Research Open

Journal of International Perspectives on COVID-19

Volume 1 Issue 2

Research Article

Safety of Surgical Management of Diverticulitis during the COVID-19 Pandemic

Robert Goldstone N, MD[1]*, Jianying Zhang, MD, MPH[2], Caitlin Stafford, BS[1], Christy Cauley, MD[1], Liliana Bordeianou, MD[1], Hiroko Kunitake, MD[1], Todd Francone, MD[1], David L. Berger, MD[1] and Rocco Ricciardi, MD, MPH[1]

[1]Section of Colon and Rectal Surgery, Massachusetts General Hospital, Boston, MA, USA

[2]Medtronic Healthcare Economics Outcomes Research Division, New Haven, CT, USA, USA

Corresponding author: Robert N. Goldstone, Massachusetts General Hospital, Section of Colon and Rectal Surgery, 15 Parkman St. WACC 460, Boston, MA 02114, USA; Tel: (617) 219-1285; Email: rgoldstone@partners.org

Received: September 28, 2020; **Accepted:** October 06, 2020; **Published:** October 11, 2020

Abstract

Aim: The impact of the global COVID-19 on colorectal conditions remains unknown. Thus, we aimed to determine the effect of COVID-19 limitations on diverticular disease.

Method: Retrospective analysis of Premier hospital inpatient files from 1/1/2019 through 6/30/2020 for admissions and surgical procedures for patients with diverticular disease. Comparison between first six months of 2019 and 2020 for disease incidence, severity, operative management, and adverse events. Primary outcome measure was pulmonary failure and secondary outcome measures were adverse events, rates of hospitalization and surgical intervention.

Results: Admissions for diverticulitis declined by 25% in 2020 as compared to 2019. The proportion of urgent diverticular disease cases rose significantly in April 2020 to 59.1% from an average of 37.5% in 2019 ($p<0.0001$). Although diverticular abscess comprised 55.1% of all admissions in 2019, the proportion of abscess cases rose to 69.3% in April 2020. Consequently, 38% of all procedures in the spring of 2020 resulted in a stoma, 29% higher than in 2019. Select postoperative complications including organ space infections and sepsis were significantly higher in April 2020. Most importantly, pneumonia complications were similar in 2019 (1.6%) and 2020 (1.8%) ($p=0.5$) as were respiratory failure rates (4.2% in both 2019 and 2020).

Conclusions: During the COVID-19 pandemic, there was a notable decreased rate of hospitalization for diverticulitis but an increased disease severity among those admitted. The increase in diverticular abscess procedures coincided with higher rates of organ space infections and ostomy creations but no difference in respiratory complications. These data indicate that surgery for diverticulitis in the setting of the COVID-19 pandemic can be safely performed.

Statement: Limitations incited by the COVID-19 pandemic resulted in decreased hospitalization rates for diverticulitis but increased severity of disease for those admitted, which coincided with increased rates of postoperative organ space infections and ostomy creations. However, respiratory complications remained stable demonstrating continued safety of operative management in this critical time.

Introduction

Coronavirus disease 2019 (COVID-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Although COVID-19 has a variable clinical course, the virus is associated with severe respiratory, vascular, and/or gastrointestinal symptoms which can progress in severity in high-risk individuals. In the most common case, COVID-19 is characterized by symptoms of viral pneumonia such as fever, fatigue, and dry cough [1]. The virus is highly contagious as it is spread from person to person through respiratory secretions and/or contaminated fomites. Within short order, Coronavirus spread around the world leading the World Health Organization to declare COVID-19 a pandemic on March 11, 2020 [2].

The COVID-19 pandemic changed many dimensions of health care in the United States and affected the operations of a host of healthcare facilities in 2020 [3]. In surgery, the American College of Surgeons recommended that *"each hospital, health system, and surgeon should thoughtfully review all scheduled elective procedures with a plan to minimize, postpone, or cancel electively scheduled operations, endoscopies, or other invasive procedures until we have passed the predicted inflection point in the exposure graph and can be confident that our health care infrastructure can support a potentially rapid and overwhelming uptick in critical patient care needs."* These recommendations led to reduced numbers of patients in ambulatory clinics, fewer screening and other elective procedures, as well as other interruptions in inpatient services [4,5]. Models of these interruptions in cancer screening and treatment have predicted over 10,000 excess deaths from breast and colorectal cancer over the next decade [6].

Given the limitations and restrictions in surgical care as well as other concerns related to obtaining non COVID-19 related treatment, we undertook a study to determine the impact of COVID-19 on colorectal surgery care in the United States. In particular we sought to evaluate diverticulitis care during the height of the pandemic as

well as outcomes from surgery during the height of the pandemic as compared to one year prior. In addition, we evaluated the risk of respiratory complications related to surgery during the COVID-19 pandemic, as well as all other postoperative complications, as compared to one year earlier. These data are of particular importance as other COVID surges occur as well as other potential respiratory epidemics.

Methods

Database

We abstracted records from the Premier hospital inpatient files from 1/1/2019 through 6/30/2020 accounting for 586 hospitals. The Premier Healthcare Database is one of the most comprehensive electronic healthcare databases originating from the merger of Premier with American Healthcare Systems and SunHealth in 1997 [7]. Data derive from a large, U.S. hospital-based, service-level, all-payer capture model that contains information on inpatient discharges, primarily from geographically diverse non-profit, non-governmental and community and teaching hospitals and health systems from rural and urban areas [7]. Hospitals and healthcare systems submit administrative, healthcare utilization and financial data from patient encounters approximating 10 million inpatient visits per year or twenty-five percent of annual United States inpatient admissions. The data are de-identified and HIPAA compliant, thereby considered exempt from Institutional Review Board oversight as dictated by Title 45 Code of Federal Regulations, Part 46 of the United States, specifically 45 CFR 46.101(b).

Cohort

All adult patients with diverticular disease were identified based on the primary diagnosis with ICD-10 codes of K57.20, K57.21, K57.32 or K57.33 for hospitalization. Patient demographics were collected as covariates including race, sex, age, and marital status. Charlson comorbidity score was also calculated and can be calculated as described in previous publications [8]. In addition, the covariates of payer information, hospital regional location, hospital rural urban location, hospital bed size, and teaching status of hospital were also abstracted. Presence of abscess at time of admission was determined based on patients who had ICD-10 diagnosis codes K57.20 or K57.21. Patients were then assigned as either medical or surgical based on having surgical Disease Related Group (DRG) codes and ICD-10 procedure codes (Appendix 1). Minimally invasive procedures were identified with the ICD-10 surgical procedure codes possessing the 5th digit as 3, 4 or 6 while open procedures were identified with the ICD-10 surgical procedure codes possessing the 5th digit as 0. Formation of stoma was identified based on ICD-10 procedure codes listed in appendix 1. Cases were classified as urgent cases by hospital admission type.

Primary Outcome

The outcome of primary interest was respiratory failure defined with hypoxia or hypercapnia during the index hospital stay and identified with ICD-10 diagnostic codes of J80, J96, or J98.1 (Appendix 1).

Secondary Outcomes

Secondary outcomes of interest include pneumonia as recorded by ICD-10 codes (see appendix 1). Additionally, we recorded adverse events of ileus/small bowel obstruction, peritonitis/organ space infection, superficial surgical site infection, gastrointestinal bleeding, urinary tract infection, myocardial infarction, sepsis, acute renal failure, and hemorrhage complications. A full list of ICD-10 codes is included in appendix 1.

Analysis

Admissions and surgical procedures for patients with diverticular disease were compared for the first six months of 2019 (1/1/2019 through 6/30/2019) as compared to the first six months of 2020 (1/1/2020 through 6/30/2020) during the COVID-19 pandemic. Patient demographics, patient covariates, use of surgery procedures, presence of abscess, and adverse events were compared during the two periods with Chi square analysis for categorical variables. Analysis was performed at the monthly basis for admissions and outcomes. In addition, we compared the development of respiratory complications such as pneumonia or pulmonary failure during the two time periods with the same analysis. Multivariable logistic regression analyses were performed to control for urgent nature of surgery while evaluating postoperative complications. The multivariable analysis only included use of urgent nature of surgery and not additional variables due to the small sample size. All analyses were performed with SAS 9.4 and p value of less than 0.05 was considered significant based on multiple tests of variance.

Results

Cohort

Admissions for diverticulitis for the first six months of 2019 totaled 20,717 patients with 14,408 (69.6%) medical admissions and 6,309 (30.5%) surgical admissions. However, during the first six months of 2020, there were 24.6% fewer total admissions comprising 15,630 total admissions with 10,829 (69.2%) medical admissions and 4,801 (30.7%) surgical admissions. Patient demographics were similar across time periods. There were proportionately more women admitted during each time period. In addition, there were proportionately more patients over age 65 and with Charlson Comorbidity of 0 regardless of time period. Commercial insurers were the most common payer for both time periods and most patients were treated at hospitals with over 500 beds (Table 1).

Disease Severity

There were proportionately more patients admitted with diverticular abscess in the first six months of 2020 as compared to the same time period in 2019 ($p<0.0001$). There were 9,872 patients (47.7%) admitted with diverticular abscess in 2019 as compared to 7,860 patients (50.3%) in 2020 (Table 2).

The number of urgent surgical cases for diverticular disease was 2,123 for the first six months of 2019 or 33.7% of surgical cases. However, the number of urgent cases in the first six months of 2020 was 1,756 or 36.6% of surgical cases ($p<0.001$). Comparing individual

Table 1: Patient and hospital characteristics.

Month	Jan				Feb				Mar				Apr				May				Jun				Total			
Year	2019		2020		2019		2020		2019		2020		2019		2020		2019		2020		2019		2020		2019		2020	
Gender	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Female	619	58.9	591	58.2	504	54.0	508	55.3	575	57.0	437	55.0	603	57.7	223	55.6	537	54.4	372	55.1	535	57.7	431	56.3	3373	56.7	2562	56.1
Male	432	41.1	424	41.8	430	46.0	410	44.7	433	43.0	357	45.0	442	42.3	178	44.4	450	45.6	303	44.9	393	42.4	335	43.7	2580	43.3	2007	43.9
Age group																												
age 18 - 34	31	2.95	44	4.3	38	4.1	34	3.7	32	3.2	25	3.2	32	3.1	14	3.5	50	5.1	30	4.4	38	4.1	31	4.1	221	3.7	178	3.9
age 35 - 44	119	11.32	117	11.5	90	9.6	102	11.1	92	9.1	93	11.7	108	10.3	42	10.5	99	10.0	59	8.7	99	10.7	72	9.4	607	10.2	485	10.6
age 45 - 54	194	18.46	172	17.0	186	19.9	178	19.4	222	22.0	154	19.4	198	19.0	76	19.0	204	20.7	141	20.9	180	19.4	157	20.5	1184	19.9	878	19.2
age 55 - 64	296	28.16	292	28.8	269	28.8	260	28.3	269	26.7	218	27.5	326	31.2	118	29.4	272	27.6	199	29.5	269	29.0	223	29.1	1701	28.6	1310	28.7
age>=65	411	39.11	390	38.4	351	37.6	344	37.5	393	39.0	304	38.3	381	36.5	151	37.7	362	36.7	246	36.4	342	36.9	283	37.0	2240	37.6	1718	37.6
Race/Ethnicity																												
Caucasian	843	80.21	796	78.4	758	81.2	734	80.0	807	80.1	623	78.5	817	78.2	301	75.1	797	80.8	566	83.9	735	79.2	619	80.8	4757	79.7	3639	79.6
African American	64	6.09	77	7.6	58	6.2	54	5.9	55	5.5	51	6.4	72	6.9	35	8.7	53	5.4	40	5.9	62	6.7	38	5.0	364	6.1	295	6.5
Hispanic	83	7.9	79	7.8	82	8.8	81	8.8	85	8.4	74	9.3	100	9.6	40	10.0	82	8.3	47	7.0	86	9.3	71	9.3	518	8.7	392	8.6
Others	61	5.8	63	6.2	36	3.9	49	5.3	61	6.1	46	5.8	56	5.4	25	6.2	55	5.6	22	3.3	45	4.9	38	5.0	314	5.3	243	5.3
Marital status																												
Married	586	55.76	567	55.9	545	58.4	519	56.5	585	58.0	468	58.9	583	55.8	216	53.9	548	55.5	388	57.5	522	56.3	438	57.2	3369	56.6	2596	56.8
Single	398	37.87	378	37.2	346	37.0	342	37.3	358	35.5	281	35.4	391	37.4	163	40.7	385	39.0	246	36.4	344	37.1	295	38.5	2222	37.3	1705	37.3
Others	67	6.37	70	6.9	43	4.6	57	6.2	65	6.5	45	5.7	71	6.8	22	5.5	54	5.5	41	6.1	62	6.7	33	4.3	362	6.1	268	5.9
Discharge status*																												
Death	<10	NR	10	1.0	<10	NR	<10	NR	<10	NR	<10	NR	<10	NR	<10	NR	<10	NR	<10	NR	<10	NR	<10	NR	39	0.7	32	0.7
Skill Nursing Facility	76	7.23	61	6.0	44	4.7	40	4.4	56	5.6	37	4.7	70	6.7	16	4.0	56	5.7	27	4.0	54	5.8	38	5.0	356	6.0	219	4.8
Home under care	224	21.31	197	19.4	195	20.9	189	20.6	229	22.7	207	26.1	255	24.4	129	32.2	221	22.4	192	28.4	177	19.1	161	21.0	1301	21.9	1075	23.5
Home self-care	721	68.6	717	70.6	657	70.3	652	71.0	689	68.4	524	66.0	679	65.0	237	59.1	675	68.4	432	64.0	657	70.8	537	70.1	4078	68.5	3099	67.8
IRF/LTCH	16	1.52	>10	NR	18	1.9	19	2.1	22	2.2	13	1.6	28	2.7	10	2.5	21	2.1	>10	NR	22	2.4	18	2.4	127	2.1	94	2.1
unknow/others	<10	NR	<10	NR	>10	NR	>10	NR	<10	NR	<10	NR	<10	NR	<10	NR	<10	NR	10	1.5	>10	NR	<10	NR	52	0.9	50	1.1
CCI Group**																												
CCI=0	628	59.75	606	59.7	558	59.7	522	56.9	593	58.8	464	58.4	602	57.6	206	51.4	592	60.0	408	60.4	533	57.4	448	58.5	3506	58.9	2654	58.1
CCI 1-2	336	31.97	306	30.2	293	31.4	303	33.0	315	31.3	255	32.1	343	32.8	123	30.7	302	30.6	206	30.5	305	32.9	238	31.1	1894	31.8	1431	31.3
CCI 3-4	51	4.85	64	6.3	52	5.6	59	6.4	60	6.0	40	5.0	59	5.7	39	9.7	55	5.6	42	6.2	66	7.1	50	6.5	343	5.8	294	6.4
CCI>=5	36	3.43	39	3.8	31	3.3	34	3.7	40	4.0	35	4.4	41	3.9	33	8.2	38	3.9	19	2.8	24	2.6	30	3.9	210	3.5	190	4.2
Insurance***																												
Medicare	437	41.58	405	39.9	358	38.3	351	38.2	395	39.2	308	38.8	403	38.6	161	40.2	368	37.3	246	36.4	344	37.1	280	36.6	2305	38.7	1751	38.3
Medicaid	94	8.94	100	9.9	74	7.9	87	9.5	88	8.7	58	7.3	85	8.1	45	11.2	93	9.4	49	7.3	74	8.0	58	7.6	508	8.5	397	8.7
Commercial	445	42.34	452	44.5	458	49.0	408	44.4	464	46.0	376	47.4	488	46.7	158	39.4	460	46.6	309	45.8	442	47.6	378	49.4	2757	46.3	2081	45.5
Others	75	7.14	58	5.7	44	4.7	72	7.8	61	6.1	52	6.6	69	6.6	37	9.2	66	6.7	71	10.5	68	7.3	50	6.5	383	6.4	340	7.4
Teaching Hospital																												
	478	45.48	438	43.2	397	42.5	363	39.5	435	43.2	324	40.8	441	42.2	165	41.2	438	44.4	305	45.2	394	42.5	314	41.0	2583	43.4	1909	41.8
Rural Hospital****																												
	133	12.65	128	12.6	115	12.3	107	11.7	112	11.1	116	14.6	141	13.5	68	17.0	114	11.6	76	11.3	123	13.3	81	10.6	738	12.4	576	12.6
Bed size																												
000-099	53	5.04	61	6.0	61	6.5	58	6.3	66	6.6	55	6.9	58	5.6	28	7.0	63	6.4	47	7.0	55	5.9	57	7.4	356	6.0	306	6.7
100-199	125	11.89	140	13.8	135	14.5	130	14.2	128	12.7	110	13.9	150	14.4	55	13.7	122	12.4	84	12.4	135	14.6	97	12.7	795	13.4	616	13.5
200-299	205	19.51	196	19.3	161	17.2	166	18.1	167	16.6	168	21.2	171	16.4	83	20.7	167	16.9	116	17.2	157	16.9	154	20.1	1028	17.3	883	19.3
300-399	161	15.32	166	16.4	157	16.8	163	17.8	191	19.0	136	17.1	187	17.9	59	14.7	186	18.8	119	17.6	167	18.0	130	17.0	1049	17.6	773	16.9
400-499	139	13.23	124	12.2	114	12.2	114	12.4	125	12.4	85	10.7	131	12.5	44	11.0	127	12.9	77	11.4	123	13.3	94	12.3	759	12.7	538	11.8
500+	368	35.01	328	32.3	306	32.8	287	31.3	331	32.8	240	30.2	348	33.3	132	32.9	322	32.6	232	34.4	291	31.4	234	30.6	1966	33.0	1453	31.8

Chi-square analysis was used to compare difference in each characteristic between the years 2019 and 2020 within each month. All p >0.05, except: *p=0.0114 and 0.0036 in April and May respectively; **p=0.0002 in April; ***p=0.024 in April and ****p=0.0266 in March. All cells less than 10 were marked as "<10" and their corresponding percentages were not reported (NR). CCI: Charlson Comorbidity Index.

Table 2: Incidence of diverticular abscess among all hospital admissions.

Year	2019		2020		
Months	**N**	**%**	**N**	**%**	**p-value**
Jan	1646	48.0	1615	48.4	0.6934
Feb	1537	48.5	1558	49.0	0.6771
Mar	1671	47.3	1330	49.9	0.0416
Apr	1670	47.6	917	54.6	<.0001
May	1715	47.8	1148	51.0	0.0173
Jun	1633	47.0	1292	51.4	0.0008
Total	9872	47.7	7860	50.3	<.0001

months of both calendar years, there were proportionately more urgent cases in April 2020 (59.2%) as compared to 36.9% in April 2019 (p<0.0001). There were no other significant differences in urgent surgical cases by month for the other months (Table 3).

Surgery

When surgery was performed in 2019, 55.1% had a diverticular abscess yet 58.6% had an abscess during the same time period in 2020 (p=0.004). In April of 2020, there were substantially more surgical patients with diverticular abscess (69.3%) then in the same time period in 2019 (55.6%) (p<0.0001) (Table 4). In addition, minimally invasive surgical treatment for diverticular disease was slightly less common in 2019 (41.9%) as compared to 2020 (42.8%). The most significant difference in use of minimally invasive procedures occurred in April at which time minimally invasive procedures were used in 43% of all procedures in 2019, yet only 34% of cases in April 2020 (p<0.004) (Table 4).

A stoma was made in 28.6% of all patients who underwent surgery during 2019. Yet in 2020, there was a substantially greater proportion of stomas fashioned (31.7% of all surgical procedures; p=0.0005). In April of 2020, the proportion of patients who received a stoma reached 43.9% which was substantially higher (30.7%) than in April of 2019 (p<0.0001) (Table 4).

Respiratory Adverse Events

Most importantly, pneumonia complications were similar in 2019 (1.7%) as they were in 2020 (1.8%) (p=0.5). There was no difference in pneumonia rates by month across time periods. In addition, respiratory failure rates were similar across time periods, 4.2% in 2019 and 2020, with the only significant difference occurring in April (4.2% in 2019 vs 6.8% in 2020). Rates of respiratory failure were higher in patients who had urgent surgery and no different even in April of 2020 (10.1%) as compared to April 2019 (7.9%) (p=0.4) (Table 6).

Adverse Events

There was no difference in the rates of the majority of postoperative complications including superficial surgical site infection, gastrointestinal bleeding, hemorrhage, or urinary tract infection. However, other postoperative complications such as sepsis were significantly higher (6.8%) in April 2020 as compared to the same time period 1 year earlier (3.4%; p<0.005) (Table 5). Similarly, there were statistically significant increases in the rates of postoperative peritonitis or organ space infection as well as ileus/small bowel obstruction in the month of April 2020 compared to April 2019. However, when controlling for the urgent nature of the operation, the rate of all postoperative complications including sepsis became statistically equivalent between the 2019 and 2020 time periods except for organ space infection (OR=1.20 95% CI:1.10-1.31; p<0.001).

Mortality

In hospital mortality occurred rarely in patients treated for diverticulitis. The proportion of patients who experienced an inpatient mortality was 0.7% in both time periods (Table 1).

Table 3: Urgent Operations by Month.

Year	2019		2020		
Months	**N**	**%**	**N**	**%**	**p-value**
Jan	360	34.3	336	33.1	0.5805
Feb	322	34.5	326	35.5	0.64
Mar	365	36.2	322	40.6	0.0595
Apr	392	37.5	237	59.1	<.0001
May	360	36.5	285	42.2	0.0182
Jun	324	34.9	250	32.6	0.3245
Total	2123	35.7	1756	38.4	0.0035

Table 4: Abscess rate and surgical approach among patients who underwent surgery.

		2019		2020		
		N	**%**	**N**	**%**	**p-value**
Abscess	Jan	590	56.1	558	55.0	0.5953
	Feb	509	54.5	504	54.9	0.8610
	Mar	543	53.9	463	58.3	0.0593
	Apr	581	55.6	278	69.3	<.0001
	May	551	55.8	400	59.3	0.1647
	Jun	509	54.9	447	58.4	0.1475
	Total	3283	55.1	2650	58.0	0.0035
MIS	Jan	465	44.2	430	42.4	0.3889
	Feb	393	42.1	415	45.2	0.1745
	Mar	451	44.7	339	42.7	0.3846
	Apr	449	43.0	138	34.4	0.003
	May	401	40.6	248	36.7	0.1106
	Jun	389	41.9	346	45.2	0.179
	Total	2548	42.8	1916	41.9	0.3723
Stoma Creation	Jan	281	26.7	284	28.0	0.5260
	Feb	255	27.3	262	28.5	0.5525
	Mar	291	28.9	278	35.0	0.0053
	Apr	321	30.7	176	43.9	<.0001
	May	287	29.1	241	35.7	0.0044
	Jun	265	28.6	207	27.0	0.4838
	Total	1700	28.6	1448	31.7	0.0005

MIS: Minimally Invasive Surgery.

Table 5: Post-operative adverse events.

		2019		2020		
		N	%	N	%	p-value
Ileus/ Small Bowel Obstruction (included constipation and PONV)						
	Jan	161	15.4	149	14.6	0.6843
	Feb	126	13.4	125	13.6	0.9368
	Mar	132	13.0	113	14.2	0.4847
	Apr	146	14.0	75	18.8	0.0252
	May	134	13.6	119	17.6	0.0239
	Jun	133	14.4	109	14.2	0.9523
	Total	832	14.0	690	15.1	0.1037
Peritonitis/Organ space SSI						
	Jan	234	22.2	264	26.0	0.0466
	Feb	196	21.0	262	28.6	0.0002
	Mar	272	27.0	231	29.0	0.3217
	Apr	260	24.8	131	32.6	0.0028
	May	271	27.4	211	31.2	0.0934
	Jun	231	24.8	205	26.0	0.3809
	Total	1464	24.6	1304	28.5	<0.0001
Superficial SSI and wound complications (Hematoma/ Seroma, Wound Infection, Wound Dehiscence)						
	Jan	26	2.4	19	1.8	0.3488
	Feb	22	2.4	21	2.2	0.9227
	Mar	22	2.2	19	2.4	0.7662
	Apr	31	3.0	16	4.0	0.3258
	May	23	2.4	20	3.0	0.4249
	Jun	14	1.6	15	2.0	0.4777
	Total	138	2.3	110	2.4	0.7645
GI bleeding						
	Jan	66	6.2	63	6.2	0.9455
	Feb	54	5.8	48	5.2	0.6021
	Mar	59	5.8	47	6.0	0.9527
	Apr	58	5.6	24	6.0	0.7489
	May	54	5.4	48	7.2	0.1713
	Jun	50	5.4	42	5.4	0.9315
	Total	341	5.7	272	6.0	0.6253
Urinary tract infection/Retention of urine						
	Jan	90	8.6	63	6.2	0.0409
	Feb	61	6.6	54	5.8	0.563
	Mar	63	6.2	49	6.2	0.9452
	Apr	70	6.6	38	9.4	0.0721
	May	62	6.2	42	6.2	0.9608
	Jun	55	6.0	52	6.8	0.468
	Total	401	6.7	298	6.5	0.6624
MI/Cardio complication						
	Jan	46	4.4	53	5.2	0.3687
	Feb	40	4.2	45	5.0	0.5243
	Mar	51	5.0	38	4.8	0.7901
	Apr	45	4.4	31	7.8	0.009
	May	65	6.6	35	5.2	0.2384
	Jun	33	3.6	43	5.6	0.0417
	Total	280	4.7	245	5.4	0.124
Sepsis						
	Jan	25	2.4	37	3.6	0.0916
	Feb	30	3.2	24	2.6	0.4447
	Mar	31	3.0	32	4.0	0.2733
	Apr	35	3.4	27	6.8	0.0045
	May	23	2.4	14	2.0	0.7281
	Jun	35	3.8	21	2.8	0.2379
	Total	179	3.0	155	3.4	0.2635
Dehydration/ Acute renal failure						
	Jan	131	12.4	127	12.6	0.9737
	Feb	111	11.8	104	11.4	0.7091
	Mar	123	12.2	108	13.6	0.3776
	Apr	122	11.6	60	15.0	0.0915
	May	105	10.6	96	14.2	0.0278
	Jun	102	11.0	79	10.4	0.653
	Total	694	11.7	574	12.6	0.1576
Hemorrhage						
	Jan	41	4.0	38	3.8	0.8522
	Feb	39	4.2	42	4.6	0.6742
	Mar	36	3.6	33	4.2	0.5208
	Apr	45	4.4	15	3.8	0.6293
	May	29	3.0	29	4.2	0.1384
	Jun	29	3.2	33	4.4	0.1968
	Total	219	3.7	190	4.2	0.2071

Table 6: Postoperative respiratory adverse events.

Year	2019		2020		
Month	N	%	N	%	p-value
Pneumonia					
Jan	15	1.4	23	2.2	0.156
Feb	20	2.2	20	2.2	0.9559
Mar	22	2.2	18	2.2	0.9038
Apr	14	1.4	<10	NR	0.8896
May	15	1.6	<10	NR	0.7544
Jun	12	1.2	<10	NR	0.6371
Total	98	1.7	83	1.8	0.5053
Pulmonary failure					
Jan	51	4.8	45	4.4	0.651
Feb	36	3.8	44	4.8	0.3205
Mar	37	3.6	29	3.6	0.9837
Apr	43	4.2	27	6.8	0.0378
May	37	3.8	19	2.8	0.3001
Jun	44	4.8	28	3.6	0.2701
Total	248	4.2	192	4.2	0.9266

All cells less than 10 were marked as "<10" and their corresponding percentages were not reported (NR).

Discussion

Data from these analyses reveal a substantial decline in the number of inpatients with diverticulitis during the height of the COVID-19 pandemic or the first two quarters of 2020 as compared to the same time period in 2019. Despite the net decline in diverticulitis admissions, the proportion of cases deemed urgent rose significantly during COVID-19. In addition, there was a marked reduction in the proportion of patients who had minimally invasive surgery during the COVID surge in early 2020. These changes were associated with a temporal increase in sepsis and deep organ space complications in April of 2020. However, this observed increase in postoperative complications during the COVID-19 period became statistically insignificant when accounting for the emergent nature of the operations, with the exception of organ space infection likely secondary to the higher rate of preoperative abscesses. Of great importance, despite high numbers of COVID-19 hospitalizations during the height of the pandemic, there was no increase in respiratory complications. These results indicate that surgery for diverticulitis (both urgent and elective) can be safely performed without any additional increase in respiratory consequences or mortality.

Across the board, many patients with non-respiratory health conditions delayed or avoided care during the height of the COVID-19 pandemic. A number of studies demonstrated reduced emergency room visits across the United States and United Kingdom during the height of the COVID-19 pandemic, including fewer evaluations for acute coronary syndromes and strokes [9-17]. Similarly, our data confirm fewer admissions for diverticular disease as total numbers declined by 25 percent during the height of the pandemic. In addition, among the patients who were admitted for diverticular disease, proportionately more patients were admitted with much more severe disease (i.e. abscess) leading to far greater rates of stoma creation as compared to one year prior.

There are a number of possible explanations for the decline in numbers of diverticulitis admissions during the height of the COVID-19 pandemic. Although lifestyle changes during this time may be one explanation, it is more likely that many patients simply deferred evaluation because of anxiety related to management during the pandemic. In a survey of adult respondents, 40.9% reported having delayed or avoided any medical care, including urgent or emergency care (12.0%) and routine care (31.5%), because of concerns about COVID-19 [18]. Avoidance of routine care was particularly common among unpaid caregivers who sought to avoid potential virus risk for many reasons. Data do reveal that it is difficult for patients to anticipate when emergency department evaluation is necessary [19]. As with other studies our data similarly raise concerns about patients deferring care and presenting to the emergency department when diverticulitis progressed to more complicated forms [20].

In addition to patient avoidance of routine care, many healthcare services underwent paradigm shifts in order to more safely deliver care while reducing potential points of transmission. Elective procedures were prohibited leading to sharp declines across the board for many orthopedic conditions as we also noted with diverticular disease. Delays in surgery are likely to have real impact on patient health outcomes, hospital finances and resources, as well as training and research programs [21]. Delays in surgery have been shown to result in higher rates of surgical site infections, leading to increased costs ranging from $7000 to $17,000 for coronary artery bypass graft and colon and lung resections [22]. It is unclear what the costs of delay in care may be for patients with diverticulitis, but an increase in septic complications was noted during the height of the COVID-19 pandemic.

To promote safe surgery many surgical societies as well as Intercollegiate guidelines from the United Kingdom advocated for non-operative management of many surgical conditions and avoidance of laparoscopy when surgery is unavoidable [23]. The effects of these guidelines on appendicitis treatment in the United Kingdom was associated with many practice changes during the pandemic [20]. Early concerns were also raised involving the risk of aerosolization with minimally invasive surgery in the operating room. Many hospitals began to screen patients for the virus before any scheduled surgery and when not possible, personal protective equipment to decrease susceptibility to aerosol diffusion was advised. As expected, we identified a reduction in the rate of laparoscopic treatment during the pandemic which may have been related to the suggested guidelines. It is, however, highly likely that the changes we noted in use of laparoscopy may have been related to more severe diverticular disease.

Interestingly, in the previously described appendicitis study (English et al.), the investigators did not notice an increase in short-term complications nor any detriment in length of stay related to appendicitis treatment during COVID [20]. Our data, however, revealed a significant change in septic complications during the height of the COVID-19 pandemic following surgery for diverticular disease. In addition, there were substantial concerns of pulmonary complications related to surgical treatment. Our data from 586 hospitals across the country indicate no significant increase in pulmonary complications throughout the study period, with only slight increase during the single month of April. After accounting for disease severity, this difference became insignificant.

Conclusions

In conclusion, data from these studies reveal deferral of care in patients with diverticular disease during the COVID-19 pandemic. Patients who did seek care for diverticulitis experienced no additional respiratory complications. Given that postoperative pulmonary complications occur in half of patients with perioperative COVID-19 infection, regardless of whether the diagnosis is made with laboratory-confirmation or due to clinical signs, these data can be used to reassure patients needing surgery [24]. Some have advocated that during COVID-19 outbreaks, consideration should be given for postponing non-critical procedures [25]. However, as we prepare for future waves of COVID cases, these studies may help us answer questions related to patient safety while reassuring our patients regarding surgical care. Awareness of community COVID-19 prevalence, testing, as well as patient and provider preparedness are critical elements of surgical care during respiratory pandemics.

References

1. Cucinotta D, Vanelli M (2020) WHO Declares COVID-19 a Pandemic. *Acta Biomed* 91: 157-160. [crossref]
2. WHO Director-General's opening remarks at the media briefing on COVID19 - March 2020.
3. Healthcare Facilities: Managing Operations During the COVID-19 Pandemic. National Center for Immunization and Respiratory Diseases (NCIRD), Division of Viral Diseases.
4. Schrag D, Hershman DL, Basch E (2020) Oncology practice during the COVID-19 pandemic. *JAMA* 323: 2005-2006. [crossref]
5. van de Haar J, Hoes LR, Coles CE, Seamon K, Frohling S, et al. (2020) Caring for patients with cancer in the COVID-19 era. *Nat Med* 26: 665-671. [crossref]
6. Sharpless N (2020) COVID-19 and cancer. *Science* 368: 1290.
7. Premier Data. Available at https://products.premierinc.com/downloads/PremierHealthcareDatabaseWhitepaper.pdf
8. Charlson M, Wells MT, Ullman R, King F, Shmukler C (2014) The Charlson comorbidity index can be used prospectively to identify patients who will incur high future costs. *PloS One* 9: e112479. [crossref]
9. Siegler JE, Heslin ME, Thau L, Smith A, Jovin TG (2020) Falling stroke rates during COVID-19 pandemic at a comprehensive stroke center. *Journal of Stroke and Cerebrovascular Diseases* 29: 104953.
10. Garcia S, Albaghdadi MS, Meraj PM, Schmidt C, Garberich R, et al. (2020) Reduction in ST-segment elevation cardiac catheterization laboratory activations in the United States during COVID-19 pandemic. *J Am Coll Cardiol* 75: 2871-2872. [crossref]
11. Bullrich MB, Fridman S, Mandzia JL, Mai LM, Khaw A, et al. (2020) COVID-19: Stroke Admissions, Emergency Department Visits, and Prevention Clinic Referrals. *Canadian Journal of Neurological Sciences* 47: 693-696. [crossref]
12. Morelli N, Rota E, Terracciano C, Immovilli P, Spallazzi M, et al. (2020) The baffling case of ischemic stroke disappearance from the casualty department in the COVID-19 era. *Eur Neurol* 83: 213-215. [crossref]
13. Kansagra AP, Goyal MS, Hamilton S, Albers GW (2020) Collateral effect of Covid-19 on stroke evaluation in the United States. *New England Journal of Medicine* 383: 400-401. [crossref]
14. Solomon MD, McNulty EJ, Rana JS, Leong TK, Lee C, et al. (2020) The Covid-19 pandemic and the incidence of acute myocardial infarction. *New England Journal of Medicine* 383: 691-693. [crossref]
15. Kim HS, Cruz DS, Conrardy MJ, Gandhi KR, Seltzer JA, et al. (2020) Emergency department visits for serious diagnoses during the COVID-19 pandemic. *Acad Emerg Med* 27: 910-913. [crossref]
16. Westgard BC, Morgan MW, Vazquez-Benitez G, Erickson LO, Zwank MD (2020) An analysis of changes in emergency department visits after a state declaration during the time of COVID-19. *Ann Emerg Med* 76: 595-601. [crossref]
17. Jeffery MM, D'Onofrio G, Paek H, Platts-Mills TF, Soares WE, et al. (2020) Trends in emergency department visits and hospital admissions in health care systems in 5 states in the first months of the COVID-19 pandemic in the US. *JAMA Intern Med* 180: 1328-1333. [crossref]
18. Czeisler MÉ, Marynak K, Clarke KE, Salah Z, Shakya I, et al. (2020) Delay or Avoidance of Medical Care Because of COVID-19–Related Concerns--United States, June 2020. *MMWR Morb Mortal Wkly Rep* 69: 1250-1257.
19. Coster JE, Turner JK, Bradbury D, Cantrell A (2017) Why do people choose emergency and urgent care services? A rapid review utilizing a systematic literature search and narrative synthesis. *Acad Emerg Med* 24: 1137-1149. [crossref]
20. English W, Bedwani NB, Smith C, Doganay E, Marsden M, et al. (2020) Suspected appendicitis and COVID-19, a change in investigation and management-a multicentre cohort study. *Langenbecks Arch Surg* 406: 357-365. [crossref]
21. Fu SJ, George EL, Maggio PM, Hawn M, Nazerali R (2020) The Consequences of Delaying Elective Surgery: Surgical Perspective. *Ann Surg* 272: e79-e80. [crossref]
22. Vogel TR, Dombrovskiy VY, Lowry SF (2010) In-hospital delay of elective surgery for high volume procedures: the impact on infectious complications. *J Am Coll Surg* 211: 784-790. [crossref]
23. Mowbray NG, Ansell J, Horwood J, Cornish J, Rizkallah P, et al. (2020) Safe management of surgical smoke in the age of COVID-19. *Br J Surg* 107: 1406-1413. [crossref]
24. COVID Surg Collaborative (2020) Mortality and pulmonary complications in patients undergoing surgery with perioperative SARS-CoV-2 infection: an international cohort study. *Lancet* 396: 27-38.
25. American College of Surgeons. COVID-19: guidance for triage of non-emergent surgical procedures. https://www.facs.org/covid-19/clinical-guidance/triage. Date: March 17, 2020.

Citation:

Goldstone NR, Zhang J, Stafford C, Cauley C, Bordeianou L, et al. (2021) Safety of Surgical Management of Diverticulitis during the COVID-19 Pandemic. *J Int Pers COVID-19* Volume 1(2): 1-8.

Appendix 1: List of ICD-10 codes for Selected Complications

Complications	**ICD-10 Diagnosis Codes**
Pulmonary failure	"J80", "J96","J98.1"
Pneumonia	"J13", "J14" "J15.0", "J15.1", "J15.3", "J15.4","J18"
Ileus/ Small Bowel Obstruction (included constipation and PONV)	"K56.0", "K56.5" ,"K56.6" ,"K59", "K91.0", "K91.1", "K91.2", "K91.3", "R11"
Peritonitis/Organ space SSI	"K65", "K66", "K67"
Superficial SSI and wound complications (Hematoma/ Seroma, Wound Infection, Wound Dehiscence)	"T81.3", "T81.4","T79.8", "K68.11"
GI bleeding	"K22.8", "K25.0", "K25.1", "K25.2", "K25.4", "K25.6" ,"K26.0", "K26.1", "K26.2", "K26.4", "K26.6"
Urinary tract infection/Retention of urine	"N39.0", "T83.5", "R33.8", "R33.9"
MI/cardio complication	"I21", "I24", "I46", "I50"
sepsis	"R65.2", "A41"
Dehydration/ Acute renal failure	"N17", "N28.0", "N28.9", "E86.0"
Hemorrhage	"K91.6", "K91.8", "K92.2", "L760","L762"
	ICD-10Procedure Codes
Stoma formation	"0D1B", "0D1E", "0D1H", "0D1K", "0D1L", "0D1M","0D1N"