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The Impact of COVID-19 Pandemic Upon Non-elective Admissions and Surgery at a Safety-Net Hospital
A Retrospective Cohort Study

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ABSTRACT

Introduction: In response to the COVID-19 pandemic, hospitals reported decreased admissions for acute surgical diagnoses, but scant data was available to quantify the decrease and its consequences. The objective of this study was to examine the incidence of acute care surgery encounters before and during the COVID-19 pandemic.

Materials and Methods: A retrospective cohort study was performed at a single, urban, United States safety-net hospital. Emergency room encounters, admissions, non-elective surgical procedures, patient acuity, and surgical complications were compared before and after the start of the COVID-19 pandemic. The primary outcome of the study was the incidence rate (IR) and incidence rate ratios (IRR) for surgical admissions, laparoscopic appendectomy, and urgent laparoscopic cholecystectomy.

Results: During the COVID-19 (exposure) time period, the number of nonelective procedures was 143 (IR 4.76) which was significantly lower than the control periods ($n = 431$, IR 7.2), $P < 0.001$. During the COVID-19 exposure period, there were significantly fewer urgent cholecystectomies performed (1.37 per day *versus* 2.80-2.93 per day, $P < 0.001$). There was a trend toward fewer appendectomies performed, but not significant. There was little difference in patient acuity between the exposure and control periods. A higher proportion of patients that underwent urgent cholecystectomy during the COVID time period had been seen in the ED in the prior 30 d (22% *versus* 5.6%).

Conclusions: Surgical volume significantly decreased during the COVID-19 pandemic. Management of acute cholecystitis may require re-evaluation as nonsurgical management appears to increase repeat presentations.

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Introduction

In 2019, SARS-CoV-2 (Coronavirus) emerged as worldwide viral pathogen. In early 2020 international reports of viral community spread resulted in the COVID-19 pandemic.[1] The first case in the United States was diagnosed January 20, 2020, and exponential growth was observed in the following weeks.[2] As cases, hospital admissions and deaths began to increase in March 2020, Texas declared a state of emergency on March 13, 2020. Additionally, a restriction was placed on 'elective' surgical procedures to conserve personal protective equipment (PPE), intensive care unit beds and other critical hospital resources. Operative volume decreased substantially as low- and intermediate-acuity cases, screening procedures, orthopedic procedures, and even some cancer procedures were postponed.[3,4] Deferring hospitalization and non-urgent surgeries became a major priority to relieve hospital capacity issues. Surgical management for life-threatening conditions was not restricted.

Concurrently many hospitals and insurance companies reported decreased admissions for traditional emergency room diagnoses during the COVID pandemic-related shutdown (e.g., atrial fibrillation, epilepsy/seizure, gastrointestinal bleed, transient ischemic attacks).[5,6] In parallel, the incidence of acute-care surgical diagnoses, such as abdominal pain, appendicitis and acute cholecystitis, also appeared to decline.[7,8] The health care challenge for un- or under-insured patients may become more significant. As the concurrent economic shutdown led to increased unemployment, the absolute number of those lacking health insurance is expected to rise.[9] This may disproportionately impact safety-net hospitals (SNH) that, by mission or mandate, provide care to a substantial share of vulnerable patients regardless of their ability to pay.[10] Prior studies have shown, SNH patients are at-risk for worse outcomes secondary to surgical complications.[11]

Now that the COVID-19 Delta and Omicron variants are contributing to increases in COVID-related hospitalizations and deaths, the experience of the early-2020 pandemic remain acutely relevant. We sought to examine the incidence of acute care surgery encounters and outcomes in an SNH. Our hypotheses were: (1) fewer patients sought care at the ER during the exposure period and (2) of those who did present to the ER, their acuity level was higher than the control time periods.

Materials and Methods

Study design and participants

Institutional Review Board approval was obtained for a retrospective observational cohort study of emergency room encounters, admissions, and surgical procedures in a safety-net hospital: Lyndon B. Johnson Hospital (LBJ), Houston, Texas. LBJ is a licensed 207 bed acute care safety-net hospital for the Harris Health System affiliated with the McGovern Medical School at the University of Texas Health Sciences Center at Houston. LBJ is the busiest Level III trauma center in Texas, with more than 70,000 emergency patient visits each year.[12] The majority of patients at this safety-net hospital are uninsured (54%) with a demographic distribution of 54% Latino, 25% African American, 12% Asian/other and 9% Caucasian.[13]

Patient encounters in the emergency room (ER) were prospectively identified between March 14, 2020, through April 13, 2020. The COVID-19 exposure time period was defined as 30 d following the March 14, 2020 declaration of Texas State of emergency. Two equivalent control periods were chosen for comparison: March 14, 2018 to April 13, 2018 and March 14, 2019 to April 13, 2019.

All emergency room encounters were queried and exported from the electronic medical record (EPIC; Verona, WI), including presenting vital signs (temperature, respiratory rate, pulse, and blood pressure) white blood cell count (WBC), serum bicarbonate and serum creatinine. Emergency Severity Index (ESI) acuity was also recorded for each encounter. ESI is five-level triage algorithm that estimates patients into five groups from one (most serious) to five (least serious).[14] All general surgery ER encounters and admissions during the same time periods were recorded. The primary surgical diagnoses of interest for this study were acute appendicitis and acute cholecystitis. Surgical operations were classified as either non-elective (urgent and emergent) or elective. The main surgical procedures queried were open or laparoscopic appendectomy and open or laparoscopic cholecystectomy.

The study was approved by the McGovern Medical School Committee for the Protection of Human Subjects (protocol HSC-MS-20-0578). Waiver for informed consent was granted due to the study design and lack of feasibility.

Outcomes

The primary outcome of the study was the incidence rate (IR) and incidence rate ratios (IRR) for surgical admissions, specifically for acute appendicitis and acute cholecystitis. Secondary outcomes included ER disposition (admission or discharge), time to operative intervention (defined as time from ER admission to time in the operating room), length of stay (LOS), post-operative complications, readmissions, and unplanned ER visits. Findings of perforated *versus* simple appendicitis and number of cases converted to an open procedure were secondary outcomes for the appendicitis and cholecystitis groups, respectively. As reference data, ER encounters in the 30 d prior and 30 d after each study period were also recorded. These additional date intervals were chosen to determine if a surgical patient had (1) previously sought care in the emergency room within 30 d prior to surgical admission or (2) presented to the ER within 30 d after surgical discharge.

Statistical analysis

Means and standard deviations or median and interquartile ranges (IQRs) were reported for normally or non-normally distributed continuous variables. Categorical variables were presented as counts and percentages. Standard two-tailed t-tests were used to compare continuous variables and chi-square to compare categorical data associations.

Table 1 – Hospital encounters during COVID-19 and control time periods.

Variable	COVID-19 ($n = 5029$)	Control ($n = 15,639$)	P-value
Age, y (SD)	43.6 (17.1)	43.1 (17.8)	0.14
Gender (%)			<0.001
Male	2648 (52.7%)	7419 (47.4%)	
Female	2381 (47.4%)	8220 (52.6%)	
ESI acuity (%)			<0.001
1	22 (0.4%)	105 (0.7%)	
2	1392 (27.9%)	3986 (25.8%)	
3	2547 (51.0%)	8422 (54.6%)	
4	955 (19.1%)	2687 (17.4%)	
5	78 (1.6%)	230 (1.5%)	
Unknown	35 (0.7%)	211 (1.4%)	
Pulse, bpm (SD)	81.0 (16.0)	81.2 (16.9)	0.62
Systolic, mmHg (SD)	132.6 (20.8)	131.4 (20.7)	<0.01
Diastolic, mmHg (SD)	78.9 (13.1)	78.4 (13.2)	0.04
Respiratory rate, per min (SD)	18.2 (2.7)	18.4 (3.0)	<0.01
Temperature, °F (SD)	98.3 (0.6)	98.2 (1.0)	<0.01
ER disposition (%)			0.02
Admission	817 (16.2)	2291 (14.7)	
Discharged	4211 (83.8)	13,348 (85.3)	
ER duration, h (IQR)	3.5 (4.3)	5.1 (4.6)	<0.01
Admission LOS, h (IQR)	87.2 (96.7)	72.3 (83.7)	<0.01

A comparison of patient demographics and characteristics in the time period before (Control) and during the COVID-19 pandemic. Unit labels are in column 1.

Kruskal–Wallis test was performed to compare nonparametric continuous variables. IRR comparing the COVID-19 exposure period to each control period were calculated using Poisson regression to model the number of events per day. Stata 16 (College Station, TX) was used for all statistical analyses.

Results

During the COVID-19 (exposure) time period, there were a total of 5029 ER encounters (Table 1). This was significantly lower than both control periods ($n = 7585$ and $n = 8054$). A higher proportion of male patients presented to the ER during COVID (52.7% *versus* 47.4%, $P < 0.001$). The ESI Acuity status (ESI 1 or ESI 2) was also slightly higher during COVID (28.3% *versus* 26.5%). The rate of hospital admission from the ER was higher in the COVID cohort (16.2% *versus* 14.7%; $P = 0.02$) and the total time spent in the ER per encounter was significantly lower during the study period (3.5 *versus* 5.1 h, $P < 0.001$). However, once a patient was admitted to the hospital the length of stay was significantly longer during COVID (87.2 *versus* 72.3 h).

During the exposure period, admissions to the General Surgery service were significantly lower (142 *versus* 281 admissions/30 d, IRR 0.51, $P < 0.001$ and 142 *versus* 293 admissions/30 d, IRR 0.48, $P < 0.001$) (Table 2). The total number of non-elective general surgery procedures was also significantly lower than both controls (143 *versus* 219 procedures/30 d, IRR 0.65, $P < 0.001$ and 143 *versus* 212 procedures/30 d, IRR 0.67, $P < 0.001$). The frequency of laparoscopic appendectomy was lower albeit not significantly (13 *versus* 22 procedures/30 d, IRR 0.59, $P = 0.13$ and 13 *versus* 23 procedures/30 d, IRR 0.67, $P = 0.10$). Among patients undergoing laparoscopic appendectomy, there were no differences between groups with regards to vital signs at presentation, WBC, serum creatinine or bicarbonate, length of surgical procedure (Table 3). There were also no differences in patients treated non-operatively. However, there was a significant difference in the time to the operating room, 11.5 h during the control time period compared to 8.0 h for the COVID-19 time period ($P < 0.01$). There was a trend toward shorter length of stay during the COVID-19 exposure time period (24.8 *versus* 46.6 h, $P = 0.16$). The percentage of perforated appendicitis was higher in the control periods (26.6% *versus* 15.3%, $P < 0.01$). There were no reported complications, unplanned post-operative ER visits, or readmissions during the COVID-19 exposure period, compared with two unplanned post-operative ER visits and two complications during the control period.

The frequency of laparoscopic cholecystectomy was significantly lower in the exposure period than the control time periods (41 *versus* 84 procedures/30 d, IRR 0.49 and 41 *versus* 88 procedures/30 d, IRR 0.47; $P < 0.001$) (Table 2). For those who presented with acute cholecystitis during COVID, the systolic blood pressure (124.5 *versus* 119.0) and diastolic blood pressure (76.1 *versus* 72.7) were significantly higher ($P < 0.05$) (Table 4). There was no difference in WBC, serum creatinine, bicarbonate, duration of case or length of stay between

Table 2 – Incidence rates and incidence rate ratios.

Variable	COVID-19	Control 1	Control 2
All ER encounters ($n = 20,668$)	5029	7585	8054
Incidence rate (per day)	167.6	252.8	268.5
Incidence rate ratio (95% CI)		0.66 (0.64-0.69)	0.62 (0.60-0.65)
P-value		<0.001	<0.001
All admissions ($n = 3108$)	817	1156	1135
Incidence rate (per day)	27.2	38.5	37.8
Incidence rate ratio (95% CI)		0.71 (0.65-0.77)	0.72 (0.66-0.79)
P-value		<0.001	<0.001
Surgery admissions ($n = 716$)	142	281	293
Incidence rate (per day)	4.73	9.37	9.77
Incidence rate ratio (95% CI)		0.51 (0.41-0.62)	0.48 (0.39-0.59)
P-value		<0.001	<0.001
All non-elective add-on cases ($n = 574$)	143	219	212
Incidence rate (per day)	4.77	7.30	7.07
Incidence rate ratio (95% CI)		0.65 (0.53-0.81)	0.67 (0.54-0.84)
P-value		<0.001	<0.001
Add-on laparoscopic appendectomy ($n = 58$)	13	22	23
Incidence rate (per day)	0.43	0.73	0.77
Incidence rate ratio (95% CI)		0.59 (0.27-1.23)	0.57 (0.26-1.16)
P-value		0.13	0.10
Add-on laparoscopic cholecystectomy ($n = 213$)	41	84	88
Incidence rate (per day)	1.37	2.80	2.93
Incidence rate ratio (95% CI)		0.49 (0.33-0.72)	0.47 (0.31-0.68)
P-value		<0.001	<0.001

A comparison of the daily incidence rate for ER encounters, all admissions, surgical admissions, non-elective add-on cases, appendectomy, and cholecystectomy. This compares the incidence before (Control) and during the COVID-19 pandemic.

laparoscopic cholecystectomy groups. There was a trend toward a shorter time to operating room during the COVID-19 time period (26.3 *versus* 32.2 h, $P = 0.14$). There was also no difference in post-operative ER visits and readmissions. During COVID, there were no conversions to an open cholecystectomy; however, the surgical site infection (SSI) rate was higher during the COVID time period. There were no differences in the other surgical complications. There were also no differences in patients treated non-operatively.

As noted above, during COVID significantly fewer patients underwent non-elective laparoscopic cholecystectomy. Of the patients with acute cholecystitis undergoing laparoscopic cholecystectomy during COVID, 22% had been seen and discharged from the ER in the prior 30 d for the same complaint (Table 5). This recurrence or relapse rate was significantly lower in the control periods (5.6%) ($P = 0.01$). There were no recurrences or relapses observed among patients with acute appendicitis, as no patients in either group had previously been seen in the ER.

Discussion

Emergency room encounters and surgical admissions at the LBJ safety-net hospital significantly decreased following the state of emergency declaration in Texas. The absolute number of emergency room encounters were 30%-35% lower than the two control time periods in this study. In addition, the frequency of traditional acute-care surgery admissions and non-elective operations were much lower during the COVID-19 pandemic.

Palisi *et al.* reported a significant decrease in overall ER admissions during the COVID-19 pandemic in Italy, although they did not find a significant change in the number of surgical consultations and types of operations performed.[15] Our original assumption was the incidence of acute appendicitis and acute cholecystitis would be relatively constant. However, the number of observed non-elective general surgery cases was much lower than expected. Similar to our findings, emergency surgery activity at Spanish hospitals was significantly decreased following the start of the pandemic, and the change was most pronounced for acute cholecystitis and acute appendicitis.[16,17]

Other investigators noted a significant decrease in the incidence and volume of common, urgent medical conditions.[15,18,19] As recently reported, patients may be voluntarily avoiding the ER and even delaying necessary operations such as organ transplantation.[20,21] Avoiding the ER has led some to fear patients may be staying at home with mild strokes, bowel obstructions and other serious medical conditions.[15-17,22]

Table 3 – Laparoscopic appendectomy.

COVID-19 Patients	COVID-19	Controls	P-value
Non-operative cases ($n = 7$)	($n = 2$)	($n = 5$)	
Age, y (SD)	33.5 (19.1)	35.4 (16.7)	0.92
Gender			0.81
Male (%)	1 (50%)	2 (40%)	
Female (%)	1 (50%)	3 (60%)	
ER heart rate, bpm (SD)	77.5 (24.8)	66.4 (6.1)	0.33
ER temperature, °F (SD)	98.0 (0.3)	98.0 (0.3)	0.94
ER systolic BP, mmHg (SD)	113.5 (7.8)	121.0 (25.6)	0.58
ER diastolic BP, mmHg (SD)	68.5 (9.2)	77.4 (16.6)	0.42
WBC, $\times 10^9$/L (SD)	14.6 (0.2)	11.5 (3.5)	0.12
CO2, mEq/L (SD)	28.5 (0.7)	25.0 (1.6)	0.01
Creatinine, mg/dL (SD)	0.85 (0.2)	0.58 (0.3)	0.27
Hospital LOS, h (SD)	36.0 (16.8)	62.4 (26.4)	0.21
Perforated (%)/Simple (%)	2 (100%)/0 (0%)	1 (20%)/4 (80%)	0.053
Readmissions (%)	0 (0%)	0 (0%)	NA
Unplanned ER visits (%)	0 (0%)	0 (0%)	NA
Complications (%)	0 (0%)	0 (0%)	NA
Operative cases ($n = 58$)	($n = 13$)	($n = 45$)	
Age, y (SD)	33.1 (8.2)	34.5 (12.7)	0.71
Gender			
Male (%)	9 (69%)	28 (62%)	0.64
Female (%)	4 (31%)	17 (38%)	
ESI acuity			
2 (%)	1 (8%)	7 (16%)	0.47
3 (%)	12 (92%)	38 (84%)	
ER heart rate, bpm (SD)	79.8 (8.0)	77.6 (14.4)	0.61
ER temperature, °F (SD)	98.3 (0.4)	98.3 (0.4)	0.64
ER systolic BP, mmHg (SD)	121.2 (20.1)	121.4 (15.1)	0.97
ER diastolic BP, mmHg (SD)	71.2 (13.6)	73.6 (10.9)	0.52
WBC (SD)	14.7 (5.0)	14.0 (5.0)	0.64
CO2 (SD)	26.4 (3.7)	25.6 (2.7)	0.35
Creatinine (SD)	0.9 (0.3)	0.8 (0.2)	0.07
Duration of procedure (SD)	107.4 (13.1)	109.2 (32.8)	0.84
Time to OR (SD)	8.0 (4.6)	11.5 (3.4)	<0.01
Hospital LOS (SD)	24.8 (9.6)	46.6 (54.5)	0.16
Perforated (%)/Simple (%)	2 (15%)/11 (85%)	12 (27%)/33 (73%)	<0.01
Readmissions (%)	0 (0%)	0 (0%)	NA
Unplanned ER visits (%)	0 (0%)	2 (4%)	<0.01
Complications (%)	0 (0%)	2 (4%)	<0.01

A comparison of appendicitis patient characteristics before and during the COVID-19 pandemic.
The top part of the table includes all patients managed non-operatively, while the bottom area includes patients managed with surgery.
The units are displayed in column 1.

Patients may have also been affected by the decreased availability of public transportation during the lockdown and certain patients at the safety-net hospital may have chosen to stay home and self-treat mildly symptomatic surgical conditions rather than face the longer wait times and infection risk associated with public transit during the pandemic.[7,23]

Interestingly, a higher percentage of male patients presented to the ER during the study period. In addition, higher acuity (ESI-1 or ESI-2) and a higher rate of hospital admission was observed in the COVID cohort. Patients spent less time in the ER which may reflect a more focused approach to triage resulting in quicker discharges of non-acute patient

Table 4 – Laparoscopic cholecystectomy.

COVID-19 Patients	COVID-19	Controls	P-value
Non-operative cases ($n = 6$)	($n = 1$)	($n = 5$)	
Age (SD)	46.0 (NA)	47.4 (8.9)	0.89
Gender			0.01
Male (%)	1 (100%)	0 (0%)	
Female (%)	0 (0%)	5 (100%)	
ER heart rate, bpm (SD)	60.0 (NA)	77.6 (17.1)	0.40
ER temperature, °F (SD)	98.0 (NA)	98.1 (0.4)	0.81
ER systolic BP, mmHg (SD)	147.0 (NA)	121.6 (14.2)	0.18
ER diastolic BP, mmHg (SD)	86.0 (NA)	75.6 (11.0)	0.44
WBC, $\times 10^9$/L (SD)	4.9 (NA)	11.9 (6.2)	0.36
CO2, mEq/L (SD)	25.0 (NA)	26.4 (2.7)	0.66
Creatinine, mg/dL (SD)	0.9 (NA)	0.7 (0.1)	0.19
Hospital LOS, h (SD)	2.0 (NA)	1.8 (1.0)	0.88
Converted to open	NA	NA	
Readmissions (%)	0 (0%)	0 (0%)	NA
Unplanned ER visits (%)	0 (0%)	1 (20%)	0.62
Complications (%)	0 (0%)	0 (0%)	NA
Operative cases ($n = 213$)	($n = 41$)	($n = 172$)	
Age (SD)	36.8 (12.1)	39.6 (14.4)	0.25
Gender			
Male (%)	12 (29%)	33 (19.2%)	0.12
Female (%)	29 (71%)	139 (80.8%)	
ESI acuity			
2 (%)	5 (12%)	16 (9.3%)	0.68
3 (%)	36 (8%)	154 (89.5%)	
> 3 (%)	0 (0%)	2 (1.2%)	
ER heart rate, bpm (SD)	76.5 (12.6)	78.6 (12.5)	0.34
ER temperature, °F (SD)	98.3 (0.4)	98.2 (0.4)	0.27
ER systolic BP, mmHg (SD)	124.5 (15.7)	118.7 (15.1)	0.03
ER diastolic BP, mmHg (SD)	76.1 (10.4)	72.5 (9.2)	0.03
WBC, $\times$ 10^9/L (SD)	11.3 (3.4)	10.7 (4.5)	0.42
CO2, mEq/L (SD)	25.6 (3.3)	25.5 (2.5)	0.85
Creatinine, mg/dL (SD)	0.7 (0.2)	0.7 (0.3)	0.80
Duration of procedure, min (SD)	136.4 (41.2)	130.9 (40.1)	0.43
Time to OR (SD)	26.3 (20.2)	32.2 (23.3)	0.14
Hospital LOS (SD)	61.2 (39.4)	62.2 (38.3)	0.87
Converted to open (%)	0 (0%)	2 (1.16%)	0.51
Readmissions (%)	3 (7%)	13 (7.6%)	0.93
Unplanned ER visits (%)	4 (8%)	26 (15.1%)	0.48
Complications (%)	7 (17%)	19 (11.1%)	0.20
SSI (%)	4 (8%)	2 (1.1%)	<0.01
Bile Leak (%)	2 (5%)	4 (2.3%)	0.32
Other (%)	1 (2%)	13 (7.6%)	0.28

A comparison of cholecystectomy patient characteristics before and during the COVID-19 pandemic.
The top part of the table includes all patients managed non-operatively, while the bottom area includes patients managed with surgery.
Units are displayed in column one.

Table 5 – Prior ER presentations for same complaint.

Patients With Prior ER Presentation	Prior ER presentations	No prior ER presentation	P-value
Acute appendicitis			
Control (%)	0 (0%)	45 (100%)	N/A
COVID-19 (%)	0 (0%)	13 (100%)	
Acute cholecystitis			
Control (%)	12 (7.0)	160 (93.0)	0.01
COVID-19 (%)	9 (22.0)	32 (78.0)	

This table displays the patients in each category who had previously been evaluated in the emergency room for the same complaint. Of the patients who had appendicitis, no patients had previously been evaluated in the ER in either time period. Of the patients who had cholecystitis, 6.98% of patients during the control time period compared with 22% of patients during the COVID-19 period were return patients after previous discharge from the ER for the same complaint.

conditions. Yet after patients were admitted during COVID, the hospital length of stay was longer. Reasons behind this observation may be more complex as hospital inpatient efficiency significantly slowed down due to new workflows and SARS-CoV-2 testing requirements. Patient navigation, social work and case management services were also consolidated and reduced during the pandemic. The process of inpatient transfer to rehab hospitals and/or skilled nursing facilities also become more challenging. The sum of these effects likely prolonged the length of stay, which may be viewed as counterproductive during a time when all available resources were needed for COVID related care.

We hypothesized that patients seeking emergent care during COVID for appendicitis and cholecystitis would present with more advanced disease. However, the available data did not demonstrate a significant difference between groups. Patients undergoing laparoscopic appendectomy did not show any difference in pre-operative indices of disease severity; furthermore, the percentage of cases with perforated appendicitis was higher during the control time periods. The shorter time from ER admission to the operating room observed during the COVID-19 time period may have contributed to the decrease in cases of perforated appendicitis. The reduced operative volume and decrease in elective cases allowed emergency appendectomies to be performed with less delay. Thus, a "fast track" approach to the management of acute appendicitis may be beneficial, although additional research is required to determine whether decreased time to operation is definitively associated with decreased incidence of perforated appendicitis. The observed trend toward shorter length of stay following laparoscopic appendectomy during the COVID exposure time period can be partly explained by the lower percentage of perforated cases.

An Israeli study of similar design also found the weekly incidence of appendicitis decreased 40.7% during the pandemic.[7] They also did not observe a significant difference in percentage of complicated *versus* uncomplicated appendicitis, duration of symptoms prior to presentation, rate of post-operative peritoneal drainage or percentage of serious post-operative complications.[7] In contrast, a Turkish study noted a 73% decrease in patients who underwent appendectomy, however, they noted an increased proportion of patients with complicated appendicitis.[24] A United States study in Massachusetts also observed a decrease in cases of uncomplicated appendicitis and a corresponding increase in cases of complicated appendicitis, however their sample did include pediatric patients while our sample did not.[25] The difference in rates of complicated and uncomplicated appendicitis may be partially explained by differences in access to care and differing attitudes about the pandemic. LBJ hospital, the site of the current study, is part of a county-wide health system, so even the under-privileged and un-insured population can readily access surgical care. Additionally, Texas did not experience the initial COVID-19 surge as acutely as the Northeast, so the attitude toward COVID-19 has been relatively more relaxed. These factors may have contributed to patients in the current study presenting earlier compared to their counterparts in other studies.

Patients that underwent laparoscopic cholecystectomy during COVID did have higher systolic and diastolic blood pressure at ER presentation that may be indirect evidence of more severe pain. However, the duration of cholecystectomy and hospital length of stay was not different. It is plausible that patients with mild symptoms may have stayed at home due to fears of COVID exposure if they sought care in the ER.[26] Time to operating room also tended to be lower during the COVID-19, again likely a result of empty operating rooms. We suspected the complication rates, post-operative ER presentations, and re-admissions may differ between groups; however, this was not observed. This could be due to the relatively low sample size of surgical cases. Whereas other investigators observed an increase in in-hospital mortality for surgical admissions, this was not observed in our cohort.[16,24] The one exception is the significantly higher percentage of SSI during the COVID time period, the reasons for which are unclear. A study at an urban, safety-net hospital in Boston also observed a 49% decrease in admissions for cholecystitis.[27] However, when stratified by severity, only admissions for Tokyo I mild cholecystitis declined significantly.[27] The authors concluded that not all cases of acute cholecystitis progress to more severe disease and some mild cases resolve with outpatient antibiotics or symptomatic treatment.[27]

Near the start of the COVID-19 timeframe, the American College of Surgeons (ACS) published guidelines for the management of surgical emergencies during the pandemic. These guidelines recommend pain management and delayed

surgery for symptomatic cholelithiasis, and laparoscopic cholecystectomy for crescendo symptoms, refractory pain, or acute cholecystitis.[28] This study found a significantly higher percentage of cholecystitis patients in the COVID cohort who had previously presented to the ER and were discharge for the same complaint. It seems these patients were managed according to the ACS guidelines. Patients deemed to have mild symptomatic cholelithiasis were discharged from the ED rather than scheduled for surgery. Like other studies, a percentage of these patients re-presented following failed non-operative management or the return of symptoms.[29] These returning patients made up a significantly larger percentage of laparoscopic cholecystectomies during the COVID-19 exposure period, a finding that hints at increased prevalence of initial non-operative management. A secondary analysis of this group of patients revealed that all nine patients were Hispanic females, and on average, on initial ER presentation, they exhibited high-normal heart rate (88.9 bpm), alkaline phosphatase (ALP; 83.7 U/L), and white blood cell count (10.8×10^9/L). The demographic makeup of that group may be explained by cultural and culinary preferences. While it was not possible to use the current data to examine all ER patients presenting with abdominal pain and compare the above group to those who were discharged and did not return, the findings are interesting on their own. These findings certainly suggest higher suspicion for acute cholecystitis or refractory/crescendo cholelithiasis requiring surgical intervention in Hispanic females with elevated heart rate, WBC, and ALP. We propose screening criteria of HR $\geq$ 100 or WBC $\geq$ 10 or ALP $\geq$ 90. If this screening criteria is retrospectively applied to the above group, eight out of nine patients would have been initially admitted for cholecystectomy. However, the population served at this hospital is $>$ 50% Hispanic, and symptomatic cholelithiasis is more common in females, so these observations may not be generalizable to hospitals serving a different demographic. Regardless, these observations raise interesting questions for further research.

There was little difference in the severity of patient presentation or post-operative complications in the COVID-19 time period compared with the control time period, which suggests that non-operative management of mild right upper quadrant pain without systemic symptoms or systemic markers of inflammation may be a safe approach when necessary to conserve hospital resources.

Lastly, the lack of differences in outcome may be explained in part by the makeup of resident/faculty care teams and the increased availability of operative facilities. Due to the need to minimize exposures as well as the need to quarantine infected residents/faculty, the makeup of resident teams was changed dramatically during the COVID-19 time period. Usually, four teams of one or two interns, one or two mid-level residents, and one upper-level resident are at the hospital during the day, and one night intern, one night mid-level resident, and one night upper-level resident are on at night. During the COVID-19 period, one team was on during the day and one team was on at night for a week straight. Usually, a different faculty member is on during the day and another faculty member on at night, and the faculty change daily. During the COVID-19 period, one faculty was on for a week straight during the day and a different faculty for a week straight at night. While the ratio of residents and faculty to patient remained relatively constant, it is very conceivable that this schedule allowed for greater continuity and potentially better care, helping to offset and possibly prevent some complications. Additionally, the increased availability of operative facilities led to decreased ER to OR times, also possibly offsetting and maybe preventing complications associated with increased time to definitive operative intervention.

Limitations

There are several limitations of this study. This data was not collected for the primary purposes of research which may lead to misclassification bias. It is also possible that patients sought care at other hospitals; however, the majority of patients seen at this safety-net hospital are uninsured and have limited healthcare options. It was not possible to objectively separate patients with symptomatic cholelithiasis from those with acute cholecystitis, the blurring of the two conditions in the data set makes it difficult to provide evidence to definitively support the ACSguidelines. While this is a large dataset of 41,465 emergency room encounters (COVID, controls and reference Groups) and nearly 300 acute care surgery admissions, the actual sample size of appendectomy and cholecystectomy patients is relatively small (approximately 100 patients per time period). Therefore, the study is vulnerable to type II error. Additionally, the study was conducted at a single, urban, safety-net-hospital with the demographics described above, so the findings may not be generalizable to other populations.

Future directions

This project can be expanded to analyze the rates of appendicitis and cholecystitis over the entire time period since the start of the COVID-19 pandemic. It would be interesting to examine if the lower rates of these disease processes persisted, if there were rebounds after the surges, and if the rates of these conditions returned to the pre-COVID-19 baseline. It would also be interesting to examine whether a shorter time to operative intervention, or a “fast track” appendicitis pathway can result in decreased rates of perforated appendicitis. It would also be possible to expand upon the selection of cholecystitis patients who could safely be managed conservatively without admission or cholecystectomy. It is possible to test the above proposed screening criteria and examine whether it can reduce ER readmissions with persistent or smoldering symptoms of cholecystitis.

Conclusions

Despite the advances in vaccination over the past 9 mo, the Delta and Omicron variants have put COVID-19 back in the national spotlight with continued surges. Cases, hospitalizations, and deaths are increasing again at an unprecedented rate. New variants and spikes are expected in the future, so the experience of the early-2020 pandemic is very relevant today. Based on the presented data, surgical volume can once again be expected to decrease. While patients with mild

disease may resist seeking care, surgical patient acuity is not expected to differ significantly. Moreover, surgical complications are not expected to increase significantly. Additionally, the pandemic experience at different hospitals and in different countries seems to suggest that mild cases of appendicitis and cholecystitis are being managed conservatively without concomitant increases in more severe disease presentation. An important finding of this study is multiple patients with acute cholecystitis had been seen previously in the ER and relapsed during the COVID timeframe. This may reflect bias toward early disposition and discharge of 'non-COVID' related illness. During this unprecedented time of healthcare system stress and crisis, improved workflow protocols are needed to prevent multiple emergency room encounters with increased resource consumption for routine surgical diagnoses.[30] Preventable emergency room visits should be avoided to reduce potential COVID-19 exposure and conserve healthcare resources. More research is necessary to delineate patients in whom mild appendicitis and cholecystitis may be managed conservatively without increasing the risk of return to the ER or progression of disease. Ongoing efforts to provide safe, surgical care in this era will continue to be a challenge for the foreseeable future as healthcare resources are shifted to combat the COVID-19 pandemic and new emerging faces of this disease.

Author Contributions

The idea for the study was conceived by Dr Artem Boyev, Dr Curtis Wray, and Dr Srinivas Sanjeevi. Dr Boyev, Dr Wray, Dr Sanjeevi, Dr Estrada and Dr Ko all contributed to data analysis, manuscript writing, and manuscript review and editing.

Disclosure

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