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Impact of the COVID-19 pandemic on management and outcomes in acute appendicitis: Should these new practices be the norm?

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ABSTRACT

Background: In early 2020, the COVID-19 pandemic significantly altered management of surgical patients globally. International guidelines recommended that non-operative management be implemented wherever possible (e.g. in proven uncomplicated appendicitis) to reduce pressure on healthcare services and reduce risk of peri-operative viral transmission. We sought to compare our management and outcomes of appendicitis during lockdown vs a non-pandemic period.

Methods: All presentations to our department with a clinical diagnosis of acute appendicitis between 12/03/2020 and 30/06/2020 were compared to the same 110-day period in 2019. Quantity and severity of presentations, use of radiological investigations, rate of operative intervention and histopathological findings were variables collected for comparison.

Results: There was a reduction in appendicitis presentations (from 74 to 56 cases), and an increase in radiological imaging (from 70.27% to 89.29%) ($P = 0.007$) from 2019 to 2020. In 2019, 93.24% of patients had appendicectomy, compared to 71.42% in 2020($P < 0.001$). This decrease was most pronounced in uncomplicated cases, whose operative rates dropped from 90.32% to 62.5% ($P = 0.009$). Post-operative histology confirmed appendicitis in 73.9% in 2019, compared to 97.5% in 2020 ($P = 0.001$). Normal appendiceal pathology was reported for 17 cases (24.64%) in 2019, compared to none in 2020 ($P < 0.001$) – a 0% negative appendicectomy rate (NAR).

Discussion: The 0% NAR in 2020 is due to a combination of increased CT imaging, a higher threshold to operate, and is impacted by increased disease severity due to delayed patient presentation. This study adds to growing literature promoting routine use of radiological imaging to confirm appendicitis diagnosis. As we enter a second lockdown, patients should be encouraged to avoid late presentations, and surgical departments should continue using radiological imaging more liberally in guiding appendicitis management.

Introduction

Acute appendicitis (AA) is the most common general surgical presentation requiring emergency operative management. It has an incidence of 112 per 100,000 a year in Europe,[1] and an overall lifetime risk of 7–8%.[2] Appendicectomy is the standard treatment in most incidence of AA. It is a low-risk operation with mortality rates of 0.07–0.6% in uncomplicated cases, and 0.5–1.2% in complicated AA.[3,4] While appendicectomy is deemed a routine surgical procedure, rates of negative appendicectomy have been high historically, ranging from 10 to

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20%,[5] and is associated with a considerable degree of morbidity.[6] Non-operative management emerged as an alternative to appendicectomy in recent years. Several high-level studies have reported successful non-operative treatment of AA with antibiotics.[7–14] However, AA treated with antibiotics alone remains at risk of recurring – requiring readmission and appendicectomy at a later date.

In early 2020, the COVID-19 (SARS-CoV-2) pandemic instigated a change in many healthcare practices globally. As our understanding was evolving, information and advice regarding management of surgical patients underwent continuing revision. The first official guidelines were published by the American College of Surgeons (ACS)[15] and the four surgical royal colleges of the United Kingdom and Ireland (Royal College of Surgeons, RCS)[16] in late March. These recommended that non-operative management be implemented where possible (e.g. in proven early appendicitis or acute cholecystitis) and cautioned regarding risks of aerosol-type transmission during laparoscopy.

Aims

During the pandemic, we observed a decrease in acute surgical presentations to our Emergency Department. The cases that did present were often clinically more severe. This was presumed to be attributable to delays in presentation, as patients tried to both avoid and preserve hospitals. We sought to quantify these observations and to compare our management and our outcomes of appendicitis patients during the lockdown period vs the same period in 2019.

Methods

This case-control study was carried out in the Surgical Department of Beaumont Hospital, a Level 4, University teaching hospital. We compared all consecutive patients above the age of 16 years old who presented with AA between the 12th March (when the WHO declared a global pandemic) and the 30th June 2020, to their counterparts during the same dates in 2019.

Patient demographics, previous antimicrobial therapy, laboratory findings at admission, radiological diagnosis, type of surgical treatment, and histopathological findings were the variables included for analysis.

Radiological data was gathered from NIMIS (National Integrated Medical Imaging System), a nation-wide radiological viewing system. Operative data was collected from our electronic theatre records, and both laboratory and histopathological data is recorded on Beaumont Hospital's laboratory system, PIPE (Patient Information Profile Explorer).

To stratify severity of cases, both radiological and histopathological data were classified using the AAST grading system.[17] This system, first proposed by Garst et al.,[18] grades acute appendicitis as follows: (G1). Acutely inflamed appendix, (G2). Gangrenous/Necrotising appendix, (G3). Perforated with local contamination, (G4). Perforated with periappendiceal phlegmon/abscess, (G5). Perforated with generalised peritonitis. Additional variables for radiological data included those with no imaging, and those with inconclusive imaging. Additional variables in the histology data were normal appendiceal histology, alternate abnormal histology, and those that had no operation.

Statistical analysis was performed using Stata (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX). Univariate analysis results are presented with a mean and SD or percentage. Bivariate analysis with the χ^2 or the Fisher test for qualitative variables. Statistical significance was considered when $P < 0.05$.

Results

Population

There were 74 patients treated for AA from 12th March to 30th June in 2019, and 56 patients presenting for the same period in 2020. Age and gender were similar in both groups (Table 1), with a female predominance at 52.7% (2019) and 51.8% (2020).

Radiology

Radiology was used in 70.27% of patients in 2019, and 89.29% in 2020 (risk ratio [RR], 0.79; 95% confidence interval [CI], 0.66–0.94; $P = 0.007$).

The most used imaging modality across both groups was computed tomography (CT). CT was performed on 54.05% of presentations in 2019, and 69.64% in 2020 (RR 0.77; 95% CI, 0.59–1.01; $P = 0.051$) (Fig. 1).

Ultrasound was the second most used imaging modality, accounting for 10.8% of investigations in 2019 and 12.5% in 2020. MRI was utilised the least, at 5.4% in 2019 and 7.14% in 2020.

Overall, those presenting in 2020 had more severe radiological features when compared to 2019 (Fig. 2). There were increased rates of both uncomplicated (from 41.89% to 57.14%) (RR, 0.71; 95% CI, 0.58–0.87; $P = 0.001$) and complicated (20.27% to 30.36%) (RR, 0.66; 95% CI 0.37–1.22; $P = 0.132$) radiologically confirmed appendicitis in our pandemic period in 2020 when compared to the 2019 cohort. In particular, rates of perforation at presentation were higher in the 2020 cohort, with 9 patients (16.07%) having perforated features on imaging, compared to 2 patients (2.7%) in 2019 (RR 0.17; CI 95% 0.04–0.75; $P = 0.008$).

Management

In 2019, 93.24% of patients had appendicectomy, and all carried out laparoscopically. In 2020, only 71.42% of patients had appendicectomy (RR 1.3; 95% CI, 1.09–1.56; $P < 0.001$) (Table 2). Of these, one patient (1.79%) underwent open appendicectomy. The remaining 39 (69.64%) were laparoscopic.

Table 1 – Population comparison.

Characteristics	2019 N = 74	2020 N = 56	P value
Age, *years – mean ± SD*	36.6 ± 16.5	36.5 ± 14.9	0.9565
Age, *years – range*	16–78	17–82	–
Male, gender – *n (%)*	35 (47.3%)	27 (48.2%)	0.9182

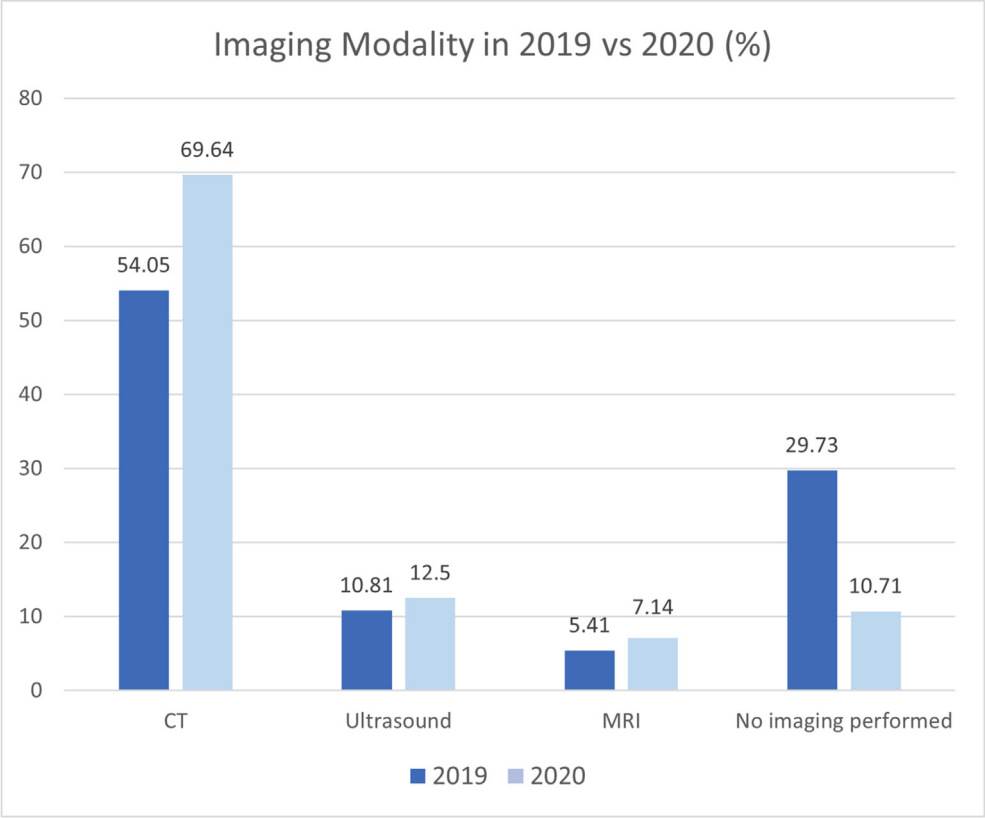

Fig. 1 – Imaging modality. The percentage use of each imaging modality used in 2019 vs 2020.

Rates of appendicectomy for Grade 1 AA dropped from 90.32% in 2019 to 62.5% in 2020 (RR 1.44; 95% CI, 1.07–1.94; $P = 0.009$). With increasing case severity in 2020, came increased operative rates (76.47% for complicated). However, this was still lower than in 2019, where 86.66% of complicated cases received appendicectomy. This stricter operating criterion was not reflected in 2019, when patients were equally likely to undergo operation for both

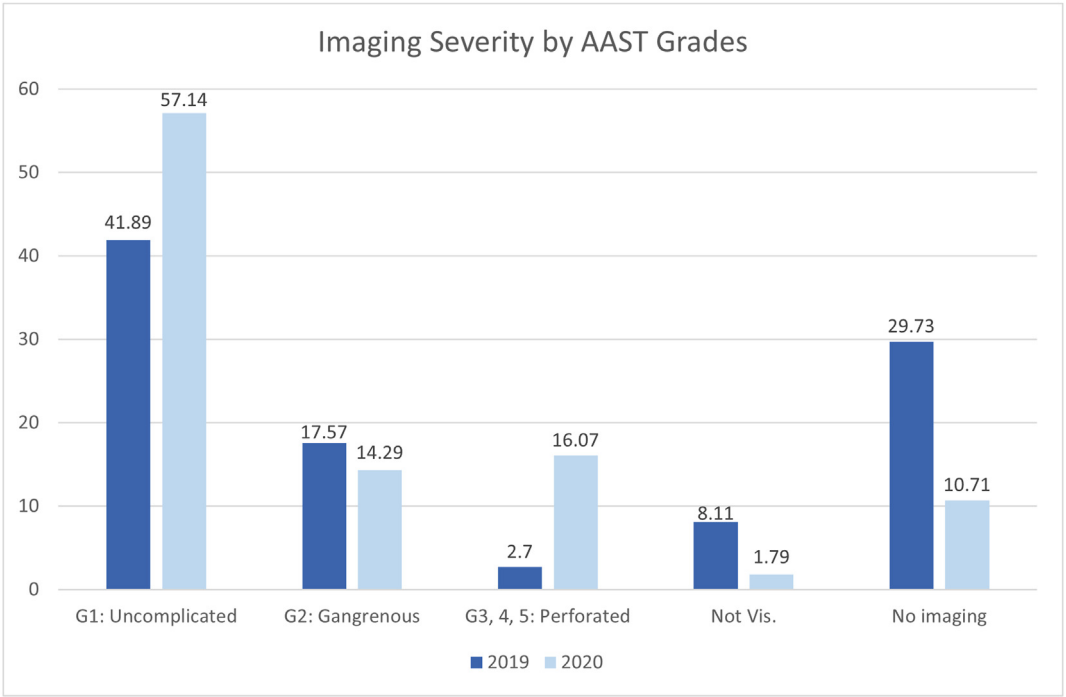

Fig. 2 – Imaging severity by AAST grade. Severity based on imaging results – grouped by the AAST grades/classification.

Table 2 – Operative vs conservative management.

	2019 N = 74		2020 N = 56		Risk ratio (95% CI)	P value
	No. of patients (%)					
Operative management	69	(93.24)	40	(71.42)	1.3 (1.09–1.56)	<0.001
Laparoscopic	69	(100% of op.)	39	(97.5% of op.)	1.02 (0.96 to 1.08)	0.367
Open	0	(0)	1	(2.5% of op.)	–	0.367
No operation	5	(6.76)	16	(28.57)	0.23 (0.09–0.61)	<0.001

uncomplicated (90.32%) and complicated (86.66%) disease (Table 3).

In both years, every patient who had either inconclusive imaging or no imaging performed at all, proceeded to theatre.

Histology

The post-operative histology results confirmed AA in 73.9% of cases in 2019, compared to 97.5% in 2020 (RR 0.75; 95% CI, 0.65–0.87; $P = 0.001$) (Table 4/Fig. 3). In 2020, there was a decrease in uncomplicated (G1) appendicitis on histology from 62.32% in 2019 to 57.5% in 2020 (RR 1.08; 95% CI, 0.78–1.49; $P = 0.348$). There was a substantial rise in complicated (G2–5) cases in 2020 vs 2019. Gangrenous or necrotising histology (G2) was reported in 20% of cases in 2020, and an additional 20% of cases had perforation (G3–5). The rate of complicated appendicitis was therefore 40% in 2020, compared to 11.6% in 2019 (RR 0.29; 95% CI, 0.14–0.62; $P < 0.001$).

In each group there was one case each of alternate abnormal histology. In 2019, this was a neuroendocrine tumour and in 2020, a pin worm was present on histology.

In 2019, 17 cases (24.64%) were found to have a normal appendix on post-operative histology. There were no normal appendixes reported from our group of patients in 2020 (risk difference 0.24; 95% CI 0.14–0.35; $P < 0.001$).

Discussion

This study demonstrates a reduction in appendicitis presentations to our institution during the COVID-19 lockdown period. We also identified increases in utilisation of imaging, in severity of disease, in conservative management and a significant improvement in accuracy of diagnosis, reflected in histopathological findings.

There was a reduction in the number of presentations, from 74 to 56, during the pandemic period. This is concordant with international studies published recently regarding the same period.[19–21]

Significantly, there was increased use of radiological imaging. In 2020, 89.3% of presentations underwent imaging, compared to 69.3% in 2019 ($P = 0.007$). There was an increase in the use of CT – from 54.07% in 2019 to 69.64% in 2020. Despite being not statistically significant (RR 0.7; 95% CI 0.59–1.01; $P = 0.051$), this demonstrated a noticeable increase of CT use.

Over the last decade, use of imaging for AA has been increasing worldwide. A contemporary global observational study[22] reported that 71.2% of presentations with suspected AA have radiological investigations performed. Although our institution matched these rates during "normal times" (70.27% imaged in 2019), that global figure encompasses a wide variation of countries with different levels of radiological access. We should be trying to match the higher imaging rates achieved during 2020 (89.29%), which mirrors rates in other countries with similar healthcare standards and technologies to Ireland, where imaging confirmation prior to operative intervention is becoming a standard of care.[23,24]

Of those imaged, there was increased severity in the 2020 group, with 30.36% having complicated disease (G2–5), including 16.07% with evidence of perforation (G3–5). This compares to 20.27% and 2.7% in 2019, respectively.

Considering the controversy in the early pandemic period regarding proposed conservative management of appendicitis patients, a non-operative rate of 28.57% in 2020 was rather unexpectedly low. However, it is still significantly higher than the 6.67% treated conservatively in 2019 ($P < 0.001$). Similarly, following the dissemination of surgical guidelines in late March, there was local discussion about avoidance of laparoscopic surgery. In these guidelines, the ACS[15] and the RCS of

Table 3 – Progression to theatre – grouped by severity on radiological imaging.

	2019 N = 74		2020 N = 56		Risk ratio (95% CI)	P value
	No. of patients who underwent surgery/total no. of pts. with same imaging grade (%)					
Imaging description						
Uncomplicated (G1)	28 of 31 patients	(90.32)	20 of 32 patients	(62.50)	1.44 (1.07–1.94)	0.009
Complicated (G2–5)	13 of 15 patients	(86.66)	13 of 17 patients	(76.47)	1.13 (0.81–1.58)	0.3919
Not vis./inconclusive	6 of 6 patients	(100)	1 of 1 patient	(100)	–	–
No imaging	22 of 22 patients	(100)	6 of 6 patients	(100)	–	–

Table 4 – Histology results – post-operative groups.

	2019 N = 69	2020 N = 40	Risk ratio (95% CI)	P value
	No. of patients (%)			
Acute Appendicitis	51 (73.91)	39 (97.5)	0.75 (0.65–0.87)	0.001
G1: uncomplicated	43 (62.32)	23 (57.5)	1.08 (0.78–1.49)	0.384
G2: gangrenous	4 (5.8)	8 (20.0)	0.29 (0.09–0.90)	0.027
G3–5: perforated	4 (5.8)	8 (20.0)	0.29 (0.09–0.90)	0.027
Normal underlying pathology	17 (24.64)	0 (0)	RD: 0.24 (0.14–0.35)	<0.001
Other abnormal pathology	1 (1.45)	1 (2.5)	0.58 (0.04–9.02)	0.601

the United Kingdom and Ireland[16] cautioned regarding the potential for viral transmission during laparoscopy. Despite this, only one patient (1.79%) in our 2020 cohort underwent open appendectomy.

In 2020, a higher threshold for operative intervention is noted. Radiologically uncomplicated cases were much less likely to progress to theatre (62.5%) than complicated (76.47%) cases. By comparison, in 2019 both uncomplicated (90.32%) and complicated (86.88%) cases were much more likely to undergo appendicectomy. This reflects our institution's implementation of international guidelines. However, despite best efforts to treat conservatively where possible, it is apparent that the vast majority of appendicitis patients do require surgery, and will progress to theatre.

In both groups, all patients who had either no imaging or inconclusive imaging proceeded to theatre. This group of patients with no radiological confirmation of disease was substantially larger in the 2019 cohort with 28 patients (37.8%) vs 7 patients (12.5%) during the lockdown period.

Of all patients that underwent operation, AA was histologically confirmed in 97.5% in 2020, compared to only 73.91% in 2019. There was also a shift in the severity of the cases. Acute uncomplicated cases accounted for 62.32% in 2019, and 57.5% in 2020 ($P = 0.061$). In 2020, 40% of patients had histological features of complicated disease, and half of those (20% of whole group) had evidence of perforation (G3–5). This is significantly higher than rates of 11.6% complicated, including 5.8% perforated histology seen in 2019 ($P < 0.001$). This is likely reflective of patients' attitudes during lockdown period where they avoided presenting to hospital until late.

In 2019, 17 cases (24.6%) were found to have a normal appendix on post-operative histology. There were no normal appendixes reported from our group of patients in 2020.

A negative appendicectomy rate (NAR) is defined as the incidence of histologically normal appendixes removed from patients undergoing operation for appendicitis. It is a key performance indicator. This rate historically has been reported to be between 15 and 25%, but it is decreasing globally.

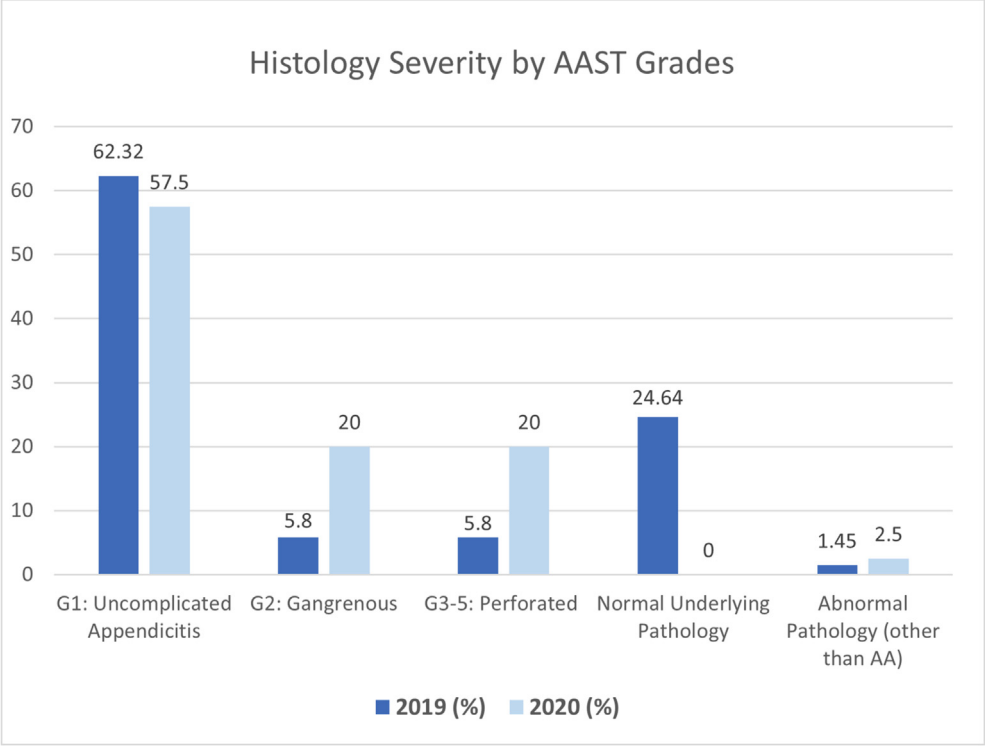

Fig. 3 – Histology severity by AAST grades. Severity based on histology results – grouped by the AAST grades/classification.

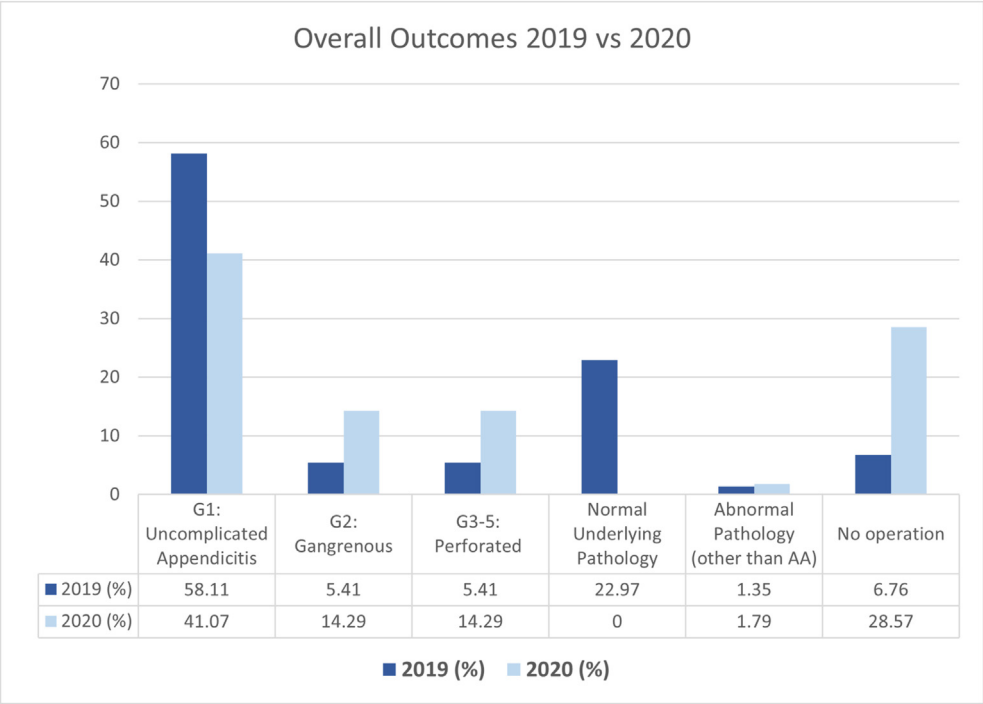

Fig. 4 – Outcomes 2019 vs 2020. Overall outcomes including conservatively and surgically managed patients.

Growing evidence suggests that it can be lowered through pre-operative imaging.[25,26]

In the UK, the reported diagnostic accuracy for appendicitis without pre-operative imaging is between 76 and 80% – leading to approximately a 20% NAR.[24,27] This NAR figure matches our institute's results from 2019, where CT was used less liberally. In 2019, our imaging rates were similar to those reported throughout the UK.[26] Studies demonstrate that the UK shows higher NAR rates than countries where imaging is used routinely such as the U.S.A. and Netherlands.[26] A large multinational trial, including 1975 patients across 62 Dutch hospitals, demonstrated that introduction of mandatory pre-operative imaging dropped the NAR from 15% to 3.3% in the Netherlands.[23]

In the U.S.A., the Surgical Care Outcomes and Assessment Program (SCOAP) collaborative identified that in 20,000 patients from 60 hospitals, preoperative imaging improved NAR to 5.4%. It also reported that CT achieved statistically significant ($P < 0.001$) reduction in comparison to ultrasound.[28] Another multi-centre study demonstrated a statistically significant inverse correlation rho $= -1$ ($P < 0.05$), between CT use and NAR in these groups.[29]

The 0% NAR in our 2020 patient group is multifactorial. The increased utilisation of CT imaging, higher threshold to operate, and probable late patient presentation are thought to be major factors. In 2020 only 67.3% of cases with confirmed AA progressed to theatre compared to 89.1% in 2019. This would indicate that the clinical decision made regarding on whom to operate had a larger role in our negative NAR than severity of cases alone. A 0% NAR is quite an achievement considering that NAR is one of the key performance indicators. The results of this study add to the significant body of published literature that radiological imaging should be used routinely to confirm AA diagnosis. The results may also suggest that not all simple AA should be treated operatively. More studies are needed to look into these uncomplicated cases, and establish which other factors influenced their management decisions.

When looking at outcomes of all presentations, including non-operative cases, it is interesting to note the 17 patients in 2019 (22.57%) with normal appendiceal histology and the 16 patients in 2020 (28.57%) who were managed conservatively (Fig. 4). Looking at these two groups, we could consider that if some of those 16 patients in 2020 had undergone appendicectomy, they may well have had a normal appendix on histology. In 2020, the majority of our management decisions were supported by radiological information. And despite the pressure placed on the hospital system during that period, we have seen very good outcomes.

One limitation to this study is the lack of follow-up data on AA recurrence on those who are treated conservatively. We aim to follow-up the group of patients that were treated conservatively in one year's time and determine the recurrence rate, rate of delayed appendicectomy, and whether there were persistent symptoms following non-operative treatment.

Appendicitis has been historically referred to as a 'clinical diagnosis'. Due to this, requests for radiological confirmation pre-operatively can be wrongly dismissed as unnecessary. In this institutional study, we have demonstrated that increased imaging can mitigate unnecessary surgery and the complications and costs associated with same. In a country and in a time where there is ease of access to radiological investigations, we believe this should be the standard of care. There is increasing literature to support this view and we aim to maintain these standards in our institution well past the pandemic period.

Conclusion

During the acute pandemic era in Ireland in 2020, there was a decrease in overall presentations to our institution with acute appendicitis, an increased use of radiological imaging, a decrease in operative intervention, and most significantly, a 0% NAR. We have demonstrated that with increased use of imaging and stricter criterion for progression to theatre, we can accurately identify those cases that require operation most. As we enter a second surge of COVID-19 cases, and consequent lockdown, we would encourage the general population to avoid late presentations and continue to seek timely medical attention. Furthermore, we propose that use of radiological imaging to confirm the diagnosis of acute appendicitis should be adopted as routine practice - both during the pandemic period and beyond it.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author upon request.

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Declaration of competing interest

The authors whose names are listed above certify that there are no affiliations with or involvement in any organisation or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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