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ORIGINAL ARTICLE

The role of imaging in the diagnosis of acute appendicitis during the COVID-19 pandemic: a retrospective cohort study

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Abstract

Acute appendicitis is one of the most common general surgical emergencies worldwide; however, its diagnosis remains challenging, with a high proportion of negative appendicectomies. The purpose of this study was to investigate the benefit of routine use of pre-operative imaging for the evaluation of suspected appendicitis. This retrospective cohort study included all cases of appendicectomies performed for suspected acute appendicitis during the first and second peaks of the COVID-19 pandemic, between March 2020 and February 2021. The control group included all cases of appendicectomies performed for suspected acute appendicitis in the previous 12 months (March 2019-February 2020). One hundred and four patients underwent appendicectomy in the study group, compared to 209 in the control group, with similar gender distribution but a significantly higher median age in the study group (33 vs. 28, $p = 0.001$). The two groups had similar rates of perforation and similar median white cell count (WCC) and CRP. Imaging was used in 80.77% of the patients in the study group, compared to 61.72% in the control group ($p = 0.001$), with 55.77% of patients in the study group undergoing CT scans. Despite this, the negative appendicectomy rate (NAR) in the two groups did not differ significantly (11.54% vs. 15.79%, $p = 0.320$). The increase in the use of imaging for the diagnosis of acute appendicitis during the COVID-19 pandemic did not lead to a significantly lower negative appendicectomy rate. *Registration*: The study was pre-registered at ClinicalTrials.gov (NCT05205681).

Keywords Acute appendicitis · COVID-19 · Pre-operative imaging · Computer tomography · Ultrasonography · Negative appendicectomy rate

Introduction

Acute appendicitis is one of the most common acute presentations in General Surgery, with an incidence of 151 per 100,000 person-years in Western Europe [1]; however, its diagnosis remains challenging; around 50,000 emergency appendicectomies are performed in the UK annually [2], with the final histology confirming the pre-operative diagnosis in only 79.4% of the cases, giving a negative appendicectomy rate (NAR) of 20.6% [3]. This is significantly higher than in other developed countries, such as the Netherlands (NAR 3.2%) [4] and the USA (NAR 1.7%) [5]; however, a great deal of variation in NAR exists in various UK centres (3.3–36.8%) [3]. These differences are attributable to many factors, including the lack of a standardised diagnostic pathway, the difference in subjective evaluation of clinical findings and the difference in the use of pre-operative imaging modalities, such as computer tomography (CT) and ultrasonography (US). With a mean age at presentation of 25.4 years [6], there have been concerns about subjecting young patients to radiations and US has proven to have inadequate sensitivity to be used as the sole imaging modality [7]; therefore, the diagnosis has historically remained mainly clinical.

In March 2020, the COVID-19 pandemic, caused by the SARS-CoV-2 virus, erupted worldwide, causing significant morbidity and mortality. In the UK, 444,354 people were admitted to hospitals from March 2020 to February 2021 [8], putting great pressures on hospitals throughout the country. This prompted a pursuit of new strategies to improve the

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diagnosis of acute appendicitis, avoiding unnecessary admissions and procedures.

Methods

This was a single-centre retrospective cohort study carried out at University College Hospital in London, UK, a tertiary referral centre. Data for all emergency appendicectomies performed from March 2020 to February 2021 were extracted from *Epic*® (Epic Systems Corporation, Verona (WI), USA), the hospital's Electronic Health Record (EHR), and retrospectively analysed. They were compared with a control group, containing all emergency appendicectomies performed in the same hospital in the 12 months prior (March 2019–February 2020). Demographics, laboratory findings on admission, operative and histological data were collected anonymously for all patients. A negative appendicectomy was defined as a normal appendix reported in final histology.

Statistical analysis was performed using R (R Foundation for Statistical Computing, Vienna, Austria) and RStudio (RStudio, Inc., Boston (MA), USA). Data are presented as medians and InterQuartile Range (IQR) for continuous variables or frequencies and percentages for categorical variables. Risk Ratio (RR) and 95% Confidence Interval (CI) were calculated. Mann–Whitney *U* test and Pearson's χ^2 test were used to compare the characteristics of the two groups. Statistical significance was defined as $p < 0.05$.

The study was conducted in accordance with the Helsinki Declaration and reported according to the STROBE guidelines for observational studies [9] and in line with the STROCSS criteria for reporting cohort studies in surgery [10]. The need for ethical approval was waived by the UCL/UCLH Joint Research Office in accordance with the NHS Health Research Authority guidelines. The study was pre-registered at ClinicalTrials.gov (NCT05205681).

Results

One hundred and four patients underwent emergency appendicectomy from March 2020 to February 2021 (pandemic group), compared to 209 in the control group, from March 2019 to February 2020. Gender distribution was similar in both groups (females 46.15% vs. 42.58%, RR 1.08, 95% CI 0.83–1.41, $p = 0.551$); however, median age was significantly higher in the pandemic group (33 vs. 28, $p = 0.001$).

There was no statistically significant difference in median C-Reactive Protein (CRP) levels (27.7 mg/L vs. 24.3 mg/L, $p = 0.164$) or in median White Cell Count (WCC) (13.31 vs. 13.46, $p = 0.910$) between the pandemic group and the control group. There was a similar rate of appendix perforation in both groups (24.04% vs. 22.97%, RR 1.05, 95% CI 0.69–1.60, $p = 0.828$), confirmed either intra-operatively or on final histology.

80.77% of the patients in the pandemic group underwent pre-operative imaging, compared to 61.72% in the control group (RR 1.31, 95% CI 1.13–1.51, $p = 0.001$), and this difference was mainly due to a higher proportion of CT scans (55.77% vs. 36.84%, RR 1.51, 95% CI 1.18–1.94, $p = 0.001$), while there was no significant difference in US performed (26.92% vs. 28.23%, RR 0.95, 95% CI 0.65–1.40, $p = 0.814$) (Fig. 1).

Median post-operative length of stay (LOS) was similar in both the groups (2 days vs. 1 day, $p = 0.565$). There was a higher complication rate in the pandemic group (9.61% vs. 5.26%), but the difference was not statistically significant (RR 1.83, 95% CI 0.80–4.16, $p = 0.147$).

The negative appendicectomy rate (NAR) in the pandemic group was lower (11.54%) compared to the control group (15.79%), but the difference did not reach statistical significance (RR 0.73, 95% CI 0.39–1.35, $p = 0.320$). All data are summarised in Table 1.

Discussion

This study demonstrates the impact of the COVID-19 pandemic on surgical admissions in our tertiary centre. First, the number of patients who underwent an emergency appendicectomy in the pandemic group was half the number observed in the control group in the previous 12 months. This difference can be explained mainly in two ways: fewer Emergency Department (ED) presentations of patients with mild, self-resolving symptoms because of the pandemic,

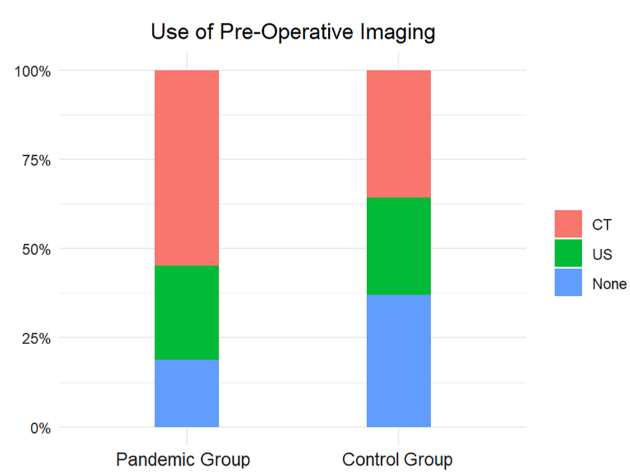

Fig. 1 Use of pre-operative imaging. CT = computer tomography; US = ultrasonography

Table 1 Demographic, pre-operative and post-operative data

	Pandemic group	Control group	*p* value
No	104	209	
Females (%)	48 (46.15%)	89 (42.58%)	0.551
Age (years—median, IQR)	33, 50–26	28, 40–21	0.001
CRP (mg/L—median, IQR)	27.7, 132.88–4.3	24.3, 65–6	0.164
WCC ($\times 10^9$/L—median, IQR)	13.31, 15.94–10.79	13.46, 16.08–10.36	0.910
Imaging (%)	84 (80.77%)	129 (61.72%)	0.001
CT (%)	58 (55.77%)	77 (36.84%)	0.001
US (%)	28 (26.92%)	59 (28.22%)	0.814
Perforation (%)	25 (24.04%)	48 (22.97%)	0.828
LOS (days—median, IQR)	2, 2–1	1, 2–1	0.565
Complications (%)	10 (9.61%)	11 (5.26%)	0.147
NAR (%)	12 (11.54%)	33 (15.79%)	0.320

CRP C-reactive protein, *CT* computer tomography, *LOS* (post-operative) length of stay, *NAR* negative appendicectomy rate, *US* ultrasonography, *WCC* white cell count

and a higher proportion of patients who were treated conservatively.

Conservative treatment with antibiotics has been shown to be a feasible alternative in non-complicated appendicitis, despite the risk of recurrence [11]. At the start of the COVID-19 pandemic, many international surgical guidelines discouraged the use of laparoscopy in fear of the aerosol-generating potential of laparoscopic insufflation and gas extraction, which could contribute to the spread of SARS-CoV-2 viral particles [12, 13]. For this reason, the pandemic group also shows a higher proportion of cases performed with an open technique rather than with the routine laparoscopy (9.61% vs. 3.35%, $p = 0.031$) and this difference is statistically significant. These recommendations had the effect of a higher proportion of patients with mild, non-complicated appendicitis being treated conservatively, although it was not possible to obtain this number in the present study because of how the data extraction was performed.

Similar studies performed in Italy [14] and in the Republic of Ireland [15] have shown a statistically significant improvement in the NAR during the pandemic, which was not replicated in this study. This is, however, consistent with other studies performed elsewhere previous to the pandemic, such as a Dutch study [16] in which the introduction of US and CT imaging did not lower the NAR, which remained around 12%. The reason for these discrepancies is multifactorial, accounting for different expertise of the surgeons performing the clinical examination and, in case of the patients who underwent US, the operator-dependent nature of this imaging technique. Furthermore, a subgroup analysis of our study showed no overall difference in NAR in patients in which pre-operative imaging was used for the diagnosis of appendicitis compared to those who were diagnosed with clinical judgement alone (14.55% vs. 14%, RR 1.04, 95% CI 0.58–1.86, $p = 0.910$). The NAR was higher in the pandemic group, but this difference was not statistically significant, reflecting the possibility that pre-operative imaging is useful in selected cases. Negative appendicectomies were more common in females (20.44% vs 9.66%, RR 2.12, 95% CI 1.21–3.70, $p = 0.001$); therefore, females might especially benefit from pre-operative imaging, as previously demonstrated [17].

The main limitations of this study are the lack of randomisation and the retrospective nature of the study; furthermore, as the patients were assessed clinically by a number of different surgeons (consultants and trainees), there was a significant inter-personal variability in clinical judgement and decision to perform pre-operative imaging was not standardised; clinical scoring systems were used inconsistently and were, therefore, not included in the study, but they might represent a cost-effective alternative to imaging, as recently demonstrated by the DIAMOND Randomised Trial [18].

In conclusion, this study contributes to the current debate in surgical practice by showing that a more liberal use of pre-operative imaging may not be the definitive answer to the appendicitis diagnostic uncertainties, and alternative solutions are warranted, in the form of clinical prediction rules and standardised pathways, together with case-by-case pre-operative imaging.

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Data availability The datasets generated during and/or analysed during the current study are not publicly available due to the sensitive nature of the data; however, they are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declare no conflicts of interests.

Ethical approval The need for ethical approval was waived by the UCL/UCLH Joint Research Office in accordance with the NHS Health Research Authority guidelines.

Informed consent For this type of study, formal consent in not required.

References

1. Ferris M, Quan S, Kaplan BS, Molodecky N, Ball CG, Chernoff GW et al (2017) The global incidence of appendicitis: a systematic review of population-based studies. Ann Surg 266(2):237–241
2. Baird DLH, Simillis C, Kontovounisios C, Rasheed S, Tekkis PP (2017) Acute appendicitis. BMJ 357:j1703
3. National Surgical Research Collaborative (2013) Multicentre observational study of performance variation in provision and outcome of emergency appendicectomy. Br J Surg 100(9):1240–1252
4. van Rossem CC, Bolmers MDM, Schreinemacher MHF, Bemelman WA, van Geloven AAW, Pinkney TD et al (2016) Diagnosing acute appendicitis: surgery or imaging? Colorectal Dis 18(12):1129–1132
5. Raja AS, Wright C, Sodickson AD, Zane RD, Schiff GD, Hanson R et al (2010) Negative appendectomy rate in the era of CT: an 18-year perspective. Radiology 256(2):460–465
6. Ceresoli M, Zucchi A, Allievi N, Harbi A, Pisano M, Montori G et al (2016) Acute appendicitis: epidemiology, treatment and outcomes- analysis of 16544 consecutive cases. World J Gastrointest Surg 8(10):693–699
7. Rait JS, Ajzajian J, McGillicuddy J, Sharma A, Andrews B (2020) Acute appendicitis and the role of pre-operative imaging: a cohort study. Ann Med Surg 59:258–263
8. UK Government. GOV.UK Coronavirus (COVID-19) in the UK [Internet]. Available from: https://www.coronavirus.data.gov.uk/details/healthcare#card-patients_admitted_to_hospital. Accessed 2021 Oct 9
9. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP (2014) The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. Int J Surg 12(12):1495–1499
10. Agha R, Abdall-Razak A, Crossley E, Dowlut N, Iosifidis C, Mathew G et al (2019) STROCSS 2019 guideline: strengthening the reporting of cohort studies in surgery. Int J Surg 72:156–165
11. Yang Z, Sun F, Ai S, Wang J, Guan W, Liu S (2019) Meta-analysis of studies comparing conservative treatment with antibiotics and appendectomy for acute appendicitis in the adult. BMC Surg 19(1):1–10
12. American College of Surgeons. COVID 19: considerations for optimum surgeon protection. before, during, and after operation. 1st ed
13. RCSEng, RCSEd, RCPSG, RCSI, AUGIS, ASGBI, et al. updated intercollegiate general surgery guidance on COVID-19. 1st ed
14. Ceresoli M, Coccolini F, Magnone S, Lucianetti A, Bisagni P, Armao T et al (2021) The decrease of non-complicated acute appendicitis and the negative appendectomy rate during pandemic. Eur J Trauma Emerg Surg 47(5):1359–1365
15. Somers K, AbdElwahab S, Raza MZ, O'Grady S, DeMarchi J, Butt A et al (2021) Impact of the COVID-19 pandemic on management and outcomes in acute appendicitis: Should these new practices be the norm? Surgeon 19(5):e310–e317
16. Schok T, Simons PCG, Janssen-Heijnen MLG, Peters NALR, Konsten JLM (2014) Prospective evaluation of the added value of imaging within the Dutch national diagnostic appendicitis guideline–do we forget our clinical eye? Dig Surg 31(6):436–443
17. Bendeck SE, Nino-Murcia M, Berry GJ, Jeffrey RB (2002) Imaging for suspected appendicitis: negative appendectomy and perforation rates. Radiology 225(1):131–136
18. Lastunen KS, Leppäniemi AK, Mentula PJ (2022) Diagnostic imaging or observation in early equivocal appendicitis (DIAMOND): open-label, randomized clinical trial. Br J Surg 109(7):588–594

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