Heliyon 9 (2023) e18459

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Impact of COVID-19 on the gastrointestinal surgical oncology patient population

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ARTICLE INFO

Keywords:
Covid-19
Pandemic
Gastrointestinal cancer
Surgery
Telemedicine
Access to care
Neoadjuvant chemotherapy

ABSTRACT

Background: The onset of the COVID-19 pandemic led to substantial alterations in healthcare delivery and access. In this study, we aimed to evaluate the impact of COVID-19 on the presentation and surgical care of patients with gastrointestinal (GI) cancers.
Methods: All patients who underwent GI cancer surgery at a large, tertiary referral center between March 15, 2019 and March 15, 2021 were included. March 15, 2020 was considered the start of the COVID-19 pandemic. Changes in patient, tumor, and treatment characteristics before the pandemic compared to during the pandemic were evaluated.
Results: Of 522 patients that met study criteria, 252 (48.3%) were treated before the COVID-19 pandemic. During the first COVID-19 wave, weekly volume of GI cancer cases was one-third lower than baseline ($p = 0.041$); during the second wave, case volume remained at baseline levels ($p = 0.519$). There were no demographic or tumor characteristic differences between patients receiving GI cancer surgery before versus during COVID-19 ($p > 0.05$ for all), and no difference in rate of emergency surgery ($p > 0.9$). Patients were more likely to receive preoperative chemotherapy during the first six months of the pandemic compared to the subsequent six months (35.6% vs. 15.5%, $p < 0.001$). Telemedicine was rapidly adopted at the start of the pandemic, rising from 0% to 47% of GI surgical oncology visits within two months.
Conclusions: The COVID-19 pandemic caused an initial disruption to the surgical care of GI cancers, but did not compromise stage at presentation. Preoperative chemotherapy and telemedicine were utilized to mitigate the impact of a high COVID-19 burden on cancer care.

1. Introduction

The height of the COVID-19 pandemic saw significant changes in healthcare delivery – including the temporary postponement of elective and semi-elective surgical operations [1]. Globally, it is estimated that at least 21 million elective surgeries were canceled during the first few weeks of the pandemic [1]. In the United States, the onset of the pandemic brought unprecedented demands on

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https://doi.org/10.1016/j.heliyon.2023.e18459
Received 22 May 2023; Received in revised form 17 July 2023; Accepted 18 July 2023
Available online 20 July 2023

healthcare systems and increased mortality rates and hospitalizations, ultimately leading to the declaration of a national emergency in March 2020 [2]. In response to the pandemic, surgical societies released guidance for the postponement of non-essential surgical operations to limit strain on hospital personnel and resources [3,4].

Though oncologic operations were widely prioritized ahead of elective surgeries such as asymptomatic hernia repair, as many as 1 in 7 individuals recommended for cancer surgery in areas that experienced full lockdown did not ultimately undergo their planned surgery [5,6]. After the declaration of a national emergency, oncologic case volumes in the United States decreased by more than 60% as compared to the prior year [7]. International guidelines recommended discussion of oncologic surgical prioritization in virtual tumor boards and weighing the risk of disease progression against the risks of adding to the acute systemic burden on hospital resources [5]. In order to mitigate the risk of progression due to delays in oncologic surgery, consideration of other less resource-intensive modalities such as preoperative chemotherapy were recommended where appropriate [5].

Prior research has reported rapid and sustained rebounds in surgical procedure volume after the initial postponement period [8]. However, there have been conflicting reports on the impact of delayed oncologic surgical care of patients during the pandemic. One multinational study reported that up to 23.8% of patients experienced oncologic surgery delays greater than 12 weeks during the pandemic, but that there were no differences in resectability at the time of operation for those undergoing delayed rather than prompt surgery [9]. Similarly, a retrospective study of 22 different cancer types showed that a delay in surgery of 4 weeks was not associated with increased margin positivity at time of operation [10]. However, an Italian study showed that patients treated during the pandemic were more likely to have advanced stage colorectal cancer than those treated before the pandemic [11]. Overall, in the United States, nationwide mortality rates from gastrointestinal tract cancers were stable from 2019 to 2020 [12].

The onset of the COVID-19 pandemic required hospitals in the United States to adjust their patient care workflow and to reallocate operating room resources [13]. Operating room staff, personal protective equipment (PPE), and other resources, such as ventilators, were often redistributed to COVID-positive patient units, limiting operative capacity [14]. Bioethical discussions around prioritization of healthcare services including surgical services took place, with early rescheduling provided for oncology patients in some instances [5]. However, little information was available on the risks of contracting COVID-19 during a hospital admission or on the possible consequences of surgical delays, especially in vulnerable populations such as those with cancer, racial minorities, and the elderly [15]. In response to ongoing resource reallocation away from operating rooms, modifications were leveraged to limit disruption of surgical care amidst the pandemic, including the expansion of telehealth use, increased preoperative patient screening, and utilization of outpatient surgery and ambulatory surgical centers where appropriate [16–18]. The impacts of these modifications are still coming to light.

In this study, we aimed to characterize how a large healthcare system compensated for limitations on surgical services during the COVID-19 pandemic and to evaluate the potential sequelae of the pandemic on the presentation of patients with gastrointestinal tract cancers. As a secondary aim, we sought to assess if Black or elderly patients with surgically-treated GI cancer were disproportionately affected by the pandemic or by the institution's response. Our analysis adds to existing international studies on gastrointestinal surgical oncology care during the COVID-19 pandemic by providing insight at the hyperlocal level into the real-world timing and character of healthcare delivery adaptations at a single institution with respect to local COVID-19 trends and the overall effect of these adaptations and the pandemic on the presentation and surgical outcomes of these patients.

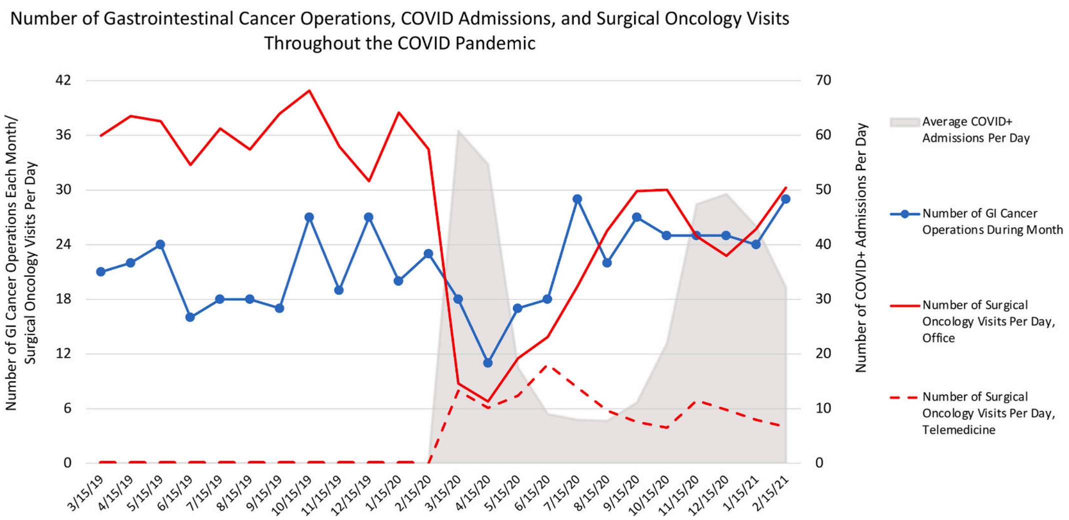

Fig. 1. Run chart of number of cancer operations per fortnight over the study period, overlaid with COVID-19 inpatient census. Could also include graphs of the breakdown of operation type before and after COVID-19 hit on the same figure.

2. Methods

2.1. Data source and study sample

The Yale Electronic Medical Record (EMR) Database was queried for patients who underwent an oncologic gastrointestinal resection between March 15, 2019 and March 15, 2021. Surgeries performed before March 15, 2020 were considered to be during the "pre-COVID-19" reference period, and those performed after this date were considered to be during the "COVID-19" time period. Patient, tumor, and treatment characteristics before and during the COVID-19 pandemic were compared for all patients as well as for elderly and Black subpopulations. The study and collection of de-identified patient data for this project was reviewed and approved by the Yale Institutional Review Board. This observational study followed STROBE reporting guidelines.

2.2. Temporal trends

In order to gain an understanding of the institution's response to the first two waves of the pandemic, the number of gastrointestinal cancer resections, number of in-office surgical oncology encounters, number of telemedicine surgical oncology encounters, and number of COVID-19 positive admissions were all tracked over time, reported on a biweekly basis. During the start of the pandemic, telemedicine visits were used in lieu of all in-person visits, specifically for new patient consults, post-operative visits, and surveillance visits. In our analyses, the "first wave" of the pandemic was defined as March 15, 2020 to June 15, 2020 and the "second wave" as October 15, 2020 to February 15, 2021 in light of the local trends in COVID incidence highlighted in Fig. 1. For the purposes of this analysis, telephone encounters, video encounters, and "e-visits" were all considered telemedicine.

2.3. Variables

Outcomes of interest included the number of GI surgical cases performed, type of operations performed, use of neoadjuvant and adjuvant chemotherapy, and tumor characteristics of resected specimens. Demographic characteristics were compared between patients receiving surgery in the study and control time periods, including age, gender, race, ethnicity, and primary insurer. Characteristics of interest of the resected cancer included site of tumor, pathologic T stage (pT stage), pathologic N stage (pN stage), metastatic status, lymphovascular invasion, perineural invasion, and resection margins. Information on surgical considerations, such as procedure emergentness, was also collected based on presentation to the emergency room.

2.4. Statistical analysis

Analyses focused on comparisons between patients receiving surgery before versus during the COVID-19 pandemic. Descriptive statistics were run to characterize the patient population in aggregate and stratified by time period of surgery. Unpaired t-tests were used to compare surgical case volume and number of office or telemedicine visits during the two waves of the COVID-19 pandemic. Metrics of interest were compared between the two time periods with Chi-squared tests. Further stratification was done to identify any differences in care across age and racial groups before versus during the pandemic. A significance threshold of $p < 0.05$ was used. All analyses were conducted in R Studio (Version March 1, 1093).

3. Results

A total of 522 patients receiving gastrointestinal cancer surgery during the time period of interest met our inclusion criteria. There was a male predominance in the study with 296 men (56.7%) and 226 women (43.2%). The majority were White (78.4%) and non-Hispanic (91.8%). There were 252 patients in the "pre-COVID" group and 270 patients in the "post-COVID" group.

At the height of the first wave of local COVID-19 hospital admissions, there was an initial drop in GI oncologic surgical volume by over 80% from pre-COVID-19 levels: only six gastrointestinal cancer surgeries were performed in April 2020 during the height of surgical restrictions, compared to 21 performed in April 2021 (Fig. 1). During the first COVID-19 wave, monthly volume of GI cancer cases was one-third lower than baseline (22.3 cases vs. 15.3 cases, $p = 0.041$). However, surgical volume recovered to baseline numbers within two months of this nadir. During the second wave of COVID admissions in December 2020, 17 surgeries were also performed compared to 23 in December of the year prior – a decrease of about one-fourth. Though, the difference in monthly case volume was not statistically significant across the entire second wave period (23.3 cases vs. 24.8 cases, $p = 0.519$).

Telemedicine was hardly ever utilized for surgical oncology visits prior to COVID-19, but made up nearly half of visits during the first month of the pandemic. Total number of surgical oncology encounters dropped by almost two-thirds in the first month of the pandemic and did not return to baseline levels until six or seven months into the pandemic. In April 2020, there was an 82% decrease in office visits compared to the year prior, and a 76% monthly decrease across the first wave of the pandemic (37.2 visits vs. 9.0 visits, $p < 0.001$). During that same month, 68% of new patients were seen virtually, compared to only 43% of return patients ($p < 0.001$). The second wave similarly saw a monthly decrease in office visits as compared to the year prior (36.3 visits vs. 25.9 visits, $p = 0.008$). The local peak of the second wave of COVID-19, in December 2020, saw a 26% decrease in office visits compared to the year prior and an increase in telemedicine visits (representing 21% of all visits compared to 0% the year prior) – a change from baseline, but an overall much more blunted response than during the first wave. New patients and returning patients were now utilizing telehealth at similar rates (21% vs. 22%, $p = 0.698$).

3.1. Patient presentation

There were no observed differences between patients receiving surgery before versus during COVID-19 (Table 1). When stratified by decade of age, there were no differences in presentation of patients between the pre-COVID-19 and COVID-19 cohorts ($p = 0.917$). Though patients in their 70s were trending towards less likely to be seen during the COVID-19 year (29.5% vs. 20.6%), this finding was not statistically significant. Additionally, there was no difference in the gender of patients receiving surgical care before or during COVID-19. Men composed 53.6% of patients receiving GI cancer surgery in the pre-COVID-19 time period and 59.6% of the patients during the COVID-19 time period ($p = 0.191$). With regard to race, there again was no significant difference in the patients seen either before or during the COVID-19 pandemic ($p = 0.559$). Although not reaching statistical significance, Black patients represented a lower percentage of patients seen during COVID-19 than before (13.5% vs. 10.4%). There were no differences in ethnicity in the cohort treated during COVID-19 compared to the reference group ($p = 0.961$). Patients with Medicaid insurance represented a higher percentage of those treated during the COVID-19 time period (6.0% vs. 10.7%), and patients with Medicare represented a lower percentage during COVID-19 (31.7% vs. 26.3%), though Chi-squared tests were not statistically significant ($p = 0.096$). There were no observed differences in cancer site between patients receiving surgery before versus during COVID-19 ($p = 0.881$).

3.2. Tumor characteristics

There were no observed differences in the tumor characteristics of patients receiving surgery in the year preceding versus the first year of the COVID-19 pandemic (Table 2). Specifically, no observed differences were seen with regard to pathologic T stage ($p = 0.801$), pathologic N stage ($p = 0.998$), presence of metastasis ($p = 0.140$), or presence of perineural invasion ($p = 0.624$). There were also no differences observed between these two time periods when comparing the prevalence of pT1 tumors versus any higher stage tumors ($p = 0.950$) or the prevalence of any positive lymph node ($p = 0.943$). Patients who received surgery for their GI cancer during COVID-19 were trending towards less likely to have a tumor with lymphovascular invasion (50.0% vs. 40.4%), but this finding was not

Table 1
Characteristics of patients in study, stratified by before and during COVID-19 pandemic. Reporting age, sex, race, ethnicity, insurance, family history, personal history, cancer diagnosis.

Variable	Pre-COVID (n = 252)	COVID (n = 270)	*P*-value
Age Group (%)			0.917
<30	1 (0.4)	2 (0.7)	
30–39	6 (2.4)	7 (2.6)	
40–49	16 (6.4)	23 (8.6)	
50–59	47 (18.7)	54 (20.1)	
60–69	67 (26.7)	76 (28.3)	
70–79	74 (29.5)	70 (20.6)	
80–89	38 (15.1)	34 (12.6)	
>90	2 (0.8)	3 (1.1)	
Gender (% male)	135 (53.6)	161 (59.6)	0.191
Race (%)			0.559
AI/AN	1 (0.4)	0 (0.0)	
Asian	6 (2.4)	4 (1.5)	
Black or African American	34 (13.5)	28 (10.4)	
White or Caucasian	192 (76.2)	217 (80.4)	
Other/Unknown	19 (7.5)	21 (7.8)	
Ethnicity			0.961
Hispanic or Latino	18 (7.1)	21 (7.8)	
Non-Hispanic	232 (92.1)	247 (91.5)	
Unknown	2 (0.8)	2 (0.7)	
Family history of any cancer (% yes)	160 (68.1)	159 (63.1)	0.288
Insurance			0.096
Medicaid	15 (6.0)	29 (10.7)	
Medicare	80 (31.7)	71 (26.3)	
Private	144 (57.1)	149 (55.2)	
Other/Unspecified	13 (5.2)	21 (7.8)	
Organ site of cancer			0.881
Anus	1 (0.4)	0 (0.0)	
Appendix	5 (2.0)	6 (2.2)	
Biliary tract	15 (6.0)	13 (4.8)	
Colon	105 (41.8)	112 (41.5)	
Esophagus	3 (1.2)	4 (1.5)	
Gallbladder	2 (0.8)	1 (0.4)	
Liver	17 (6.8)	27 (10.0)	
Pancreas	38 (15.1)	44 (16.3)	
Rectum	37 (14.7)	31 (11.5)	
Small intestine	18 (7.2)	23 (8.5)	
Stomach	10 (4.0)	9 (3.3)	

Table 2
Tumor characteristics, stratified by before and after COVID-19hit. Comparison of overall stage, pT stage, and pN stage.

Variable	Pre-COVID (n = 252)	COVID (n = 270)	*P*-value
Pathologic T Stage (%)			0.801
pT0	15 (6.9)	12 (5.3)	
pT1	28 (12.8)	31 (13.7)	
pT2	45 (20.6)	56 (24.8)	
pT3	92 (42.2)	88 (38.9)	
pT4	38 (17.4)	39 (17.3)	
pT1 vs pT2, pT3, pT4 (% pT1)	175 (86.2)	183 (85.5)	0.950
Pathologic N Stage (%)			0.998
pN0	116 (56.6)	124 (57.4)	
pN1	47 (22.9)	49 (22.7)	
pN2	41 (20.0)	42 (19.4)	
pN3	1 (0.5)	1 (0.5)	
pN- vs pN+ (% pN-)	116 (56.6)	124 (57.4)	0.943
Pathologic M Stage (% pM0)	187 (85.8)	185 (80.1)	0.140
Lymphovascular invasion (% present)	100 (50.0)	82 (40.4)	0.066
Perineural invasion (% present)	68 (33.2)	63 (30.4)	0.624

statistically significant.

3.3. Treatment characteristics

Surgical patients seen prior to versus during the pandemic received similar treatment as well. There was no difference in the likelihood of a patient receiving neoadjuvant chemotherapy ($p = 0.586$) or any chemotherapy ($p = 0.307$) when comparing the two time periods (Table 3). Similarly, there was no observed difference in the percentage of patients undergoing an emergent surgery (10.8% vs. 10.0%, $p = 0.901$). However, patients undergoing surgical resection of their GI cancer during COVID-19 were slightly more likely to have negative resection margins than those receiving surgery before COVID-19 (92.0% vs. 97.0%, $p = 0.030$). Additionally, patients were more likely to receive preoperative chemotherapy during the first six months of the pandemic compared to the subsequent six months (35.6% vs. 15.5%, $p < 0.001$).

3.4. Racial stratifications

On subgroup analysis, non-Black patients treated during COVID-19 had higher rates of negative surgical margins than the same group treated before COVID-19 (96.7% vs. 91.1%, $p = 0.032$). This increase in negative resection margins during COVID-19 was not statistically significant among Black patients (97.1% vs. 100.0%, $p = 1.000$) (Table 4a). There were no other observed statistically significant differences in any characteristics before versus during COVID-19 for either Black or non-Black patients. However, there was a trend towards an increase in emergent surgical cases for Black patients (14.7% vs. 25.0%, $p = 0.485$) during the COVID-19 time period, while the trend for non-Black patients was a drop in emergent cases (10.1% vs. 8.3%, $p = 0.604$) (Table 4b).

3.5. Age stratifications

When stratifying by age, patients over age 65 had higher rates of negative surgical margins than the same group treated before COVID-19 (89.6% vs. 97.9%, $p = 0.010$). This was not observed among patients under age 65 (95.5% vs. 95.7%, $p = 1.000$) (Table 5a). Otherwise, there were no statistically significant differences in any characteristics before versus during COVID-19 for either younger (<65 years old) or older (≥65 years old) GI cancer patients. However, it was observed that younger patients trended towards a higher rate of neoadjuvant chemotherapy during COVID-19 as compared to the same group treated before COVID-19 (34.5% vs. 26.0%, $p = 0.381$), while older patients were trending towards less likely to receive neoadjuvant chemotherapy during COVID-19 (21.6% vs. 19.3%, $P = 0.729$) (Table 5b).

Table 3
Treatment characteristics and outcomes, stratified by before and after COVID-19hit. Comparison of proportion receiving neoadjuvant therapy, proportion undergoing emergency surgery, proportion undergoing chemotherapy of any kind, and proportion receiving negative resection margin.

Variable	Pre-COVID (n = 252)	COVID (n = 270)	*P*-value
Received neoadjuvant chemotherapy (%)	58 (23.4)	68 (25.9)	0.586
Received any chemotherapy (%)	144 (58.5)	140 (53.6)	0.307
Underwent emergent surgery (%)	27 (10.8)	27 (10.0)	0.901
Negative surgical resection margins (%)	206 (92.0)	227 (97.0)	0.030

Table 4A
Tumor and treatment characteristics and outcomes of Black patients, stratified by before and after COVID-19 hit.

Variable	Pre-COVID (n = 34)	COVID (n = 28)	*P*-value
Tumor Characteristics			
Pathologic T Stage (%)			0.935
pT0	1 (3.2)	1 (4.2)	
pT1	5 (16.1)	3 (12.5)	
pT2	4 (12.9)	5 (20.8)	
pT3	15 (48.4)	10 (41.7)	
pT4	6 (19.4)	5 (20.8)	
Pathologic N Stage (%)			0.559
pN0	17 (58.6)	13 (54.2)	
pN1	8 (27.6)	5 (20.8)	
pN2	4 (13.8)	6 (25.0)	
pN3	0 (0.0)	0 (0.0)	
Pathologic M Stage (% pM0)	24 (80.0)	17 (65.4)	0.353
Lymphovascular invasion (% present)	13 (41.9)	8 (34.8)	0.802
Perineural invasion (% present)	12 (42.9)	6 (26.1)	0.341
Treatment Characteristics			
Received neoadjuvant chemotherapy (%)	7 (20.6)	4 (15.4)	0.858
Received any chemotherapy (%)	17 (50.0)	13 (50.0)	1.000
Underwent emergent surgery (%)	5 (14.7)	7 (25.0)	0.485
Negative surgical resection margins (%)	33 (97.1)	24 (100.0)	1.000

Table 4B
Tumor and treatment characteristics and outcomes of non-Black patients, stratified by before and after COVID-19 hit.

Variable	Pre-COVID (n = 218)	COVID (n = 242)	*P*-value
Tumor Characteristics			
Pathologic T Stage (%)			0.839
pT0	14 (7.5)	11 (5.4)	
pT1	23 (12.3)	28 (13.9)	
pT2	41 (21.9)	51 (25.2)	
pT3	77 (41.2)	78 (38.6)	
pT4	32 (17.1)	34 (16.8)	
Pathologic N Stage (%)			0.959
pN0	99 (56.2)	111 (57.8)	
pN1	39 (22.2)	44 (22.9)	
pN2	37 (21.0)	36 (18.8)	
pN3	1 (0.6)	1 (0.5)	
Pathologic M Stage (% pM0)	163 (86.7)	168 (82.0)	0.249
Lymphovascular invasion (% present)	87 (51.5)	74 (41.4)	0.067
Perineural invasion (% present)	56 (31.6)	57 (31.0)	0.983
Treatment Characteristics			
Received neoadjuvant chemotherapy (%)	51 (23.8)	64 (27.0)	0.507
Received any chemotherapy (%)	127 (59.9)	127 (54.0)	0.248
Underwent emergent surgery (%)	22 (10.1)	20 (8.3)	0.604
Negative surgical resection margins (%)	173 (91.1)	203 (96.7)	0.032

4. Discussion

In this study of a large academic comprehensive cancer center, the COVID-19 pandemic caused an initial reduction in surgical volume on patients with GI cancers, but patients who ultimately underwent surgical resection during the first year of the pandemic did not have more advanced disease than those that underwent surgery in the year prior. There were no cohort differences with respect to sex, age, ethnicity, or race when comparing patients receiving surgery in the year preceding versus the first year of the COVID-19 pandemic. Tumor burden did not differ significantly with regard to pathologic T stage, pathologic N stage, presence of metastasis or presence of perineural invasion, nor did need for emergent oncologic surgery. Additionally, overall use and sequence of different chemotherapy did not significantly differ when comparing treatment pre-COVID-19 to treatment during COVID-19, however neo-adjuvant chemotherapy was more heavily utilized in the first six months of the pandemic compared to the second six months. During the pandemic, remote healthcare delivery was rapidly adopted.

Prior research has reported similar reductions in surgical volume during the COVID-19 pandemic with a sustained rebound in case volume during the second wave [8]. This experience reflects rapidly changing information, resources, and institutional response throughout the early pandemic. The first wave of the pandemic saw major resource reallocations in response to the increased COVID-19 patient burden [13,14]. Operating room staff and equipment were utilized in the care of patients with COVID-19 and therefore relatively unavailable for elective and semi-elective procedures. In addition to resource strain, uncertainty regarding the impending severity of the pandemic, the risk of transmission to both patients and hospital staff, and limited viral testing capacities

Table 5A
Tumor and treatment characteristics and outcomes of <65 patients, stratified by before and after COVID-19 hit.

Variable	Pre-COVID (n = 102)	COVID (n = 117)	*P*-value
Tumor Characteristics			
Pathologic T Stage (%)			0.912
pT0	6 (7.0)	6 (6.4)	
pT1	12 (14.0)	12 (12.8)	
pT2	15 (17.4)	21 (22.3)	
pT3	37 (43.0)	41 (43.6)	
pT4	16 (18.6)	14 (14.9)	
Pathologic N Stage (%)			0.763
pN0	43 (52.4)	48 (55.2)	
pN1	18 (22.0)	17 (19.5)	
pN2	21 (25.6)	21 (24.1)	
pN3	0 (0.0)	1 (1.1)	
Pathologic M Stage (% pM0)	72 (84.7)	76 (76.8)	0.243
Lymphovascular invasion (% present)	36 (46.8)	28 (35.0)	0.182
Perineural invasion (% present)	26 (32.9)	20 (25.3)	0.381
Treatment Characteristics			
Received neoadjuvant chemotherapy (%)	26 (26.0)	39 (34.5)	0.231
Received any chemotherapy (%)	63 (63.6)	69 (61.1)	0.807
Underwent emergent surgery (%)	10 (9.8)	10 (8.6)	0.947
Negative surgical resection margins (%)	85 (95.5)	90 (95.7)	1.000

Table 5B
Tumor and treatment characteristics and outcomes of ≥65 patients, stratified by before and after COVID-19 hit.

Variable	Pre-COVID (n = 150)	COVID (n = 153)	*P*-value
Tumor Characteristics			
Pathologic T Stage (%)			0.725
pT0	9 (6.8)	6 (4.5)	
pT1	16 (12.1)	19 (14.4)	
pT2	30 (22.7)	35 (26.5)	
pT3	55 (41.7)	47 (35.6)	
pT4	22 (16.7)	25 (18.9)	
Pathologic N Stage (%)			0.779
pN0	73 (59.3)	76 (58.9)	
pN1	29 (23.6)	32 (24.8)	
pN2	20 (16.3)	21 (16.3)	
pN3	1 (0.8)	0 (0.0)	
Pathologic M Stage (% pM0)	115 (86.5)	109 (82.6)	0.480
Lymphovascular invasion (% present)	64 (52.0)	54 (43.9)	0.251
Perineural invasion (% present)	42 (33.3)	43 (33.6)	1.000
Treatment Characteristics			
Received neoadjuvant chemotherapy (%)	32 (21.6)	29 (19.3)	0.729
Received any chemotherapy (%)	81 (55.1)	71 (48.0)	0.268
Underwent emergent surgery (%)	17 (11.4)	17 (11.1)	1.000
Negative surgical resection margins (%)	121 (89.6)	137 (97.9)	0.010

compounded for a steep decline in surgical volume [19,20]. By March 25, 2020, the total operating room volume at our site was approximately 30% of normal volume, with over 2000 cases rescheduled [21]. By May 1, 2020, we were operating at only 15% of normal surgical volume. However, at the time of the second wave, PPE optimization protocols were in place, telehealth had been readily adopted and was in use for preoperative visits, and viral testing capacity had been widely expanded and expedited [22,23]. At our center, starting October 23, 2020, use of ambulatory surgical centers was also leveraged to preserve surgical volume amidst the increasing number of COVID-positive hospital admissions [24]. These adaptations and the process experience gained from the first wave of COVID-19 likely contributed to a relatively sustained oncologic surgical case volume throughout the second wave.

The findings of our study provide insight into the role of telemedicine in facilitating this recovery of oncology surgeries. We demonstrate rapid and sustained increase in telemedicine visits in response to the pandemic. This unprecedented adoption of technology into healthcare delivery was in part made possible by swift policy changes at the state level. In our state, executive orders in April 2020 suspended provider licensure and certification requirements for telemedicine, expanded Medicaid coverage of visits, and required insurers to reimburse telemedicine at parity with in-person visits [25]. While accessibility to and affordability of telemedicine augmented the capacity of healthcare delivery in our state, it should be recognized that telemedicine comes with its own inherent access issues. Ability to receive care through telemedicine can be limited for patients without access to technology or internet and may prove difficult for patients with lower technology literacy, such as older patients – like those in this study [26]. This may help explain why, even at peak adoption levels, overall telemedicine visits reached only a quarter the volume of pre-COVID-19 office visits at our institution, and for total visit numbers to return to baseline levels, office visits needed to again represent a vast majority of encounters.

Overall, while state legislative action clearing barriers to telemedicine certainly facilitated increased access to care during the pandemic, there is still progress to be made in ensuring that this increased access is equitable and benefits all patients.

Another mitigating strategy observed in our study was the increased use of preoperative chemotherapy, particularly during the first few months of the pandemic compared to later in the pandemic. This observation reflects the implementation of strategies proposed by specialty societies for delaying surgical resection and hospitalization without delaying the initiation of anticancer treatment [27–29]. Unlike surgery, chemotherapy is typically administered in an outpatient setting and does not require the use of hospital facilities or an inpatient stay; thus, a shift from surgical treatment to chemotherapy at the right time can limit strain on hospital resources and reduce the risk of patient exposure to the virus. We report an increase in negative resection margins for some cohorts in the COVID-19 period compared to pre-COVID-19, which could be a consequence of this increased utilization of neoadjuvant therapy. While a good strategy for managing system resources and combating the consequences of surgical delays for many cancers, some gastrointestinal tract cancers lack strong evidence for efficacy of neoadjuvant chemotherapy, which limits the utility of this approach for some patients [30].

Overall, in this study, we provide an example of adjustments to oncologic treatment protocols, such as the use of neoadjuvant chemotherapy in appropriate patient populations and the robust and rapid adoption of telemedicine, to preserve access to cancer care during a pandemic. These two adaptations leveraged during the pandemic likely assisted the provision of adequate care to patients with cancer amidst unprecedented healthcare limitations. In order to mitigate the impact of the pandemic on access to timely cancer care, a coordinated and multifaceted response by individual clinicians, hospital administration, community care providers, state leadership, and patients was required. The potentially devastating impact on the mortality and severity of presentation of cancer patients that was predicted at the start of the pandemic, was possibly mitigated by these strategies, which could be implemented in future times of crisis in healthcare delivery [31].

5. Limitations

These findings must be considered within the context of its limitations. These data reflect the experience of a single academic comprehensive care center in the United States and may have variable external validity for other types of healthcare facilities or patient populations. However, the large healthcare system comprising the study cohort serves a diverse patient population, improving generalizability of results for other patient populations [32]. Our study analyzes multiple GI tract cancers in a single cohort, which may reduce generalizability across cancer subtypes, but permits a broad view of impacts to GI surgical cancer care during the COVID-19 pandemic. However, our study is also limited by our inability to capture patients intended for surgery that did not ultimately get it due to progression of disease beyond the point of resectability or due to loss to follow up. Additionally, several trends that did not reach statistical significance were observed in our data that reflected national trends observed elsewhere in the literature; it is possible that these findings reflect type II error in the setting of the single-institution design of our study that limits statistical power. For example, subgroup analyses such as those by race and age show valuable descriptive results, but may not powered for significance. Additionally, the recent study period does not allow for meaningful investigation of survival or recurrence outcomes for this population of patients with resectable cancers as data collection occurred in 2022.

6. Conclusion

In this study of a single academic comprehensive cancer center, the COVID-19 pandemic caused an initial disruption to surgical care of patients with gastrointestinal cancers, but the disruption was short-lived and did not ultimately significantly impact oncologic presentation or treatment for this patient population. These results suggest that changes to policy and protocols at a large, comprehensive cancer center and in its surrounding community and state were able to adequately compensate for limitations in surgical care during the COVID-19 pandemic primarily through increased utilization of neoadjuvant chemotherapy and telemedicine. These findings may be used as a framework to guide modification of cancer care in times of future crises in healthcare delivery.

Ethics statement

The study and collection of de-identified patient data for this project was reviewed and approved by the Yale Institutional Review Board with IRB Protocol ID #2000030583.

Funding/financial support

This study was supported by grants 1R21CA223686-01 (Dr. Khan), and CTSA UL1 TR001863 (Dr. Khan) from the NIH; and award T35DK104689 from the NIH (Ms. Bakkila).

Author contribution statement

Baylee F Bakkila, Victoria A Marks and Daniel Kerekes: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

John W Kunstman, Ronald R Salem and Kevin G Billingsley: Conceived and designed the experiments; Analyzed and interpreted the data.

Nita Ahuja: Conceived and designed the experiments; Analyzed and interpreted the data.

Maxwell Laurans: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.
Kelly Olino and Sajid A Khan: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Data availability statement

Data will be made available on request.

Additional information

No additional information is available for this paper.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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