



COVID-19 and Acute Appendicitis

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Abstract

Objective: To compare the rate of uncomplicated and complicated acute appendicitis, and their management strategies between the COVID-19 pandemic period and the control group.

Summary background data: Literature shows significant reduction in the emergency department visit due to patients' fear of contracting the COVID-19. Healthcare professionals are concerned that this may lead to delayed presentations of high acuity illnesses. Acute appendicitis is one of the most common general surgery emergencies, and the authors aim to investigate if the rate of complicated appendicitis has increased during the COVID-19 pandemic period due to delayed presentation.

Methods: Electronic charts are reviewed retrospectively during the COVID-19 pandemic period and the control period. Results will be compared and subjected to statistical analysis for significance in the finding.

Results: The rate of complicated appendicitis was 34.2% and 28.3% in the COVID-19 pandemic period, and the control period respectively. There was no statistical significance in the finding. There was no significant difference in the duration of symptoms perceived by the patients, time from triage to the operating room, and management strategies.

Conclusions: Despite the concern of decreased number of emergency department visit, presentation and management of patients with acute appendicitis does not appear to be impacted by COVID-19.

Introduction

The emergence of the novel COVID-19 continues to impact countries across the world since its first reported case in Wuhan, China, on Dec. 31, 2019 [1]. The WHO declared COVID-19 a global pandemic on March 11, 2020 and the Canada government announced guidance for mandatory social distancing and avoidance of non-essential social contacts in an attempt to decrease virus transmission [2]. Number of hospital visits decreased dramatically due to fear of contracting the disease. The Canadian Institute for Health Information (CIHI) reported a 25%

decrease in Emergency Department (ED) visits from January to March 2020 [3]. Data from the study by Wong et al. suggests that decreased ED visits was a driving factor in increasing mortality and morbidity as high-acuity patients stayed home due to fear of contracting COVID-19 [4]. The investigators of this study also encountered several patients with acute appendicitis who reported delayed hospital presentation due to the fear of contracting COVID-19 or limited access to primary care in the community.



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Acute appendicitis is one of the most common general surgery emergencies, with an estimated lifetime risk of 7–8% [5]. Laparoscopic appendectomy is a safe and cost-effective treatment for uncomplicated appendicitis [6]. However, management of complicated appendicitis may vary depending on pre-operative assessment of the patient. Hemodynamically stable patients with radiographic evidence of mild and localized peri-appendiceal inflammation, but no obvious walled-off collection may be treated surgically [7]. Patients presenting with prolonged duration of symptoms, and radiographic finding of severe inflammatory phlegmon or large abscess are generally managed non-operatively followed by possible interval appendectomy due to risk of requiring ileocolic or right colon resection which can be quite morbid. Non-operative management includes antibiotics with or without percutaneous drainage of the abscess if feasible [8]. Lastly, unstable patients with evidence of peritonitis inevitably require surgery as they have high risk of further clinical deterioration with non-operative management [9].

The aim of this retrospective chart review study is to investigate the impact of the COVID-19 pandemic on the presentation of acute appendicitis, and subsequent management strategies in a large, urban population. We will also investigate if the management of acute appendicitis was impacted during the COVID-19 pandemic period.

Methods

Study design

This was a retrospective chart review study. We identified all adult and pediatric patients admitted under the general surgery acute care service with the diagnosis of acute appendicitis in four tertiary level care hospitals in Calgary, AB, Canada between March 11 – May 6, 2020. Patients that were managed non-operatively (ie. Antibiotics +/- percutaneous drainage) due to medical reasons (ie. Significant comorbidities, or pregnancy) or patients' requests were excluded from analysis. Electronic charts were retrieved from Sunrise Clinical Manager, which is an electronic medical record system used in Calgary, Alberta, Canada. WHO declared COVID-19 as a global pandemic on March 11, 2020, and patients admitted since the WHO declaration were reviewed until May 6, 2020. The same time period in 2019 was reviewed for comparison. Therefore, two groups were created: March 11 - May 6, 2019 (Group 1) and March 11 – May 6, 2020 (Group 2).

Diagnostic images (Ultrasound, CT, or MRI), operative reports, and in-hospital documentations were reviewed to classify patients into uncomplicated and complicated acute appendicitis. In this study, uncomplicated acute appendicitis was defined as appendicitis with intraoperative finding of either grossly normal or acute inflammation with no perforation. Complicated appendicitis was defined as acute appendicitis with intraoperative or radiographic findings of perforation, necrosis, gangrene, abscess, and/or inflammatory phlegmon.

The primary outcome of the study was to compare the rate of patients presenting with complicated acute appendicitis during COVID-19 pandemic period compared to the same time period in 2019. Secondary outcomes included duration of symptoms perceived by the patients, time from triage to the operating room, abnormal vital signs at triage, radiographic findings, treatment strategies, intraoperative findings, pathology results, and length of hospital stay. Patient demographics including age and gender were also collected.

Statistical analysis

Each outcome measure was subjected to statistical analysis to investigate for statistical significance of differences between group 1 and group 2. Independent 2-tailed t-tests or chi-square tests were performed to study statistical significance for continuous and categorical data respectively. We set $p < 0.05$ to be statistically significant level. STATA 12 was used for statistical analyses.

Results

Demographics and clinical characteristics

There was a total of 457 patients with acute appendicitis identified during the study period in group 1 and group 2. Patient's demographic characteristic is summarized in Table 1. There was no statistically significant difference in demographics between the 2 groups. The rate of patients with abnormal vital signs at triage were higher in group 2 compared to group 1 (35.3% vs. 26.6%), but this difference did not reach statistical significance ($\chi^2(1, N=456)=3.7503, p=0.053$). Average duration of symptoms perceived by the patients was 49.4 hours in group 1 and 52.7 hours in group 2. The difference was not statistically significant ($t(428)=-0.4602, p=0.6456$). There was a trend of higher number of patients presenting to the emergency department after 72 hours of symptoms in group 2 compared to group 1 (29.0 % vs. 21.4%). Differences in mean time from triage to operating room did not reach statistical significance.

Disease characteristics

The diagnosis of uncomplicated vs. complicated appendicitis was established based on clinical history, imaging, and intraoperative findings. There was no difference in use of imaging modalities between the two groups ($\chi^2(3, N=456)=1.9700, p=0.579$), and no significant difference in the radiographic diagnosis of complicated appendicitis between the two groups ($\chi^2(1, N=455)=0.4262, p=0.514$).

In 2019, 166 patients were diagnosed with uncomplicated appendicitis (71.2%), and 66 patients were diagnosed with complicated appendicitis (28.3%). All the patients with uncomplicated appendicitis were managed operatively. Amongst the patients with complicated appendicitis, 15 patients (6.4%) were diagnosed with missed appendicitis based on radiographic finding of significant inflammatory phlegmon requiring non-operative management to avoid increased morbidity from operation. Of the patients that received surgical treatment, 9 patients had grossly normal appearing appendices (4.1%), 157 patients had appendicitis with no complications (72.4%), 14 patients had appendicitis with contained perforation (6.5%), 22 patients had appendicitis with purulent contamination (10.1%), 4 patients had appendicitis with feculent contamination (1.8%), 4 patients had necrotic appendices (1.8%), and 7 patients had gangrenous appendices (3.2%).

In 2020, 146 patients were diagnosed with uncomplicated appendicitis (65.8%), and 76 patients were diagnosed with complicated appendicitis (34.2%). All the patients with uncomplicated appendicitis were managed surgically. Amongst the patients with complicated appendicitis, 19 patients (8.5%) were diagnosed as missed appendicitis based on radiographic finding of severe inflammatory phlegmon requiring non-operative management to avoid morbidity from operation. Of the patients that were treated surgically, 1 patient had a grossly normal appearing appendix (0.5%), 145 patients had uncom-

plicated appendicitis (70.7%), 6 patients had appendicitis with contained perforation (2.9%), 32 patients had appendicitis with purulent contamination (15.6%), 4 patients had appendicitis with feculent contamination (2.0%), 7 patients had necrotic appendices (3.4%), 3 patients had gangrenous appendices (1.5%), 5 patients had appendicitis with severe inflammatory phlegmon (2.4%), and 2 patients had other findings (1.0%).

Comparison revealed 5.9% increase in the rate of complicated appendicitis in 2020 compared to 2019 (34.2% vs. 28.3%), but this was not statistically significant ($\chi^2(1, N=454) = 1.7669, p=0.184$). There was a statistically significant increase in the rate of intraoperatively diagnosed complicated appendicitis in 2020 compared to 2019 of 4.3%. This comparison can be seen in Table 2. No single finding was responsible for this difference.

Analysis of management strategies

Management strategies were analysed and compared between 2019 and 2020. In Calgary, AB, the standard management of acute appendicitis is operative management, unless there is anticipation of a morbid operation when imaging shows significant inflammatory phlegmon. These patients are typically managed non-operatively with antibiotics +/- percutaneous drainage to avoid increased morbidity from the surgery. After successful non-operative management, these patients are subsequently reassessed for interval appendectomy.

In 2019, 217 patients were managed operatively (92.7%). The breakdowns of surgical management were: 209 laparoscopic appendectomy (89.3%), 4 open appendectomy with McBurney's incision (1.7%), 4 partial cecectomy, 1 right hemicolectomy (0.4%), and 1 conversion to laparotomy (0.4%). 6 patients received antibiotics only (2.6%), and 9 patients were treated with antibiotics + percutaneous drainage (3.8%), all due to radiographic finding of missed appendicitis.

In 2020, 205 patients were taken to the operating room (91.5%). The breakdowns of surgical management were: 188 laparoscopic appendectomy (83.9%), 1 open appendectomy with McBurney's incision (0.4%), 1 washout + drain insertion without appendectomy (0.4%), 11 partial cecectomy (4.9%), 2 ileocolic resection (0.9%), and 2 right hemicolectomy (0.9%). 10 patients received antibiotics only (4.5%), and 9 patients were treated with antibiotics + percutaneous drainage (4.0%), all due to radiographic finding of missed appendicitis.

Although there was a 2.1% increase in the rate of missed appendicitis requiring non-operative management in group 2, there was no statistical significance in difference of overall treatment strategies between two groups ($\chi^2(2, N=457)=3.1195, p=0.210$).

Table 1: Patient demographics and clinical characteristics.

Variables	March 11 - May 6, 2019	March 11 - May 6, 2020	p-value
Total, n	233	224	
Demographics			
Male, n (%)	117 (50.2%)	103 (46.0%)	p = 0.365
Female, n (%)	116 (49.8%)	121 (54.0%)	p = 0.365
Mean age, years (SD)	40.8 (16.9)	40.8 (16.3)	p = 0.645
Age range, years	15-92	16-81	
Adults, n (%)	228 (97.9%)	223 (99.6%)	
Pediatrics, n (%)	5 (2.1%)	1 (0.4%)	
Triage vitals			
Abnormal triage vitals, n (%)	62 (26.6%)	79 (35.3%)	p = 0.053
Abnormal BP (SBP < 80 mmHg, DBP < 40 mmHg), n (%)	0 (0.0%)	0 (0.0%)	
Abnormal HR (> 100 bpm, or < 60 bpm), n (%)	52 (83.9%)	73 (92.4%)	
Abnormal temp (>38.0C, or <35.0C)	14 (22.6%)	5 (6.3%)	
Abnormal respiratory rate (>24 /min, or < 16/min), n (%)	14 (1.6%)	0 (0.0%)	
Abnormal SpO2 (<92%), n (%)	0 (0.0%)	0 (0.0%)	
Duration of symptoms perceived by the patients			
0 - 72 hours, n (%)	184 (78.6%)	147 (71.0%)	
72 - 168 hours, n (%)	27 (11.5%)	39 (18.8%)	
> 168 hours, n (%)	17 (7.3%)	17 (8.2%)	
Unknown, n (%)	6 (2.6%)	4 (1.9%)	
Mean hours (SD)	49.4 (79.6)	52.7 (74.2)	p = 0.646
Minimum hours	1	2	

Maximum hours	720	672	
Time from triage to operating room			
0 - 12 hours, n (%)	144 (66.1%)	153 (74.6%)	
12 - 24 hours, n (%)	72 (33.0%)	44 (21.5%)	
> 24 hours, n (%)	2 (0.9%)	4 (2.0%)	
Unknown, n (%)	0 (0.0%)	4 (2.0%)	
Mean hours (SD)	10.3 (5.20)	9.9 (7.13)	p = 0.621
Minimum hours	1	2	
Maximum hours	28	72	
Preoperating imaging			p = 0.579
Ultrasound, n (%)	64 (27.4%)	63 (28.1%)	
CT, n (%)	167 (71.4%)	161 (71.9%)	
MRI, n (%)	1 (0.4%)	0 (0.0%)	
No imaging, n (%)	1 (0.4%)	0 (0.0%)	
Unknown, n (%)	1 (0.4%)	0 (0.0%)	
Radiographic diagnosis			p = 0.514
Uncomplicated appendicitis	197 (84.2%)	185 (82.6%)	
Complicated appendicitis	35 (15.0%)	39 (17.4%)	
Length of Stay			
Mean length of stay, days (SD)	1.90 (2.36)	2.22 (2.88)	p = 0.186

Table 2: Diagnosis, management, intraoperative findings, and pathology.

	March 11 - May 6, 2019	March 11 - May 6, 2020	p-value
Diagnosis			p = 0.184
Uncomplicated appendicitis, n (%)	166 (71.2%)	146 (65.8%)	
Complicated appendicitis, n (%)	66 (28.3%)	76 (34.2%)	
Unknown, n (%)	1		
Management			p = 0.195
Laparoscopic appendectomy, n (%)	209 (89.3%)	188 (83.9%)	
Open appendectomy with McBurney's incision, n (%)	4 (1.7%)	1 (0.4%)	
Laparoscopic washout + drain placement without appendectomy, n (%)	0 (0.0%)	1 (0.4%)	
Laparoscopic partial cecectomy, n (%)	4 (1.7%)	11 (4.9%)	
Ileocolic resection, n (%)	0 (0.0%)	2 (0.9%)	
Right hemicolectomy, n (%)	1 (0.4%)	2 (0.9%)	
Conversion to laparotomy, n (%)	1 (0.4%)	0 (0.0%)	
Antibiotics only, n (%)	6 (2.6%)	10 (4.5%)	
Antibiotics + percutaneous drain insertion, n (%)	9 (3.8%)	9 (4.0%)	
Intraoperative findings			p = 0.010
Normal appendix, n (%)	9 (4.1%)	1 (0.5%)	
Uncomplicated appendicitis, n(%)	157 (72.4%)	145 (70.7%)	
Appendicitis with contained perforation, n(%)	14 (6.5%)	6 (2.9%)	

Appendicitis with purulent contamination, n (%)	22 (10.1%)	32 (15.6%)	
Appendicitis with feculent contamination, n (%)	4 (1.8%)	4 (2.0%)	
Necrotic appendix, n (%)	4 (1.8%)	7 (3.4%)	
Gangrenous appendix, n (%)	7 (3.2%)	3 (1.5%)	
Inflammatorh phlegmon, n (%)	0 (0.0%)	5 (2.4%)	
Others, n (%)	0 (0.0%)	2 (1.0%)	
Pathology			p = 0.397
Normal appendix, n (%)	6 (2.8%)	2 (1.0%)	
Acute appendicitis with no other pathological diagnosis, n (%)	206 (94.5%)	196 (96.1%)	
Appendiceal polyp, n (%)	3 (1.4%)	2 (1.0%)	
Carcinoid tumor, n (%)	1 (0.5%)	0 (0.0%)	
Neuroendocrine tumor, n (%)	2 (0.9%)	1 (0.5%)	
Mucinous neoplasm, n (%)	0 (0.0%)	1 (0.5%)	
Adenocarcinoma, n (%)	0 (0.0%)	2 (1.0%)	

Discussion

This study was initially motivated by the authors' observation of several patients with complicated acute appendicitis potentially owing to delayed presentations during the COVID-19 pandemic period. Multiple patients reported that their presentation was delayed due to the fear of contracting COVID-19 and/or lack of access to primary care in the community. Based on this experience, we designed this study to investigate the impact of COVID-19 on the presentation and management of acute appendicitis. To our knowledge, this is the first Canadian study that investigated the impact of COVID-19 on acute appendicitis.

The results of our study showed no significant difference in the rate of complicated acute appendicitis, duration of symptoms, and their management during the COVID-19 pandemic period.

A similar study published earlier by Orthopoulos et al. from Massachusetts Medical School-Baystate Medical Center shows different findings [10]. This study shows a 21.1% increase in perforated appendicitis, and a 29% increase in gangrenous appendicitis since March 15, 2020 which was the date elective surgeries were postponed due to the pandemic. The authors of this study state that delayed presentation from fear of contracting COVID-19, and the encouragement from the authorities including state and hospital officials to avoid unnecessary presentations to the clinic and/or ER may be the explanation for these findings. However, it is interesting that the study shows no significant increase in duration of symptoms since elective surgery postponement, which does not support delayed presentation as the explanation. The difference in the studies may be explained by the response from the authorities. The regional hospital and provincial officials in Alberta were aware of decreased emergency department visits, and potential delayed presentations of patients with high-acuity illnesses. In response, provincial authorities reinforced safety measures in the hospital to prevent the spread of COVID-19 and encouraged the public to present to the emergency department when necessary. Emergency resources such as "Health Link" were also made available to aid in the decision-making process for patients requiring an

emergency department visit [11]. Similar to other health regions, Alberta Health Services also announced postponement of elective surgeries in response to the COVID-19 pandemic, but the public was ensured that adequate resources and staff were available for emergency surgeries. This was evident in our study as there was no difference between the 2019 and 2020 group in time from triage to the operating room or the strategies used to treat patients with acute appendicitis.

Another study from Israel by Tankel et al. showed findings in accordance with our study [12]. They reported no significant increase in the length of symptoms, length of surgery, and the rate of complicated acute appendicitis since the first case of COVID-19 in Israel. One significant finding from their study was that there were decreased incidence of acute appendicitis since the first case of COVID-19, which they attributed to the aggressive national policy of social isolation and reduction in public transport, limiting access to healthcare services.

This study has several limitations. First, this study is limited by the nature of the retrospective design. The database was not specifically created for this study, and there is a potential for interpretation bias during data extraction from the charts. Second, the time period may have failed to accurately capture the impact of COVID-19 on the patients with acute appendicitis. The 8-week study period from March 11 2020 was arbitrarily set by the author, and changing the study period may alter the findings. Lastly, this is a single region study, which may not represent the entire healthcare system in Canada.

Since the onset of the COVID-19 pandemic, studies have shown that emergency department visits have significantly decreased. This study shows a trend in increased rates of complicated appendicitis and delayed presentations since the onset of the pandemic. It is reassuring that our study findings were not significant, and patients are not managed differently from the standard of care during the COVID-19 pandemic when compared to the non-COVID-19 period. We are in unprecedented and difficult times and multiple challenges have emerged for patients and healthcare providers in the hospital setting. Acute appendicitis is one of the most common general surgery emergencies with ongoing burden to the healthcare system. It is im-

portant for us to continue advocating for patients by emphasizing the need for them to seek appropriate care in a timely fashion, while ensuring adequate safety measures in the hospital.

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