 March–

Table 1 General demographics of study participants

Patient characteristic	2020	2018	2019	<i>P</i>
Total number of patients	144	129	127	—
Male: female	85:57	79:50	80:47	ns (<i>P</i> = 0.87)
Mean age (years)	10.1 ± 3.2	10.1 ± 3.2	9.7 ± 2.8	ns (<i>P</i> = 0.53)
Australia: NZ	106:38	86:43	91:36	—

ns, not significant.

30 April; 2018, 2019 and 2020). These time periods were chosen based on the timing of border closure to non-residents, requirements for forced quarantine, and strict self-isolation measures in both countries. Control periods were 12 and 24 months prior. Data from six hospitals with paediatric surgical units across Australia and New Zealand were included for analysis (Canberra Hospital, ACT; Monash Health, VIC; Perth Children's Hospital, WA; Wai-kato Hospital, NZ; Wellington Hospital, NZ and Starship Children's Hospital, NZ).

Exclusion criteria were patients aged 16 years or over, those undergoing planned interval appendectomy, as well as those with a final diagnosis other than appendicitis (based on histopathology for operatively managed patients or radiological diagnosis for non-operatively managed patients).

The primary outcomes of our study were incidence of delayed presentation (as defined by duration of symptoms in days prior to presentation) and severity of disease (presence of sepsis or septic shock at presentation, length of stay, complicated disease as defined by perforation and presence of complications). Sepsis was defined as systemic inflammatory response syndrome in the presence of, or as a result of, suspected or proven infection.

Secondary outcomes included the management approach (incidence of non-operative management and open appendectomy compared with laparoscopic appendectomy). We hypothesised that the duration of symptoms prior to presentation, the incidence of perforated appendicitis and complications would be higher during COVID-19 when compared with previous years.

Table 2 Severity of disease outcomes

	2020	2018	2019	<i>P</i> -value
Duration of symptoms (days)	2.2 (±1.9)	2.0 (±1.3)	2.3 (±2.0)	ns (<i>P</i> = 0.54)
Sepsis on presentation, <i>n</i> (%)	25 (17.4%)	14 (10.9%)	21 (16.5%)	ns (<i>P</i> = 0.27)
Complicated disease, <i>n</i> (%)	49 (34.0%)	44 (34.1%)	52 (40.9%)	ns (<i>P</i> = 0.41)
Length of stay (days)	3.0 (±2.4)	4.1 (±3.1)	4.2 (±7.5)	ns (<i>P</i> = 0.09)
Duration of IV antibiotics (days)	2.4 (±2.3)	3.5 (±2.9)	3.0 (±2.9)	<i>P</i> = 0.0038
Total antibiotic course (days)	3.7 (±4.1)	5.2 (±5.0)	4.6 (±4.9)	<i>P</i> = 0.04
Complications, <i>n</i> (%)	15 (10.4%)	24 (18.6%)	17 (13.4%)	ns (<i>P</i> = 0.15)
Ileus	2 (1.4%)	14 (10.9%)	7 (5.5%)	—
Bowel obstruction	0 (0%)	6 (4.7%)	1 (0.8%)	—
Parenteral nutrition	0 (0%)	9 (7.0%)	2 (1.6%)	—
Post-appendectomy abscess	5 (3.5%)	9 (7.0%)	7 (5.5%)	—
Interventional radiology drainage of collection	1 (0.7%)	4 (3.1%)	1 (0.8%)	—
Return to theatre	1 (0.7%)	5 (3.9%)	2 (1.6%)	—
Wound infection	1 (0.7%)	1 (0.8%)	2 (1.6%)	—
Readmission	4 (2.8%)	7 (5.4%)	5 (3.9%)	—
Other complications	7 (4.9%)	4 (3.1%)	5 (3.9%)	—

Data reported as mean ± standard deviation, or as a percentage of the total.

Statistical analysis was performed using Prism 9 (GraphPad Software, LLC). *P*-value of 0.05 was considered significant. Ethics approval was obtained at each centre separately, as per local protocols.

Results

General demographics

A total of 400 patients were identified with a diagnosis of appendicitis over the study period (120 days total). This included 144 patients in 2020, 129 patients in 2018 and 127 in 2019 (Table 1). There was no significant difference in age or sex breakdown between the three groups.

Duration of symptoms

The mean duration of symptoms prior to presentation to the hospital was 2.2 days in 2020, compared with 2.0 days in 2018 and 2.3 days in 2019 (*P* = 0.54) (Table 2).

Severity of disease

Although a greater percentage of patients presented with features of sepsis or septic shock in 2020 compared with other years (17.4%, compared with 10.9% in 2018 and 16.5% in 2019), these findings did not reach statistical significance. Similarly, rates of complicated appendicitis (confirmed perforation on histopathology or imaging findings) were not significantly different between years (34.0% in 2020, compared with 34.1% in 2018 and 40.9% in 2019; *P* = 0.41).

Length of stay in hospital was shorter in the 2020 cohort, but this did not reach statistical significance (3.0 days, compared with 4.1 days in 2018 and 4.2 in 2019; *P* = 0.09). Duration of intravenous (IV) antibiotic therapy was significantly shorter in 2020 (2.4 days, compared with 3.5 in 2018 and 3.0 in 2019; *P* = 0.0038), as well as overall duration of antibiotics (3.7 days in 2020, compared with 5.2 in 2018, and 4.6 in 2019; *P* = 0.04).

Table 3 Management approach to children with appendicitis

	2020	2018	2019	P-value
Operative management, <i>n</i> (%)	140 (97.2%)	126 (97.7%)	125 (98.4%)	ns (<i>P</i> = 0.80)
Operative approach	—	—	—	—
Laparoscopic	137 (97.9%)	126 (100%)	122 (97.6%)	—
Open	3 (2.1%)	0 (0%)	3 (2.4%)	—

Complications

Complications were reviewed, including ileus, bowel obstruction, need for parenteral nutrition, post-appendectomy abscess, interventional radiology drainage of collection, return to theatre, wound infection or re-admission within 30 days. Other complications included acute kidney injury, urinary retention with urinary tract infection, pleural effusion, chronic pain and pneumonia.

Overall 15 patients experienced complications in 2020, compared with 19 in 2018 and 17 in 2019 (10.4, 18.6 and 13.4%, respectively; *P* = 0.15). There was no statistically significant difference between time periods. Ileus and post-appendectomy abscess development were the most common complications seen throughout the study (Table 2).

Management approach

The majority of patients during each time period were managed operatively; 140/144 in 2020, 126/129 in 2018, 125/127 in 2019 and (Table 3). During the 2018 time period, one other patient was also initially managed non-operatively however proceeded to surgery due to clinical deterioration. Of those patients who were operatively managed, the majority underwent laparoscopic procedures (137/140 in 2020, 126/126 in 2018 and 122/125 in 2019).

Comparison of appendicitis in Australia and New Zealand

During the study period in 2020, patients in New Zealand demonstrated a significantly higher incidence of sepsis at presentation (47.4 versus 6.6%) when compared with patients in Australia (Table 4). Patients in New Zealand also reported longer duration of symptoms at presentation (2.7 versus 1.7 days) and had higher rates of complicated disease (44.7 versus 30.2%), although these findings

Table 4 Comparison of outcomes in Australia and New Zealand 2020

	Australia	New Zealand	P-value
Duration of symptoms	2.0 (±1.8)	2.7 (±1.9)	ns (<i>P</i> = 0.07)
Sepsis at presentation, <i>n</i> (%)	7 (6.6%)	18 (47.4%)	<i>P</i> < 0.0001
Complicated disease, <i>n</i> (%)	32 (30.2%)	17 (44.7%)	ns (<i>P</i> = 0.11)
Complications, <i>n</i> (%)	12 (11.3%)	3 (7.9%)	ns (<i>P</i> = 0.80)
Length of stay (days)	3.2 (±2.6)	2.7 (±1.5)	ns (<i>P</i> = 0.24)

Data reported as mean ± standard deviation, or as a percentage of the total.

Table 5 Comparison of outcomes in Australia and New Zealand 2018

	Australia	New Zealand	P-value
Duration of symptoms	1.8 (±1.0)	2.4 (±1.7)	<i>P</i> = 0.02
Sepsis at presentation, <i>n</i> (%)	7 (8.1%)	7 (16.3%)	ns (<i>P</i> = 0.23)
Complicated disease, <i>n</i> (%)	24 (27.9%)	20 (46.5%)	<i>P</i> = 0.0486
Complications, <i>n</i> (%)	13 (15.1%)	11 (25.6%)	ns (<i>P</i> = 0.16)
Length of stay (days)	3.8 (±2.6)	4.6 (±4.0)	ns (<i>P</i> = 0.19)

Data reported as mean ± standard deviation, or as a percentage of the total.

were not statistically significant. Complication rates and length of stay was shorter in the New Zealand cohort but, again, this did not reach statistical significance.

During the 2018 period, patients in New Zealand reported longer duration of symptoms (2.4 versus 1.8 days, *P* = 0.02) and had higher rates of complicated disease (46.5 versus 27.9%, *P* = 0.0486) (Table 5). Rates of sepsis at presentation were higher than in the Australian cohort (16.3 versus 8.1%) but were not statistically significantly different. We did not demonstrate any difference in primary outcomes between the two countries during the 2019 period (Table 6).

Discussion

We had hypothesised that markers of disease severity in children with appendicitis would be higher during COVID-19 compared with previous years. The results of our study, however, did not demonstrate a significant difference overall in the duration of symptoms prior to presentation, nor in the rates of complicated appendicitis during COVID-19. Rates of sepsis or septic shock at presentation were higher during 2020 compared with previous years; however, this did not reach statistical significance. These findings differ from those previously reported in another centre in Australia.¹⁴ The authors did not report on other variables, such as duration of symptoms or presence of sepsis. Complicated appendicitis was also defined as any patient with free pus, gangrene or perforation, in contrast to our study where we limited this to patients with confirmed perforation on histology or imaging (for patients not managed operatively).

In contrast, other markers of disease severity, including duration of intravenous antibiotic treatment and overall duration of antibiotics, were significantly reduced in the 2020 cohort. The reason for this difference is unclear, given that other variables, including rate

Table 6 Comparison of outcomes in Australia and New Zealand 2019

	Australia	New Zealand	P-value
Duration of symptoms	2.3 (±2.1)	2.1 (±1.9)	ns (<i>P</i> = 0.66)
Sepsis at presentation, <i>n</i> (%)	12 (13.2%)	9 (25%)	ns (<i>P</i> = 0.12)
Complicated disease, <i>n</i> (%)	37 (40.7%)	15 (41.7%)	ns (<i>P</i> > 0.99)
Complications, <i>n</i> (%)	11 (12.1%)	6 (16.7%)	ns (<i>P</i> = 0.57)
Length of stay (days)	4.5 (±8.7)	3.5 (±2.6)	ns (<i>P</i> = 0.50)

Data reported as mean ± standard deviation, or as a percentage of the total.

of complicated appendicitis and presence of complications, did not differ significantly. Length of stay during the COVID-19 period was over a day shorter than the previous years, although this did not reach statistical significance. Concern regarding public hospital resources, such as inpatient beds and personal protective equipment during the early days of the pandemic, may have resulted in earlier discharge of some patients and shorter duration of treatment in an effort to conserve resources. Similarly, though not measured in the study, the authors recall several instances of parental anxiety at spending any more time than necessary in healthcare facilities.

During 2020, we demonstrated significantly higher incidence of sepsis or septic shock in New Zealand patients compared with those in Australia. Duration of symptoms and rates of complicated disease were also higher in this cohort, although this did not reach significance.

Given the similar public health approaches of Australia and New Zealand during the initial weeks of the COVID-19 pandemic, it is unclear why these outcomes differed between the two countries. The New Zealand response was somewhat stricter and more unified than the Australian response, where more variation was seen between states.²⁰ During the majority of the study time period the entirety of New Zealand was at Alert Level 3 (closure of all non-essential businesses as well as schools) or Alert Level 4 (full lockdown).²¹ Most elective surgeries (all non-acute planned surgeries) were also postponed from March 24 onwards.²² More stringent public health measures and messaging in New Zealand potentially may therefore have contributed to parental anxiety and delayed presentation. In contrast, the Australian response varied somewhat more from state to state during the study period. Both Victoria and the ACT brought forward school holidays as well as transitioning to remote learning, whereas in Western Australia although families were encouraged to keep children at home schools remained open.²³ Elective surgeries were also scaled back in each of the states and territories involved in the study, although Category 2 and select Category 3 procedures had been recommenced in the ACT towards the end of the study period. Overall, rates of sepsis and complicated disease were higher in New Zealand compared with Australia across all three-time periods. This may potentially imply an underlying demographic difference between the two populations.

In our study, children with appendicitis, both simple and complicated, were nearly universally managed with laparoscopic appendectomy across the different time periods. We did not demonstrate any significant differences in the management approach during COVID-19, either in terms of non-operative management, nor in the operative approach.

Our results indicate that the early stages of the COVID-19 pandemic did not result in a change in the practice of paediatric surgeons in Australia and New Zealand in terms of their management of paediatric appendicitis. This stands in contrast to data from other countries with high rates of COVID-19 affected patients. In particular, studies from the United Kingdom during a similar time frame demonstrated much higher rates of non-operative management and of open, rather than laparoscopic, appendectomies during COVID-19.^{24,25} These practice changes reflect the advice of the UK Intercollegiate General Surgery Guidance, which recommended both conservative management of appendicitis where possible and open appendectomy when not. In contrast to the UK response,

guidelines from the Royal Australasian College of Surgeons (RACS) regarding safe surgical practices during COVID-19 (first published 9 April 2020) did not recommend avoidance of laparoscopic procedures.²⁶

In regards to choice of operative or non-operative management, RACS guidelines²⁷ did advise that surgeons should opt for non-operative management wherever possible. Emergency operations necessary for patients with acute, life-threatening conditions were still to proceed. Despite this recommendation, we did not show an increase in non-operative management of appendicitis during COVID-19. Laparoscopic appendectomy was still the preferred treatment of appendicitis in children in Australia and New Zealand. As new data, emerge regarding the safety and efficacy of non-operative management of appendicitis in children^{28,29} there is potential for this paradigm to change. Surgery was, however, clearly the treatment of choice in all centres involved in this study.

Conclusion

Despite the significant upheaval caused by COVID-19, we did not identify an increase in the rates of complicated appendicitis in children in Australia and New Zealand in the early days of the pandemic. Delayed presentation and markers of disease severity (sepsis on presentation, complicated disease or presence of complications) did not significantly differ between the studied time periods. Duration of intravenous antibiotic treatment and total antibiotic treatment was shorter in 2020 compared with previous years. Whether this is related to public health policy and resource preservation, or even parental preference, is unclear.

We cannot make conclusions about the reasons for the lack of difference in presentation patterns, be it secondary to the lower population rate of COVID-19 or successful public health messaging (advising people with severe illness to still present to healthcare services).

Clearly, much has changed in both countries since the study period, with the development and administration of vaccines, new, highly transmissible variants and a move away from an elimination strategy in both countries. The relevance of our findings, however, remains, as lockdowns, pausing of elective surgery and stay-home advice may once again be instituted. Should these measures be taken, possibly in smaller, more targeted areas, the advice must remain that parents bring their unwell children to be assessed in a timely fashion. Paediatric surgical units must also remain equipped to deal with a similar number of acute cases and this must be factored in to any decisions on redeployment or reallocation of resources.

Conflict of interest

None declared.

Author contributions

Kiera Roberts: Data curation; formal analysis; writing – original draft; writing – review and editing. **Tim Little:** Data curation; writing – original draft; writing – review and editing. **Jessica Rayner:** Conceptualization; investigation; methodology; project administration. **Ela**

Hyland: Conceptualization; investigation; methodology; project administration. **Damir Ljuhar:** Conceptualization; investigation; methodology; project administration. **Sebastian King:** Supervision; writing – review and editing. **Tim Greer:** Investigation. **Adelene Houlton:** Investigation. **Vivek Meiyappan:** Investigation. **Prabal Mishra:** Investigation. **Rosemary Lane:** Investigation. **Alexandra Rout:** Investigation. **Youzhi Zhao:** Investigation. **Pagan Tawhai:** Investigation. **Georges Tinawi:** Investigation.

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A APPENDIX

ANZSCRAFT (Australia and New Zealand Surgery in Children Registrars' Association for Trials) Collaborative

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