

Emergency abdominal surgical operative findings in patients infected with the COVID-19 virus in Kirkuk governorate during the period 2020-2021

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Abstract

Objective: To assess the effect of COVID-19 infection on laboratory results, intraoperative surgical outcomes, and preoperative clinical characteristics, and to ascertain if COVID-19 status is associated with increased disease burden, physiological disturbances, and surgical complexity in patients undergoing emergency abdominal surgery.

Methods: This retrospective case-control study was performed at Azadi Teaching Hospital, Kirkuk, Iraq, between March 1, 2020, and September 1, 2021. A total of 350 patients who underwent emergency surgery were included: 146 COVID-19-positive patients and 204 COVID-19-negative patients. COVID-19 diagnosis was made via CT scan and detection of IgM and IgG antibodies. Serological and biochemical markers measured included C-reactive protein, lymphocyte percentage, urea, and creatinine. The main outcomes were postoperative complications, hospital stay, and mortality.

Results: Significantly higher CRP levels (15.2 ± 7.8 mg/L) were seen in COVID-19-positive patients versus controls (6.48 ± 3.05 mg/L; $p < 0.0001$), along with lower lymphocyte percentages ($21.4 \pm 5.66\%$ vs $35.95 \pm 4.05\%$; $p < 0.0001$) and elevated renal function parameters. Higher postoperative complications occurred in COVID-19-positive patients (43.2% vs 26.0% ; $p = 0.001$), with longer hospital stay (19.5 ± 5.65 days vs 8.10 ± 3.66 days; $p < 0.0001$). Mortality was not significantly different (4.8% vs 2.0% ; $p = 0.212$). Surgical conditions differed notably: mesenteric ischemia (39.04% vs 5.88%) and retroperitoneal bleeding (34.93% vs 6.86%).

Conclusions: COVID-19 in emergency abdominal surgery patients was associated with increased clinical severity, postoperative complications, and hospitalisation. Mortality was not significantly different, suggesting patients can safely undergo emergency surgery despite COVID-19.

Keywords: COVID-19, Emergency Surgery, Abdominal Surgery, Postoperative Complications, SARS-CoV-2

Plain English Summary

The current research aims to identify and discuss the effects of SARS-CoV-2 infection on emergency abdominal surgeries carried out on patients in a teaching hospital in Kirkuk, Iraq, during 2020 and 2021. A total of 146 COVID-19 positive patients were compared with 204 COVID-19 negative patients who underwent similar emergency surgeries. The research revealed that COVID-19 positive patients experienced increased inflammatory markers, extended periods of hospitalisation (approximately 19 days compared with 8 days for negative patients), and an increased rate of complications following surgery. However, there were no significant differences in mortality rates between positive and negative patient populations. Another notable difference was that COVID-19 positive patients were more prone to mesenteric ischemia and intra-abdominal haemorrhage compared with negative patient populations. This research helps to guide surgeons on how best to manage COVID-19-positive patients by

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identifying the clinical course that such patients are expected to follow during emergency surgeries and how such surgeries can be conducted safely with appropriate patient care.

Introduction

Serious questions have been raised concerning whether the rapidly spreading severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), also known as COVID-19, was caused by the virus or by other factors. One important feature of this virus was its fast rate of mutation, which implies that the viral genome changes as it travels through different environments (1). On February 22, 2020, the first COVID-19-infected patient case was reported in Najaf, Iraq. Following that, reports of an increasing number of cases and fatalities began to emerge (2).

Several organisations created new recommendations that informed surgeons on what treatments to perform in response to the COVID-19 outbreak (3, 4). In this challenging situation, only emergency, cardiovascular, and oncological operations were routinely performed, which exacerbated the issue of non-COVID-19 patients' delayed emergency presentations (5, 6). Research revealed that during the pandemic, more people postponed receiving treatment, and there were fewer emergency admissions overall (7, 8). Due to the possibility of a worse prognosis, this delayed presentation should be regarded as a serious healthcare concern. Emergency surgery was associated with poorer outcomes in COVID-19 patients. When considering elderly and vulnerable individuals, who frequently contract COVID-19, the risks could be substantially increased. The mortality rate could reach 40% in the presence of COVID-19, compared to 23% in the same group in the absence of the virus (9, 10).

Delaying definitive surgical therapy for acute surgical conditions could lead to a considerable rise in morbidity and mortality rates, in contrast to elective procedures, which could usually be postponed with minimal danger to patients. Patients might be more vulnerable to negative outcomes if elective and urgent surgeries were generally delayed. Information about the prognosis and course of treatment for surgical patients with COVID-19 was urgently needed, and current guidelines advised against non-delayable procedures (11, 12, 13, 14, 15).

As the scientific community continues to study the disease process and its effects on specific organ systems, acute surgical care must be maintained. Understanding how the COVID-19 pandemic might impact post-operative outcomes in both elective and emergency surgery was also critical. Acute care surgical activity decreased in Spain, Italy, and other COVID-19-affected countries during the pandemic peaks (11, 12).

The restructuring of surgical activities under COVID-19 has been covered in several publications. Nevertheless, very few have examined the impact on the management of acute abdominal pain and emergency trauma surgery (16). Residency trainees in Medicine, Surgery, and specialised fields have also faced enormous, distinct, and unprecedented challenges. These difficulties stem from their crucial role in providing medical and surgical care to COVID-19 patients as well as their obligation to maintain an appropriate and dynamic learning environment while taking appropriate personal safety precautions. Surgical practice underwent substantial modification during this period (17). Inflammatory alterations are among the gastrointestinal and abdominal complications that can result from COVID-19 infection. COVID-19-positive patients were shown to have higher surgical risks and worse outcomes during the pandemic, and many patients arrived late with more serious abdominal problems. The Kirkuk Governorate has limited information on the surgical outcomes of these individuals. Examining these cases will yield valuable local data to enhance surgical decision-making, patient outcomes, and surgical teams' safety procedures.

Materials and Methods

Study Design, Setting, and Period

The current study was a retrospective case-control study conducted to assess the preoperative characteristics, intraoperative findings, and postoperative outcomes of patients who tested positive for COVID-19 and underwent emergency abdominal surgery. Azadi Teaching Hospital in Kirkuk City, Iraq, which serves as the major referral facility for urgent surgical cases in the governorate, was the study site. Data were gathered from all qualifying cases that presented between March 1st, 2020 and September 1st, 2021.

Study Population and Eligibility Criteria

We conducted a retrospective review of all consecutive adult patients (≥ 18 years) who underwent emergency abdominal surgery at Azadi Teaching Hospital during the study period.

Inclusion criteria

Emergency operative management for acute abdominal pathology and availability of preoperative COVID-19 testing (chest CT-scan and/or serological testing for anti-COVID-19 antibodies).

Exclusion criteria

Elective surgical procedures, age less than 18 years, and incomplete medical records prevented data extraction.

The study included 350 participants 146 COVID-19-positive patients and 204 COVID-19-negative patients who underwent emergency abdominal surgery. The participants included 87 male and 57 female patients in the COVID-positive group, and 113 male and 91 female patients in the non-COVID-19 group, with ages ranging from 20 to 70 years.

Body Mass Index Classification

The World Health Organisation's (WHO) body mass index (BMI) guidelines were used to determine obesity classification. BMI was calculated by dividing weight in kilograms by height in meters squared, with the following categories:

Underweight: BMI < 18.5 kg/m²

Normal weight: BMI 18.5-24.9 kg/m²

Overweight: BMI 25-29.9 kg/m²

Obese: BMI 30-39.9 kg/m² (18)

COVID-19 Detection Methods

CT-Scan Assessment

All patients underwent chest CT-scanning (Siemens Co.) to evaluate for pulmonary findings suggestive of SARS-CoV-2 infection. CT findings consistent with COVID-19 pneumonia included bilateral ground-glass opacities, consolidation, and typical peripheral distribution patterns. The control group (COVID-19-negative) had CT scans showing no evidence of SARS-CoV-2-related pulmonary changes.

Serological Testing

Detection of anti-COVID-19 IgM and IgG antibodies was performed using a commercial kit (ANHUI DEEPBLUE MEDICAL TECHNOLOGY CO., LTD, Lot No. 20231201, Made in Germany). All testing procedures were conducted strictly according to the manufacturer's recommendations. Patients were classified as COVID-19-positive if they had either characteristic CT findings consistent with COVID-19 pneumonia or positive serology (IgM and/or IgG antibodies), or both. Timing of testing relative to surgery was recorded from hospital records, with all tests performed within 48 hours of hospital admission.

Laboratory Parameters

The following laboratory parameters were extracted from hospital records for all participants: C-reactive protein (CRP) levels, serum creatinine, blood urea, and lymphocyte percentages. All measurements were obtained

from preoperative blood samples collected at the time of hospital admission.

Data Collection and Variable Definitions

Clinical Variables

Data collected included demographic information (age, sex), presenting symptoms (including respiratory symptoms), comorbid conditions (hypertension, diabetes mellitus, chronic obstructive pulmonary disease, heart-related conditions), and ICU admission status before surgery.

Surgical Variables

The surgical approach was categorised as open or laparoscopic. Intraoperative peritoneal exudate was classified as none, serous, localised purulent, or diffuse purulent based on the surgeon's intraoperative description. Blood loss during surgery was estimated by the anaesthesia team and categorised as <100 mL, 101-500 mL, 501-1000 mL, or >1000 mL.

Surgical Complexity

The complexity of surgery was classified as minor, moderate, or major based on the operative time, extent of dissection, and technical difficulty as documented in operative notes. Minor procedures included simple appendectomies and hernia repairs; moderate procedures included cholecystectomies and bowel resections without extensive dissection; major procedures included complex bowel resections, mesenteric ischemia interventions, and procedures requiring extensive retroperitoneal dissection.

Postoperative Outcomes

Postoperative complications were defined as any deviation from the normal postoperative course occurring within 30 days of surgery, recorded in clinical notes. Length of hospital stay was calculated from the date of surgery to the date of discharge or death. Clinical outcome at discharge was recorded as released (discharged home) or death during hospitalisation.

Statistical Analysis

Computerised statistical analysis was performed using SPSS (Statistical Package for Social Sciences) version 26. Numerical variables were presented as mean $\pm$ standard deviation and analysed using the unpaired Student's t-test. Categorical variables were presented as frequencies and percentages and analysed using the Chi-square test. Correlation between continuous variables was assessed using the Pearson correlation coefficient.

Given the retrospective observational design, we did not perform multivariable adjustment due to the absence of an a priori analysis plan and the

exploratory nature of the study. However, we acknowledge that unmeasured confounding may influence the observed associations, and this limitation is addressed in the discussion.

Results were deemed statistically significant at $p < 0.05$, highly significant at $p < 0.01$, and non-significant at $p > 0.05$. All tests were two-tailed.

Results

Participant Characteristics

A total of 350 patients who underwent emergency abdominal surgery during the study period met the inclusion criteria. Of these, 146 (41.7%) were classified as COVID-19-positive and 204 (58.3%) as COVID-19-negative. The demographic and baseline clinical characteristics of both groups are presented in Table 1.

Table 1: Study Population's Demographics, Co-morbidities, Clinical, Analytical and Surgical Factors

Variables	COVID-19-Positive No. (%) N=146	COVID-19-Negative No. (%) N=204	P Value
Sex			0.445
Male	87 (59.6)	113 (55.4)	
Female	59 (40.4)	91 (44.6)	
Mean age (years) $\pm$ SD	51.64 $\pm$ 13.79	47.57 $\pm$ 18.85	0.31
BMI (Kg/m²)			0.169
Underweight	6 (4.1)	2 (1.0)	
Normal weight	50 (34.2)	65 (31.9)	
Overweight	60 (41.1)	83 (40.7)	
Obese	30 (20.5)	54 (26.5)	
Respiratory system			<0.0001
Normal	60 (41.1)	140 (68.6)	
Dyspnoea with exercise	40 (27.4)	33 (16.2)	
Dyspnoea at rest	46 (31.5)	31 (15.2)	
Underlying diseases			0.007
Hypertension	50 (34.2)	90 (44.1)	
Diabetes Mellitus	32 (21.9)	61 (29.9)	
COPD	25 (17.1)	20 (9.8)	
Heart-related conditions	39 (26.7)	33 (16.2)	
ICU admission before surgery			0.051
Urgent	90 (61.6)	144 (70.6)	
Emergency	56 (38.4)	60 (29.4)	
Laboratory Findings (Mean $\pm$ SD)			
CRP (mg/L)	15.2 $\pm$ 7.8	6.48 $\pm$ 3.05	<0.0001
Lymphocyte %	21.4 $\pm$ 5.66	35.95 $\pm$ 4.05	<0.0001
Blood Urea (mg/dL)	48.75 $\pm$ 15.72	28.10 $\pm$ 8.39	<0.0001
Serum Creatinine (mg/dL)	1.94 $\pm$ 1.25	0.68 $\pm$ 0.29	<0.0001
Surgical method			0.164
Open	83 (56.8)	104 (51.0)	
Laparoscopic	63 (43.2)	100 (49.0)	
Intraoperative peritoneal exudate			0.272
None	74 (50.7)	100 (49.0)	
Serous	55 (37.7)	67 (32.8)	
Localized purulent	10 (6.8)	27 (13.2)	
Diffuse purulent	7 (4.8)	10 (4.9)	
Blood loss during surgery (mL)			0.022
<100	100 (68.5)	160 (78.4)	
101-500	24 (16.4)	33 (16.2)	
501-1000	15 (10.3)	8 (3.9)	
>1000	7 (4.8)	3 (1.5)	
Complexity of surgery			0.005
Minor	46 (31.5)	34 (16.7)	
Moderate	60 (41.1)	100 (49.0)	

Major

40 (27.4)

70 (34.3)

Chi-square test used for categorical variables; unpaired t-test used for numerical variables. Bold p-values indicate statistical significance

Demographics

Among COVID-19-positive patients, 87 (59.6%) were male, and 59 (40.4%) were female, compared to 113 (55.4%) male and 91 (44.6%) female patients in the COVID-19-negative group. This difference was not statistically significant ($p=0.445$). The mean age of COVID-19-positive patients was 51.64 ± 13.79 years, while COVID-19-negative patients had a mean age of 47.57 ± 18.85 years, with no significant difference between groups ($p=0.310$).

Body Mass Index

In the COVID-19-positive group, the highest proportion (60 patients, 41.1%) were overweight, followed by 50 (34.2%) with normal weight, 30 (20.5%) obese, and 6 (4.1%) underweight. Among COVID-19-negative patients, 83 (40.7%) were overweight, 65 (31.9%) had normal weight, 54 (26.5%) were obese, and only 2 (1.0%) were underweight. These differences in BMI distribution between groups were not statistically significant ($p=0.169$).

Respiratory Symptoms

Highly significant differences were observed between groups regarding respiratory system involvement ($p<0.0001$). Among COVID-19-positive patients, only 60 (41.1%) had normal respiratory status, while 40 (27.4%) experienced dyspnoea with exercise and 46 (31.5%) had dyspnoea at rest. In contrast, 140 (68.6%) of COVID-19-negative patients had normal respiratory status, with only 33 (16.2%) reporting dyspnoea with exercise and 31 (15.2%) experiencing dyspnoea at rest.

Comorbid Conditions

The distribution of underlying diseases differed significantly between groups ($p=0.007$). Hypertension was present in 50 (34.2%) of COVID-19-positive patients compared to 90 (44.1%) of COVID-19-negative patients. Diabetes mellitus was documented in 32 (21.9%) of COVID-19-positive patients versus 61 (29.9%) of COVID-19-negative patients. Chronic obstructive pulmonary disease (COPD) was more common in COVID-19-positive patients (25, 17.1%) than in COVID-19-negative patients (20, 9.8%). Heart-related conditions were also more prevalent in the COVID-19-positive group (39, 26.7%) compared to the COVID-19-negative group (33, 16.2%).

ICU Admission Before Surgery

Before surgical intervention, 90 (61.6%) of COVID-19-positive patients required urgent ICU admission compared to 144 (70.6%) of COVID-19-negative patients. Emergency ICU admission was required for 56 (38.4%) of COVID-19-positive patients and 60 (29.4%) of COVID-19-negative patients. These differences approached but did not reach statistical significance ($p=0.051$).

Laboratory Findings

Marked differences in laboratory parameters were observed between the two groups, as shown in Table 1. COVID-19-positive patients demonstrated significantly higher mean CRP levels (15.2 ± 7.8 mg/L) compared to COVID-19-negative patients (6.48 ± 3.05 mg/L; $p<0.0001$). Conversely, lymphocyte percentages were significantly lower in COVID-19-positive patients ($21.4 \pm 5.66\%$) than in COVID-19-negative patients ($35.95 \pm 4.05\%$; $p<0.0001$).

Renal function parameters also differed significantly between groups. Mean blood urea levels were elevated in COVID-19-positive patients (48.75 ± 15.72 mg/dL) compared to COVID-19-negative patients (28.10 ± 8.39 mg/dL; $p<0.0001$). Similarly, serum creatinine was higher in the COVID-19-positive group (1.94 ± 1.25 mg/dL) than in the COVID-19-negative group (0.68 ± 0.29 mg/dL; $p<0.0001$).

Surgical Approach and Intraoperative Findings

Surgical Method: Among COVID-19-positive patients, 83 (56.8%) underwent open surgery while 63 (43.2%) had laparoscopic procedures. In the COVID-19-negative group, 104 (51.0%) had open surgery, and 100 (49.0%) underwent laparoscopic surgery. These differences were not statistically significant ($p=0.164$).

Intraoperative Peritoneal Exudate

Most COVID-19-positive patients (74, 50.7%) had no peritoneal exudate, followed by 55 (37.7%) with serous exudate, 10 (6.8%) with localised purulent exudate, and 7 (4.8%) with diffuse purulent exudate. Similar patterns were observed in COVID-19-negative patients, with no significant differences between groups ($p=0.272$).

Blood Loss During Surgery

Significant differences in estimated blood loss were noted between groups ($p=0.022$). Among COVID-19-positive patients, 100 (68.5%) lost <100 mL, 24 (16.4%) lost 101-500 mL, 15

(10.3%) lost 501-1000 mL, and 7 (4.8%) lost >1000 mL. In the COVID-19-negative group, 160 (78.4%) lost <100 mL, 33 (16.2%) lost 101-500 mL, 8 (3.9%) lost 501-1000 mL, and 3 (1.5%) lost >1000 mL.

Surgical Complexity

The distribution of surgical complexity differed significantly between groups ($p=0.005$). In COVID-19-positive patients, 46 (31.5%) underwent minor procedures, 60 (41.1%) moderate procedures, and 40 (27.4%) major procedures. Among COVID-19-negative patients, 34 (16.7%) had minor procedures, 100 (49.0%) moderate procedures, and 70 (34.3%) major procedures.

Postoperative Outcomes

Length of Hospital Stay: As shown in Table 2, COVID-19-positive patients had significantly

longer hospital stays compared to COVID-19-negative patients (19.5 ± 5.65 days vs 8.10 ± 3.66 days; $p < 0.0001$).

Postoperative Complications: Complications following surgery occurred in 63 (43.2%) of COVID-19-positive patients compared to only 53 (26.0%) of COVID-19-negative patients, a highly significant difference ($p=0.001$). Conversely, 83 (56.8%) of COVID-19-positive patients had no complications versus 151 (74.0%) of COVID-19-negative patients.

Clinical Outcome: Despite the increased morbidity, mortality rates were comparable between groups. In the COVID-19-positive group, 139 (95.2%) patients were discharged, and 7 (4.8%) died, while in the COVID-19-negative group, 200 (98.0%) were discharged, and 4 (2.0%) died. This difference was not statistically significant ($p=0.212$).

Table 2: Postoperative Outcomes for Patients with Acute Abdominal Pain

Features	COVID-19-Positive No. (%) N=146	COVID-19-Negative No. (%) N=204	P Value
Duration of hospital stay (days) Mean $\pm$ SD	19.5 $\pm$ 5.65	8.10 $\pm$ 3.66	<0.0001
Complications following surgery			0.001
No	83 (56.8)	151 (74.0)	
Yes	63 (43.2)	53 (26.0)	
Clinical outcome			0.212
Discharged	139 (95.2)	200 (98.0)	
Died	7 (4.8)	4 (2.0)	

Bold p-values indicate statistical significance.

Correlation Analysis

Figure 1 illustrates a significant positive correlation between age and CRP levels among COVID-19-positive patients (Pearson correlation

coefficient = 0.544, $p < 0.01$). This indicates that older COVID-19-positive patients tended to have higher inflammatory responses as measured by CRP.

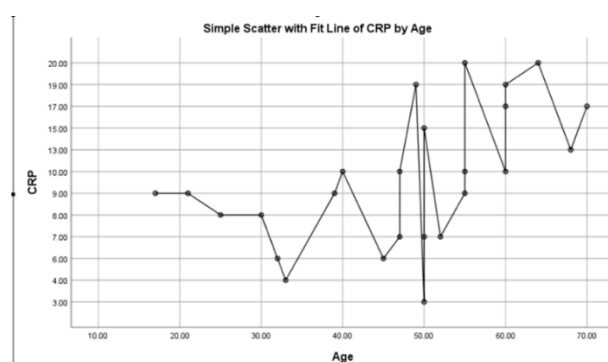


Figure 1: Correlation between Age and CRP Levels in COVID-19-Positive Patients

This scatter plot illustrates the significant positive correlation between patient age and C-reactive protein (CRP) levels among the 146 COVID-19-positive patients undergoing emergency abdominal surgery. Pearson correlation coefficient = 0.544, $p < 0.01$. The regression line demonstrates that older patients tended to have higher inflammatory responses as measured by

CRP concentration (mg/L). This finding suggests that age-related differences in immune-inflammatory responses may contribute to the increased severity of COVID-19 observed in older adults.

Surgical Diagnoses at Presentation

Table 3 presents the distribution of surgical diagnoses between the two groups. Notable differences were observed in the patterns of surgical pathology:

Severe Appendicitis

Twenty-five (17.12%) of COVID-19-positive patients presented with severe appendicitis compared to only 10 (4.90%) of COVID-19-negative patients.

Peptic Ulcer Perforation

This diagnosis was far more common in COVID-19-negative patients, affecting 168 (82.35%)

compared to only 13 (8.90%) of COVID-19-positive patients.

Mesenteric Acute Ischemia

A striking difference was observed for mesenteric ischemia, which affected 57 (39.04%) of COVID-19-positive patients but only 12 (5.88%) of COVID-19-negative patients.

Retroperitoneal Bleeding

Similarly, retroperitoneal bleeding was diagnosed in 51 (34.93%) of COVID-19-positive patients compared to only 14 (6.86%) of COVID-19-negative patients.

Table 3: Comparison of Surgical Diagnoses at Presentation Between Groups

Diagnosis by Surgery	COVID-19-Positive No. (%) N=146	COVID-19-Negative No. (%) N=204
Severe appendicitis	25 (17.12)	10 (4.90)
Peptic ulcer perforation	13 (8.90)	168 (82.35)
Mesenteric acute ischemia	57 (39.04)	12 (5.88)
Retroperitoneal bleeding	51 (34.93)	14 (6.86)
Total	146 (100%)	204 (100%)

Discussion

This study, which was conducted as a retrospective case-control study in one of the most prestigious hospitals in Kirkuk, Iraq, provides valuable insights about the effect of COVID-19 infection in patients undergoing emergency abdominal surgery during the COVID-19 pandemic period. The results showed that patients with COVID-19 infection have a different clinical profile, a more complicated postoperative course, a longer hospital stay, yet a comparable mortality rate with patients without COVID-19 infection.

Demographic and Clinical Characteristics

The study also reveals a male dominance in COVID-19-positive patients, i.e., 59.6%, which agrees with the increasing body of evidence showing that COVID-19 disease severity is subject to sex-related variations, with more severe disease manifestations in male patients (19). The gender difference may be attributed to variations in immune responses, hormonal influences, or a greater prevalence of underlying conditions in male patients. The average age of COVID-19-positive patients in the current study is 51.64 ± 13.79 years, which is in agreement with the hypothesis that increasing age is a significant prognostic factor for adverse outcomes in COVID-19, as well as in SARS-CoV-2 infections in general (20), with no significant difference in age between the groups under investigation.

A high percentage of overweight (41.1%) and obese (20.5%) patients in the COVID-19-positive

group also supports earlier observations showing that high body weight is a vulnerability factor for COVID-19 disease severity (21). The high prevalence of respiratory symptoms in COVID-19-positive patients, with more than half of them presenting with dyspnoea, is also in agreement with the pulmonary tropism of SARS-CoV-2, as well as the high incidence of hypoxemic respiratory failure, which requires perioperative management in COVID-19 patients (22). The high prevalence of chronic obstructive pulmonary disease and cardiovascular conditions in COVID-19-positive patients also highlights the significance of cardiopulmonary function in determining perioperative outcomes in COVID-19 patients.

Laboratory Markers and Disease Severity

Significantly elevated C-reactive protein levels in COVID-19-positive patients, i.e., 15.2 ± 7.8 mg/L as opposed to 6.48 ± 3.05 mg/L, reflect the high degree of systemic inflammation, a hallmark of SARS-CoV-2 infection. C-reactive protein, an acute-phase reactant induced in response to interleukin-6, has been consistently linked with disease severity and prognosis in COVID-19 patients (23). The positive correlation of age with C-reactive protein levels in COVID-19-positive patients, as depicted in Figure 1, suggests that elderly patients show more pronounced inflammatory responses, which may be a contributory factor to their increased disease severity.

Lymphopenia, a hallmark of COVID-19, was also observed in COVID-19-positive patients, i.e., $21.4 \pm 5.66\%$ as opposed to $35.95 \pm 4.05\%$ in COVID-19-negative patients. The direct effect of SARS-CoV-2 on lymphocytes with ACE2 receptors contributes to lymphopenia, which in turn results in immune system dysregulation, increasing the host's susceptibility to secondary infections (23). The concomitant elevation of C-reactive protein and lymphopenia in COVID-19-positive patients reflects the typical immune-inflammatory profile in COVID-19 patients with moderate to severe disease.

Significantly elevated renal parameters, i.e., urea and creatinine, in COVID-19-positive patients may be due to a variety of reasons, such as direct viral injury to renal tissue, cytokine-mediated injury, prerenal azotaemia from dehydration or decreased oral intake, as well as thrombotic microangiopathy involving renal vasculature, as suggested in COVID-19 patients (23).

Surgical Approach and Intraoperative Findings

The similarity in rates of open and laparoscopic surgery between groups ($p = 0.164$) shows that COVID-19 status did not significantly influence surgical modality at our centre. This result is at variance with earlier recommendations for the avoidance of laparoscopy in COVID-19 patients due to theoretical risks of viral aerosolisation during minimally invasive surgical techniques (24). More recent investigations have not consistently shown SARS-CoV-2 in peritoneal fluid or surgical plume in most patients (24, 25), supporting the safety of laparoscopic techniques in these patients when properly employed.

The marked difference in intraoperative blood loss between COVID-19-positive and control patients, with 4.8% of COVID-19-positive patients experiencing blood loss of more than 1000 mL compared with 1.5% of controls ($p = 0.022$), may be due to coagulopathy associated with COVID-19. SARS-CoV-2 infection can cause hypercoagulopathy by endothelial injury, inflammation, and activation of the complement cascade (26). Paradoxically, this hypercoagulable state can result in bleeding tendencies in some patients, especially those receiving anticoagulation (26). The greater proportion of major surgical cases in COVID-19-positive patients (27.4% compared with 16.7% in controls) may also have contributed to this finding.

Postoperative Outcomes

The significantly longer hospital stays (19.5 ± 5.65 vs. 8.10 ± 3.66 days, $p < 0.001$) and increased complication rate (43.2% vs. 26.0%, $p = 0.001$) among COVID-19 positive patients are in keeping with other international cohorts (27,

28). Several factors presumably contribute to this increased morbidity. The systemic inflammatory response associated with COVID-19 infection may impair healing and increase susceptibility to infection. In addition, respiratory compromise may delay recovery and mobilisation. Finally, infection control precautions may have contributed to a longer hospital stay even after successful surgical recovery.

Despite these challenges, the mortality rates between groups are comparable (4.8% vs. 2.0%, $p = 0.212$). These results differ from early pandemic reports, suggesting significantly increased postoperative mortality among COVID-19-positive patients. In fact, some studies have suggested mortality rates as high as 20% (29). The improved outcomes in this study may be attributed to several factors. These include a better understanding of perioperative COVID-19 management in mid-2020. In addition, meticulous patient selection for surgical intervention, improved infection control practices, and the value of clinical experience are also likely contributing factors. Finally, the use of computed tomography and serological markers in COVID-19 diagnosis may have identified a cohort with a more favourable prognosis compared with other studies relying on RT-PCR.

Distinct Surgical Diagnoses in COVID-19 Patients

Perhaps our most striking findings relate to the different patterns of surgical pathology between groups. The high proportion of COVID-19-positive patients presenting with mesenteric ischemia (39.04%) and retroperitoneal bleeding (34.93%) compared to controls (5.88% and 6.86%, respectively) points to specific COVID-19-associated abdominal complications.

Mesenteric ischemia in COVID-19 patients likely results from the virus's pro-thrombotic effects. SARS-CoV-2 infection induces endothelialitis, microvascular thrombosis, and a hypercoagulable state that can compromise mesenteric circulation (30). Patients may present with acute abdominal pain out of proportion to physical findings, and the diagnosis requires a high index of suspicion. The history of postprandial pain or "food fear" in some patients suggests that chronic mesenteric ischemia may have been present before acute thrombotic events (30).

Retroperitoneal bleeding in COVID-19 patients has been increasingly recognised, particularly in those receiving therapeutic anticoagulation for thromboprophylaxis (26). The combination of coagulopathy, anticoagulant use, and possibly vessel wall inflammation may predispose to spontaneous haemorrhage. This complication

carries high morbidity and requires careful consideration of anticoagulation risks and benefits in COVID-19 patients.

The higher rate of severe appendicitis in COVID-19-positive patients (17.12% vs 4.90%) may reflect delayed healthcare seeking during the pandemic, as patients with mild symptoms may have avoided hospital presentation until disease progression occurred (31). Alternatively, inflammation from COVID-19 may worsen appendiceal pathology. The significantly lower rate of peptic ulcer perforation in COVID-19-positive patients was unexpected and might be due to differences in patient characteristics, drug intake such as NSAIDs and steroids, and referral patterns during the pandemic. Some studies have indicated that patients with COVID-19 might have atypical abdominal complaints, which might mask peptic ulcer disease (32).

Study Limitations and Future Directions

Overall, there are certain limitations to the study, which need to be taken into consideration while interpreting the results. First, the retrospective nature of the study may have certain limitations in terms of selection bias, which may affect the ability to establish causality, though every effort was made to reduce such bias by studying consecutive patients and using standardised case record forms to extract the data.

Second, the definition of COVID-19 cases was based on CT results along with serology, rather than RT-PCR, which is considered the gold standard for the diagnosis of active infections. This may have created a certain type of bias, as the results from CT may be non-specific, though RT-PCR may not have been available during the initial phase of the pandemic in Iraq, as in the rest of the world, and the results reflect a practical approach to the diagnosis of COVID-19 in a clinical scenario.

Third, the results may not be generalizable to settings with different populations, as the study was conducted in a single centre, though the results may not be generalizable to settings with different COVID-19 prevalence, variant types, and treatment practices.

Fourth, there was no multivariable adjustment for possible confounding variables such as age, comorbidity burden, and complexity of surgery. Therefore, it is possible that confounding variables rather than the virus itself might be responsible for the observed associations with patient outcomes. Therefore, it is recommended that future studies use more advanced methodologies to overcome this limitation.

Fifth, there was limited information on the disease severity of COVID-19, time from infection to surgery, type of treatment used, and cause-specific mortality rates. These variables might be

critical determinants of patient outcomes and should be included in future prospective studies. Sixth, there was limited information on how complications were defined and classified and whether it was based on any grading system, such as the Clavien-Dindo system.

In spite of all these limitations, this study contributes valuable data from a resource-limited setting and during a critical time in history. Future studies should be prospective and include all possible variables, including the severity of disease and treatment variables used in the patient population with COVID-19. Mechanistic studies on the possible mechanisms responsible for specific complications due to COVID-19, such as mesenteric ischemia and retroperitoneal bleeding, might provide valuable insights into the prevention and treatment of such complications. Similarly, studies on long-term outcomes in patients with COVID-19 who undergo surgery might provide valuable insights into patient outcomes after discharge from the hospital.

Clinical Implications

The results have several implications for surgeons dealing with COVID-19-infected individuals who undergo emergency abdominal surgery. First, the increased rates of mesenteric ischemia and retroperitoneal bleeding should increase clinical suspicion for these conditions in relevant clinical scenarios. Second, the increased complication rates and prolonged hospital stays underscore the importance of providing additional support and care. Third, similar mortality rates suggest that emergency surgery in COVID-19-infected individuals can be safely conducted with appropriate precautions and patient care when clinically indicated. Finally, different rates for each complication underscore the importance of considering the patient's status regarding COVID-19 in preoperative assessment and planning.

Conclusions

SARS-CoV-2 infection was associated with specific clinical manifestations, more severe inflammatory and biochemical profiles, increased postoperative complications, and longer hospital stay in patients undergoing emergency abdominal surgery during the COVID-19 pandemic. In this study, COVID-19-positive patients showed a higher incidence of mesenteric ischaemia and retroperitoneal bleeding, while peptic ulcer perforation was more common in non-infected patients. Despite these complications, mortality rates were comparable between groups. These results support the safety of emergency abdominal surgery in COVID-19 patients with proper perioperative care. These results add to the expanding body of literature on

the outcomes of abdominal surgery in COVID-19 patients. These results could have important implications in the clinical care of patients in similar settings. Further investigations are required to validate these results.

List of Abbreviations

BMI: Body Mass Index
 CI: Confidence Interval
 COPD: Chronic Obstructive Pulmonary Disease
 COVID-19: Coronavirus Disease 2019
 CRP: C-reactive Protein
 CT: Computed Tomography
 DM: Diabetes Mellitus
 ICU: Intensive Care Unit
 IgM: Immunoglobulin M
 IgG: Immunoglobulin G
 OR: Odds Ratio
 PCR: Polymerase Chain Reaction
 RT-PCR: Reverse Transcription
 Polymerase Chain Reaction
 SARS-CoV-2: Severe Acute Respiratory
 Syndrome Coronavirus 2
 SD: Standard Deviation
 SPSS: Statistical Package for Social Sciences
 WHO: World Health Organisation

Declarations

Ethics Approval and Consent to Participate

This study was approved by the Institutional Review Board of the College of Medicine, University of Kirkuk (Approval Number: 45/2022 dated 15 January 2022). Due to the retrospective nature of the study and the use of de-identified patient data, the requirement for written informed consent was waived by the IRB.

Consent for Publication

All authors have reviewed the final manuscript and give their consent for publication under the Creative Commons Attribution Non-Commercial 4.0 license.

Data Availability

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

Competing Interests

The authors declare that they have no competing interests, financial or non-financial, related to this work.

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Author Contributions

AHQ: Conceptualisation, Methodology, Investigation, Writing – Original Draft, Supervision, Project administration
 SAH: Methodology, Formal analysis, Investigation, Data Curation, Writing – Review & Editing
 MDO: Investigation, Resources, Visualisation, Writing – Review & Editing

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