





Management and early outcomes of children with appendicitis in the UK and Ireland during the COVID-19 pandemic: a survey of surgeons and observational study

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ABSTRACT

Objectives Acute appendicitis is the most common surgical condition in children. In the UK, appendicectomy is the most common treatment with non-operative management unusual. Due to concerns about the risk of SARS-CoV-2 transmission during surgical procedures, surgeons were advised to consider non-operative treatment and avoid laparoscopy where possible. This study aims to report management and outcomes, to date, of children with appendicitis in the UK and Ireland during the COVID-19 pandemic.

Design Survey of consultant surgeons who treat children with appendicitis that informed a prospective multicentre observational cohort study.

Setting Data were collected from centres in the UK and Ireland for cases admitted between 1 April and 31 May 2020 (first 2 months of the COVID-19 pandemic) at both general surgical and specialist paediatric surgical centres.

Participants The study cohort includes 838 children with a clinical and/or radiological diagnosis of acute appendicitis of which 527 (63%) were male.

Main outcomes measured Primary outcome was treatment strategy used for acute appendicitis. Other outcomes reported include change in treatment strategy over time, use of diagnostic imaging and important patient outcomes to 30 days following hospital admission.

Results From very early in the pandemic surgeons experienced a change in their management of children with appendicitis and almost all surgeons who responded to the survey anticipated further changes during the pandemic. Overall, 326/838 (39%) were initially treated non-operatively of whom 81/326 (25%) proceeded to appendicectomy within the initial hospital admission. Of cases treated initially surgically 243/512 (48%) were performed laparoscopically. Diagnostic imaging was used in 445/838 (53%) children. Cases treated non-operatively had a shorter hospital stay than those treated surgically but hospital readmissions within 30 days were similar between groups. In cases treated surgically the negative appendicectomy rate was 4.5%. There was a trend towards increased use of surgical treatment and from open to laparoscopic appendicectomy as the pandemic progressed.

What is known about the subject?

- Acute appendicitis is a common condition in children and in the UK is typically treated with emergency appendicectomy.
- The SARS-CoV-2 pandemic has caused widespread disruption to healthcare delivery and surgeons were advised to alter their usual practice due to possible viral transmission during surgery.
- How the pandemic would impact on the management and outcomes of children with appendicitis was unclear.

What this study adds?

- During the first 2 months of the pandemic, nearly 40% of all cases of appendicitis were managed non-operatively.
- Non-operative treatment appears a safe alternative to surgery for selected cases in this real-world setting and overall treatment outcomes are satisfactory.

Conclusion Non-operative treatment of appendicitis has been widely used for the first time in children in the UK and Ireland and is safe and effective in selected patients. Overall patient outcomes do not appear to have been adversely impacted by change in management during the pandemic thus far.

INTRODUCTION

Acute appendicitis is the most common surgical condition in children and affects approximately 8% of all people throughout their lifetime. In the UK, treatment of children with appendicitis is shared between general surgeons in district general hospitals and specialist paediatric surgeons at specialist paediatric centres,¹ but typically treatment is surgical with the majority of cases undergoing urgent appendicectomy. Although

international guidelines do support the use of non-operative treatment for selected children with uncomplicated acute appendicitis,² non-operative treatment is not widespread in the UK being used by only a small minority of surgeons or as part of a research study.³

The SARS-CoV-2 (COVID-19) pandemic has caused widespread disruption to hospitals worldwide. The disruption to the delivery of acute surgical services was anticipated to impact how children with appendicitis were managed for a wide variety of reasons including staff redeployment, operating theatre availability and concerns about transmission of SARS-CoV-2 from patients to healthcare staff during anaesthesia and surgical procedures, particularly during laparoscopic procedures.⁴ Early guidance from the Royal College of Surgeons England suggested that laparoscopy should only be used in procedures where the risk of an open procedure to the patient outweighed the potential risk to staff in theatre as laparoscopy was believed to be an aerosol generating procedure.⁴ It was also recommended that non-operative treatment should be used to avoid surgery for all conditions, including appendicitis, if it was considered an acceptable alternative treatment option.⁵ In addition, it has been shown that exposing a patient with COVID-19 to a surgical procedure has a significant adverse impact on outcome.⁶ This may also have influenced surgeons towards greater use of non-operative treatment for children with appendicitis, although data emerged through the first months of the pandemic that children are much less likely to become infected with COVID-19 than adults and the impact of COVID-19 on outcomes following surgery in children is less clear.⁷

The Children with Appendicitis during the Coronavirus pandemic study was initiated in late March 2020 to capture data relating to the impact of this disruption on the management and outcomes of children with appendicitis during the pandemic. The study comprised a rapid survey of surgeons in the UK who treat children to understand the current or anticipated impact of the pandemic on management of children with appendicitis followed by an observational cohort study. This report details the findings of the survey and the management observed during the first 2 months of the pandemic in the UK and early (30 days) outcomes. It is provided to assist surgeons with clinical decision making throughout the pandemic and in the event that there is a second wave resulting in further disruption to acute surgical services.

METHODS

Survey of surgeons who treat children

A survey was designed to understand the impact of the pandemic on treatment being offered to children with acute appendicitis at the start of the pandemic. Questions were developed, piloted on a convenience sample of surgeons and modified prior to survey distribution. Specialist paediatric and general surgeons who treat children with appendicitis were invited to complete the

survey during the 2-week period leading up to 14 April 2020. Invitations were made via personal contacts, social media and mailshots from the British Association of Paediatric Surgeons and the survey was advertised repeatedly through these channels. The survey was administered online using REDCap data capture tool⁸ and is available in online supplemental material S1. Questions asked were focused around understanding the impact of the COVID-19 pandemic on the management of children with appendicitis experienced to date, the anticipated impact over the coming weeks and the rationale behind any change in management.

Cohort study design

This is a prospective multicentre observational cohort study of children aged <16 years at time of hospital admission diagnosed with and treated for acute appendicitis in the UK and Ireland. This includes children treated by general surgeons and specialist paediatric surgeons. Participating hospitals were not required to alter diagnostic or treatment pathways and no changes were made to patient care as part of this study. Data collection for the study commenced 1 April 2020.

Centre recruitment and patient identification

Hospitals providing acute surgical care to children were invited to participate in this study via a number of channels including targeted emails, newsletters, social media and websites of surgical and paediatric national organisations including the British Association of Paediatric Surgeons, the Royal College of Surgeons of England and the Royal College of Paediatrics and Child Health. Children were included in the study if they were diagnosed with and treated for acute appendicitis in hospital. Diagnosis was based on clinical and/or radiological criteria. Children who presented with abdominal pain but not felt to have appendicitis were excluded. This report includes all children in the study dataset with an initial admission date between 1 April 2020 and 31 May 2020 and for whom 30-day outcome data were provided to the coordinating team by the data cut-off date of 13 July 2020. Follow-up data were censored at 30 days posthospital discharge from initial admission.

Outcomes

The primary outcome was the initial treatment strategy for acute appendicitis, defined as surgical or non-operative. Secondary outcomes related to patient management included number and proportion of operative cases performed open and laparoscopically, use of diagnostic imaging and variation in patient management over time, as the pandemic progressed. Other clinical outcomes were failure rate of non-operative treatment (defined as appendicectomy within initial hospital inpatient episode in a case in whom the initial treatment strategy was non-operative), need for hospital readmission, wound infection, bowel obstruction, intra-abdominal collection, further surgery or interventional radiology procedure,

length of hospital stay and mortality. These outcomes were all reported to 30 days following initial hospital admission and were selected as important outcomes from a core outcome set for paediatric appendicitis.⁹

Data collection and analysis

Anonymous data were collected by local study teams within each hospital and submitted to the study team monthly. Data were checked for duplication since we were aware that some cases were transferred from one hospital to another during the study period (typically from a district general hospital to a local specialist paediatric surgery centre) and we wished to avoid duplication. Duplicated data records were identified and excluded if all of age, sex, C reactive protein (CRP) and white cell count (WCC) at admission were identical.

Statistical analysis was performed using StataSE V.15 (StataCorp, Texas, USA) and the figures were produced using GraphPad Prism V.8 (GraphPad Software, La Jolla, California, USA). Data are presented as median (IQR or range) and/or number/total (%) as appropriate. Fisher's exact test or χ^2 test, as appropriate, were used for comparison of categorical data and the Mann-Whitney

U test was used for continuous data. A p value of <0.05 was considered as statistically significant. The study was conducted according to Strengthening the Reporting of Observational studies in Epidemiology guidelines for observational studies.¹⁰

Patient and public involvement

Given the restrictions and need for rapid study commencement, there was no active patient and public involvement in this study at this stage. There is no relevant patient group to disseminate findings of this study.

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This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors. The corresponding author had full access to all study data and responsibility for publication.

RESULTS

Survey of surgeons who treat children

One hundred and one complete responses (75% specialist paediatric surgeons, 25% general surgeons)

Table 1 Anticipated future effect on management of children with appendicitis during coronavirus pandemic

Anticipated change	GS, n=21 (%)	SPS, n=65 (%)
Simple appendicitis: I will actively offer non-operative treatment to all children with simple appendicitis	15 (71)	45 (69)
Simple appendicitis: I will consider non-operative treatment for children with simple appendicitis at parental request	5 (24)	14 (22)
Simple appendicitis: I will actively perform open (as opposed to laparoscopic) appendicectomy in children with simple appendicitis	4 (19)	32 (49)
Complicated appendicitis: I will actively offer non-operative treatment to children with complicated appendicitis	3 (14)	10 (15)
Complicated appendicitis: I will consider non-operative treatment to children with complicated appendicitis at parental request	6 (29)	11 (17)
Complicated appendicitis: I will actively perform open (as opposed to laparoscopic) appendicectomy in children with complicated appendicitis	12 (57)	44 (68)
Complicated appendicitis: I will actively pursue a shorter than usual course of intravenous antibiotics in children with complicated appendicitis	5 (24)	9 (14)
Appendix mass: I will actively offer non-operative treatment to children with appendix mass	12 (57)	26 (40)
Appendix mass: I will consider non-operative treatment to children with appendix mass at parental request	4 (19)	6 (9)
Appendix mass: I will not offer routine interval appendicectomy in children who have has successful non-operative treatment of appendix mass	3 (14)	17 (26)
Any appendicitis: routine imaging for all cases of suspected appendicitis to be certain of diagnosis	6 (29)	14 (22)
Any appendicitis: CT scan instead of US for diagnosis of appendicitis	0	0
Any appendicitis: more frequent use of imaging to guide management (eg, select cases for non-operative treatment/reduce negative appendicectomy rate)	13 (62)	31 (48)
Any appendicitis: consultant review for all cases prior to considering surgery	15 (71)	46 (71)
Any appendicitis: we will likely be sending children with appendicitis to another hospital for treatment	3 (14)	1 (2)
Any appendicitis: we will likely be treating children at my hospital who would usually be treated somewhere else	0	33 (51)

GS, general surgeons; SPS, specialist paediatric surgeons; US, ultrasound.

were received from surgeons at 19 district general hospitals and 26 specialist children's centres. One-fifth of respondents (representing 60% of hospitals) had already experienced some change in their usual clinical management of children with appendicitis. The most frequent changes experienced were the use of non-operative treatment for uncomplicated acute appendicitis (63%), open (instead of laparoscopic) appendicectomy for complicated appendicitis (37%), more frequent use of imaging to confirm diagnosis and greater use of oral rather than intravenous antibiotics (both 32%). In the majority of cases (95%), this change was an active individual surgeon or departmental decision.

Most respondents (87%) indicated they anticipated some change in the management pathway for these children, either in their diagnostic workup, the type of treatment offered or that they would cease treating children with appendicitis altogether during the coronavirus pandemic (table 1).

Observational cohort study: children included and radiological investigations

Data were submitted prior to the data cut-off date for this report for 838 children treated for appendicitis between 1 April and 31 May 2020 in 67 centres (approximately half of all centres who treat children with appendicitis in the UK). No duplicated records were identified so all are included. The median age was 10 (range 1–15) years and 527 (63%) children were male. General surgeons treated 343 (41%) of cases with the remaining 496 (59%) being treated by specialist paediatric surgeons. In this cohort of children treated for appendicitis, diagnostic imaging was used in 445 (53%) children with abdominal ultrasound (US) and abdominal CT scan undertaken in 420 (50%) and 46 (5.5%) cases, respectively. At the point of diagnosis, 600 children (72%) were suspected by the treating surgeon to have simple acute appendicitis, 201 (24%) complicated appendicitis and 35 (4%) an appendix mass (data missing in 3 cases).

At diagnosis of acute appendicitis, the COVID-19 status was known positive in 4 (0.5%) children, known

negative in 171 (20%) children, tested awaiting result in 397 (47%) children and 266 (32%) children were untested.

Initial treatment strategy

Initial treatment strategy was non-operative in 326 (39%) children. In the 512 (61%) children treated initially with surgery, 262 (52%) had an open procedure and 243 (48%) an initially laparoscopic procedure (data on surgical approach not available for 7 cases). Initial treatment stratified by suspected severity of appendicitis at diagnosis is shown in figure 1.

Comparative clinical, laboratory and radiological details for cases treated surgically and non-operatively are shown in table 2. Cases treated surgically typically had more advanced appendicitis with higher CRP and white cell count at diagnosis and were more likely to have suspected complicated (as opposed to simple) appendicitis. A higher proportion of cases treated non-operatively had an US scan than of cases treated surgically. Of cases suspected to be simple appendicitis, 43% (259/600) were initially treated non-operatively compared with 20% (40/201) of cases suspected to be complicated appendicitis.

For cases treated surgically with either open or laparoscopic appendicectomy, comparative clinical, laboratory and radiological details for are shown in table 3. Overall, 48% (n=243) of cases that were treated surgically underwent a laparoscopic procedure. There was no relationship identified between choice of procedure and suspected severity of appendicitis pre-operatively. Cases treated laparoscopically were older, more likely to be treated by a specialist paediatric surgeon and more likely to have had a diagnostic US than cases performed open. For both open and laparoscopic procedures surgeons tended to underestimate disease severity at diagnosis compared with the surgical findings (table 3). The overall negative appendicectomy rate was 4.5% (n=23) in cases treated surgically.

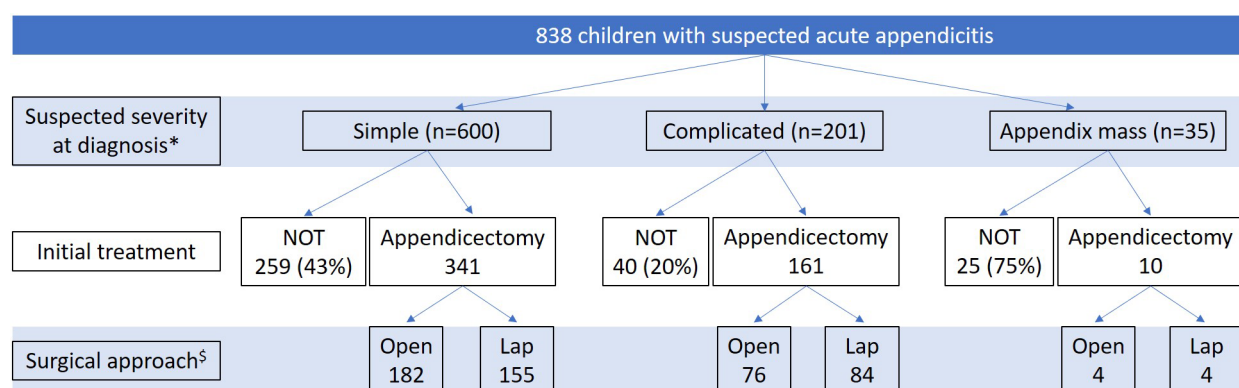


Figure 1 Initial treatment stratified by suspected severity of appendicitis at diagnosis. *Data on severity at diagnosis missing for two cases; both had non-operative treatment (NOT). § Data on surgical approach missing for seven cases. Lap, laparoscopic.

Table 2 Clinical, laboratory and radiological characteristics of cases treated initially non-operatively or operatively

		Non-operative (n=326)	Operative (n=512)	P value
Age (years)		10.5 (8–13)	10 (8–12)	0.19
Male (n, %)		195 (60)	331 (65)	0.16
Duration of symptoms (hours)		36 (24–72)	48 (24–72)	0.58
Specialty (n, %)	GS	140 (43)	202 (39)	0.35
	SPS	186 (57)	310 (61)	
Admission bloods	WCC— $\times 10^9/L$	14.4 (10.7–17.8)	15.2 (12.0–18.5)	0.01
	CRP—mg/L	32 (7.1–81)	52 (15–126)	<0.0001
US performed (n, %)		193 (59)	227 (44)	<0.0001
CT performed (n, %)		16 (4.9)	30 (5.9)	0.76
Suspected severity at diagnosis (n, %)*	Simple	259 (80)	341 (67)	<0.0001
	Complicated	40 (12)	161 (31)	
	Appendix mass	25 (7.7)	10 (2.0)	

*For two cases suspected severity was missing.

CRP, C reactive protein; GS, general surgeon; SPS, specialist paediatric surgeon; US, Ultrasound scan; WCC, white cell count.

Change in initial treatment method during the pandemic

During the first week of April 2020, the proportion of cases initially treated non-operatively was 49% which reduced to 33% in the last week of May 2020 (figure 2). Of those cases treated operatively, 79% were by open appendicectomy during the first week of April 2020 and this reduced to 41% in the last week of May 2020 (figure 3).

Patient outcomes to 30 days

For 326 cases treated non-operatively, 81 (25%) children failed non-operative treatment during the initial admission. This failure rate in cases suspected to be simple

appendicitis was 24% (62/259) and for those suspected to be complicated appendicitis was 30% (12/40). All these cases proceeded to appendicectomy which was approached via an open procedure in 35 (44%) cases and a laparoscopic procedure in 45 (56%) cases (data missing in 1 case). Where available (missing n=2), intra-operative findings in those who failed initial non-operative treatment were normal appendix in 4 (4.9%) children, simple appendicitis in 37 (47%) children, complicated appendicitis in 32 (41%) children and appendix mass in 6 (7.4%) children.

Table 3 Clinical, laboratory and radiological characteristics of cases treated initially operatively stratified by open or laparoscopic procedure

		Open (n=262)	Laparoscopic (n=243)	P value
Age (years)		10 (7–12)	11 (9–13)	0.0004
Male (n, %)		176 (67)	149 (61)	0.19
Specialty (n, %)	GS	119 (60)	81 (40)	0.006
	SPS	143 (47)	162 (53)	
Admission bloods	WCC— $\times 10^9/L$	15.6 (12.3–18.6)	14.9 (11.6–18.0)	0.34
	CRP—mg/L	52 (15–130)	52 (15–124)	0.91
US performed (n, %)		101 (39)	122 (50)	0.009
CT performed (n, %)		18 (6.8)	12 (4.9)	0.19
Suspected severity pre-operatively (n, %)	Simple	182 (69)	155 (64)	0.40
	Complicated	76 (29)	84 (35)	
	Appendix mass	4 (1.5)	4 (1.7)	
Operative findings (n, %)	Normal	13 (5.0)	10 (4.1)	0.66
	Mass	7 (2.7)	8 (3.3)	
	Simple	128 (49)	108 (44)	
	Complicated	113 (43)	117 (48)	

Data missing for seven cases.

CRP, C reactive protein; GS, general surgeon; SPS, specialist paediatric surgeon; US, Ultrasound scan; WCC, white cell count.

Initial Management of Suspected Appendicitis Operative vs non-operative per week

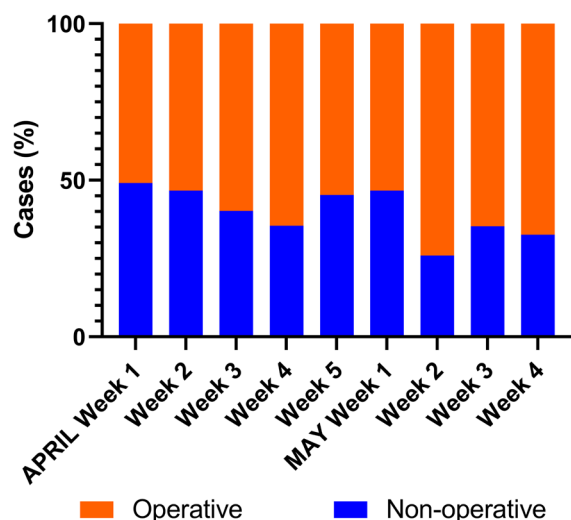


Figure 2 Initial management strategy of appendicitis by week, operative versus non-operative. The orange bars represent operative treatment and the blue bars represent non-operative treatment demonstrating a trend towards operative treatment over time.

Overall, cases treated operatively had a longer length of initial inpatient stay compared with those treated initially non-operatively (3 (2–5) vs 2 (1–4) days, $p < 0.0001$). Overall, the 30-day readmission rate was 12% (30/245) for non-operative treatment in those that were discharged home without an operation and 7.4% (38/512) in those treated initially with an operation. Reasons for readmission in cases treated operatively were

Initial Management of Suspected Appendicitis Open vs Laparoscopic per week

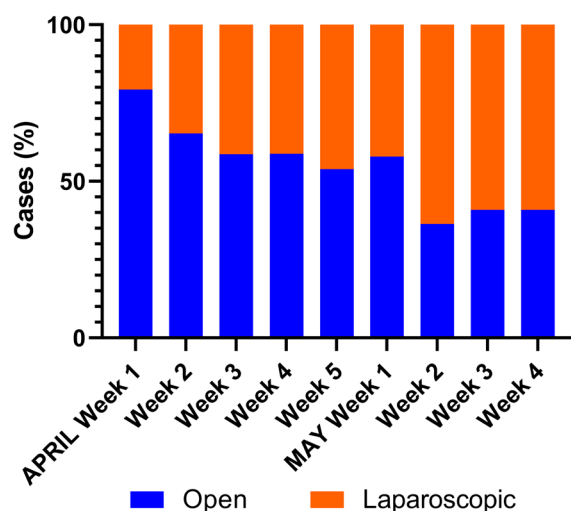


Figure 3 Initial operative management strategy of appendicitis by week, open versus laparoscopic. The orange bars represent laparoscopic appendectomy and the blue bars represent open appendectomy demonstrating a trend towards laparoscopic appendectomy over time.

abdominal collection/abscess ($n=17$), abdominal pain ($n=11$), fever ($n=2$), wound dehiscence/infection ($n=6$) and small bowel obstruction ($n=1$). Reasons for readmission in the group which underwent non-operative treatment without appendectomy prior to discharge were abdominal collection/abscess ($n=4$), abdominal pain ($n=20$) and fever ($n=4$). Note that in some cases there were multiple reasons for readmission or the reason was not specified.

At 30 days there were no reported deaths. Children undergoing an open procedure had a similar rate of readmission (7 ($n=19$) vs 8% ($n=19$), $p=0.87$), wound infection (4 ($n=10$) vs 2% ($n=4$), $p=0.18$), bowel obstruction (1 ($n=2$) vs 1% ($n=3$), $p=0.68$), intra-abdominal collection (8 ($n=21$) vs 10% ($n=25$), $p=0.44$) and re-operation (3 ($n=8$) vs 5% ($n=13$), $p=0.27$) to those who had a laparoscopic procedure. An open procedure was associated with a shorter length of inpatient stay compared with a laparoscopic procedure (2 (2–4) vs 3 (2–6), $p=0.005$). These outcomes are further stratified by severity of appendicitis in table 4.

DISCUSSION

This report confirms anecdotal suspicion that the management of children with appendicitis has been significantly changed during the coronavirus pandemic with a clear shift towards non-operative management and towards open appendectomy in cases managed surgically. Although we do not present here any comparative data to a different time period, the use of non-operative treatment for children with acute appendicitis was extremely limited in a survey performed in 2018³ and anecdotally we do not believe there has been a significant change in practice prior to the start of the pandemic. The fact that overall just under 40% of children with suspected appendicitis were treated initially non-operatively represents a huge change in practice. This change was seen from early in the pandemic as reported in our initial survey and was anticipated by the majority of survey respondents. A small number of recent reports suggest that such changes in the management of appendicitis are not unique to the UK but have been implemented in a number of countries.^{11–13}

Interestingly, over the course of this data collection period the proportion of cases undergoing non-operative management decreased and the proportion of cases treated surgically having a laparoscopic procedure increased over time. We suspect this pattern is a reflection of initial guidance from professional bodies proposing non-surgical treatments be sought wherever possible and cautioning against the use of laparoscopy.⁵ Subsequent evolution of that guidance over time may have encouraged surgeons to resume their normal practice. We intend to monitor surgical practice longer term during the pandemic to identify any further changes in management.

Table 4 Comparative outcomes for cases treated initially operatively stratified by operative findings

	Simple or no appendicitis			Complicated appendicitis or appendix mass		
	Open (n=141)	Laparoscopic (n=118)	P value	Open (n=120)	Laparoscopic (n=125)	P value
Readmission (n, %)	4 (2.8)	4 (3.4)	1	15 (13)	15 (12)	1
Wound infection (n, %)	0 (0)	2 (1.7)	0.21	10 (8.3)	2 (1.6)	0.02
Bowel obstruction (n, %)	0 (0)	0 (0)	1	2 (1.7)	3 (2.4)	1
Intra-abdominal collection/abscess (n, %)	4 (2.8)	2 (1.7)	0.69	17 (14)	23 (18)	0.39
Reoperation /IR procedure (n, %)	1 (0.7)	0 (0)	1	7 (5.8)	13 (10)	0.25
Length of stay (days, median and IQR)	2 (1-3)	2 (1-3)	0.33	4 (2-6)	6 (4-8)	0.001

IR, interventional radiology.

The sudden widespread uptake of non-operative treatment of appendicitis seen to date during the pandemic presents an opportunity to evaluate non-operative treatment in a real-world setting across multiple centres in a way that until recently would not have been imagined possible. These early data suggest that non-operative treatment of acute appendicitis is effective and safe in a real-world setting. Further work is needed however, to determine whether the outcomes from non-operative management are acceptable to children with appendicitis, their parents and other stakeholders including surgeons. Cases treated non-operatively achieved a shorter length of stay than cases treated surgically, there were no deaths and the adverse event profile of each treatment approach was similar. These data suggest that surgeons selected less severe cases for non-operative treatment despite no formal guidelines existing for this purpose. Yet it remains likely that non-operative treatment has been used here outside the criteria used to date in formal research studies in which it has been evaluated.¹⁴⁻¹⁶ Of note, 12% of cases in which non-operative treatment was used as first-line therapy were suspected to be complicated appendicitis.

Both open and laparoscopic appendicectomy are recognised to be safe and effective treatments for children with appendicitis, although there has been increased uptake of laparoscopic appendicectomy in children in the UK in recent years.¹⁷ The reversal of this trend during the pandemic such that just 48% of all cases treated surgically were performed laparoscopically is likely in response to guidance from professional bodies that laparoscopy may increase the risk of SARS-CoV-2 transmission in positive cases.⁴ Anecdotally, we are aware that a move away from laparoscopy has been implemented by some individual surgeons and also by some institutions. The trend towards a higher proportion of cases being performed laparoscopically over time (figure 2) is consistent with updated guidance from professional bodies and a greater understanding about the epidemiology of COVID-19 in children.⁷

Recently the high negative appendicectomy rate observed in the UK (15.9% in children) has been highlighted and achieved significant public interest.^{18 19} It is

therefore of particular note that the negative appendicectomy rate seen in this dataset is extremely low, and in fact one of the lowest rates reported in the UK to date.^{1 18 20} The caveat to this, however, is that we have reported intraoperative findings rather than histological findings and the rate based on histology may in fact be higher. Alongside this, radiological imaging (both US and CT) has been seen more frequently during the period of the pandemic than in a published national dataset (53% vs 41%).¹⁸ It is not clear whether increasing use of imaging has resulted in such a low negative appendicectomy rate but it is certainly a possibility. Other factors may also be contributory however, including increased use of non-operative treatment and potentially increased consultant involvement in decision making. Given cases have been selected for non-operative treatment by clinicians, it is possible that some children who would have otherwise undergone negative appendicectomy were selected for non-operative treatment instead. Although we do not have data on consultant involvement in decision making on a case-by-case basis within this dataset, just over 70% of consultants anticipated there would be greater consultant involvement in management of children with appendicitis in the survey undertaken at the beginning of the pandemic. This is certainly an area worthy of further investigation since a reduction in the negative appendicectomy rate may be seen as an unanticipated benefit that it would be beneficial to maintain in the longer term. The COVID-19 pandemic may inadvertently be presenting opportunities for quality improvement that should be realised beyond the period of the pandemic itself.

The strengths of this study are that data have been collected prospectively from multiple centres, including representation from all nations, across the UK and Ireland. We deliberately did not involve other international centres so as to achieve a region across which there is relative consistency in management of children with appendicitis. This early analysis has been performed following a change in surgical practice to inform ongoing management during the pandemic and in the event of a second wave. The findings are likely generalisable to

other countries in whom management is similar to that in the UK and Ireland. As a pragmatic real-world study, it provides an overview of real-life outcomes outside the confines that would typically be achieved in a clinical trial. Conversely, some may view this pragmatism as a limitation since we have not used precise definitions for severity of appendicitis nor have we proposed criteria for different treatment strategies. This may explain a comparable failure rate of non-operative treatment in those with suspected simple and complicated appendicitis. An additional limitation of any study looking at non-operative treatment of appendicitis is that we cannot be sure whether those who underwent non-operative treatment definitely had appendicitis. While any such resulting 'overtreatment' may be viewed by some as regrettable, the risk/benefit profile of these two treatments is likely to be in favour of non-operative treatment over unnecessary operation for the majority of cases. However, improved positive identification of cases with appendicitis should remain the goal so that only children who truly have appendicitis receive treatment for it. A further limitation on terms of assessing the outcomes following non-operative treatment is that we have only reported outcomes to 30 days. We plan further analysis of a larger patient cohort to include long-term follow-up particularly of the group of children managed thus far without surgery. Finally, it is conceivable that the initial survey raised awareness of the use of alternative management strategies and may in itself have influenced practice, although 95% of respondents stated that an active decision was being made suggesting this is unlikely for the majority.

In conclusion, we present evidence that the COVID-19 pandemic has had a marked impact on the management of children with appendicitis with clear shifts towards increased use of non-operative treatment and open (as opposed to laparoscopic) appendicectomy. Despite the absence of formal guidelines, non-operative treatment appears safe and effective in children who have been selected for this treatment modality. Overall, these data should reassure surgeons about management strategy used during the pandemic in the face of restrictions to normal surgical services and may inform best practice in future times of limited surgical capacity.

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