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Increased Complications of Emergent Surgical Procedures During the First Wave of COVID-19

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ABSTRACT

Introduction: Based on recommendations by CMS elective surgery was stopped during the first wave of COVID-19. Despite hospitals being open for emergent surgery, there were some studies that showed a decrease in surgical volume.

Methods: A retrospective analysis for all surgeries from 185 affiliated hospitals from the first wave of the COVID-19 pandemic (March 2020 to May 2020) and as a comparison the previous year, March 2019 to May 2019 were obtained. Five surgeries were further analyzed: appendectomies, cholecystectomies, craniotomies, exploratory laparotomies, and endoscopic retrograde cholangiopancreatographies (ERCPs).

Results: Between March 2019 and May 2019, 326,726 surgeries were performed, and between March 2020 and May 2020, 237,809 surgeries were performed. The highest specialty for both years was gastroenterology. In 2020, 15.7% of the patients were admitted to the ICU *versus* 13.7% in 2019. For appendectomies, cholecystectomies, craniotomies, exploratory laparotomies and ERCPs, there was an increase from 2019 to 2020 in acute kidney injuries rate, infection, systemic inflammatory response syndrome (SIRS), and sepsis. All the changes in surgical volumes for the five surgeries from 2019 to 2020 were significant. For appendectomy, the statistically significant complications were infection and SIRS and sepsis.

Conclusions: Across the board, there was a decrease in surgical volume during the COVID-19 pandemic first wave. There was a statistically significant decrease in appendectomy, cholecystectomy, exploratory laparotomy, craniotomy, and ERCP. For all five surgeries, we did see an increase in mortality rates and several complications. The only statistically significant complications were infection and SIRS and sepsis, for appendectomy.

Introduction

During the early months of the COVID-19 pandemic, there was a recommendation from Centers for Medicare and Medicaid Services (CMS) to stop all elective surgery.[1] This was in hopes to decrease patient risk factors, preserve bed availability, protect staff, and conserve personal protective equipment (PPE). While most hospitals closed elective surgery, hospitals

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remained open to acute care surgery needs. A study out of Spain saw a 58.9% decrease in acute care surgery when comparing March to April in 2020 to 2019.[2] They also saw a longer time from onset of symptoms to emergency department (ED) visits and an increase in morbidity, but that was not statistically significant.

Several other studies showed substantial decreases in surgical volume; one study out of Shanghai, China had an 80% decrease,[3] a study out of India had a 52.2% decrease in neurosurgical cases,[4] a study from the US had a 54% decrease in cardiac surgery,[5] and a study out of Italy had a 78% decrease in urologic procedures.[6]

Appendicitis is the most common operative disease with a lifetime risk of 7%-8%.[7] A study out of Israel found that during the COVID-19 pandemic, there was a 40.7% decrease in acute appendicitis.[8] However, there wasn't a difference in the length of preoperative symptoms, length of surgery, or complicated *versus* uncomplicated appendicitis. Another study that came out of the US showed a 45.5% decrease during the COVID-19 pandemic of uncomplicated appendectomies; they also saw a significant increase in complicated *versus* uncomplicated appendicitis.[9] Two different studies which showed a decrease in appendectomies, but opposite results when looking at complicated *versus* uncomplicated appendicitis.

A study that came out of Ireland saw a 63% increase in cases of acute calculous cholecystitis.[10] They hypothesized that more people were sitting at home during COVID eating a high-fat diet.

In the Netherlands, there was a study on gastroenterology procedures where they saw that both colonoscopies and endoscopies decreased, but endoscopic retrograde cholangiopancreatography (ERCP) volumes were unchanged.[11]

We hypothesized that there would be a decrease in appendectomies and cholecystectomies, but no change in emergent surgeries such as craniotomies, exploratory laparotomies, and ERCP. We also hypothesized that there would be an increase in complications of patients who presented with appendicitis and cholecystitis because they would be sitting at home longer before presenting to the hospital.

Material and Methods

A retrospective analysis of deidentified patient electronic medical records for all surgeries from 185 HCA Healthcare–affiliated hospitals from the first wave of the COVID-19 pandemic (March 2020 to May 2020) and as a comparison the previous year, March 2019 to May 2019 were obtained. Patient records were selected by the presence of CPT and ICD procedure codes during that time period. Data were abstracted from these records regarding patient demographics, surgery type, Intensive Care Unit (ICU) admission, ventilator use, COVID-19 status, and outcomes. Invasive ventilation was defined as mechanical ventilation through an endotracheal tube or a tracheostomy tube. Noninvasive ventilation was identified as Continuous positive airway pressure (CPAP) and Bilevel Positive Airway Pressure (BiPAP). Procedures were categorized by surgery subspecialty. Since we were recording every surgery that happened during the time periods above, if a patient had multiple surgeries in that time period, each encounter was separately recorded by surgery.

The five surgeries were further analyzed (these were chosen since they are high-volume procedures at our institutions).

Table 1 – Demographics.

Demographics	March-May 2019	March-May 2020
Surgeries, No.	326,726	237,809
Gender, No. (%)		
Female	180,286 (55.2%)	125,165 (52.6%)
Male	146,440 (44.8%)	112,644 (47.4%)
Race, No. (%)		
White	244,667 (74.9%)	176,471 (74.2%)
Black	42,063 (12.9%)	31,660 (13.3%)
Asian	6355 (1.9%)	4642 (2.0%)
Hispanic	222 (0.1%)	164 (0.1%)
Other	33,419 (10.2%)	24,872 (10.5%)
Age, Mean (SD)	57.9 (16.9)	57.4 (17.0)
Specialties, No. (%)		
Cardiology	701 (0.2%)	450 (0.2%)
Cardiothoracic	11,359 (3.5%)	8505 (3.6%)
Colorectal	5631 (1.7%)	4532 (1.9%)
Endocrine	776 (0.2%)	511 (0.2%)
ENT	8122 (2.5%)	5090 (2.1%)
Gastroenterology	83,722 (25.6%)	53,745 (22.6%)
General surgery	56,871 (17.4%)	45,620 (19.2%)
Interventional radiology	631 (0.2%)	496 (0.2%)
Neurosurgery	13,540 (4.1%)	11,151 (4.7%)
OBGYN	26,287 (8.0%)	17,755 (7.5%)
Oncology	241 (0.1%)	144 (0.1%)
Ophthalmology	4912 (1.5%)	2745 (1.2%)
Oral & maxillofacial	19 (0.0%)	14 (0.0%)
Orthopedics	61,889 (18.9%)	48,044 (20.2%)
Pediatrics	270 (0.1%)	212 (0.1%)
Plastic surgery	11,720 (3.6%)	8612 (3.6%)
Podiatry	5851 (1.8%)	4756 (2.0%)
Pulmonary	4842 (1.5%)	2513 (1.1%)
Transplant & hepatobiliary	1319 (0.4%)	1017 (0.4%)
Urology	20,891 (6.4%)	15,955 (6.7%)
Vascular	7132 (2.2%)	5942 (2.5%)
Admission Source		
Home, No. (%)	311,348 (95.3%)	223,875 (94.1%)
Other No. (%)	15,378 (4.7%)	13,934 (5.9%)
Elixhauser comorbidity index, median [Min, Q1, Q3, Max]	2.00, [0, 1.00, 4.00, 17.0]	2.00, [0, 1.00, 4.00, 18.0]
COVID-19, No. (%)	N/A	404 (0.2%)

Table 2 – Outcome measures for all surgeries stratified by year of surgery.

Outcomes	March-May 2019	March-May 2020
Surgeries, No.	326,726	237,809
ICU admission, No. (%)	44,693 (13.7%)	37,440 (15.7%)
Days in ICU (of ICU Admits), median [Min, Q1, Q3, Max]	4.35, [0, 1.94, 11.1, 85.7]	4.59, [0, 1.96, 12.2, 81.4]
Hospital length of stay (Days), median [Min, Q1, Q3, Max]	2.00, [1.00, 1.00, 6.00, 92.0]	2.00, [1.00, 1.00, 7.00, 89.0]
Mortality, No. (%)	7161 (2.2%)	6706 (2.8%)
Invasive ventilator use, No. (%)	24,983 (7.6%)	21,053 (8.9%)
Invasive ventilator days used (of users), median [Min, Q1, Q3, Max]	4.00, [1.00, 2.00, 13.0, 86.0]	5.00, [1.00, 2.00, 15.0, 65.0]
Noninvasive ventilator use, No. (%)	13,873 (4.2%)	10,164 (4.3%)
Non-invasive ventilator days used (of users), median [Min, Q1, Q3, Max]	3.00, [1.00, 1.00, 7.00, 61.0]	2.00, [1.00, 1.00, 7.00, 46.0]
ASA score, median [Min, Q1, Q3, Max]	3.00, [0, 2.00, 3.00, 6.00]	3.00, [0, 2.00, 3.00, 6.00]
Discharge disposition, No. (%)		
Home	278,921 (85.4%)	200,444 (84.3%)
Hospital transfer	2230 (0.7%)	2237 (0.9%)
Rehabilitation facility	38,414 (11.8%)	28,422 (12.0%)
Expired/Hospice	7161 (2.2%)	6706 (2.8%)

1. Appendectomy
2. Cholecystectomy
3. Exploratory Laparotomy
4. Craniotomy
5. Endoscopic Retrograde Cholangio-Pancreatography (ERCP)

For these above procedures, inpatient complications (acute kidney failure, congestive heart failure, deep vein thrombosis, infection, myocardial infarction, pneumonia, sepsis, and urinary tract infections) were identified based on ICD codes. The observed number of complications were compared from March to May of 2019 and March to May of 2020.

G-tests were used to examine the proportion of the five surgeries as well as mortality and complications within appendectomies and cholecystectomies in March through May of 2019 compared to the same timeframe in 2020. A total of 21 G-tests were conducted and the Holm-Bonferroni method was used to adjust for multiple comparisons. The *P*-value for each covariate indicates rejection of, or failure to reject, the null hypothesis. *P*-value of less than 0.05 ($\leq$0.05) is statistically significant.

This research activity was determined to be exempt from Institutional Review Board.

(IRB) oversight in accordance with current regulations and institutional policy. All data had identifiers removed and was compiled before our receival of it. Our internal reference number for this determination is 2020-999.

Results

In the 185 hospitals nationwide between March of 2019 to May of 2019, 326,726 surgeries were performed, and between March of 2020 to May of 2020, 237,809 surgeries were performed. Exclusions were for patients under 18 or any incomplete data.

Table 1 shows the demographic data. There were more females that had surgery during both time periods 55.2% in 2019 and 52.6% in 2020. Mean age was 57.9 in 2019 and 57.4 in 2020. The highest specialty for both years was gastroenterology. The vast majority of patients came from home for both years, but a higher percentage of patients came from other facilities in 2020 5.9% *versus* 4.7% in 2019. Elixhauser Comorbidity Index was 2 for both years. In 2020, 0.2% of the patients that underwent surgery had COVID-19.

In Table 2, we compare surgical outcomes of the first wave of the COVID-19 pandemic to the previous year. In 2020, 15.7% of the patients were admitted to the ICU *versus* 13.7% in 2019. Hospital length of stay was 2 d for both groups. Invasive ventilator use was higher in 2020 5 d *versus* 4 d in 2019; however, noninvasive ventilator use was higher 2019 3 d *versus* 2 d. In 2020, more patients required invasive ventilation 8.9% *versus* 7.6% in 2019. ASA score was 3 in both years. Discharges to patient's homes were the highest in both groups 85.4% in 2019 and 84.3% in 2020.

In Table 3, we looked specifically at appendectomies, cholecystectomies, exploratory laparotomies, craniotomies and ERCPs. There was a decrease in surgical volume for all 5 from 2019 to 2020. The majority of patients were female who had cholecystectomies, exploratory laparotomies, and ERCP. The majority of patients were male who had appendectomies and craniotomies. The Elixhauser Comorbidity Index, median for appendectomies and exploratory laparotomies increased from 2019 to 2020. ICU admission was lower in 2020 for all surgeries except for ERCP which went from 7.9% to 8.9%. All the mortality rates increased from 2019 to 2020. Invasive ventilation rates from 2019 to 2020 had little variation appendectomy 1% *versus* 0.7%, cholecystectomy 1.4% to 1.3%, exploratory laparotomy 54.7% *versus* 54.3%, craniotomy 40.5% to 40.3%, ERCP 3.3% *versus* 3.4%. All surgery invasive ventilation rates went down from 2019 to 2020 except ERCP. ASA score was unchanged from 2019 to 2020 for all of the surgeries.

In Table 4, we look at complication rates for the five surgery types. For all surgeries, there was an increase from 2019 to 2020 in acute kidney injuries rate, infection, systemic inflammatory response syndrome (SIRS) and sepsis.

Table 3 – Outcomes for appendectomies, cholecystectomies, exploratory laparotomies, craniotomies, and ERCPs stratified by year of surgery.

Outcomes	Appendectomy		Cholecystectomy		Exploratory laparotomy		Craniotomy		ERCP	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Surgeries, No. (% of surgeries)	4663 (1.4%)	3894 (1.6%)	12,691 (3.9%)	9671 (4.1%)	4875 (1.5%)	4672 (2.0%)	1287 (0.4%)	1210 (0.5%)	4959 (1.5%)	4468 (1.9%)
Gender										
Female, No. (%)	2307 (49.5%)	1918 (49.3%)	8558 (67.4%)	6492 (67.1%)	2554 (52.4%)	2507 (53.7%)	586 (45.5%)	498 (41.2%)	2975 (60.0%)	2638 (59.0%)
Male, No. (%)	2356 (50.5%)	1976 (50.7%)	4133 (32.6%)	3179 (32.9%)	2321 (47.6%)	2165 (46.3%)	701 (54.5%)	712 (58.8%)	1984 (40.0%)	1830 (41.0%)
Elixhauser comorbidity index, median [Min, Q1, Q3, Max]	0, [0, 0, 1.00, 10.0]	1.00, [0, 0, 1.00, 10.0]	1.00, [0, 0, 3.00, 13.0]	1.00, [0, 1.00, 3.00, 14.0]	3.00, [0, 1.00, 5.00, 13.0]	4.00, [0, 2.00, 7.00, 15.0]	4.00, [0, 2.00, 6.00, 13.0]	4.00, [0, 3.00, 6.00, 14.0]	2.00, [0, 1.00, 4.00, 12.0]	2.00, [0, 1.00, 4.00, 15.0]
COVID-19, No. (%)	N/A	11 (0.3%)	N/A	15 (0.2%)	N/A	6 (0.1%)	N/A	4 (0.3%)	N/A	4 (0.1%)
ICU admission, No. (%)	131 (2.8%)	85 (2.2%)	470 (3.7%)	350 (3.6%)	2845 (58.4%)	2697 (57.7%)	1032 (80.2%)	958 (79.2%)	391 (7.9%)	397 (8.9%)
Days in ICU (of ICU Admits), median [Min, Q1, Q3, Max]	2.05, [0.09, 0.932, 5.17, 20.3]	1.52, [0.01, 0.731, 3.98, 14.8]	2.41, [0.01, 1.17, 4.72, 34.9]	2.25, [0.07, 1.37, 4.00, 50.2]	7.83, [0, 3.26, 18.5, 57.5]	8.15, [0.01, 2.94, 20.7, 58.2]	5.48, [0, 2.70, 13.9, 64.5]	6.01, [0.05, 2.80, 12.9, 50.4]	2.74, [0.01, 1.53, 5.70, 45.1]	2.67, [0.05, 1.45, 5.25, 55.9]
Hospital length of stay (Days), median [Min, Q1, Q3, Max]	2.00, [1.00, 2.00, 3.00, 30.0]	2.00, [1.00, 2.00, 3.00, 41.0]	2.00, [1.00, 1.00, 4.00, 59.0]	2.00, [1.00, 1.00, 4.00, 80.0]	13.0, [1.00, 7.00, 23.0, 87.0]	13.0, [1.00, 7.00, 25.0, 70.0]	10.0, [1.00, 5.00, 20.0, 76.0]	10.0, [1.00, 6.00, 19.0, 89.0]	4.00, [1.00, 2.00, 7.00, 72.0]	5.00, [1.00, 2.00, 7.00, 61.0]
Mortality, No. (%)	12 (0.3%)	15 (0.4%)	43 (0.3%)	52 (0.5%)	906 (18.6%)	893 (19.1%)	144 (11.2%)	168 (13.9%)	125 (2.5%)	138 (3.1%)
Invasive ventilator use, No. (%)	45 (1.0%)	29 (0.7%)	183 (1.4%)	127 (1.3%)	2667 (54.7%)	2537 (54.3%)	521 (40.5%)	488 (40.3%)	165 (3.3%)	151 (3.4%)
Invasive ventilator days used (of Users), median [Min, Q1, Q3, Max]	3.00, [1.00, 2.00, 6.00, 14.0]	3.00, [1.00, 2.00, 4.00, 24.0]	2.00, [1.00, 1.00, 5.00, 48.0]	2.00, [1.00, 1.00, 5.00, 34.0]	7.00, [1.00, 3.00, 16.0, 55.0]	6.00, [1.00, 3.00, 20.0, 58.0]	6.00, [1.00, 2.00, 12.0, 66.0]	7.00, [1.00, 2.00, 13.0, 51.0]	2.00, [1.00, 1.00, 8.00, 53.0]	4.00, [1.00, 2.00, 7.50, 57.0]
Noninvasive ventilator use, No. (%)	56 (1.2%)	45 (1.2%)	250 (2.0%)	170 (1.8%)	699 (14.3%)	680 (14.6%)	83 (6.4%)	103 (8.5%)	175 (3.5%)	163 (3.6%)
Noninvasive ventilator days used (of users), median [Min, Q1, Q3, Max]	2.00, [1.00, 1.00, 3.00, 25.0]	2.00, [1.00, 1.00, 5.00, 18.0]	2.00, [1.00, 1.00, 4.00, 34.0]	2.00, [1.00, 1.00, 3.00, 20.0]	2.00, [1.00, 1.00, 6.00, 51.0]	3.00, [1.00, 1.00, 8.00, 36.0]	5.00, [1.00, 1.00, 7.00, 29.0]	2.00, [1.00, 1.00, 4.50, 19.0]	3.00, [1.00, 1.00, 9.00, 28.0]	1.00, [1.00, 1.00, 4.00, 19.0]
ASA score, median [Min, Q1, Q3, Max]	2.00, [0, 2.00, 2.00, 4.00]	2.00, [0, 2.00, 2.00, 4.00]	2.00, [0, 2.00, 3.00, 5.00]	2.00, [0, 2.00, 3.00, 5.00]	3.00, [0, 3.00, 4.00, 6.00]	3.00, [0, 3.00, 4.00, 6.00]	3.00, [0, 3.00, 4.00, 5.00]	3.00, [0, 3.00, 4.00, 5.00]	3.00, [0, 2.00, 3.00, 5.00]	3.00, [0, 2.00, 3.00, 5.00]
Discharge disposition										
Home, No. (%)	4581 (98.2%)	3816 (98.0%)	12,265 (96.6%)	9354 (96.7%)	2655 (54.5%)	2586 (55.4%)	538 (41.8%)	541 (44.7%)	4418 (89.1%)	3994 (89.4%)
Hospital transfer, No. (%)	37 (0.8%)	40 (1.0%)	50 (0.4%)	35 (0.4%)	68 (1.4%)	118 (2.5%)	21 (1.6%)	18 (1.5%)	76 (1.5%)	84 (1.9%)
Rehabilitation facility, No. (%)	33 (0.7%)	23 (0.6%)	333 (2.6%)	230 (2.4%)	1246 (25.6%)	1075 (23.0%)	584 (45.4%)	483 (39.9%)	340 (6.9%)	252 (5.6%)
Expired/Hospice, No. (%)	12 (0.3%)	15 (0.4%)	43 (0.3%)	52 (0.5%)	906 (18.6%)	893 (19.1%)	144 (11.2%)	168 (13.9%)	125 (2.5%)	138 (3.1%)

Table 4 – Complications for appendectomies, cholecystectomies, exploratory laparotomies, craniotomies, and ERCPs stratified by year of surgery.

Complications	Appendectomy		Cholecystectomy		Exploratory laparotomy		Craniotomy		ERCP	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Surgeries, No. (% of surgeries)	4663 (1.4%)	3894 (1.6%)	12,691 (3.9%)	9671 (4.1%)	4875 (1.5%)	4672 (2.0%)	1287 (0.4%)	1210 (0.5%)	4959 (1.5%)	4468 (1.9%)
Acute kidney failure, No. (%)	175 (3.8%)	175 (4.5%)	842 (6.6%)	698 (7.2%)	2035 (41.7%)	2271 (48.6%)	141 (11.0%)	188 (15.5%)	636 (12.8%)	636 (14.2%)
Congestive heart failure, No. (%)	37 (0.8%)	28 (0.7%)	283 (2.2%)	221 (2.3%)	468 (9.6%)	306 (6.5%)	45 (3.5%)	68 (5.6%)	193 (3.9%)	182 (4.1%)
Deep vein thrombosis, No. (%)	4 (0.1%)	8 (0.2%)	46 (0.4%)	30 (0.3%)	243 (5.0%)	273 (5.8%)	103 (8.0%)	79 (6.5%)	71 (1.4%)	83 (1.9%)
Infection, No. (%)	408 (8.7%)	449 (11.5%)	1217 (9.6%)	999 (10.3%)	2231 (45.8%)	2461 (52.7%)	288 (22.4%)	312 (25.8%)	983 (19.8%)	915 (20.5%)
Myocardial infarction, No. (%)	10 (0.2%)	9 (0.2%)	61 (0.5%)	40 (0.4%)	236 (4.8%)	159 (3.4%)	20 (1.6%)	16 (1.3%)	29 (0.6%)	36 (0.8%)
Pneumonia, No. (%)	40 (0.9%)	37 (1.0%)	154 (1.2%)	125 (1.3%)	696 (14.3%)	626 (13.4%)	114 (8.9%)	160 (13.2%)	136 (2.7%)	147 (3.3%)
SIRS and sepsis, No. (%)	330 (7.1%)	360 (9.2%)	863 (6.8%)	716 (7.4%)	1846 (37.9%)	2177 (46.6%)	130 (10.1%)	149 (12.3%)	704 (14.2%)	656 (14.7%)
Urinary tract infection, No. (%)	139 (3.0%)	121 (3.1%)	645 (5.1%)	459 (4.7%)	533 (10.9%)	600 (12.8%)	136 (10.6%)	160 (13.2%)	422 (8.5%)	314 (7.0%)

Table 5, showed the G-tests that were conducted for analysis. All the changes in surgical volumes for the five surgeries from 2019 to 2020 were significant with a *P*-value of less than 0.05. We further analyzed appendectomy and cholecystectomy. For appendectomy, the statistically significant complications were infection and SIRS and sepsis. For cholecystectomy, there were no statistically significant complications.

Discussion

We hypothesized that there would be a decrease in appendectomies, cholecystectomies, and an increase in the complication rates of the patients that did present due to them staying at home longer during the pandemic. What we observed was that there was a decrease in appendectomy and cholecystectomy volume which was statistically significant. We did observe that there was an increase in complications rates of appendectomies from acute kidney failure, infection, pneumonia, urinary tract infection (UTI) and SIRS and sepsis, but only infection and SIRS and sepsis was statistically significant. In addition, we also saw an increase in acute kidney failure, congestive heart failure, infection, pneumonia, and SIRS and sepsis in cholecystectomies; however, none of them were statistically significant. We did not perform a G-test on DVT and MI in appendectomy since the case volume was too small to accurately analyze.

We also hypothesized that the more emergent surgeries exploratory laparotomies, craniotomies, and ERCPs would not see a decrease in volume. All three of them had a decrease in volume that was statistically significant.

For all five surgeries, we did see an increase in mortality rates. It was not statistically significant for appendectomy and cholecystectomy.

It was interesting to observe that social distancing and staying at home did decrease the case volume of appendectomies. However, this may indicate that more patients were being managed medically and not surgically. While in Europe there has been a bigger trend to treat appendicitis medically, a multicenter study found that during COVID-19 there was a universal increase in the medical management of appendicitis.[12]

Risk factors of cholecystitis as mentioned in the Tokyo guidelines are pregnancy (elevation in estrogen and progesterone), birth control, obesity, dieting, female, Ascaris infection and several drugs such as ceftriaxone, fibrate, dapsone, etc.[13] Murphy *et al.* observed an increase in acute calculous cholecystitis; they believed this was due to patients staying at home and eating more fatty food.[10] We observed a decrease in cholecystectomies and ERCPs. Again, this may be that more patients were being managed medically and not surgically.

There were fewer observed craniotomies and exploratory laparotomies during the first wave of the COVID-19 pandemic than during the same time period in 2019. It was possible that this was due to the fact that more patients were staying home and not going out, thus there were less traumatic causes, which decreased the operative volume. Ram *et al.* did mention in his study, "Where Have All the Fractures Gone?," that they found a significant decrease in patients presenting with

Table 5 — Results of G-tests for chosen comparisons, adjusted for multiple comparisons using Holm-Bonferroni method.

Surgery type	Metric	2019	2020	P-value
Appendectomy	Surgeries, No. (% of yearly surgeries)	4663 (1.4%)	3894 (1.6%)	<0.0001
	Mortality, No. (%)	12 (0.3%)	15 (0.4%)	1
	Acute kidney failure, No. (%)	175 (3.8%)	175 (4.5%)	0.977
	Congestive heart failure, No. (%)	37 (0.8%)	28 (0.7%)	1
	Infection, No. (%)	408 (8.7%)	449 (11.5%)	0.0004
	Pneumonia, No. (%)	40 (0.9%)	37 (1.0%)	1
	SIRS and sepsis, No. (%)	330 (7.1%)	360 (9.2%)	0.004
	Urinary tract infection, No. (%)	139 (3.0%)	121 (3.1%)	1
Cholecystectomy	Surgeries, No. (% of yearly surgeries)	12,691 (3.9%)	9671 (4.1%)	0.008
	Mortality, No. (%)	43 (0.3%)	52 (0.5%)	0.341
	Acute kidney failure, No. (%)	842 (6.6%)	698 (7.2%)	0.977
	Congestive heart failure, No. (%)	283 (2.2%)	221 (2.3%)	1
	Deep vein thrombosis, No. (%)	46 (0.4%)	30 (0.3%)	1
	Infection, No. (%)	1217 (9.6%)	999 (10.3%)	0.868
	Myocardial infarction, No. (%)	61 (0.5%)	40 (0.4%)	1
	Pneumonia, No. (%)	154 (1.2%)	125 (1.3%)	1
	SIRS and sepsis, No. (%)	863 (6.8%)	716 (7.4%)	0.977
	Urinary tract infection, No. (%)	645 (5.1%)	459 (4.7%)	1
Exploratory laparotomy	Surgeries, No. (% of Yearly surgeries)	4875 (1.5%)	4672 (2.0%)	<0.0001
Craniotomy	Surgeries, No. (% of Yearly surgeries)	1287 (0.4%)	1210 (0.5%)	<0.0001
ERCP	Surgeries, No. (% of Yearly surgeries)	4959 (1.5%)	4468 (1.9%)	<0.0001

fractures during this time.[14] They also found that the children presenting with fractures had more events at home or on bicycles then the previous years. They hypothesized that this was due to no organized sports and closing of playgrounds, but that children were playing near or in the home.

This study is limited by the retrospective nature of the data. We identified patients based on surgery type. Individuals could be double counted if they underwent multiple surgeries during their admission since we were recording based on each surgery. Small surgical volumes prohibited us from doing data analysis on all complications. ICD9 and CPT codes were used to identify patient, procedures, and complications. We were only able to identify complications based on the ICD9 codes. In addition, we used the Elixhauser comorbidity index which a summary measure may only be as good as the variables used to create it. Thus, a limitation is that all the data needed to be entered appropriately.

Conclusions

Across the board for all surgical subspecialties, there was a decrease in surgical volume during the COVID-19 pandemic first wave. There was a statistically significant decrease in appendectomy, cholecystectomy, exploratory laparotomy, craniotomy, and ERCP. For all five surgeries, we did see an increase in mortality rates. It was not statistically significant for appendectomy and cholecystectomy. While appendectomy and cholecystectomy had several observed increases in complication rates, the only statistically significant complications were infection, SIRS, and sepsis for appendectomy.

Authors Contributions

CC—conceived and designed analysis, preformed analysis, wrote the paper. BI—collected the data, wrote the paper. JW—edited the manuscript. PO—edited the manuscript. JY-conceived and designed analysis, wrote the paper, edited the manuscript. None of the authors have any disclosures to report.

Disclosure

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