



Surgical treatment of gastrointestinal tumors in a COVID-19 pandemic hospital: Can open versus minimally invasive surgery be safely performed?

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Abstract

Purpose: In order for patients with gastrointestinal cancer not to suffer the consequences of delayed treatment, they should be operated on in pandemic hospitals under adequate conditions. We aimed to discuss the outcomes of our gastrointestinal cancer surgery patients and to present our patient management recommendations to resume operative treatment during the ongoing COVID-19 pandemic while taking into account hospital facilities.

Materials and Methods: This study included 129 gastrointestinal cancer patients who underwent surgery between March 2020 and May 2021 in the gastrointestinal surgery clinic of our hospital, which was assigned as a pandemic hospital in March 2020. Patients' demographic characteristics and preoperative and postoperative findings were recorded.

Results: Among the patients, 42.6% ($n = 55$) were female and 57.3% ($n = 74$) were male. The mean age was 61.89 ± 3.4 years. The primary tumor organs were the stomach 37.2% ($n = 48$), pancreas 36.4% ($n = 47$), rectum 11.6% ($n = 15$), colon 8.5% ($n = 11$), and esophagus 6.2% ($n = 8$). The patients were treated with open (75.2%, $n = 97$) or minimally invasive surgery (24.8%, $n = 32$; laparoscopic 11.6%, $n = 15$; robotic 13.2%, $n = 17$). Eight patients tested positive for COVID-19 before surgery. No patients developed COVID-19 during postoperative intensive care or after being moved to the floor unit. There was no COVID-19-related morbidity or mortality.

Conclusion: Failure to treat gastrointestinal cancer patients during the pandemic may result in undesirable consequences, such as stage shift and mortality. Cancer patients can be treated safely with conventional and minimally invasive surgery guided by current recommendations and experience.

KEYWORDS

COVID-19, gastrointestinal cancer, pandemic

1 | INTRODUCTION

COVID-19, the disease caused by a novel coronavirus (2019-nCoV), was declared a pandemic by the World Health Organization (WHO). The agent causing COVID-19 pneumonia was established to be

severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).¹ Following its rapid spread around the world, COVID-19 was declared a pandemic by the World Health Organization (WHO) on March 11, 2020.² This agent infected host cells via the angiotensin-converting enzyme 2 (ACE2). The ACE2 receptor is expressed not only in

pulmonary alveolar cells but also in the enterocytes of the intestinal mucosa.^{3,4} SARS-CoV-2 RNA has also been detected in feces. Due to the risk of disease transmission, gastrointestinal surgeons must meticulously follow adequate measures. Frontline healthcare workers are at increased risk of exposure to and illness from COVID-19, which may also compromise the workforce fighting the epidemic.⁵

Open surgery and particularly extensive upper abdominal surgery are associated with an increased risk of pulmonary complications.⁶ An open surgical approach should be avoided to reduce the length of hospital stay and possible postoperative morbidity, thereby reducing the in-hospital spread of COVID-19. Although minimally invasive surgery improves short-term patient outcomes and is associated with faster recovery compared to traditional surgery, there are concerns regarding the application of minimally invasive surgery in patients potentially infected with COVID-19. Infectious pathogens can potentially be transmitted via surgical smoke.^{7,8} There is no concrete evidence suggesting that SARS-CoV-2 can be transmitted to operating room staff during electrosurgery. Transmission of various diseases through surgical smoke has been reported⁷; however, documented cases of RNA virus transmission are very few.⁸ Healthcare workers should be protected against the possible risk of COVID-19 infection by all available measures.

The pandemic has delayed the diagnosis, follow-up, and treatment of cancer patients. Most elective surgeries were postponed during the pandemic, but delays in the surgical treatment of cancer can have dire consequences. After the first confirmed case of COVID-19 in Turkey on March 11, 2020, our hospital was assigned as a pandemic hospital to cope with the challenges of a pandemic setting. Almost all hospital facilities were allocated for the treatment of COVID-19 patients. In addition, after this change in status of our hospital, we resumed the treatment of cancer patients under adequate protective measures and conditions, to prevent the negative effects of delayed treatment on patient outcomes. Herein we discuss the outcomes of our gastrointestinal cancer surgery patients and present our patient management recommendations to resume operative treatment during the ongoing COVID-19 pandemic while taking into account hospital facilities.

2 | MATERIALS AND METHODS

This single-center study was conducted in the gastrointestinal surgery clinic of Erzurum City Hospital between March 2020 and May 2021. Erzurum City Hospital has been a pandemic hospital since March 2020. The study was conducted in accordance with the principles of the Declaration of Helsinki and was granted approval by the Ministry of Health Scientific Committee and the hospital's clinical research ethics committee (Erzurum BEAH KAEK 202023-279).

The data were collected prospectively and analyzed retrospectively. Patients' demographic characteristics, comorbidities, and preoperative (laboratory and imaging results, cancer type, neoadjuvant therapy, American Society of Anesthesiologists [ASA] score, type of operation, duration of operation, length of hospital stay, and

Clavien–Dindo classification score) and postoperative (tumor stage, mortality, and 30-day follow-up) findings were recorded. The duration of the operation was defined as the time that elapsed between the first skin incision and the last suture.

Nasopharyngeal swab (polymerase chain react [PCR]) results for samples obtained upon admission and on the day before the operation (>5 days after admission) were recorded. After surgery, the patients were not routinely tested for COVID-19 and PCR tests were performed only on clinical suspicion.

2.1 | Preoperative evaluation

During the pandemic, our clinic only treated patients with gastrointestinal tumors who had completed neoadjuvant therapy and who were approved for surgery by the tumor council. Patients were first admitted to a designated room near the entrance of the ward with their caregiver and informed that our hospital is an assigned pandemic hospital. All participants gave written informed consent regarding the risks of surgery and COVID-19. The patients were asked about their history of COVID-19 infection, contact with COVID-19 patients, and history of travel. After a detailed anamnesis and physical examination, preoperative laboratory tests were conducted. Chest and abdominal CT were performed to evaluate pulmonary COVID-19 findings and possible metastases. Swabs were obtained from every patient for PCR testing. Patients who were PCR-positive or those with compatible CT findings were transferred to COVID-19 wards. The remaining patients were admitted to ward rooms with their caregivers. Patients were kept in private rooms when possible. In cases of double occupancy, patients who had not developed symptoms within 3 days of hospitalization were assigned as roommates, when required.

The standard procedure was 5 days of hospital stay before surgery for all patients. The reasoning behind waiting for at least 5 days was to be able to identify patients who had unknowingly contracted COVID-19 but did not develop symptoms, to minimize risk. However, in exceptional cases in which the patients developed tumor-related complications and required emergency surgery, they were operated on without waiting for 5 days. Patients' symptoms were monitored throughout their hospital stay. Interventions were postponed for all patients with clinical suspicion. A second PCR test was performed on the day before the operation. Patients who tested negative and did not have any COVID-19 symptoms underwent elective surgery. Staff that transferred patients used personal protective equipment.

2.1.1 | Perioperative management

All patients underwent surgery in the same operating room by the same surgical team, with the exception of robotic surgery patients, who underwent surgery in the robotic operating room. All operating rooms were maintained at negative pressure. The operating room staff was not assigned to any other hospital unit. The surgical staff

used personal protective equipment including N95 masks, surgical caps, gloves, face and eye protection, and surgical shoe covers. Although the patients tested negative for COVID-19, they were regarded as COVID-19-positive during the operation. All patients were extubated in the operating room.

2.1.2 | Postoperative management

The patients were transferred to an intensive care unit (ICU) postoperatively. The intensive care rooms were private isolated rooms maintained at negative pressure. The medical personnel took great care to adhere to isolation measures to prevent patient-to-patient transmission. The patients were transferred to the floor unit after stabilization in the ICU. In the floor unit, each patient was admitted to a private room, with only their caregiver being allowed to stay in the same room. The patient and caregiver were not allowed to leave the room. Visitors were not allowed until the patient was discharged. PCR tests were performed when patients developed symptoms suggestive of COVID-19, such as a fever. Thoracic CT scans were performed when required. Before discharge, the patients were advised and trained about 15-day self-isolation, mask use, social distancing, and hygiene.

2.2 | Statistical analysis

The data were analyzed using SPSS v.21.0. The results were presented as numbers and percentages for categorical variables and as mean \pm standard deviation for continuous variables.

3 | RESULTS

A total of 129 patients were operated on for gastrointestinal tumors during the COVID-19 pandemic. Among the patients, 42.6% ($n = 55$) were female and 57.3% ($n = 74$) were male. The mean age was 61.89 ± 3.4 years. The patients were classified as ASA I ($n = 12$), ASA II ($n = 72$), and ASA III ($n = 44$). The primary tumor organs were the stomach 37.2% ($n = 48$), pancreas 36.4% ($n = 47$), rectum 11.6% ($n = 15$), colon 8.5% ($n = 11$), and esophagus 6.2% ($n = 8$). Forty-four patients received preoperative neoadjuvant chemotherapy and/or chemoradiotherapy. Postoperative complications were observed in 17.8% ($n = 23$). Complications according to the Clavien–Dindo classification are presented in Table 1. There were no mortalities. The patients were treated with open (75.2%, $n = 97$) or minimally invasive surgery (24.8%, $n = 32$; laparoscopic 11.6%, $n = 15$; robotic 13.2%, $n = 17$). The modes of treatment according to the primary tumor organs were as follows: Stomach $n = 48$, 34 open, 9 robotic, 5 laparoscopic; pancreas $n = 47$, all open; rectum $n = 15$, 12 open, 2 robotic, 1 laparoscopic; colon $n = 11$, 3 open, 2 robotic, 6 laparoscopic; esophagus $n = 8$, 1 open, 4 robotic, 3 laparoscopic. The mean duration of surgery according to the primary tumor organs were as follows:

Stomach cancer, open surgery 169.26 ± 27.47 min and minimally invasive surgery 247.85 ± 91.75 min; pancreas cancer, open surgery 302.55 ± 70.87 min; rectum cancer, open surgery 198.33 ± 33.52 min and minimally invasive surgery 286.66 ± 32.14 min; colon cancer, open surgery 143.33 ± 11.54 min and minimally invasive surgery 286.66 ± 32.14 min; esophagus cancer, open surgery 310 min and minimally invasive surgery 370 ± 41.63 min. The mean lengths of hospital stay according to the primary tumor organs were as follows: Stomach cancer, open surgery 15.28 ± 1.25 days and minimally invasive surgery 13 ± 3.28 days; pancreas cancer, open surgery 18.23 ± 5.22 days; rectum cancer, open surgery 14.83 ± 1.83 days and minimally invasive surgery 13.33 ± 1.52 days; colon cancer, open surgery 13.33 ± 4.61 days and minimally invasive surgery 12.37 ± 1.18 days; esophagus cancer, open surgery 15 days and minimally invasive surgery 15.28 ± 1.25 days. Surgical procedures performed according to the primary tumor organ, length of hospital stay, and average duration of surgery are presented in Table 2. Eight patients (stomach cancer $n = 4$, colon cancer $n = 2$, pancreas cancer $n = 1$, and rectum cancer $n = 1$) tested positive for COVID-19 during their hospital stay (upon admission $n = 2$, preoperative PCR test $n = 6$). The operation was delayed for seven COVID-19-positive patients. One COVID-19-positive patient underwent emergency total colectomy and ileorectal anastomosis for left-sided obstructive colon cancer. That patient was moved to the ICU postoperatively and to the COVID-19 ward after 2 days. The patient did not develop any postoperative complications and was discharged after 7 days. The seven remaining COVID-19 patients were treated in the infection clinic and subsequently underwent elective surgery. The characteristics of the patients who tested positive for COVID-19 before surgery are given in Table 3.

No patients developed COVID-19 during postoperative intensive care or after being moved to the floor unit. There was no COVID-19-related morbidity or mortality. None of the patients were readmitted due to COVID-19.

4 | DISCUSSION

In the context of the COVID-19 pandemic, cancer patients deserve special attention due to their immunocompromised status and, therefore, higher vulnerability to infection. Emergency surgery for gastrointestinal tumors due to bleeding or obstruction is not up for discussion. However, considering that it is unknown how long the pandemic may last, to prevent the possible consequences of delayed treatment, patients who require elective operations should undergo treatment provided that the necessary measures are taken before, during, and after surgery. Untreated tumors can progress into more advanced and possibly inoperable stages.⁹

Since the beginning of the pandemic, gastrointestinal cancer associations have published nonevidence-based recommendations.^{10–13} These early guidelines were characterized by a sense of panic. Hospitals in Wuhan, China, the United States, and multiple European countries operated at maximum capacity and many were forced to

TABLE 1 General characteristics of patients with gastrointestinal tumors

Parameters of patients (n = 129)	Esophagus cancer (n = 8)	Gastric cancer (n = 48)	Pancreatic cancer (n = 47)	Colon cancer (n = 11)	Rectum cancer (n = 15)
Sex (male/female)	3/5	29/19	27/20	7/4	8/7
Age (years)	51.62 ± 7.7	61.02 ± 11.84	64.06 ± 11.99	54.63 ± 23.41	68.66 ± 10.65
Covid 19 history					
Preoperative	0/0	1/3	0/1	1/1	0/1
PCR test (1. test/ 2. test)	0	0	0	0	0
Thorax CT	0	0	0	0	0
Postoperative					
Neoadjuvant treatment	7	22	2	0	13
Clavien–Dindo classification (open/MIS)					
Grade 1	3/0	4/1	8/0	0/0	3/1
Grade 2	0/0	1/0	0/0	0/0	0/0
Grade 3	0/0	0/0	1/0	0/0	0/0
Grade 4	0/0	0/0	1/0	0/0	0/0
Grade 5	0/0	0/0	0/0	0/0	0/0
ASA SCORE					
ASA 1	1	6	1	3	1
ASA 2	7	29	27	5	5
ASA 3	0	13	19	3	9
ASA 4	0	0	0	0	0
Histopathology	SCC 6	AC 38	AC 38	AC 11	AC 15
	NET 1	GIST 8	MCN 4	NET 1	
	AC 1	NET 2	CP		
			NET 2		
Final stage of cancer					
Stage 0	0	GIST 8	7	1	1
Stage I	4	9	13	3	4
Stage II	1	9	15	4	7
Stage III	3	20	11	3	3
Stage IV	0	2	1	0	0
Tumor localization	Upper 0	Antrum 12	Ampulla of Vater 7	RC 8	Rectum 15
	Middle 2	Cardia 8	Corpus 3	LC 3	
	Lower 6	Body 15	Head 36		
		GOJ 13	Tail 1		

Abbreviations: AC, adenocarcinoma; CP, chronic pancreatitis; GIST, gastrointestinal stromal tumor; GOJ, gastroesophageal junction; LC, left colon; MCN, mucinous cystic neoplasm; MIS, minimally invasive surgery; NET, neuroendocrine tumor; PCR, polymerase chain react; RC, right colon; SCC, squamous cell carcinoma.

choose which patients to treat. The shortage of medical equipment and staff resulted in delayed treatment of malignancies, where only emergency patients were operated on and elective surgery was either postponed or switched to neoadjuvant therapy. It is unclear how to

approach the treatment of patients whose elective surgery has been postponed and those who have completed neoadjuvant therapy, particularly because it is uncertain how long the pandemic may last and for how long the treatment will be postponed. It is entirely possible

TABLE 2 Surgical results of patients with gastrointestinal tumors

Disease of diagnosis	Open	Minimal invasive	Total	
Esophagus cancer	1	7	8	
Operation time (min)	310	370 + -41,63	362.5 ± 43.99	
Length of stay hospital (days)	15	15.28 ± 1.25	15.25 ± 1.25	
Procedure of surgery	Open (1)	Robotic (4)	Laparoscopic (3)	Total (8)
Ivor-Lewis	1	4	3	8
Gastric cancer	34	9	5	48
Operation time (min)	169.26 ± 27.47	247.85 ± 91.75	192.18 ± 64.51	
Length of stay hospital (days)	15 ± 2.25	13 ± 3.28	14.41 ± 2.71	
Procedure of surgery	Open (34)	Robotic (9)	Laparoscopic (5)	Total (48)
Subtotal gastrectomy	7	5	2	14
Total gastrectomy	26	4	0	30
Wedge resection	1	0	3	4
Pancreatic cancer	47	0	47	
Operation time (min)	302.55 ± 70.87		302.55 ± 70.87	
Length of stay hospital (days)	18.23 ± 5.22		18.23 ± 5.22	
Procedure of surgery	Open (47)	Robotic (0)	Laparoscopic (0)	Total (47)
Whipple procedure	42			42
Distal pancreatectomy + splenectomy	2			2
Total pancreaticoduodenectomy + splenectomy	2			2
Enucleation	1			1
Colon cancer	3	2	6	11
Operation time (min)	143.33 ± 11.54	250 ± 55.49	220.9 ± 68.33	
Length of stay hospital (day)	13.33 ± 4.61	12.37 ± 1.18	12.63 ± 2.33	
Procedure of surgery	Open (3)	Robotic (2)	Laparoscopic (6)	Total (11)
Right hemicolectomy	1	2	4	7
Left hemicolectomy	1	0	0	1
TC and IRA	1	0	2	3
Rectum cancer	12	2	1	15
Operation time (min)	198.33 ± 33.52	286.66 ± 32.14	216 ± 48.66	
Length of stay hospital (days)	14.83 ± 1.83	13.33 ± 1.52	14.53 ± 1.92	
Procedure of surgery	Open (12)	Robotic (2)	Laparoscopic (1)	Total (15)
APR	2	1	0	3
LAR	10	1	1	12

Abbreviations: APR, abdominoperineal resection; IRA, ileorectal anastomosis; LAR, low anterior resection; TC, total colectomy.

that their conditions worsen. Therefore, in this uncertain setting, to spare this group of patients the possibly irreparable consequences of delayed treatment, each hospital should review their own facilities and provide these patients with treatment when possible. For this purpose, diagnosis, comorbidities, disease stage, tumor pathology, and hospital resources should be evaluated with a multidisciplinary approach, and a

personalized treatment protocol should be developed for each patient.^{14,15}

Due to its location, our hospital provides medical care to approximately 7 million inhabitants of Turkey's Eastern Anatolian and Eastern Black Sea regions. After our hospital became a pandemic hospital, taking into account our available facilities and resources, we

TABLE 3 Characteristics of surgical patients who tested positive for COVID-19

Patient	Age	Sex	Diagnosis	Time interval between PCR (+) and operation (days)	Operation	Length of hospital stay (days)	Morbidity	Mortality
1.	76	Male	Stomach cancer	35	Total gastrectomy	19	Atelectasis	No
2.	70	Male	Stomach cancer	50	Total gastrectomy	15	No	No
3.	76	Male	Stomach cancer	21	Subtotal gastrectomy	15	No	No
4.	77	Female	Stomach cancer	19	Total gastrectomy	16	No	No
5.	74	Female	Pancreas cancer	20	Whipple procedure	19	No	No
6	50	Male	Colon cancer	28	Right hemicolectomy	13	No	No
7.	60	Male	Colon cancer	1 (emergency)	Total colectomy + IRA	8	No	No
8.	73	Female	Rectal cancer	36	Low anterior resection	15	No	No

Abbreviations: IRA, ileorectal anastomosis; PCR, polymerase chain reaction.

resumed the treatment of cancer patients during the pandemic to prevent the negative effects of delayed treatment on patient outcomes.

Since being assigned as a pandemic hospital, only COVID-19 patients were admitted to the emergency room of our hospital, and routine outpatient services were suspended except for outpatient cancer clinics. A 13-room 26-bed ward and a 7-room ICU were allocated for surgical cancer patients. Only cancer patients and emergency COVID-19 patients were operated on. Non-COVID-19 patients and emergency COVID-19 patients were operated on and recovered in different wings of the hospital and were attended to by separate allocated staff.

A similar recent study from Turkey reported admitting surgery patients and their caregivers 2 days before surgery to satisfy preventive measures and to facilitate preoperative preparations. All patients were tested for COVID-19 by nasopharyngeal swab PCR the day before surgery. That study reported that only non-PCR-positive patients were operated on and that none of the patients contracted COVID-19 during the immediate postoperative period.¹⁶ In contrast to that study, we waited for at least 5 days after admission before surgery and tested each patient for COVID-19 with PCR and thoracic and abdominal CT scans. The reasoning behind waiting for at least 5 days was to be able to identify patients who had unknowingly contracted COVID-19 but did not show symptoms, to minimize risk. We repeated the PCR test the day before the operation. Two patients tested positive for COVID-19 upon admission, one of whom underwent emergency surgery for left-sided obstructive colon cancer. The second COVID-19-positive patient had early-stage stomach cancer and was, therefore, transferred to a COVID-19 ward for treatment before subsequent elective surgery. Among the patients who tested negative upon admission, six (4.7%) tested positive after more than 5 days of hospital stay. Our measures allowed successful perioperative management. Developing COVID-19 during the immediate postoperative period could have caused severe complications or even death. This approach allowed us to operate with a COVID-19 incidence rate of zero. The patients were requested to attend the outpatient clinic or contacted by phone 1 month after their operations. None of the patients reported COVID-19 infection.

There is little low-level evidence on whether minimally invasive surgery is associated with an increased risk of COVID-19 transmission compared to conventional surgery among cancer patients.¹⁷ Both methods are associated with their own specific sets of risks, including the aerosol-generating procedures performed during laparoscopic surgery, and the increased risk of contact with the patient's bodily fluids in conventional surgery.¹⁸ The relevant recommendations include using CO₂ filters in laparoscopy or robotic surgery, minimizing the size of port site incisions to prevent air leakage, minimizing the use of monopolar cautery, ultrasonic dissectors, and advanced bipolar devices in both laparoscopic and conventional surgery to prevent aerosolization, and using devices with attached smoke evacuators when possible.⁵ Studies have shown that minimally invasive surgery is associated with a shorter hospital stay and a reduced complication rate. In the present study, 75.2% of

the patients underwent open and 24.8% underwent minimally invasive surgery (11.6% laparoscopic and 13.2% robotic surgery). We performed minimally invasive surgery with maximum possible adherence to the recommendations mentioned above. Minimally invasive surgery is associated with longer operation times, as was the case in our study, and may increase the risk of COVID-19 transmission due to the factors listed above; that said, none of our patients or staff contracted COVID-19 during the described treatment process. In the present study, we found that laparoscopic and robotic surgeries do not create any additional risk of infection compared to conventional surgery and can be performed safely provided that necessary measures are taken.

To conclude, failure to treat gastrointestinal cancer patients during the pandemic may result in undesirable consequences such as stage shift and mortality. In reference to our experience as a pandemic hospital during the COVID-19 pandemic, we think that cancer patients can be treated safely with conventional and minimally invasive surgery guided by current recommendations and experience. Although aerosolization during minimally invasive surgery creates a risk of disease transmission, minimally invasive surgery appears to be advantageous in terms of the safety of the operating room personnel, especially due to the shorter postoperative hospital stay and reduced exposure to contaminants such as surgical smoke and blood. There was no COVID-19-related morbidity or mortality among our participants. No participating hospital staff became infected during the study. The major limitation of our study is the lack of comparative analyses due to the small sample size.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

AUTHORS CONTRIBUTIONS

Yılmaz Özdemir and Ayetullah Temiz conceived and designed the clinical trial, performed the experiments, analyzed the data, wrote the paper, conception of the manuscript, and critical revisions.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

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