

The impact of Victorian COVID-19 lockdowns on the presentation and management of acute appendicitis

Ashray Rajagopalan [†], Blake Roschach,^{*} Katherine Grant ^{*}, Jasprit Singh,^{*} Marek Bak,^{*} Marjorie Burgess,^{*} Kerry Liu,^{*} Nevin Chen ^{*}, Jack Menzie,^{*} Sarah Chew,^{*} Namankit Gupta ^{*}, Naomi Frederick,^{*} Lachlan Hegarty,^{*} Carina Chan,^{*} Samuel Penfold,[†] Anysha Walia[†] and Daniel Croagh[†]

^{*}Department of General Surgery, Monash Health, Melbourne, Victoria, Australia and

[†]School of Clinical Sciences at Monash Health, Monash University, Melbourne, Victoria, Australia

Key words

appendicitis, COVID-19, pandemics, public health, time-to-treatment.

Correspondence

Dr Ashray Rajagopalan, Department of General Surgery, Monash Health, 246 Clayton Road, Clayton, VIC 3168, Australia.

Email: ashray.rajagopalan@monashhealth.org

A. Rajagopalan MBBS; **B. Roschach** MD;
K. Grant MBBS; **J. Singh** MBBS; **M. Bak** MBBS;
M. Burgess MBBS; **K. Liu** MBBS;
N. Chen MBBS; **J. Menzie** MD; **S. Chew** MBBS;
N. Gupta MD; **N. Frederick** MD; **L. Hegarty** MD;
C. Chan MD; **S. Penfold** MD; **Anysha Walia** MD;
D. Croagh MBBS, FRACS.

The corresponding author is not a recipient of a research scholarship.

This is an open access article under the terms of the [Creative Commons Attribution-NonCommercial-NoDerivs](https://creativecommons.org/licenses/by-nc-nd/4.0/) License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

Accepted for publication 5 March 2022.

doi: 10.1111/ans.17655

Introduction

The COVID-19 pandemic has generated an international health crisis and has forced the implementation of restrictions within and between countries globally. Despite relatively low case numbers, the COVID-19 pandemic has presented unique challenges for the delivery of healthcare within Australia. Restrictions on individual movement, known as ‘lockdowns’, have been enforced around Australia intermittently throughout the pandemic to limit the spread of the COVID-19

Abstract

Backgrounds: The COVID-19 pandemic presents ongoing challenges for healthcare. Stay at Home orders (‘lockdowns’) and community fears have been suggested to create reluctance to seek healthcare. We aimed to determine whether the rates of perforated appendicitis and negative appendectomy have been affected by the pandemic, and to analyse the effect of lockdowns on the management of acute appendicitis in Victoria.

Methods: We conducted a retrospective audit of emergency appendicectomies performed under adult General Surgery units at Monash Health in Victoria from January 2019 to September 2021, including 242 days of lockdown.

Results: 2459 patients were included. Fewer patients had perforated appendicitis during the second lockdown (6.3% versus 10.7% baseline; $p = 0.027$). The rate of negative appendectomy was reduced during the first lockdown (4.1% versus 14.9% baseline; $p = 0.002$) and during intervals between lockdown in 2021 (9.8%; $p = 0.010$). There was no difference in the rate of perforated appendicitis or negative appendectomy at other times. Time to surgery and number of appendicectomies performed were also not significantly different. Fewer appendicectomies were performed after hours during lockdowns and in 2021 more generally compared to baseline ($p < 0.05$).

Conclusion: The lower negative appendectomy rate during the first lockdown may reflect increased pre-operative imaging or clinical observation for undifferentiated presentations. There was a reduction in perforated appendicitis during the second lockdown, and no significant difference at other times. Contrary to other studies, lockdowns associated with the COVID-19 pandemic may not create a reluctance to seek healthcare in all regions.

virus. Healthcare delivery and systems have been altered and services prioritized to prevent overwhelming burden on the system, however, these prioritisations and the encouragement of self-isolation could prevent timely and effective care of patients with non-COVID disease.

It has been theorized that lockdowns, in combination with fear of entering the healthcare setting due to COVID-19, have resulted in a reluctance to seek healthcare by community members in Australia.¹ The existing literature supports this, where there have been fewer presentations to metropolitan Emergency Departments during

COVID-19 lockdowns in Melbourne,² Sydney,³ South Australia⁴ and New Zealand.⁵ Victoria has been the most affected state in Australia by the COVID-19 pandemic, with multiple extended periods of lockdown during 2020 and 2021.

We conducted a retrospective audit to examine the effect of the COVID-19 pandemic on the presentation of appendicitis managed

by General Surgical teams at Monash Health. We aimed to determine whether the rates of perforated appendicitis and negative appendicectomy have been affected by the COVID-19 pandemic, as well as to analyse the effect of lockdowns on the management of acute appendicitis in these centres in Victoria.

We examined whether COVID-19 related protocols, as well as reductions in elective surgery bookings, affected time from initial presentation to surgery, the volume of appendicectomies performed or the proportion of operations performed after hours. The analysis hopes to provide information that may assist in the management of hospital and government responses during the ongoing COVID-19 pandemic as well as future epidemics.

Table 1 Lockdown dates

	Days	Dates
Prior to COVID-19 pandemic	440	1/1/2019–15/3/2020
Prior to first lockdown	15	16/3/2020–30/3/2020
During first lockdown	43	31/3/2020–12/5/2020
Between first and second lockdowns	57	13/5/2020–8/7/2020
During second lockdown	111	9/7/2020–27/10/2020
Between second and third lockdowns	108	28/10/2020–12/2/2021
During third lockdown	5	13/2/2021–17/2/2021
Between third and fourth lockdowns	99	18/2/2021–27/5/2021
During fourth lockdown	14	28/5/2021–10/6/2021
Between fourth and fifth lockdowns	35	11/6/2021–15/7/2021
During fifth lockdown	12	16/7/2021–27/7/2021
Between fifth and sixth lockdowns	8	28/7/2021–4/8/2021
During sixth lockdown	57	5/8/2021–30/9/2021

Table 2 Rate of perforated appendicitis

	% (n)	Comparison versus prior to COVID-19 pandemic
Prior to COVID-19 pandemic	10.7% (114/1069)	<i>Baseline</i>
First lockdown	12.2% (12/98)	<i>p</i> = 0.609
Second lockdown	6.3% (19/301)	<i>p</i> = 0.027
Third, fourth and fifth lockdowns	15.8% (12/76)	<i>p</i> = 0.180
Sixth lockdown	12.0% (16/133)	<i>p</i> = 0.656
Intervals between lockdown 2020	12.1% (45/373)	<i>p</i> = 0.442
Intervals between lockdown 2021	12.7% (52/409)	<i>p</i> = 0.268

Methods

We performed a retrospective audit of adult patients who underwent emergency appendicectomy at Monash Health, a metropolitan health network in Victoria, from January 2019 to September 2021 for suspected appendicitis. Monash Health includes three acute General Surgery units (Monash Medical Centre, Dandenong Hospital and Casey Hospital). We defined the COVID-19 pandemic as beginning with the initial declaration of a State of Emergency in Victoria on 16th March 2020, and lockdowns as being those times during which ‘Stay at Home’ orders were imposed. These ‘Stay at Home’ orders required individuals to remain at home apart from specified purposes, such as seeking medical care, obtaining essential supplies, or work in an authorized industry.

There was no change to institutional protocols regarding the management of patients with suspected appendicitis during the pandemic, and surgical appendicectomy continued to be performed as clinically, biochemically or radiologically indicated, unless patients tested positive for COVID-19. During lockdown periods, patients were routinely swabbed for COVID-19 pre-operatively and surgery delayed until a negative result was returned, unless time critical. Time critical operations or operations for patients with COVID-19 were able to proceed with use of full personal protective equipment.

Fig. 1. Comparison of perforated appendicitis rates during COVID-19 pandemic.

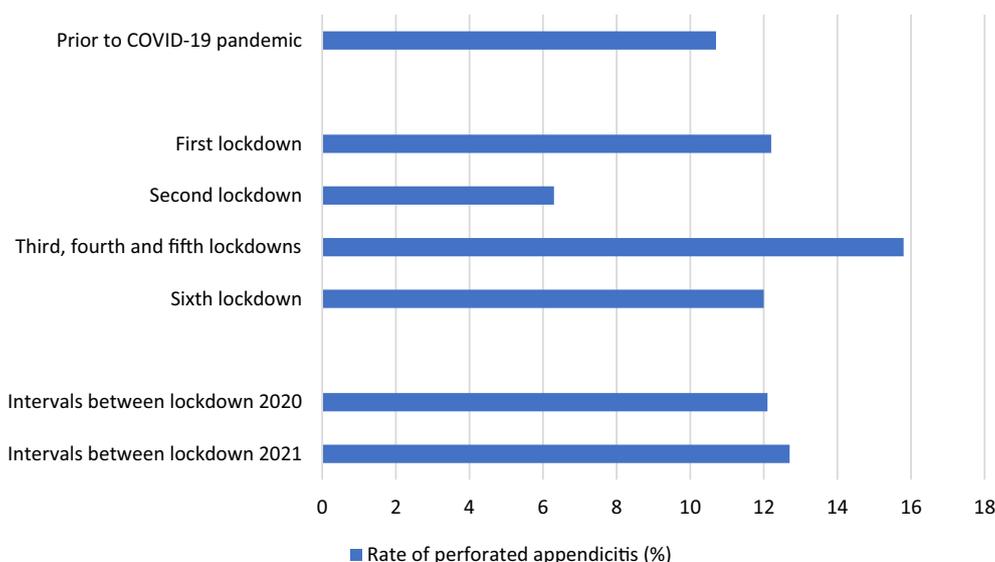


Table 3 Rate of negative appendectomy

	% (n)	Comparison versus prior to COVID-19 pandemic
Prior to COVID-19 pandemic	14.9% (159/1069)	<i>Baseline</i>
First lockdown	4.1% (4/98)	$p = 0.002$
Second lockdown	13.6% (41/301)	$p = 0.644$
Third, fourth and fifth lockdowns	15.8% (12/76)	$p = 0.868$
Sixth lockdown	14.3% (19/133)	$p = 1.000$
Intervals between lockdown 2020	12.1% (45/373)	$p = 0.196$
Intervals between lockdown 2021	9.8% (40/409)	$p = 0.010$

We analysed rates of perforated appendicitis, negative appendectomies, number of appendectomies performed, proportion of operations performed after hours, and time to surgery during lockdowns and intervening periods outside of lockdown since the beginning of the COVID-19 pandemic. Lockdowns 1, 2 and 6 were analysed individually (duration 43, 111 and 57 days, respectively), whilst shorter lockdowns 3, 4 and 5 in 2021 (maximum 14 days duration) were combined and analysed as a single lockdown period. Intervals between lockdowns were combined and analysed according to year.

Given that this is a retrospective audit, exemption from formal ethics approval was obtained and this study was registered institutionally as a Quality Assurance activity. Patients eligible for inclusion in the study were all patients aged 16 years or over who had an emergency appendectomy between January 2019 and September 2021. There were no exclusion criteria for the study. Data were collected using Monash Health electronic medical records (Cerner) and online pathology results (Monash Pathology). Cases were identified using operative records and theatre booking data. Operations commenced before 7 am or after 7 pm were considered 'after hours', and time to surgery was defined as time from initial presentation to the Emergency Department to the surgical start time. Histopathology

Table 4 Mean number of appendectomies performed per day

	n	Comparison versus prior to COVID-19 pandemic
Prior to COVID-19 pandemic	2.4	<i>Baseline</i>
First lockdown	2.3	$p = 0.998$
Second lockdown	2.7	$p = 0.626$
Third, fourth and fifth lockdowns	2.5	$p = 1.000$
Sixth lockdown	2.3	$p = 1.000$
Intervals between lockdown 2020	2.7	$p = 0.482$
Intervals between lockdown 2021	2.2	$p = 0.775$

results were reviewed to identify perforated appendicitis and negative appendectomy, which was defined as the absence of any finding on histopathology for which appendectomy would be indicated. Data were deidentified after extraction from electronic medical records, stored in a password protected Microsoft Excel database and accessed only by research investigators.

Statistical analysis was performed using IBM SPSS (version 27). Pairwise comparisons of lockdown periods and intervals between lockdown to the baseline of prior to the COVID-19 pandemic were made using Fisher's exact test for dichotomous outcomes. One-way analysis of variance with Tukey *post hoc* testing was conducted to compare time from initial presentation to surgery and number of appendectomies performed per day. A two-tailed $p < 0.05$ was considered statistically significant.

Results

We identified 2459 patients who underwent emergency appendectomy from January 2019 to September 2021. 1390 patients presented during the pandemic (including 608 presenting during lockdowns) and 1069 patients in the preceding period. Lockdown orders were in place for 242 days during the study period (Table 1).

The rate of perforated appendicitis was reduced during the second lockdown (6.3% versus 10.7% prior to the pandemic; $p = 0.027$), but there was no significant difference in rates of

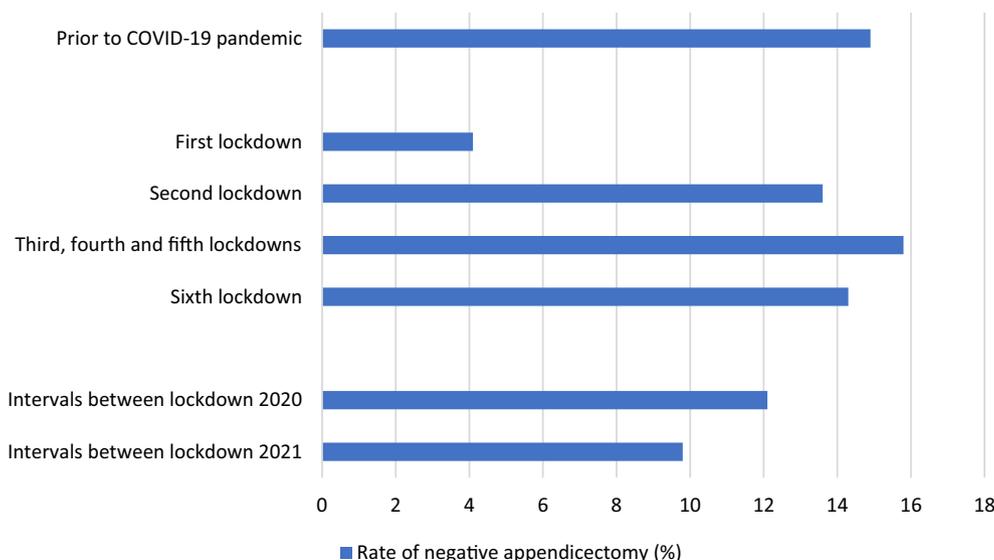
**Fig. 2.** Comparison of negative appendectomy rates during COVID-19 pandemic.

Table 5 Time from initial presentation to surgery

	Median, IQR (hours)	Comparison versus prior to COVID-19 pandemic
Prior to COVID-19 pandemic	22.3 (IQR 14.7–28.7)	<i>Baseline</i>
First lockdown	20.0 (IQR 9.8–24.5)	$p = 0.397$
Second lockdown	24.2 (IQR 19.6–31.8)	$p = 0.187$
Third, fourth and fifth lockdowns	20.6 (IQR 13.9–25.1)	$p = 0.998$
Sixth lockdown	21.8 (IQR 17.5–26.2)	$p = 0.952$
Intervals between lockdown 2020	23.0 (IQR 16.8–30.0)	$p = 0.567$
Intervals between lockdown 2021	21.2 (IQR 14.7–26.5)	$p = 1.000$

Table 6 Operations undertaken after hours

	% (n)	Comparison versus prior to COVID-19 pandemic
Prior to COVID-19 pandemic	18.1% (194/1069)	<i>Baseline</i>
First lockdown	9.2% (9/98)	$p = 0.025$
Second lockdown	9.0% (27/301)	$p < 0.001$
Third, fourth and fifth lockdowns	6.6% (5/76)	$p = 0.007$
Sixth lockdown	9.0% (12/133)	$p = 0.007$
Intervals between lockdown 2020	22.5% (84/373)	$p = 0.079$
Intervals between lockdown 2021	9.3% (38/409)	$p < 0.001$

perforated appendicitis during other lockdowns or periods outside of lockdown (Table 2; Fig. 1). The rate of negative appendectomy was reduced during the first lockdown (4.1%; $p = 0.002$) and during intervals between lockdowns in 2021 (9.8%; $p = 0.010$) compared to prior to the pandemic (14.9%) (Table 3; Fig. 2). There was no statistically significant difference in mean number of appendectomies per day (Table 4) or median time from initial presentation to surgery (Table 5) during lockdowns or intervals between lockdowns compared to baseline. A lower proportion of operations were conducted after hours during each of the lockdowns, as well as during periods outside of lockdown during 2021 ($p < 0.05$) compared to baseline (Table 6).

Discussion

Interestingly, we found that the incidence of perforated appendicitis was lower during the second COVID-19 related lockdown. Given that there was no clinically significant difference in time from initial presentation to surgery, we suggest that patients may have presented earlier in their disease course during this period and hypothesise that individuals may have been more likely to seek timely medical care in the absence of work or other commitments. This effect was not seen during other lockdowns, or at other times during the pandemic. This result is discordant with other Australian studies, with increased rates of complicated appendicitis reported at a major paediatric

tertiary centre in Queensland during the pandemic, despite improved availability of emergency operating theatres.⁶ Internationally, similar findings of increased rates of complicated appendicitis have been reported in paediatric patients in Italy,⁷ and in both paediatric⁸ and adult cohorts⁹ in Germany where appendicitis was used in these studies as a proxy for the investigation of delayed presentation to hospital more generally. Our findings suggest there may not be a similar reluctance to seek healthcare in Victoria despite extended periods of lockdown and stay at home orders. Clear public health advice that seeking medical care is an acceptable reason for individual movement during lockdowns may have abated any tendencies to delay seeking medical treatment.

The decreased rate of negative appendectomy during the first lockdown is an additional unexpected finding. This may reflect a predisposition to obtain imaging or observe patients with undifferentiated pain rather than proceeding to laparoscopy during the early phase of the pandemic, in an effort to avoid unnecessary operations and reduce potential exposure of healthcare staff to COVID-19. The lower negative appendectomy rate during intervals between lockdown in 2021, although clinically significant, is less marked, and the cause for this is unclear. The reduction in the volume of appendectomies performed after hours is consistent with reductions in planned elective surgery in the Victorian healthcare system and hence, increased operating theatre availability for emergency cases during business hours.

While our study was limited by its retrospective nature and its focus on appendicitis particularly, future research could consider multi-centre analysis of emergency surgical presentations in other states in Australia for a more thorough investigation. Further research could also include comparison of appendicitis managed non-operatively, as well as whether there was any increase in pre-operative imaging during the pandemic.

Conclusion

Our findings did not illustrate a significant increase in the rate of perforated appendicitis associated with lockdown periods in Victoria during the COVID-19 pandemic. This suggests that the pandemic may not create a reluctance to seek healthcare in all regions, as has previously been hypothesised. This study draws attention to the importance of providing timely healthcare for non-COVID diseases despite challenges of the pandemic. With appropriate public health advice of the importance of seeking medical care even during periods of lockdown, timely provision of healthcare for non-COVID related diseases can continue to be delivered despite the disruption associated with the COVID-19 pandemic.

Acknowledgments

Open access publishing facilitated by Monash University, as part of the Wiley - Monash University agreement via the Council of Australian University Librarians.

Conflict of interest

None declared.

Author contributions

Ashray Rajagopalan: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; writing – original draft; writing – review & editing. **Blake Roschach:** Data curation; formal analysis; investigation; methodology. **Katherine Mary Kerr Grant:** Conceptualization; writing – review and editing. **Jasprit Singh:** Conceptualization. **Marek Bak:** Data curation; investigation. **Marjorie Burgess:** Data curation; investigation. **Kerry Liu:** Data curation; investigation. **Nevin Chen:** Data curation; investigation. **Jack Menzie:** Data curation; investigation. **Sarah Chew:** Data curation; investigation. **Namankit Gupta:** Data curation; investigation. **Naomi Frederick:** Data curation; investigation. **Lachlan Hegarty:** Data curation; investigation. **Carina Chan:** Data curation; investigation. **Samuel Penfold:** Data curation; investigation. **Anysha Walia:** Data curation; investigation. **Daniel Croagh:** Conceptualization; supervision.

References

1. Lange PW, Gazzard M, Walker S *et al.* Where are our patients? Retrospective cohort study of acute medical unit admissions during and prior to the COVID-19 pandemic. *Intern. Med. J.* 2020; **50**: 1132–4.
2. Collyer TA, Athanosopoulos G, Srikanth V *et al.* Impact of COVID-19 lockdowns on hospital presentations and admissions in the context of low community transmission: evidence from time series analysis in Melbourne, Australia. *J. Epidemiol. Community Health* 2021; **76**: 1–9.
3. Kam AW, Chaudhry SH, Gunasekaran N, White AJR, Vukasovic M, Fung AT. Fewer presentations to metropolitan emergency departments during the COVID-19 pandemic. *Med. J. Aust.* 2020; **213**: 370–1.
4. Boyle LM, Mackay M, Bean N, Roughan M. Impact of the COVID-19 pandemic on South Australia's emergency departments: evidence from two lockdowns. *Aust. Health Rev.* 2021; **45**: 533.
5. Allen MT, Thompson BC, Atkinson B *et al.* Emergency department presentations in the Southern District of New Zealand during the 2020 COVID-19 pandemic lockdown. *Emerg. Med. Australas.* 2021; **33**: 534–40.
6. Lee-Archer P, Blackall S, Campbell H, Boyd D, Patel B, McBride C. Increased incidence of complicated appendicitis during the COVID-19 pandemic. *J. Paediatr. Child Health* 2020; **56**: 1313–4.
7. Bellini T, Rotulo GA, Carlucci M, Fiorenza V, Piccotti E, Mattioli G. Complicated appendicitis due to diagnosis delay during lockdown period in Italy. *Acta Paediatr.* 2021; **110**: 1959–60.
8. Schafer FM, Meyer J, Kellnar S *et al.* Increased incidence of perforated appendicitis in children during COVID-19 pandemic in a Bavarian multi-center study. *Front. Pediatr.* 2021; **9**: 401.
9. Willms AG, Oldhafer KJ, Conze S *et al.* Appendicitis during the COVID-19 lockdown: results of a multicenter analysis in Germany. *Langenbecks Arch. Surg.* 2021; **406**: 367–75.