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Impact of the COVID-19 pandemic on management and early outcomes of children with appendicitis

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CASCADE study collaborators

Members of the CASCADE study collaborators group are listed in the Acknowledgement section.

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Abstract

Objectives

Acute appendicitis is the most common surgical condition in children and is traditionally treated with appendicectomy. 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 the impact to date of the COVID-19 pandemic on the management and outcomes of children with appendicitis in the United Kingdom and Ireland.

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 United Kingdom and Ireland for cases admitted between April 1st and May 31st 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 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%.

Conclusion

COVID-19 has had a significant impact on the treatment of children with appendicitis in the UK and Ireland. Non-operative treatment has been widely used for the first time in children and is safe and effective. Overall patient outcomes do not appear to have been adversely impacted by change in management during the pandemic thus far.

What is known about the subject

- Acute appendicitis is a common condition in children and in the UK is typically treated with 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

- Nearly 40% of all cases of appendicitis were managed non-operatively and there was much greater use of open appendicectomy than before the pandemic
- Non-operative treatment appears a safe alternative to surgery for selected cases in this real world setting and overall treatment outcomes are satisfactory
- These data are helpful for informing ongoing management during the pandemic, when there may continue to be restrictions on surgical care, and during and second wave.

Introduction

Acute appendicitis is the most common surgical condition in children and affects approximately 8% of all people throughout their lifetime. In the United Kingdom (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. Non-operative treatment of acute appendicitis in children is not widespread in the UK and is reserved typically for highly selected cases or as part of a research study.(2)

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.(3) 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 (AGP).(3) 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.(4) In addition it has been shown that exposing a patient with COVID-19 to a surgical procedure has a significant adverse impact on outcome.(5) 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.(6)

The CASCADE study (Children with AppendicitiS during the CoronAvirus panDEmic) 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 impact on management seen during the first 2 months of the pandemic in the UK and early (30 day) 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. The survey was approved by the research committee of the British Association of Paediatric Surgeons. Specialist paediatric and general surgeons who treat children with appendicitis were invited to complete the survey during the 2-week period leading up to April 14th 2020. Invitations were made via personal contacts, social media and mailshots from the British Association of Paediatric Surgeons. The survey was administered online using REDCap data capture tool (7) and is available in supplementary material S1. Questions asked were focussed 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 less than 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 April 1st 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 April 1st 2020 and May 31st 2020 and for whom 30-day

outcome data was provided to the coordinating team by the data cut-off date of 13th July 2020. Follow-up data was censored at 30 days post hospital discharge from initial admission.

Ethical considerations

This study was registered at each site as a service evaluation, as defined by the health research authority guidance, as this was an observational study only collecting anonymised routine data with no change to clinical care pathways.

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 success 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, 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.(8)

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, CRP and WCC at admission were identical.

Statistical analysis was performed using StataSE v15 (StataCorp LLC, Texas, USA) and the figures were produced using GraphPad Prism v8 (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 chi-squared test, as appropriate, were used for comparison of categorical data and the Mann Whitney-U test was used for non-parametric continuous data. A chi-squared test for trend was used to compare changes in management over time. A *p* value of less than 0.05 was considered as statistically significant. The study was conducted according to Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines for observational studies.(9)

Patient and public involvement

Patients, parents and the public were fully involved in a recent pilot study of non-operative treatment for appendicitis carried out by our research group(2) however 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 of to disseminate findings of this study to.

Funding

The study did not receive any funding. 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) 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 work-up, the type of treatment offered or that they would cease treating children with appendicitis altogether during the coronavirus pandemic (Table 1).

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	45

Simple appendicitis: I will consider non-operative treatment for children with simple appendicitis at parental request	5	14
Simple appendicitis: I will actively perform open (as opposed to laparoscopic) appendicectomy in children with simple appendicitis	4	32
Complicated appendicitis: I will actively offer non-operative treatment to children with complicated appendicitis	3	10
Complicated appendicitis: I will consider non-operative treatment to children with complicated appendicitis at parental request	6	11
Complicated appendicitis: I will actively perform open (as opposed to laparoscopic) appendicectomy in children with complicated appendicitis	12	44
Complicated appendicitis: I will actively pursue a shorter than usual course of intravenous antibiotics in children with complicated appendicitis	5	9
Appendix mass: I will actively offer non-operative treatment to children with appendix mass	12	26
Appendix mass: I will consider non-operative treatment to children with appendix mass at parental request	4	6
Appendix mass: I will not offer routine interval appendicectomy in children who have has successful non-operative treatment of appendix mass	3	17
Any appendicitis: Routine imaging for all cases of suspected appendicitis to be certain of diagnosis	6	14
Any appendicitis: CT scan instead of US for diagnosis of appendicitis	0	0
Any appendicitis: More frequent use of imaging to guide management (e.g. select cases for non-operative treatment / reduce negative appendicectomy rate)	13	31
Any appendicitis: consultant review for all cases prior to considering surgery	15	46
Any appendicitis: we will likely be sending children with appendicitis to another hospital for treatment	3	1
Any appendicitis: we will likely be treating children at my hospital who would usually be treated somewhere else	0	33

GS – general surgeons, SPS – specialist paediatric surgeons

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 April 1st and May 31st 2020 in 67 centres. All are included. The median age was 10 (range 1-15) years and 527 (62.8%) children were male. General surgeons treated 343 (40.9%) of cases with the remaining 496 (59.1%) being treated by specialist paediatric surgeons. In this cohort of

children treated for appendicitis, diagnostic imaging was used in 445 (53.1%) children with abdominal ultrasound and abdominal computed tomography (CT) scan undertaken in 420 (50.1%) 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 (20.4%) 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 (38.9%) children. In the 512 (61.1%) of children treated initially with surgery, 262 (51.9%) had an open procedure and 243 (48.1%) an initially laparoscopic procedure (data not available for 7 cases). Of 600 cases suspected to be simple appendicitis at the point of diagnosis 44% (n=259) were treated non-operatively, 31% (n=182) with open appendicectomy and 26% (n=155) with laparoscopic appendicectomy (data missing in 4 cases). Of 201 cases suspected to be complicated appendicitis at the point of diagnosis 20% (n=40) were treated non-operatively, 38% (n=76) with open appendicectomy and 42% (n=84) with laparoscopic appendicectomy (data missing in 1 case). Of 35 cases suspected to be an appendix mass at the point of diagnosis 76% (n=25) were treated non-operatively, 12% (n=4) with open appendicectomy and 12% (n=4) with laparoscopic appendicectomy (data missing in 2 cases).

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 ultrasound scan than of cases treated surgically. Of cases suspected to be simple appendicitis 43% (259/600) were initially treated non-operatively compared to 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 48.1% (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 ultrasound than cases performed open. For both open and laparoscopic

procedures surgeons tended to underestimate disease severity at diagnosis compared to the surgical findings (Table 3). The overall negative appendicectomy rate was 4.5% (n=23) in cases treated surgically.

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 1). 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 2).

Figures

Figure 1. Initial management strategy of appendicitis by week, operative *vs* non-operative. The red bars represent operative treatment and the blue bars represent non-operative treatment. Chi-squared for trend – p=0.0045.

Figure 2. Initial operative management strategy of appendicitis by week, open *vs* laparoscopic. The red bars represent laparoscopic appendicectomy and the blue bars represent open appendicectomy. Chi-squared for trend – p<0.0001.

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

		Non-operative (n=326)	Operative (n=512)	*p*
Age (years)		10.5 (8-13)	10 (8-12)	0.19
Male (n, %)		195 (59.8)	331 (64.7)	0.16
Duration of symptoms (hours)		36 (24-72)	48 (24-72)	0.58
Speciality (n, %)	GS	140 (42.9)	202 (39.5)	0.35
	SPS	186 (57.1)	310 (60.6)	
Admission bloods	WCC – $x10^9$/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 (60.1)	227 (44.3)	<0.0001
CT performed (n, %)		16 (5.7)	30 (6.3)	0.76

Suspected severity at diagnosis (n, %)	Simple	259 (79.9)	341 (66.6)	<0.0001
	Complicated	40 (12)	161 (31.5)	
	Appendix mass	25 (7.7)	10 (2.0)	

GS – general surgeon; SPS – specialist paediatric surgeon; WCC – white cell count; CRP – C-reactive protein; L – litre; mg – milligrams.

Patient outcomes to 30-days

For 326 cases treated non-operatively, 81 (25%) children failed non-operative treatment during the initial admission and proceeded to appendicectomy. This 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=3), intra-operative findings in those who failed initial non-operative treatment were normal appendix in 4 (5%) children, simple appendicitis in 37 (47%) children, complicated appendicitis in 32 (41%) children and appendix mass in 6 (8%) children.

Overall, cases treated operatively had a longer length of initial inpatient stay compared to 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% (38/512) in those treated initially with an operation. Reasons for readmission in cases treated operatively were 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 appendicectomy 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 to 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.

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
Age (years)		10 (7-12)	11 (9-13)	0.0004
Male (n,%)		176 (67.2)	149 (61.3)	0.19
Speciality (n,%)	GS	119 (59.5)	81 (40.5)	0.006
	SPS	143 (46.9)	162 (53.1)	
Admission bloods	WCC – $x10^9$/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 (38.6)	122 (50.2)	0.009
CT performed (n,%)		18 (8.0)	12 (4.9)	0.19
Suspected severity pre-operatively (n,%)	Simple	182 (69.5)	155 (63.8)	0.40
	Complicated	76 (29)	84 (34.6)	
	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 (49.0)	108 (44.4)	
	Complicated	113 (43.3)	117 (48.2)	

Data missing for 7 cases. GS – general surgeon; SPS – specialist paediatric surgeon; WCC – white cell count; CRP – C-reactive protein; L – litre; mg – milligrams.

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

Table 4	**Simple or No appendicitis**				**Complicated appendicitis or Appendix Mass**		
	Open (n=141)	**Laparoscopic (n=118)**	**p**		**Open (n=120)**	**Laparoscopic (n=125)**	**p**
Readmission (n, %)	4 (2.8)	4 (3.4)	1.00		15 (12.5)	15 (12.0)	1.00
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)	1.00		2 (1.7)	3 (2.4)	1.00
Intra-abdominal collection/abscess (n, %)	4 (2.8)	2 (1.7)	0.69		17 (14.2)	23 (18.4)	0.39
Reoperation (n, %)	1 (0.7)	0 (0)	1.00		7 (5.8)	13 (10.4)	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

Discussion

This report confirms anecdotal suspicion that the management of children with appendicitis has been significantly impacted during the coronavirus pandemic with a clear shift towards non-operative management and towards open appendicectomy 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 2018(2) 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.

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.(4) 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.

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. 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.(10-12) 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.(13) 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.(3) 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(6). It is also possible that there is an interaction between the decreasing use of non-operative treatment and increasing use of laparoscopy if some surgeons feel reluctant to perform open appendicectomy (i.e. there may be surgeons who have preferred non-operative treatment rather than open appendicectomy in cases they would usually treat laparoscopically).

Recently the high negative appendicectomy rate observed in the UK has been highlighted and achieved significant public interest.(14, 15) 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, 14, 16). Alongside this, radiological imaging has been seen more frequently during the period of the pandemic than in a published national dataset (16). 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. 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 from across the United Kingdom 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 United Kingdom 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 weakness since we have not used precise definitions for severity of appendicitis nor have we proposed criteria for different treatment strategies. We recognise that we have only reported outcomes to 30 days and plan further analysis of a larger patient cohort to include longer term follow-up particularly of the group of children managed thus far without surgery.

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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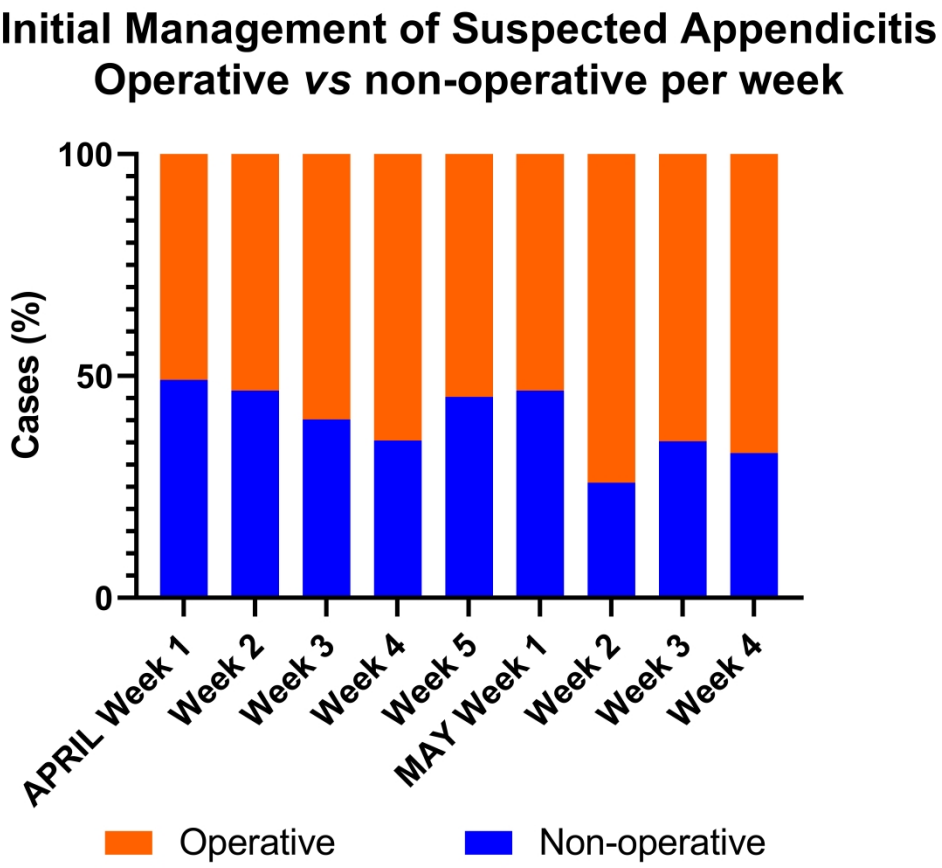

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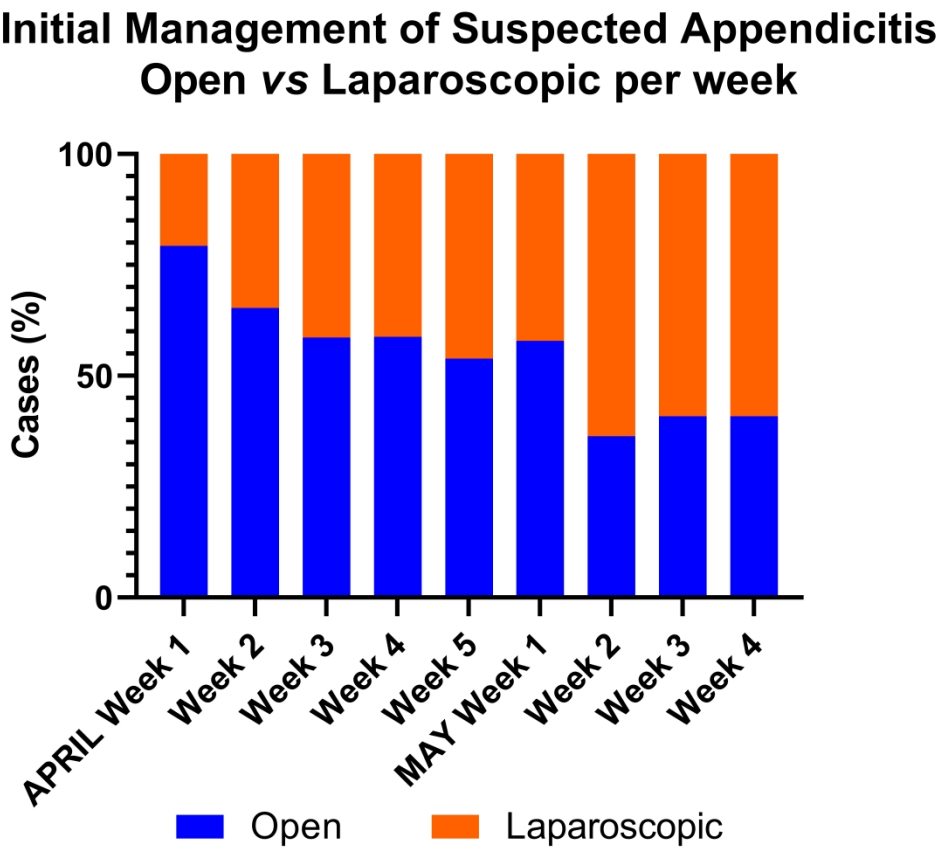

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Children with AppendicitiS during the CoronAvirus panDEmic (CASCADE)

The current coronavirus pandemic is placing NHS services in an unprecedented situation and there will be impact on the delivery of care for non-coronavirus patients. Guidance from the Royal Colleges recommends change in standard surgical treatment pathways. Clinicians may decide or be encouraged to consider treating some conditions differently to their usual practice. This will certainly have an impact on practice and may influence outcomes.

The management of children with acute appendicitis is one such condition. A number of different treatment options exist and current pathways may well be changed in some centres.

This CASCADE study has been set-up to capture data relating to this.

This initial survey aims to capture the current and anticipated impact of the coronavirus pandemic on treatment of children with acute appendicitis. It comprises just 4 questions and should take no more then 5 minutes to complete.

It is for completion by consultants only please. This is not because we don't value the views of trainees but in this particular instance we feel that consultants are more likely than ever going to be making decisions.

We will generate a rapid summary of the data in order to provide you with an overview of how practice is changing across the country and to share ideas for change that are considered useful.

All responses will be treated anonymously. Please complete the entire survey for your responses to be saved.

Definitions

For the purposes of the questions that follow please use the following definitions:

SIMPLE APPENDICITIS: a child with a presumed clinical or radiological diagnosis of simple appendicitis.

COMPLICATED APPENDICITIS: a child with a presumed clinical or radiological diagnosis of complicated appendicitis (comprising anything other than simple appendicitis but not an appendix mass).

APPENDIX MASS: a child that has a presumed clinical or radiological diagnosis of an appendix mass.

We appreciate it is not always possible to make an accurate distinction between these groups but please answer the questions the best you can according to these definitions.

Question 1

In the past 2 weeks have you managed a child with acute appendicitis differently to your usual practice as a result of the coronavirus pandemic?	◯ Yes ◯ No
In what way was your management of SIMPLE APPENDICITIS different to your usual practice?	☐ Simple appendicitis: used non-operative treatment as opposed to appendicectomy ☐ Simple appendicitis: used enteral antibiotics or shorter course of IV if managing conservatively ☐ Simple appendicitis: longer delay than usual in gaining access to operating theatre ☐ Simple appendicitis: used open approach in place of laparoscopy (Tick all that apply)
In what way was your management of COMPLICATED APPENDICITIS different to your usual practice?	☐ Complicated appendicitis: used non-operative treatment as opposed to appendicectomy ☐ Complicated appendicitis: earlier switch to oral antibiotics ☐ Complicated appendicitis: longer delay than usual in gaining access to operating theatre ☐ Complicated appendicitis: used open approach in place of laparoscopy ☐ Appendix mass: non-operative treatment as opposed to appendicectomy ☐ Appendix mass: no offer of interval appendicectomy as opposed to routine offering of interval appendicectomy (Tick all that apply)
In what way were these GENERAL ASPECTS OF MANAGEMENT different?	☐ Any appendicitis: routine imaging for all to be certain of diagnosis ☐ Any appendicitis: CT instead of US (including use of chest CT or to protect staff) ☐ Any appendicitis: transfer of a child to our hospital for treatment when that treatment would usually be provided at local hospital (Tick all that apply)
Was this different management brought about:	☐ as an active decision by you / your department ☐ as a passive decision due to different resource availability (e.g. you could not get a child to surgery and they got better on antibiotics) ☐ on the instruction of your department / institution / NHSE ☐ instigated by the parents (Tick all that apply)

Question 2

Thinking ahead and given what you currently know about the likely effect the coronavirus pandemic will have, please indicate if you anticipate that you will manage children with acute appendicitis differently compared to your usual practice DURING the pandemic (for example you may be considering different thresholds for imaging, or the use of non-operative treatment in place of appendicectomy).	◯ Yes - differently ◯ No - usual practice
If yes, in what way do you currently anticipate there will be differences for children with SIMPLE APPENDICITIS? Please only tick the box if you anticipate your management will be different to your usual practice for the specific clinical situation listed.	☐ Simple appendicitis: I will actively offer non-operative treatment to all children with simple appendicitis ☐ Simple appendicitis: I will consider non-operative treatment for children with simple appendicitis at parental request ☐ Simple appendicitis: I will actively perform open (as opposed to laparoscopic) appendicectomy in children with simple appendicitis (Tick all that apply)
If yes, in what way do you currently anticipate there will be differences for children with COMPLICATED APPENDICITIS? Please only tick the box if you anticipate your management will be different to your usual practice for the specific clinical situation listed.	☐ Complicated appendicitis: I will actively offer non-operative treatment to children with complicated appendicitis ☐ Complicated appendicitis: I will consider non-operative treatment to children with complicated appendicitis at parental request ☐ Complicated appendicitis: I will actively perform open (as opposed to laparoscopic) appendicectomy in children with complicated appendicitis ☐ Complicated appendicitis: I will actively pursue a shorter than usual course of intravenous antibiotics in children with complicated appendicitis ☐ Appendix mass: I will actively offer non-operative treatment to children with appendix mass ☐ Appendix mass: I will consider non-operative treatment to children with appendix mass at parental request ☐ Appendix mass: I will not offer routine interval appendicectomy in children who have has successful non-operative treatment of appendix mass (Tick all that apply)

If yes, in what way do you currently anticipate there will be differences in the GENERAL MANAGEMENT of children with appendicitis?

Please only tick the box if you anticipate your management will be different to your usual practice for the specific clinical situation listed.

- ☐ Any appendicitis: Routine imaging for all cases of suspected appendicitis to be certain of diagnosis
- ☐ Any appendicitis: CT scan instead of US for diagnosis of appendicitis
- ☐ Any appendicitis: More frequent use of imaging to guide management (e.g. select cases for non-operative treatment / reduce negative appendicectomy rate)
- ☐ Any appendicitis: consultant review for all cases prior to considering surgery
- ☐ Any appendicitis: we will likely be sending children with appendicitis to another hospital for treatment
- ☐ Any appendicitis: we will likely be treating children at my hospital who would usually be treated somewhere else

(Tick all that apply)

Question 3

Thus far during this pandemic, has your department or your institution made any decisions or placed any restrictions on you that you feel will influence how you manage children with acute appendicitis that are not included in responses to the questions above	◯ Yes ◯ No

Please describe

Question 4

Do you have any suggestions for practice change during the pandemic in relation to acute appendicitis that you wish to share? These may be useful to help other institutions manage children with appendicitis.

Any suggestions will be treated anonymously.

_____

Last page

In order to ensure that we send you a copy of the rapid summary findings of this survey, please provide your email address. We will also send you a link to the survey at the end of the pandemic so we can understand the impact better.	_____ (Whilst this is optional it would be really great if as many people as possible would be willing to complete a survey later in the year so we can maximise the opportunities for learning.)
Please enter the name of the institution at which you work (this is just so we can identify responses from the same centre)	_____
Are you a	◯ General Surgeon ◯ Specialist Paediatric Surgeon
If you wish to receive acknowledgement of your participation in this national survey please provide your name.	_____

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7,8
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	9,10

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9,10
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10,11
Discussion			
Key results	18	Summarise key results with reference to study objectives	12,13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	7

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

Children with AppendicitiS during the CoronAvirus panDEmic (CASCADE)

Introduction

The current coronavirus pandemic is placing NHS services in an unprecedented situation and there will be impact of the delivery of care for non-coronavirus patients. It has been suggested that where alternative non-surgical treatment approaches exist for a given condition, some may be more suitable in these times for a variety of reasons.

The management of children with acute appendicitis is a clinical scenario in which it is recognised there are a number of different treatment options and existing variation in management across the UK. This project aims to understand the impact of the COVID-19 pandemic on the management of children with appendicitis in the UK and to summarise outcomes of this patient population during this time period.

Methods

This will be a mixed methods study comprising 3 components:

1. A brief survey of consultant surgeons regarding the current and anticipated impact of COVID-19 on the management of children with acute appendicitis to be distributed as soon as possible. All responses will be treated anonymously and an early response summary will be distributed to all participants in the anticipation that the findings may guide or influence practice during the pandemic.
2. A patient level cohort study that will collect data on what treatment was provided to individual cases and what the outcomes were (data will be collected locally and anonymous data forwarded to the coordinating centre on a monthly basis). This will run until the end of the pandemic.
3. At the end of the pandemic a survey of consultant surgeons to understand what happened differently, how effective this was perceived to be, what learning there has been about how we manage appendicitis.

Data to be collected

A minimum dataset on each case of appendicitis will be recorded using an excel spreadsheet distributed to each participating centre. Each centre will be asked to return the spreadsheet for all cases discharged within a given calendar month.

- The surveys will be administered via REDCap.
- The first survey will be distributed during the week beginning March 30th 2020
- Prospective data collection will start April 1st 2020
- The final survey will be distributed at the end of the pandemic at a timepoint agreed by the study team.

Centres

All UK centres that treat children with appendicitis are encouraged to participate. Results will be shared with all those who participate as soon as they are available.

Approvals

Each participating centre will be asked to register this as a service evaluation. The study meets the criteria for a service evaluation according to the HRA guidance.

Study team

Nigel Hall (Southampton – lead centre), Clare Rees (St Marys Hospital, London), Jonathan Sutcliffe (Leeds), George Bethell (Southampton – Data co-ordinator). All units in the UK that treat children with appendicitis will be encouraged to collaborate with a named consultant and at least one trainee at each centre. If any published article arises from this work then all those who collaborate will be acknowledged under a group authorship model.

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BMJ Paediatrics Open

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

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

CASCADE study collaborators

Members of the CASCADE study collaborators group are listed in the Acknowledgement section.

All authors have completed the Unified Competing Interest form (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work.

Data sharing statement – Reasonable requests of relevant data will be considered.

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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 United Kingdom 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 United Kingdom and Ireland for cases admitted between April 1st and May 31st 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.

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.

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 two 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

Introduction

Acute appendicitis is the most common surgical condition in children and affects approximately 8% of all people throughout their lifetime. In the United Kingdom (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 (AGP).[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 CASCADE study (Children with AppendicitiS during the CoronAvirus panDEmic) 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 day) 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. The survey was approved by the research committee of the British Association of Paediatric Surgeons. Specialist paediatric and general surgeons who treat children with appendicitis were invited to complete the survey during the 2-week period leading up to April 14th 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 tool [8] and is available in supplementary material S1. Questions asked were focussed 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 less than 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 April 1st 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 April 1st 2020 and May 31st 2020 and for whom 30-day

outcome data was provided to the coordinating team by the data cut-off date of 13th July 2020. Follow-up data was censored at 30 days post hospital discharge from initial admission.

Ethical considerations

This study was registered at each site as a service evaluation, as defined by the health research authority guidance, as this was an observational study only collecting anonymised routine data with no change to clinical care pathways.

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, CRP and WCC at admission were identical.

Statistical analysis was performed using StataSE v15 (StataCorp LLC, Texas, USA) and the figures were produced using GraphPad Prism v8 (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 chi-squared 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 less than 0.05 was considered as statistically significant. The study was conducted according to Strengthening the Reporting of Observational studies in Epidemiology (STROBE) 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 of to disseminate findings of this study to.

Funding

The study did not receive any funding. 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) 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 work-up, the type of treatment offered or that they would cease treating children with appendicitis altogether during the coronavirus pandemic (Table 1).

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 (e.g. 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

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 April 1st and May 31st 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 and abdominal computed tomography (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 ultrasound scan than of cases treated surgically. Of cases suspected to be simple appendicitis 43% (259/600) were initially treated non-operatively compared to 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 ultrasound than cases performed open. For both open and laparoscopic procedures surgeons tended to underestimate disease severity at diagnosis compared to the surgical findings (Table 3). The overall negative appendicectomy rate was 4.5% (n=23) in cases treated surgically.

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 1). 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 2).

Figures

Figure 1 Initial treatment stratified by suspected severity of appendicitis at diagnosis

* Data on severity at diagnosis missing for 2 cases; both had non-operative treatment; $ Data on surgical approach missing for 7 cases; NOT – non-operative treatment; Lap - laparoscopic

Figure 2. Initial management strategy of appendicitis by week, operative *vs* non-operative.

The red bars represent operative treatment and the blue bars represent non-operative treatment demonstrating a trend towards operative treatment over time.

Figure 3. Initial operative management strategy of appendicitis by week, open *vs* laparoscopic.

The red bars represent laparoscopic appendicectomy and the blue bars represent open appendicectomy demonstrating a trend towards laparoscopic appendicectomy over time.

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

		Non-operative (n= 326)	Operative (n=512)	*p*
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

Speciality (n, %)	GS	140 (43)	202 (39)	0.35
	SPS	186 (57)	310 (61)	
Admission bloods	WCC – x10^9/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 2 cases suspected severity was missing; GS – general surgeon; SPS – specialist paediatric surgeon; WCC – white cell count; CRP – C-reactive protein; L – litre; mg – milligrams.

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.

Overall, cases treated operatively had a longer length of initial inpatient stay compared to 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 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 appendicectomy 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 to 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.

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
Age (years)		10 (7-12)	11 (9-13)	0.0004
Male (n,%)		176 (67)	149 (61)	0.19
Speciality (n,%)	GS	119 (60)	81 (40)	0.006
	SPS	143 (47)	162 (53)	
Admission bloods	WCC – $x10^9$/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 7 cases. GS – general surgeon; SPS – specialist paediatric surgeon; WCC – white cell count; CRP – C-reactive protein; L – litre; mg – milligrams.

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

Table 4	Simple or No appendicitis				Complicated appendicitis or Appendix Mass		
	Open (n=141)	Laparoscopic (n=118)	p		Open (n=120)	Laparoscopic (n=125)	p
Readmission (n, %)	4 (2.8)	4 (3.4)	1.00		15 (13)	15 (12)	1.00
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)	1.00		2 (1.7)	3 (2.4)	1.00
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)	1.00		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

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 appendicectomy 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 2018[3] 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.

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 United Kingdom 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 United Kingdom 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. 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. Whilst any such resulting 'over-treatment' 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 longer 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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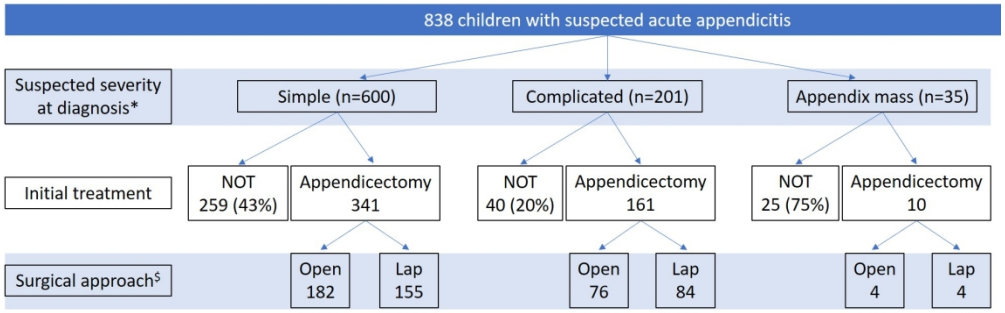

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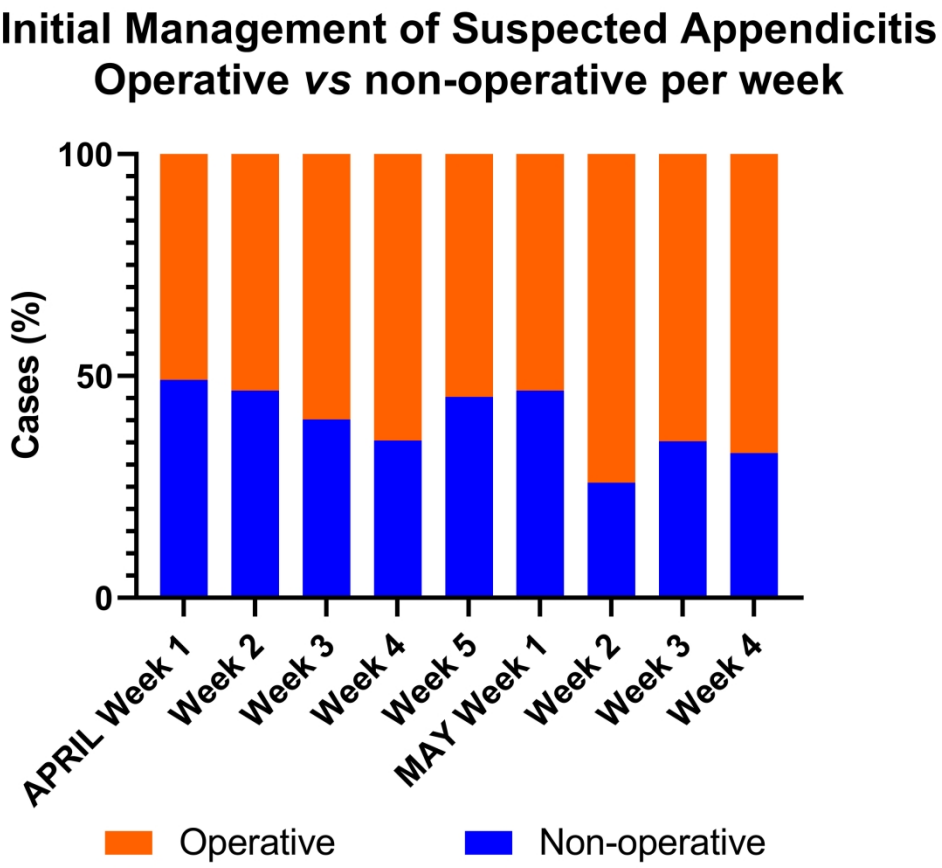

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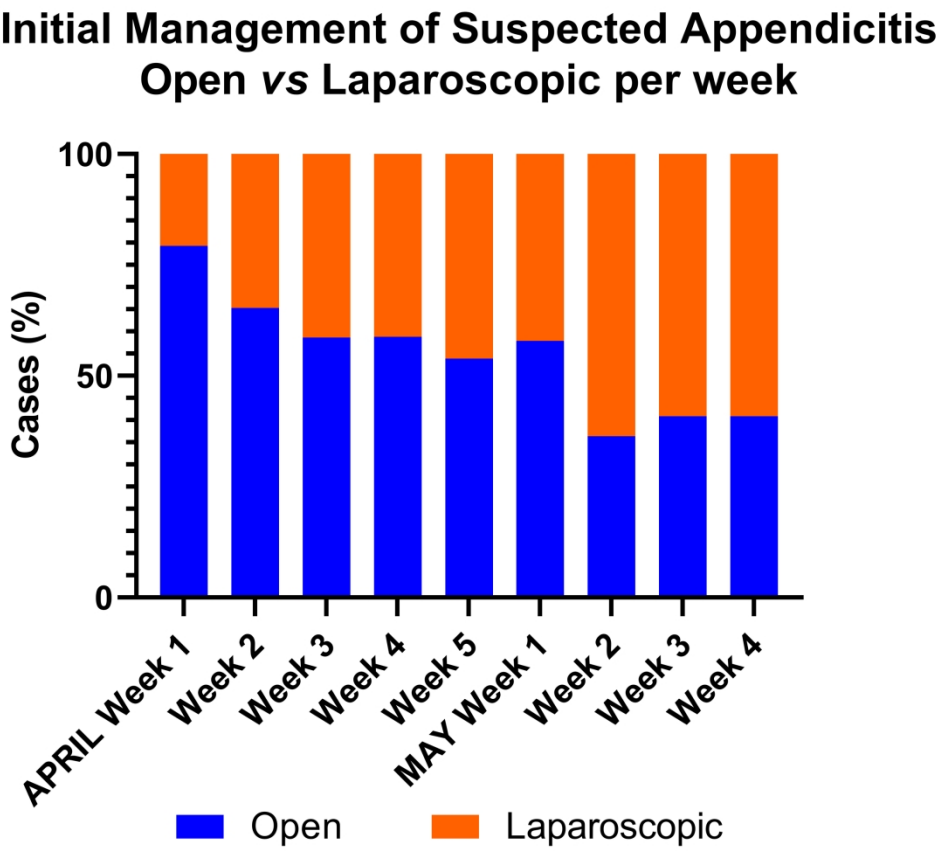

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Children with AppendicitiS during the CoronAvirus panDEmic (CASCADE)

The current coronavirus pandemic is placing NHS services in an unprecedented situation and there will be impact on the delivery of care for non-coronavirus patients. Guidance from the Royal Colleges recommends change in standard surgical treatment pathways. Clinicians may decide or be encouraged to consider treating some conditions differently to their usual practice. This will certainly have an impact on practice and may influence outcomes.

The management of children with acute appendicitis is one such condition. A number of different treatment options exist and current pathways may well be changed in some centres.

This CASCADE study has been set-up to capture data relating to this.

This initial survey aims to capture the current and anticipated impact of the coronavirus pandemic on treatment of children with acute appendicitis. It comprises just 4 questions and should take no more then 5 minutes to complete.

It is for completion by consultants only please. This is not because we don't value the views of trainees but in this particular instance we feel that consultants are more likely than ever going to be making decisions.

We will generate a rapid summary of the data in order to provide you with an overview of how practice is changing across the country and to share ideas for change that are considered useful.

All responses will be treated anonymously. Please complete the entire survey for your responses to be saved.

Definitions

For the purposes of the questions that follow please use the following definitions:

SIMPLE APPENDICITIS: a child with a presumed clinical or radiological diagnosis of simple appendicitis.

COMPLICATED APPENDICITIS: a child with a presumed clinical or radiological diagnosis of complicated appendicitis (comprising anything other than simple appendicitis but not an appendix mass).

APPENDIX MASS: a child that has a presumed clinical or radiological diagnosis of an appendix mass.

We appreciate it is not always possible to make an accurate distinction between these groups but please answer the questions the best you can according to these definitions.

Question 1

In the past 2 weeks have you managed a child with acute appendicitis differently to your usual practice as a result of the coronavirus pandemic?	◯ Yes ◯ No
In what way was your management of SIMPLE APPENDICITIS different to your usual practice?	☐ Simple appendicitis: used non-operative treatment as opposed to appendicectomy ☐ Simple appendicitis: used enteral antibiotics or shorter course of IV if managing conservatively ☐ Simple appendicitis: longer delay than usual in gaining access to operating theatre ☐ Simple appendicitis: used open approach in place of laparoscopy (Tick all that apply)
In what way was your management of COMPLICATED APPENDICITIS different to your usual practice?	☐ Complicated appendicitis: used non-operative treatment as opposed to appendicectomy ☐ Complicated appendicitis: earlier switch to oral antibiotics ☐ Complicated appendicitis: longer delay than usual in gaining access to operating theatre ☐ Complicated appendicitis: used open approach in place of laparoscopy ☐ Appendix mass: non-operative treatment as opposed to appendicectomy ☐ Appendix mass: no offer of interval appendicectomy as opposed to routine offering of interval appendicectomy (Tick all that apply)
In what way were these GENERAL ASPECTS OF MANAGEMENT different?	☐ Any appendicitis: routine imaging for all to be certain of diagnosis ☐ Any appendicitis: CT instead of US (including use of chest CT or to protect staff) ☐ Any appendicitis: transfer of a child to our hospital for treatment when that treatment would usually be provided at local hospital (Tick all that apply)
Was this different management brought about:	☐ as an active decision by you / your department ☐ as a passive decision due to different resource availability (e.g. you could not get a child to surgery and they got better on antibiotics) ☐ on the instruction of your department / institution / NHSE ☐ instigated by the parents (Tick all that apply)

Question 2

Thinking ahead and given what you currently know about the likely effect the coronavirus pandemic will have, please indicate if you anticipate that you will manage children with acute appendicitis differently compared to your usual practice DURING the pandemic (for example you may be considering different thresholds for imaging, or the use of non-operative treatment in place of appendicectomy).	◯ Yes - differently ◯ No - usual practice
If yes, in what way do you currently anticipate there will be differences for children with SIMPLE APPENDICITIS? Please only tick the box if you anticipate your management will be different to your usual practice for the specific clinical situation listed.	☐ Simple appendicitis: I will actively offer non-operative treatment to all children with simple appendicitis ☐ Simple appendicitis: I will consider non-operative treatment for children with simple appendicitis at parental request ☐ Simple appendicitis: I will actively perform open (as opposed to laparoscopic) appendicectomy in children with simple appendicitis (Tick all that apply)
If yes, in what way do you currently anticipate there will be differences for children with COMPLICATED APPENDICITIS? Please only tick the box if you anticipate your management will be different to your usual practice for the specific clinical situation listed.	☐ Complicated appendicitis: I will actively offer non-operative treatment to children with complicated appendicitis ☐ Complicated appendicitis: I will consider non-operative treatment to children with complicated appendicitis at parental request ☐ Complicated appendicitis: I will actively perform open (as opposed to laparoscopic) appendicectomy in children with complicated appendicitis ☐ Complicated appendicitis: I will actively pursue a shorter than usual course of intravenous antibiotics in children with complicated appendicitis ☐ Appendix mass: I will actively offer non-operative treatment to children with appendix mass ☐ Appendix mass: I will consider non-operative treatment to children with appendix mass at parental request ☐ Appendix mass: I will not offer routine interval appendicectomy in children who have has successful non-operative treatment of appendix mass (Tick all that apply)

If yes, in what way do you currently anticipate there will be differences in the GENERAL MANAGEMENT of children with appendicitis?

Please only tick the box if you anticipate your management will be different to your usual practice for the specific clinical situation listed.

- ☐ Any appendicitis: Routine imaging for all cases of suspected appendicitis to be certain of diagnosis
- ☐ Any appendicitis: CT scan instead of US for diagnosis of appendicitis
- ☐ Any appendicitis: More frequent use of imaging to guide management (e.g. select cases for non-operative treatment / reduce negative appendicectomy rate)
- ☐ Any appendicitis: consultant review for all cases prior to considering surgery
- ☐ Any appendicitis: we will likely be sending children with appendicitis to another hospital for treatment
- ☐ Any appendicitis: we will likely be treating children at my hospital who would usually be treated somewhere else

(Tick all that apply)

Question 3

Thus far during this pandemic, has your department or your institution made any decisions or placed any restrictions on you that you feel will influence how you manage children with acute appendicitis that are not included in responses to the questions above	◯ Yes ◯ No

Please describe

Question 4

Do you have any suggestions for practice change during the pandemic in relation to acute appendicitis that you wish to share? These may be useful to help other institutions manage children with appendicitis.

Any suggestions will be treated anonymously.

Last page

In order to ensure that we send you a copy of the rapid summary findings of this survey, please provide your email address. We will also send you a link to the survey at the end of the pandemic so we can understand the impact better.	_____ (Whilst this is optional it would be really great if as many people as possible would be willing to complete a survey later in the year so we can maximise the opportunities for learning.)
Please enter the name of the institution at which you work (this is just so we can identify responses from the same centre)	_____
Are you a	◯ General Surgeon ◯ Specialist Paediatric Surgeon
If you wish to receive acknowledgement of your participation in this national survey please provide your name.	_____

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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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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

CASCADE study collaborators

Members of the CASCADE study collaborators group are listed in the Acknowledgement section.

Competing interests statement - All authors have completed the Unified Competing Interest form (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work.

Data sharing statement – Reasonable requests of relevant data will be considered.

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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 United Kingdom 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 United Kingdom and Ireland for cases admitted between April 1st and May 31st 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.

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.

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 two 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

Introduction

Acute appendicitis is the most common surgical condition in children and affects approximately 8% of all people throughout their lifetime. In the United Kingdom (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 (AGP).[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 CASCADE study (Children with AppendicitiS during the CoronAvirus panDEmic) 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 day) 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. The survey was approved by the research committee of the British Association of Paediatric Surgeons. Specialist paediatric and general surgeons who treat children with appendicitis were invited to complete the survey during the 2-week period leading up to April 14th 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 tool [8] and is available in supplementary material S1. Questions asked were focussed 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 less than 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 April 1st 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 April 1st 2020 and May 31st 2020 and for whom 30-day

outcome data was provided to the coordinating team by the data cut-off date of 13th July 2020. Follow-up data was censored at 30 days post hospital discharge from initial admission.

Ethical considerations

This study was registered at each site as a service evaluation, as defined by the health research authority guidance, as this was an observational study only collecting anonymised routine data with no change to clinical care pathways.

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, CRP and WCC at admission were identical.

Statistical analysis was performed using StataSE v15 (StataCorp LLC, Texas, USA) and the figures were produced using GraphPad Prism v8 (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 chi-squared 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 less than 0.05 was considered as statistically significant. The study was conducted according to Strengthening the Reporting of Observational studies in Epidemiology (STROBE) 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 of to disseminate findings of this study to.

Funding

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) 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 work-up, the type of treatment offered or that they would cease treating children with appendicitis altogether during the coronavirus pandemic (Table 1).

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 (e.g. 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

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 April 1st and May 31st 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 and abdominal computed tomography (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 ultrasound scan than of cases treated surgically. Of cases suspected to be simple appendicitis 43% (259/600) were initially treated non-operatively compared to 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 ultrasound than cases performed open. For both open and laparoscopic procedures surgeons tended to underestimate disease severity at diagnosis compared to the surgical findings (Table 3). The overall negative appendicectomy rate was 4.5% (n=23) in cases treated surgically.

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 1). 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 2).

Figures

Figure 1 Initial treatment stratified by suspected severity of appendicitis at diagnosis

* Data on severity at diagnosis missing for 2 cases; both had non-operative treatment; $ Data on surgical approach missing for 7 cases; NOT – non-operative treatment; Lap - laparoscopic

Figure 2. Initial management strategy of appendicitis by week, operative *vs* non-operative.

The red bars represent operative treatment and the blue bars represent non-operative treatment demonstrating a trend towards operative treatment over time.

Figure 3. Initial operative management strategy of appendicitis by week, open *vs* laparoscopic.

The red bars represent laparoscopic appendicectomy and the blue bars represent open appendicectomy demonstrating a trend towards laparoscopic appendicectomy over time.

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

		Non-operative (n= 326)	Operative (n=512)	*p*
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

Speciality (n, %)	GS	140 (43)	202 (39)	0.35
	SPS	186 (57)	310 (61)	
Admission bloods	WCC – x10^9/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 2 cases suspected severity was missing; GS – general surgeon; SPS – specialist paediatric surgeon; WCC – white cell count; CRP – C-reactive protein; L – litre; mg – milligrams.

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.

Overall, cases treated operatively had a longer length of initial inpatient stay compared to 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 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 appendicectomy 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 to 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.

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
Age (years)		10 (7-12)	11 (9-13)	0.0004
Male (n,%)		176 (67)	149 (61)	0.19
Speciality (n,%)	GS	119 (60)	81 (40)	0.006
	SPS	143 (47)	162 (53)	
Admission bloods	WCC – $x10^9$/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 7 cases. GS – general surgeon; SPS – specialist paediatric surgeon; WCC – white cell count; CRP – C-reactive protein; L – litre; mg – milligrams.

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

Table 4	Simple or No appendicitis				Complicated appendicitis or Appendix Mass		
	Open (n=141)	Laparoscopic (n=118)	p		Open (n=120)	Laparoscopic (n=125)	p
Readmission (n, %)	4 (2.8)	4 (3.4)	1.00		15 (13)	15 (12)	1.00
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)	1.00		2 (1.7)	3 (2.4)	1.00
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)	1.00		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

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 appendicectomy 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 2018[3] 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.

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 United Kingdom 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 United Kingdom 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. Whilst any such resulting 'over-treatment' 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 longer 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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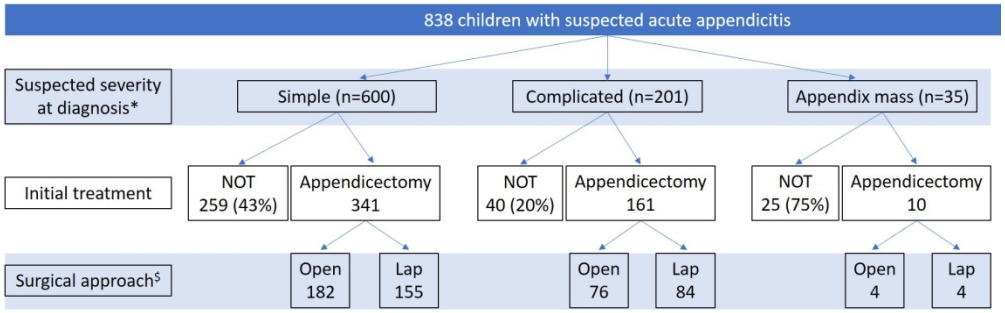
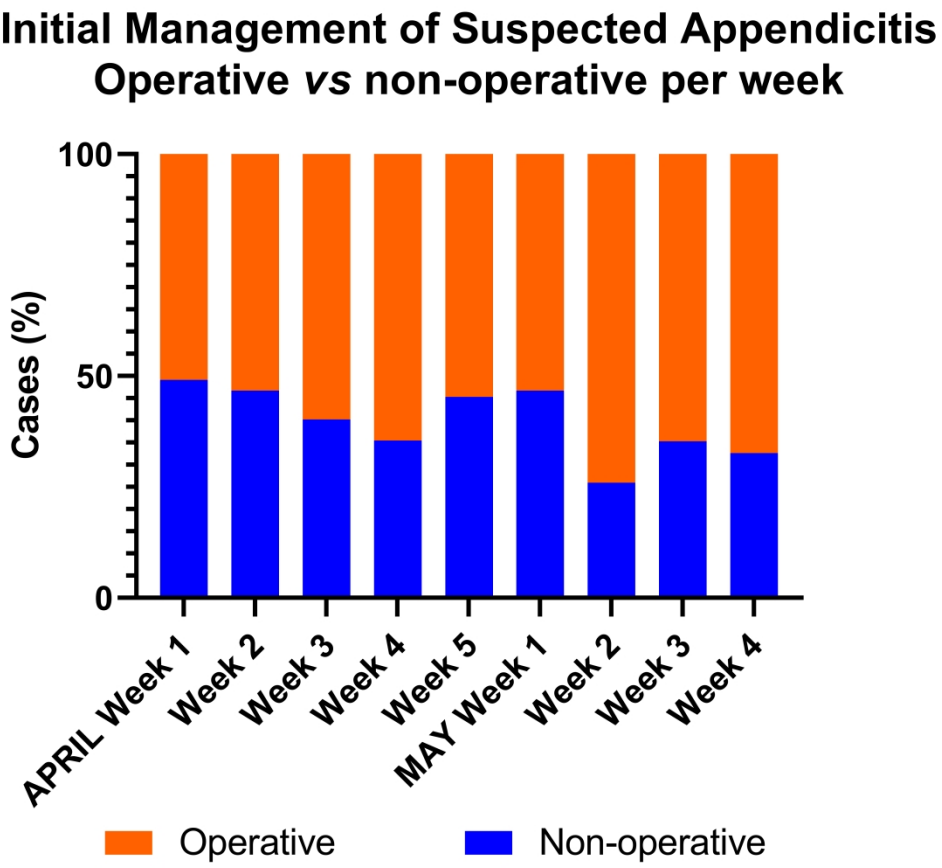

838 children with suspected acute appendicitis
Suspected severity at diagnosis*
Simple (n=600)
Complicated (n=201)
Appendix mass (n=35)
Initial treatment
NOT 259 (43%)
Appendicectomy 341
NOT 40 (20%)
Appendicectomy 161
NOT 25 (75%)
Appendicectomy 10
Surgical approach$
Open 182
Lap 155
Open 76
Lap 84
Open 4
Lap 4



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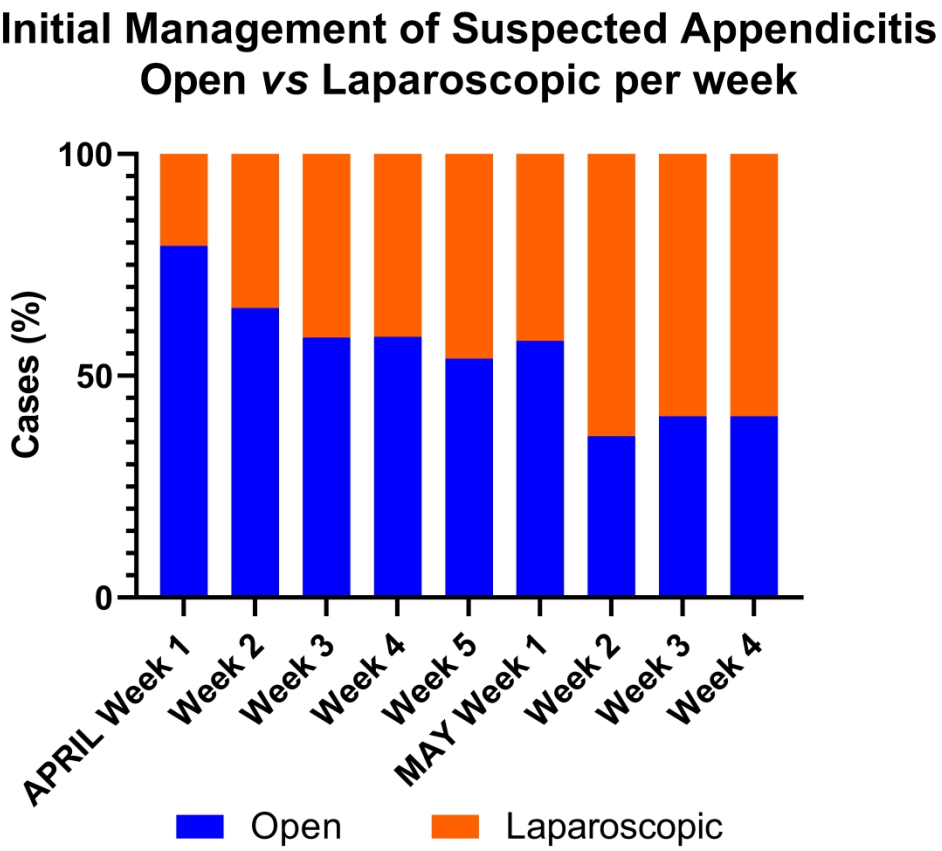

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Children with AppendicitiS during the CoronAvirus panDEmic (CASCADE)

The current coronavirus pandemic is placing NHS services in an unprecedented situation and there will be impact on the delivery of care for non-coronavirus patients. Guidance from the Royal Colleges recommends change in standard surgical treatment pathways. Clinicians may decide or be encouraged to consider treating some conditions differently to their usual practice. This will certainly have an impact on practice and may influence outcomes.

The management of children with acute appendicitis is one such condition. A number of different treatment options exist and current pathways may well be changed in some centres.

This CASCADE study has been set-up to capture data relating to this.

This initial survey aims to capture the current and anticipated impact of the coronavirus pandemic on treatment of children with acute appendicitis. It comprises just 4 questions and should take no more then 5 minutes to complete.

It is for completion by consultants only please. This is not because we don't value the views of trainees but in this particular instance we feel that consultants are more likely than ever going to be making decisions.

We will generate a rapid summary of the data in order to provide you with an overview of how practice is changing across the country and to share ideas for change that are considered useful.

All responses will be treated anonymously. Please complete the entire survey for your responses to be saved.

Definitions

For the purposes of the questions that follow please use the following definitions:

SIMPLE APPENDICITIS: a child with a presumed clinical or radiological diagnosis of simple appendicitis.

COMPLICATED APPENDICITIS: a child with a presumed clinical or radiological diagnosis of complicated appendicitis (comprising anything other than simple appendicitis but not an appendix mass).

APPENDIX MASS: a child that has a presumed clinical or radiological diagnosis of an appendix mass.

We appreciate it is not always possible to make an accurate distinction between these groups but please answer the questions the best you can according to these definitions.

Question 1

In the past 2 weeks have you managed a child with acute appendicitis differently to your usual practice as a result of the coronavirus pandemic?	◯ Yes ◯ No
In what way was your management of SIMPLE APPENDICITIS different to your usual practice?	☐ Simple appendicitis: used non-operative treatment as opposed to appendicectomy ☐ Simple appendicitis: used enteral antibiotics or shorter course of IV if managing conservatively ☐ Simple appendicitis: longer delay than usual in gaining access to operating theatre ☐ Simple appendicitis: used open approach in place of laparoscopy (Tick all that apply)
In what way was your management of COMPLICATED APPENDICITIS different to your usual practice?	☐ Complicated appendicitis: used non-operative treatment as opposed to appendicectomy ☐ Complicated appendicitis: earlier switch to oral antibiotics ☐ Complicated appendicitis: longer delay than usual in gaining access to operating theatre ☐ Complicated appendicitis: used open approach in place of laparoscopy ☐ Appendix mass: non-operative treatment as opposed to appendicectomy ☐ Appendix mass: no offer of interval appendicectomy as opposed to routine offering of interval appendicectomy (Tick all that apply)
In what way were these GENERAL ASPECTS OF MANAGEMENT different?	☐ Any appendicitis: routine imaging for all to be certain of diagnosis ☐ Any appendicitis: CT instead of US (including use of chest CT or to protect staff) ☐ Any appendicitis: transfer of a child to our hospital for treatment when that treatment would usually be provided at local hospital (Tick all that apply)
Was this different management brought about:	☐ as an active decision by you / your department ☐ as a passive decision due to different resource availability (e.g. you could not get a child to surgery and they got better on antibiotics) ☐ on the instruction of your department / institution / NHSE ☐ instigated by the parents (Tick all that apply)

Question 2

Thinking ahead and given what you currently know about the likely effect the coronavirus pandemic will have, please indicate if you anticipate that you will manage children with acute appendicitis differently compared to your usual practice DURING the pandemic (for example you may be considering different thresholds for imaging, or the use of non-operative treatment in place of appendicectomy).	◯ Yes - differently ◯ No - usual practice
If yes, in what way do you currently anticipate there will be differences for children with SIMPLE APPENDICITIS? Please only tick the box if you anticipate your management will be different to your usual practice for the specific clinical situation listed.	☐ Simple appendicitis: I will actively offer non-operative treatment to all children with simple appendicitis ☐ Simple appendicitis: I will consider non-operative treatment for children with simple appendicitis at parental request ☐ Simple appendicitis: I will actively perform open (as opposed to laparoscopic) appendicectomy in children with simple appendicitis (Tick all that apply)
If yes, in what way do you currently anticipate there will be differences for children with COMPLICATED APPENDICITIS? Please only tick the box if you anticipate your management will be different to your usual practice for the specific clinical situation listed.	☐ Complicated appendicitis: I will actively offer non-operative treatment to children with complicated appendicitis ☐ Complicated appendicitis: I will consider non-operative treatment to children with complicated appendicitis at parental request ☐ Complicated appendicitis: I will actively perform open (as opposed to laparoscopic) appendicectomy in children with complicated appendicitis ☐ Complicated appendicitis: I will actively pursue a shorter than usual course of intravenous antibiotics in children with complicated appendicitis ☐ Appendix mass: I will actively offer non-operative treatment to children with appendix mass ☐ Appendix mass: I will consider non-operative treatment to children with appendix mass at parental request ☐ Appendix mass: I will not offer routine interval appendicectomy in children who have has successful non-operative treatment of appendix mass (Tick all that apply)

If yes, in what way do you currently anticipate there will be differences in the GENERAL MANAGEMENT of children with appendicitis?

Please only tick the box if you anticipate your management will be different to your usual practice for the specific clinical situation listed.

- ☐ Any appendicitis: Routine imaging for all cases of suspected appendicitis to be certain of diagnosis
- ☐ Any appendicitis: CT scan instead of US for diagnosis of appendicitis
- ☐ Any appendicitis: More frequent use of imaging to guide management (e.g. select cases for non-operative treatment / reduce negative appendicectomy rate)
- ☐ Any appendicitis: consultant review for all cases prior to considering surgery
- ☐ Any appendicitis: we will likely be sending children with appendicitis to another hospital for treatment
- ☐ Any appendicitis: we will likely be treating children at my hospital who would usually be treated somewhere else

(Tick all that apply)

Question 3

Thus far during this pandemic, has your department or your institution made any decisions or placed any restrictions on you that you feel will influence how you manage children with acute appendicitis that are not included in responses to the questions above	◯ Yes ◯ No

Please describe

Question 4

Do you have any suggestions for practice change during the pandemic in relation to acute appendicitis that you wish to share? These may be useful to help other institutions manage children with appendicitis.

Any suggestions will be treated anonymously.

Last page

In order to ensure that we send you a copy of the rapid summary findings of this survey, please provide your email address. We will also send you a link to the survey at the end of the pandemic so we can understand the impact better.	_____ (Whilst this is optional it would be really great if as many people as possible would be willing to complete a survey later in the year so we can maximise the opportunities for learning.)
Please enter the name of the institution at which you work (this is just so we can identify responses from the same centre)	_____
Are you a	◯ General Surgeon ◯ Specialist Paediatric Surgeon
If you wish to receive acknowledgement of your participation in this national survey please provide your name.	_____