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RESEARCH ARTICLE

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Is elective cancer surgery feasible during the lock-down period of the COVID-19 pandemic? Analysis of a single institutional experience of 404 consecutive patients

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Abstract

Background: We aimed to assess the feasibility and short-term clinical outcomes of surgical procedures for cancer at an institution using a coronavirus disease 2019 (COVID-19)-free surgical pathway during the peak phase of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic.

Materials and Methods: This was a single-center study, including cancer patients from all surgical departments, who underwent elective surgical procedures during the first peak phase between March 10 and June 30, 2020. The primary outcomes were the rate of postoperative SARS-CoV-2 infection and 30-day pulmonary or non-pulmonary related morbidity and mortality associated with SARS-CoV-2 disease.

Results: Four hundred and four cancer patients fulfilling inclusion criteria were analyzed. The rate of patients who underwent open and minimally invasive procedures was 61.9% and 38.1%, respectively. Only one (0.2%) patient died during the study period due to postoperative SARS-CoV2 infection because of acute respiratory distress syndrome. The overall non-SARS-CoV2 related 30-day morbidity and mortality rates were 19.3% and 1.7%, respectively; whereas the overall SARS-CoV2 related 30-day morbidity and mortality rates were 0.2% and 0.2%, respectively.

Conclusions: Under strict institutional policies and measures to establish a COVID-19-free surgical pathway, elective and emergency cancer operations can be performed with acceptable perioperative and postoperative morbidity and mortality.

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KEYWORDS
cancer surgery, COVID-19, COVID-19-free surgical pathway, SARS-CoV2 infection

1 | INTRODUCTION

The coronavirus disease 2019 (COVID-19) outbreak officially started in Wuhan, China, in December 2019 and spread over 235 countries. Overall, more than 70 million cases were confirmed, and the virus caused approximately one million six hundred thousand deaths worldwide. The virus was named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a similar virus to SARS-CoV-1 that had caused the SARS pandemic in 2002. The Turkish Ministry of Health announced the first patient in Turkey on March 10, 2020, and the World Health Organization (WHO) declared the novel coronavirus outbreak as a pandemic on March 11, 2020, as it spread rapidly worldwide.[1]

The SARS-CoV-2 pandemic caused a paradigm shift worldwide and had tremendous effects on the healthcare system. Since the beginning of the SARS-Cov2 pandemic, cancer patients' treatment has become more challenging. More than two million cancer operations were postponed or cancelled due to in-hospital cross-infection risk.[2] Shortly after the pandemic's surge, it was well understood that COVID-19 was associated with higher perioperative pulmonary complications leading to increased morbidity and mortality.[3] Despite multiple guidelines established by various cancer associations and WHO, many questions regarding treatment approaches remain unanswered.[4,5] First, it is debatable that if the deferral of operation in cancer patients impairs clinical outcomes. Second, it is not clear if the institutional COVID-19 protection measures can prevent operative COVID-19 infection rates. Last but not least, it is not clear whether the incidence of morbidity and mortality increases during the SARS-Cov2 pandemic. Both The American College of Surgeons and the Turkish Ministry of Health have published specific guidelines emphasizing that all elective operations should be postponed. Only a selected group of cancer operations could be performed if the relevant hospitals have adequately safe settings and sufficient capacity.[5,6] At our institution, after several meetings between directors of the hospital, infectious committee members, intensive care unit (ICU) representatives, anesthesiologists, and surgeons, it was decided to proceed with surgical treatment of cancer patients. Therefore, surgical wards, operating rooms, and intensive care units were divided into COVID-19 and non-COVID-19 units to create a dedicated COVID-19-free surgical pathway for cancer patients undergoing cancer operations. All the necessary precautions, including COVID-19 screening policies, operative room settings, personal protective equipment (PPE), and postoperative care, were adapted according to surgical societies' guidelines.[5,6]

We aimed to assess the feasibility and short-term clinical outcomes of cancer operations by evaluating patients from all surgical departments on a consecutive basis using a COVID-19-free surgical pathway during the peak phase of the SARS-CoV-2 pandemic at a high-volume institution.

2 | MATERIALS AND METHODS

2.1 | Study design

This was a retrospective cohort study, including all cancer patients, who underwent elective or emergency cancer operation at all Vehbi Koç Foundation Healthcare Organization departments, namely Koc University Hospital and American Hospital. The study period was initiated on March 10, 2020, when the first COVID-19 case was officially announced in Turkey and ended on June 30, 2020, since the COVID-19 measures were gradually defused throughout June 2020. The institutional ethics committee (IRB: 2020. 260.IRB3.101) and the research ethics committee of the Turkish Ministry of Health approved the study proposal.

2.2 | Patients and procedures

All patients undergoing surgical procedures for cancer were included. A surgical procedure was defined as any procedure done by a surgeon in an operating theatre under local, regional or general anaesthesia based on oncological principles. Patients were preoperatively identified and discussed among a multidisciplinary team at the weekly institutional tumor board and subsequently scheduled for operation. Patients were followed up to postoperative day 30, with the day of operation defined as the beginning (Day 0). Patients were diagnosed for cancers including breast, endocrine (parathyroid, thyroid), gynecologic (uterine, ovarian, cervical, vulvar), head and neck (oral, oropharyngeal, laryngeal, hypopharyngeal, salivary), hepato-pancreato-biliary (liver, pancreas, gallbladder), lower gastrointestinal tract (colon, rectal), thoracic (lung, pleural, mediastinal), upper gastrointestinal tract (esophagus, stomach), urologic (prostate, bladder, renal), soft tissue and bone sarcoma, and intracranial malignancies.

2.3 | Data collection and clinical outcomes

Data were collected retrospectively including demographic variables (age, sex, comorbidities, and American Society of Anesthesiologists

[ASA] Score), preoperative workup regarding COVID-19 (symptoms, polymerase chain reaction [PCR], and/or chest computed tomography (CT) scan), the urgency of surgical procedure (elective or emergency), type of anaesthesia (local, regional or general), surgical technique (minimally invasive procedure or open procedure), cancer types, operation time, perioperative morbidity–mortality, and characteristics of postoperative care (postoperative complications, need for reoperation, admission and length of stay at intensive care unit, readmission to intensive care unit, length of stay at the hospital and postoperative mortality and morbidity related to COVID-19 infection). Data were collected from our electronic database, and patients were contacted via video-teleconference when there was a need for additional information missing in the institutional database.

The primary outcome was the COVID-19 related intraoperative, perioperative or postoperative morbidity and mortality.

2.4 | Diagnosis of COVID-19 infection

Diagnosis of COVID-19 was based on clinical symptoms suspicious for COVID-19 such as cough, fever, anosmia, and myalgia, quantitative reverse-transcription polymerase chain reaction (RT-PCR) test using nasopharyngeal/oropharyngeal swabs and computed tomography (CT) of the thorax showing characteristic findings of the disease.

2.5 | Precautions for COVID-19 infection

The preoperative workup, surgical procedures, and postoperative care and follow-up visits were performed according to the institutional infection control committee's recommendations, which organized periodic meetings and webinars to inform healthcare workers in parallel to the changes in the literature.[4–7] The patients who underwent cancer operation were strictly isolated from COVID-19 infected patients during preoperative, intraoperative, and postoperative periods.

Before surgical procedures, patients were asked about their general condition, anosmia, respiratory or gastrointestinal symptoms, or a history of contact with a person at risk of SARS-CoV2 infection. According to the national and institutional protective policies, two main strategies for preoperative SARS-CoV2 infection assessment were selected during two separate pandemic periods. Patients were evaluated with nasal/oropharyngeal swab testing and/or thorax CT between March 10 and April 29, 2020. Subsequently, starting from April 30, 2020, all patients scheduled for elective cancer operation underwent a combination of swab test and chest CT.

All medical staff used surgical masks, gloves, and bonnets appropriately. When a COVID-19 positive or a suspected patient is encountered, extra precautions have been taken to keep in a PPE that provides a high level of protection, including a disposable N95 respirator, double-layer gloves, face shield, goggles, safety shoes, and surgical dress to achieve full protection measures. All patients and medical staff had to wear surgical masks during the preoperative follow-ups, and patients' physical examinations were performed with disposable latex gloves. In our institution, a single-use PPE was never re-used neither by our patients nor the healthcare professionals.

Patient rooms, ICU beds, and recovery rooms were re-designed. Standard patient rooms were provided with vital sign monitors, oxygen support systems, and noninvasive ventilatory support equipment to decrease ICU demand. The number of ICU beds has been increased by converting the recovery rooms to ICU. In the end, we had two fully equipped ICUs, one for SARS-CoV2 negative and the other for SARS-CoV2 positive or suspicious patients. The main aim was to create SARS-CoV2-free surgical pathways. Regional anaesthesia was the first choice, if possible. However, if general anaesthesia was inevitable, the intubation was performed by an experienced anesthesiologist with a rapid sequence technique using a video-laryngoscope. Only the nurse, anesthesiology specialist, and anesthesiology technician were allowed to be present in the room during the procedure. During the operation, adequate viral filters were applied to the ventilator circuit without disconnection. The patient was extubated in the operating room and sent to the patient ward after full recovery.

Special precautions were taken for minimally invasive procedures such as laparoscopic and robotic procedures to mitigate the risk of COVID-19 infection during these procedures. All of these surgical procedures were performed in negative pressure operating theatres with a minimum number of surgeons, surgical nurses, and personnel. The insufflation pressures were set to low intraperitoneal pressures (8–10 mmHg), and low flow rates (5–10 L/min of CO_2) were preferred. The incision length at trocar sites was minimized, the trocars were placed as perpendicular as possible to the abdominal fascia, and any trocar removal or replacement was avoided until the end of the operation. The use of electrosurgical instruments such as vessel sealing devices, ultrasonic devices, and harmonic scalpels was avoided to decrease the amount of smoke created. The smoke was evacuated through one of the ports connected directly to the suction system without any leakage. After the procedures, the pathological specimens were secured for subsequent removal. The insufflation port was closed, and the smoke evacuation port was kept open until all the intra-abdominal CO_2 deflated utterly.

2.6 | Statistical analysis

Statistical analysis was performed using SPSS version 26.0 (IBM Corp. Released 2019, IBM SPSS Statistics for Windows, Version 26.0; IBM Corp.). Categorical data were calculated using the number (*n*) and percentage (%), while the continuous variables were analyzed using mean, standard deviation, median, and minimum and maximum values.

3 | RESULTS

A total of four hundred and four patients were diagnosed with cancer and underwent radical surgical procedures. A 30-day surveillance period was achieved for all patients (100.0%). The median

TABLE 1 Baseline characteristics of the patients

	n = 404
Age, median (min–max), years	61 (2-91) years
ASA score	
I	53 (13.2%)
II	238 (58.9%)
III	95 (23.6%)
IV	18 (4.3%)
V	0
Number of comorbidities	
None	172 (42.5%)
One	178 (44.1%)
Two or more	54 (13.4%)
Comorbidities	
Chronic kidney disease	7 (1.7%)
Chronic liver disease	2 (0.5%)
Chronic obstructive pulmonary disease	19 (4.7%)
Congestive heart failure	6 (1.4%)
Current smoker	139 (34.4%)
Diabetes mellitus	47 (11.6%)
Hypertension	133 (32.9%)
Coronary heart disease	45 (11.1%)
Pulmonary embolism	2 (0.5%)
Stroke or transient ischemic attack	5 (1.2%)

TABLE 2 Preoperative COVID-19 assessment strategies used during the three periods of the study

	n = 404
Preoperative SARS-CoV2 swab test	
Performed	232 (57.4%)
Not performed	172 (42.6%)
Preoperative thorax CT	
Performed	326 (80.6%)
Not performed	78 (19.4%)
SARS-CoV2 assessment	
Only clinical findings	98 (24.3%)
Only laboratory confirmation	5 (1.2%)
Only radiologic findings	68 (16.8%)
Laboratory + Radiologic findings	233 (57.7%)
Timing of SARS-CoV2 diagnosis	
Preoperative	3 (0.8%)
Postoperative	1 (0.2%)
None	400 (99.0%)

age of the cohort was 61 years (range, 2–91 years). Of the 404 cases, 232 (57.5%) had coexisting comorbidities. Hypertension was reported in 133 (32.9%) patients, diabetes mellitus in 47 (11.6%), coronary heart disease in 45 (11.1%), and chronic obstructive pulmonary disease in 19 (4.7%). One hundred thirty-nine (34.4%) patients were current tobacco smokers. The ASA scores were I, II, III, and IV in 53 (13.2%), 238 (58.9%), 95 (23.6%), and 18 (4.3%) patients, respectively. Baseline characteristics of the patients are given in Table 1.

Ninety-eight patients (24.3%) who did not have any suspicious finding, did not undergo any further testing during the first period. Only nasal/oropharyngeal swab testing was performed in five patients (1.2%), only chest CT was performed in 68 (16.8%), and the combination of a swab test and chest CT were performed in 233 patients (57.7%) (Table 2).

Table 3 outlines the surgical variables during the study period. The distribution of cancer types among patients who underwent radical surgical procedures were as follows: breast 19 (4.7%), endocrine 21 (5.2%), gynecologic 30 (7.4%), head and neck 34 (8.3%), hepato-pancreatic-biliary 46 (11.4%), intracranial 36 (8.9%), lower gastrointestinal tract 58 (14.4%), sarcoma 16 (4.0%), thoracic 57 (14.1%), upper gastrointestinal tract 16 (4.0%), and urologic 71 (17.6%). The surgical procedures performed under general anesthesia were 393 (97.3%) and 11 (2.7%) under regional anesthesia, whereas no operations were performed with local anesthesia. There was no practice change during the study period regarding operation technique (open procedures, laparoscopy, or robotic procedures) due to the SARS-CoV2 pandemic. Open procedures were performed in 250 patients (61.9%), laparoscopic procedures were performed in 86 patients (21.3%), robotic procedures were performed in 34 patients (8.3%), and endoscopic procedures were performed in 34 patients (8.3%). Three patients (0.8%) underwent emergency operations: one patient because of obstruction due to colon cancer, one due to perforation in colon cancer after stenting and one patient because of bleeding after endoscopic therapy for gastric cancer. Minimal invasive procedures were performed in 154 (38.1%) patients; 36 (8.9%) patients underwent laparoscopic procedures for colorectal and stomach cancer, three (0.8%) for hepatopancreaticobiliary surgery, 2 (0.5%) for endometrial cancer, 45 (11.1%) patients underwent video-assisted thoracic surgery (VATS) for lung cancer, 7 (1.7%) patients underwent robotic procedures for colorectal and stomach cancer, 27 (6.7%) for prostate cancer, whereas endoscopic procedures were performed for 34 (8.3%) patients with bladder or prostate cancer (Table 3).

Table 4 shows the postoperative outcomes of the patients. During the postoperative period, 79 patients (19.6%) developed complications, and reintervention and/or reoperation was necessary for 19 patients (4.7%). Postoperative complications were a leak of anastomosis or stump in six patients (1.5%), bleeding in 13 (3.2%), ileus or subileus in 14 (3.5%), pancreatic fistula in four (1.0%) and

TABLE 3 Operative characteristics of the patients

	n = 404
Urgency of surgery	
Emergency	3 (0.8%)
Elective	401 (99.2%)
Anesthesia	
Local	0
Regional	11 (2.7%)
General	393 (97.3%)
Type of surgery	
Open	250 (61.9%)
Minimally invasive	154 (38.1%)
Laparoscopic	86 (21.3%)
Robotic	34 (8.3%)
Other endoscopic procedures[a]	34 (8.3%)
Conversion to open	1 (0.2%)
Surgical department	
Breast	19 (4.7%)
Endocrine	21 (5.2%)
Gastrointestinal tract (upper)	16 (4.0%)
Esophageal cancer	2 (12.5%)
Gastric cancer	14 (87.5%)
Gastrointestinal tract (lower)	58 (14.4%)
Colon cancer	44 (75.9%)
Rectal cancer	14 (24.1%)
Gynecologic	30 (7.4%)
Ovarian cancer	14 (46.7%)
Endometrial cancer	9 (30.0%)
Cervical cancer	5 (16.7%)
Uterine sarcoma	1 (3.0%)
Vulvar cancer	1 (3.0%)
Head and neck	34 (8.3%)
Hepatopancreaticobiliary	46 (11.4%)
Cholangiocarcinoma	3 (6.5%)
Hepatocellular carcinoma	3 (6.5%)
Metastatic liver cancer	11 (23.9%)
Pancreas cancer	29 (63.1%)
Intracranial tumor	36 (8.9%)
Soft tissue and bone sarcoma	16 (4.0%)
Thoracic	57 (14.1%)
Primary lung cancer	28 (7.1%)
Secondary lung cancer	27 (6.9%)
Thymoma/thymic carcinoma	2 (0.5%)
Urologic	71 (17.6%)
Bladder cancer	30 (42.3%)
Kidney cancer	10 (14.1%)
Prostate cancer	23 (32.4%)
Testis tumor	3 (4.2%)
Ureteral cancer	5 (7.0%)
Operative time, median (min–max), minutes	175 (5–1205)

[a]Cystoscopic procedures performed for bladder and prostate cancer.

infection in 13 patients (3.2%). The main indications for reoperation were anastomotic leak in five patients (1.2%), persisting and uncontrolled bleeding despite endoscopic intervention in four patients (1.0%), abdominal dehiscence in one patient (0.2%), pneumothorax in one patient (0.2%), pleural effusion in one patient (0.2%), intraabdominal collection in one patient (0.2%) and hydrocephalus in one patient (0.2%). Pulmonary complications were observed in 12 patients (3.0%). Two patients (0.5%) were diagnosed with acute respiratory distress syndrome in the postoperative period, and only one of the patients (0.2%) was diagnosed with SARS-CoV2 infection. The other pulmonary complications were pleural effusion in 6 (1.5%) of the patients, pneumonia in 3 (0.8%) and pneumothorax in 1 (0.2%) of the patients. The overall SARS-CoV2 related 30-day morbidity and mortality rates were 0.2% and 0.2%, respectively. The overall non-SARS-CoV2 related 30-day morbidity and mortality rates were 19.3% and 1.7%, respectively. According to the Clavien-Dindo classification of surgical complications, 11 (2.7%) patients were graded as I, 29 (7.1%) as II, 32 (7.9%) as III, 2 (0.5%) as IV, and 5 (1.2%) patients as V (Table 4).

Preoperatively, three patients (0.8%) with COVID-19 like symptoms were diagnosed with SARS-CoV2 infection according to the laboratory and radiological findings. These patients were immediately transferred to the COVID-19-positive patients' ward, and they were treated for SARS-CoV2 infection. After recovery of SARS-CoV2 infection, these patients underwent radical surgical procedures for cancer, and they were discharged without any further complication.

During the study period, only one (0.2%) patient was diagnosed with SARS-CoV2 infection during the postoperative period after a total radical gastrectomy procedure due to an obstructive tumor located in the antrum of the stomach that has been previously stented. Sixty-eight years old female patient had multiple comorbidities, including coronary heart disease, hypertension, and hyperlipidemia. On the fifth postoperative day, the patient complained about shortness of breath and fever, and the patient was transferred to the ICU. Thorax CT revealed consolidation and ground-glass opacities in a multilobular and multifocal pattern at both lungs. The

TABLE 4 Postoperative outcomes of the patients

	n = 404
Mortality (total)	11 (2.7%)
7-day	1 (0.2%)
7–30-day	6 (1.5%)
31–90-day	4 (1.0%)
Postoperative complication	
Yes	79 (19.6%)
No	325 (80.4%)
The Clavien-Dindo grade	
I	11 (2.7%)
II	29 (7.1%)
III	32 (7.9%)
IV	2 (0.5%)
V	5 (1.2%)
Causes of postoperative complication	
Leak of anastomosis or stump	6 (1.5%)
Bleeding	13 (3.2%)
Bowel movement	14 (3.5%)
Sub-ileus	*8 (2.0%)*
Ileus	*6 (1.5%)*
Pancreatic fistula	4 (1.0%)
Infection	13 (3.2%)
Superficial	*8 (2.0%)*
Deep	*3 (0.8%)*
Organ space	*2 (0.5%)*
Pulmonary complications	12 (3.0%)
Acute respiratory distress syndrome	*2 (0.5%)*
Pleural effusion	*6 (1.5%)*
Pneumonia	*3 (0.8%)*
Pneumothorax	*1 (0.2%)*
Urinary retention	5 (1.2%)
Urinary tract infection	2 (0.5%)
Others	10 (2.5%)
Reoperation	
Yes	19 (4.7%)
No	385 (95.3%)
Causes of reoperation	
Abdominal dehiscence	1 (0.2%)
Anastomotic leak	5 (1.2%)
Hydrocephalus	1 (0.2%)
Uncontrolled bleeding	4 (1.0%)
Intraabdominal collection	1 (0.2%)
Pleural effusion	1 (0.2%)
Pneumothorax	1 (0.2%)
Others	5 (1.2%)
Admission to intensive care unit	
Yes	163 (40.3%)
No	241 (59.7%)
Readmission to the intensive care unit	
Yes	8 (2%)
No	396 (98%)
Length of stay	
Intensive care unit, median (range), days	1 (1–28)
Hospital, median (range), days	6 (0–57)

first swab test for SARS-CoV2 was negative, but the second SARS-CoV2 swab test, which was taken the following day in the ICU, was positive. The patient was treated with several broad-spectrum antibiotics and antiviral agents. The swab test for SARS-CoV2 became negative fifteen days after the initiation of medical treatment and the patient was discharged from the ICU after 10 days. The patient was readmitted to the ICU because of cardiopulmonary collapse on postoperative day 23. Despite all supportive measures, the patient died due to pulmonary disease progression and multiple organ dysfunction 40 days after operation.

4 | DISCUSSION

The current study shows that with strict institutional policies and measures taken for COVID-19, elective and emergency cancer operations were feasible with acceptable perioperative and postoperative morbidity and mortality. Additionally, the decision to perform or not to perform minimally invasive procedures (laparoscopic and robotic) and endoscopic procedures did not change due to the pandemic. In the present study establishing COVID-19-free surgical pathways was the most important factor along with other necessary surgical and clinical measures for achieving the best outcomes in the era of the SARS-CoV2 pandemic. To the best of our knowledge, this is the first and the largest series of a single-center experience of patients who underwent cancer operations in a wide variety of surgical departments during the COVID-19 pandemic era.

The pandemic's impact in different countries and healthcare systems affected the clinical practice, treatment approaches of many surgeons, and institutions worldwide. The main reasons for practice change regarding radical surgical procedures for cancer patients can be listed as lack of ICU and ward beds, lack of blood products, lack of ward and theatre staff, national and hospital policies, and patient

refusal. In particular, many survey-based studies reported that surgeons tend to delay cancer operations, and they tend to replace surgical procedures with chemotherapy and/or radiotherapy if possible.[8,9] However, patients diagnosed with cancer are more susceptible to infections because of the immunosuppressive state induced by the underlying disease and applied adjuvant therapies.[10] These issues should be balanced against the risk of inevitable disease progression in cancer patients.[11–13] There is a universal consensus that patients with emergent cases such as perforation, bleeding or obstruction must undergo urgent operations. These patients must be treated as SARS-CoV2-positive patients until proven otherwise.

During the earlier period of the pandemic, several guidelines, including the American College of Surgeons and the Turkish Ministry of Health referring surgical procedures, have been published.[5,6] In these guidelines, it was recommended to postpone all of the elective operations sparing only a selected group of cancer operations which can be done at relevant hospitals with appropriately safe infrastructure and sufficient capacity. Several meetings were conducted at our institution between the hospital directors, infectious committee members, intensive care unit representatives, anesthesiologists, and surgeons. As a final consensus, it was decided to proceed with the surgical treatment of cancer patients in all surgical departments. After it has been selected to proceed with surgical procedures, one of the most critical concerns was to protect healthcare professionals and patients, reduce the risk of asymptomatic hospital staff cross-contamination, and prevent hospital-acquired risk infection of COVID-19. The first step of preventing and controlling infectious diseases was identifying and isolating suspicious and infected patients. At the beginning of the pandemic in Turkey, only symptomatic cancer patients or patients suspected of COVID-19 infection due to medical history and/or symptoms were tested for COVID-19 infection with nasal/oropharyngeal swab testing and/or thorax CT. Subsequently, starting from April 30, 2020, all patients scheduled for elective operations underwent a combination of swab tests and chest CT in concordance with the change in national guidelines.[6]

The crucial importance of establishing COVID-19-free surgical pathways was demonstrated in a recently published international, multicenter COVIDSurg Collaborative study.[7] The data of 9171 patients from 447 hospitals in 55 countries who underwent surgical procedures for cancer were analyzed. It was demonstrated that surgically treated patients at hospitals with COVID-19 free surgical pathways had lower pulmonary complication rates (2.2% vs. 4.9%). The postoperative SARS-CoV-2 infection rate was also found to be lower in COVID-19-free surgical pathways (2.1% vs. 3.6%).[7] COVID-19 measures were strictly implemented at our institution to achieve this goal during the study period. These were patients' admission in COVID-19 free pathways and COVID-19 divided wards, recovery rooms, and ICU where separate healthcare workers were in charge. Additionally, the visits of patients by third parties, such as friends and relatives, were avoided.

Another concern about surgical procedures during the pandemic was the risk of SARS-CoV2 transmission via surgical smoke generated by surgical energy devices (monopolar or bipolar electrocautery) or pneumoperitoneum during open or minimally invasive procedures. This issue has attracted attention, especially after the publication of a single case report showing the isolation of high concentrations of SARS-CoV2 in peritoneal fluid.[14] However, no case of the transmission of SAR-CoV2 to operating theatre healthcare workers during abdominal procedures has been published.[15] Before the pandemic, only a few studies have analyzed the surgical smoke viral content.[16–18] Despite the isolation of some virus species (e.g., hepatitis B virus, human papillomavirus, and human immunodeficiency virus) in some studies, it is not apparent that these particles can transmit disease or even have viral infectivity.[16–18] The SARS-CoV-2 transmission risk is probably associated with aerosol-generating procedures such as head and neck surgery, tracheal intubation, mask, and noninvasive ventilation; however, abdominal surgical procedures appear to be safer. In this study, 38.1% of all cancer patients underwent minimally invasive surgical procedures. As described in detail previously, several precautions and technical modifications were undertaken to protect healthcare professionals working in the operating rooms during laparoscopic and robotic procedures.[19] We did not find any additional risk related to COVID-19 disease during the study period neither for patients nor the healthcare workers or surgeons regarding laparoscopic and robotic procedures. Also, surgical procedures were not converted from laparoscopy or robotic to laparotomy in any patient because of COVID-19.

Despite protective measures, a comprehensive risk analysis is mandatory through the perioperative period during the COVID-19 pandemic. In a small retrospective analysis, 34 patients who underwent elective surgical procedures in the incubation phase of COVID-19 developed SARS-CoV2 pneumonia shortly after the operation.[20] Fifteen (44.1%) of these patients required admission to the ICU due to disease progression, and seven patients (20.5%) died after admission to ICU.[20] In another multicenter, international cohort study analyzing the clinical outcomes of 1128 cancer patients with SARS-CoV2 infection reported, SARS-CoV2 related postoperative pulmonary complications were seen in nearly half of the patients (51.2%), and a high 30-day mortality rate of 38% was found among these patients ($n = 216$).[21] The mortality related to SARS-CoV2 induced pulmonary complications accounted for 82.6% of all deaths.[21] Nevertheless, a study comprising 39 perioperative cancer patients failed to show any SARS-CoV2 infection before or after surgical procedures with adequate necessary protective measures.[22]

We achieved good clinical outcomes regarding SARS-CoV2 or non-SARS-CoV2 related 30-day morbidity (0.2% and 19.3%, respectively) and mortality (0.2% and 1.7%, respectively). Three patients (0.8%) were diagnosed with preoperative COVID-19 infection during the study period, and one patient (0.2%) was diagnosed postoperatively by RT-PCR and chest CT. The operations of the patients with the preoperative diagnosis were postponed until they were free of the virus. After they recovered from the COVID-19 infection, they were operated on without any postoperative complication. However, a single patient with postoperative COVID19 infection was taken to

ICU twice and suffered from pulmonary complications related to COVID-19. After 40 days of follow up and multiagent therapies, the patient died due to multiorgan dysfunction syndrome induced by SARS-CoV2. They all had COVID-19 like symptoms such as fever, chills, fatigue, and shortness of breath. However, in none of these, neither laboratory nor radiological findings revealed a SARS-CoV2 infection. All suspected healthcare workers strictly avoided working for 14 days and took all the necessary precautions during their self-quarantine.

This study aimed to investigate the effectiveness of SARS-CoV2 protection measurements and clinical outcomes of cancer patients during the first wave of the pandemic. It is shown that with strict institutional policies and measures taken against COVID-19 infection, elective and emergency cancer operations were feasible with acceptable perioperative and postoperative morbidity and mortality. Additionally, minimally invasive procedures (laparoscopy and robotic) and endoscopic procedures (cystoscopy) can be performed safely. This study showed that COVID-19-free surgical pathways were the essential factor for achieving the best outcomes in the era of the SARS-Cov2 pandemic. There are two main strengths of the current study: first, all of the cancer patients surgically treated by different surgical specialties at a single institution were consecutively included in the study, and the second, the vast majority of the patients underwent major cancer operations during the peak phase of the SARS-CoV2 pandemic. However, these findings should be interpreted with caution. This is a small cohort study with a comparably short follow-up period investigating SARS-CoV2, a new disease that we discover new findings and effects each day.

To the best of our knowledge, this is one of the first and the largest series of the single-center experience of patients who underwent radical cancer operations in a wide variety of surgical departments during the COVID-19 pandemic era. We believe that the present study will provide insight into the cancer centers where primary, secondary or tertiary COVID-19 pandemic outbreaks might occur in the future.

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DATA AVAILABILITY STATEMENT

Data available upon request.

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