OXFORD

BJS, 2021, 1–10
DOI: 10.1093/bjs/znab299
Original Article

Analysis of outcomes of emergency general and gastrointestinal surgery during the COVID-19 pandemic

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Abstract

Background: Few surgical studies have provided adjusted comparative postoperative outcome data among contemporary patients with and without COVID-19 infection and patients treated before the pandemic. The aim of this study was to determine the impact of performing emergency surgery in patients with concomitant COVID-19 infection.

Methods: Patients who underwent emergency general and gastrointestinal surgery from March to June 2020, and from March to June 2019 in 25 Spanish hospitals were included in a retrospective study (COVID-CIR). The main outcome was 30-day mortality. Secondary outcomes included postoperative complications and failure to rescue (mortality among patients who developed complications). Propensity score-matched comparisons were performed between patients who were positive and those who were negative for COVID-19; and between COVID-19-negative cohorts before and during the pandemic.

Results: Some 5307 patients were included in the study (183 COVID-19-positive and 2132 COVID-19-negative during pandemic; 2992 treated before pandemic). During the pandemic, patients with COVID-19 infection had greater 30-day mortality than those without (12.6 *versus* 4.6 per cent), but this difference was not statistically significant after propensity score matching (odds ratio (OR) 1.58, 95 per cent c.i. 0.88 to 2.74). Those positive for COVID-19 had more complications (41.5 *versus* 23.9 per cent; OR 1.61, 1.11 to 2.33) and a higher likelihood of failure to rescue (30.3 *versus* 19.3 per cent; OR 1.10, 0.57 to 2.12). Patients who were negative for COVID-19 during

Received: February 12, 2021. **Accepted:** July 25, 2021

the pandemic had similar rates of 30-day mortality (4.6 *versus* 3.2 per cent; OR 1.35, 0.98 to 1.86) and complications (23.9 *versus* 25.2 per cent; OR 0.89, 0.77 to 1.02), but a greater likelihood of failure to rescue (19.3 *versus* 12.9 per cent; OR 1.56, 95 per cent 1.10 to 2.19) than prepandemic controls.

Conclusion: Patients with COVID-19 infection undergoing emergency general and gastrointestinal surgery had worse postoperative outcomes than contemporary patients without COVID-19. COVID-19-negative patients operated on during the COVID-19 pandemic had a likelihood of greater failure-to-rescue than prepandemic controls.

Introduction

Since the beginning of 2020, the rapid spread of the COronaVIrus-19 Disease (COVID-19) has stressed many healthcare systems worldwide, forcing cancellation of most programmed operations[1–5]. However, non-delayable procedures have continued to be performed, sometimes in patients infected by COVID-19[6,7]. Patients undergoing emergency surgery are at higher risk of postoperative complications and death than those having elective interventions[8,9]. In addition, patients testing positive for COVID-19 could be susceptible to poor postoperative outcomes owing to synergistic immunological dysregulation, a hyperinflammatory response to surgery, and the need for mechanical ventilation[10–15]. Therefore, clinicians face the dilemma of opting for uncertain conservative management of COVID-19-positive patients with potentially urgent surgical conditions[12–14,16,17].

Most guidelines and recommendations are of limited help, as they are based on expert opinion[18–21]. Cohort studies[11–14] of patients infected with COVID-19 who have undergone surgery have reported poor postoperative outcomes. However, these findings should be read with caution, as patients with COVID-19 infection were older, with more baseline co-morbidities, and in poorer clinical condition. Besides, during the pandemic, all patients were at risk of worse-than-expected outcomes: fear of, or difficulty in, visiting hospitals could have allowed surgical pathologies to reach a more advanced stage at consultation[21–23], and hospitals' work overload may have made rescue from postoperative complications difficult[9,23–25]. Careful benchmarking is therefore needed in order to understand the specific increased risk of performing surgery in patients infected with COVID-19 and assist evidence-based decision-making. Currently, there are no surgical studies providing an adjusted comparison of postoperative outcomes among patients testing positive for COVID-19, contemporary COVID-19-negative patients, and those treated before the pandemic.

The aim of this cohort study was to determine the outcomes of performing emergency surgery in patients with concomitant COVID-19 infection.

Methods

Study design

This was a multicentre retrospective study of patients undergoing emergency general and gastrointestinal surgery at 25 Spanish hospitals. The study protocol (COVID-CIR) was approved by the institutional review board at the leading and participating hospitals, and has already been published[26]. Informed patient consent was waived given the retrospective nature of the study. The study was carried out conducted in accordance with the principles of the Declaration of Helsinki and data were reported as stated in the STROBE checklist[27]. A high degree of confidentiality, in compliance with the provisions of personal data protection as required by Spanish Law (LOPD 3/2018), was ensured. The protocol was registered at ClinicalTrials.gov (NCT04479150, 21 July 2020).

Three cohorts of patients who underwent emergency general or gastrointestinal surgery were defined: cohort 1—patients infected with COVID-19 who had surgery between 1 March and 30 June 2020; cohort 2—patients not infected with COVID-19 who had surgery between 1 March and 30 June 2020; and cohort 3—patients operated on between 1 March and 30 June 2019 before the COVID-19 pandemic.

Participants

Participant hospitals and investigators are detailed in *Table S1*. All patients aged 18 years or more undergoing emergency gastrointestinal or general surgery during the pandemic and prepandemic periods were included. Programmed procedures were excluded, but emergency reinterventions to treat complications of elective operations were included. If patients had multiple emergency operations, the first was considered as the index procedure. Systematic preoperative detection of viral RNA in nasopharyngeal samples by quantitative RT–PCR was established in participating hospitals from the beginning of March 2020. Patients were considered to be COVID-19-positive if confirmed by positive RT–PCR testing within 15 days before or 30 days after surgery, or if there was clinical suspicion of COVID-19 infection confirmed by chest CT findings. Otherwise, patients were deemed COVID-19-negative.

Variables

Anonymized data were gathered in an electronic case record form based on REDCap™ (Research Electronic Capture, Vanderbilt University, Nashville, Tennessee, USA) software.

Demographic data included: age, sex, BMI, ASA fitness grade, and previous co-morbidities. Patients were classified according to functional status (ability to perform daily life activities) in three categories: independent, partially dependent, and totally dependent[28].

Data collected on the day of index surgery included: physiological variables (temperature, BP, heart rate, and Glasgow Coma Score); ECG findings; analytical parameters; and inflammatory indices (neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR) and systemic immune-inflammation index (SII, neutrophil × platelet/lymphocyte counts)). Operative variables included: surgical access, malignancy, type and extension of peritoneal exudates, and estimated blood loss. Complexity of surgical procedures was considered minor, moderate, major or major+, as defined originally in the POSSUM scale[29] (*Table S2*). Priority of procedures was classified asemergency, when needed less than 2 h after admission, and urgent if needed during the first 24 h[29]. Scores on two prognostic surgical scales, Portsmouth POSSUM (P-POSSUM) and aLicante sUrgical Community Emergencies New Tool for the enUmeration of Morbidities (LUCENTUM logistic regression), were calculated[29,30]. For patients positive for COVID-19, preoperative or postoperative diagnosis and RT–PCR confirmation was specified.

Outcomes

The main outcome was 30-day mortality from any cause. In the analysis, day 0 was the day of the index surgery. Secondary outcomes were: 90-day mortality; 30-day overall postoperative complications; pulmonary complications (pneumonia, respiratory infection, respiratory failure, pleural effusion, pulmonary atelectasis); thromboembolic complications (deep venous thrombosis, pulmonary embolism, acute myocardial infarction, stroke, acute limb ischemia, acute mesenteric ischaemia); severe complications (graded at least IIIA according to Clavien–Dindo classification); failure to rescue (FTR), defined as the percentage of patients dying as a consequence of any postoperative complication[31]; ICU stay 24 h or more after surgery; hospital readmission within 30 days; surgical reintervention within 30 days; and duration of hospital stay, defined as number of days from admission to discharge or death.

Data quality

Before analysis, the principal investigators confirmed the completeness and accuracy of data with senior surgeons from each centre. Hospitals failing to include at least 90 per cent of eligible patients were excluded to avoid selection bias resulting from incomplete or misleading selection of patients. Patients with relevant missing information (age, sex, functional status, previous co-morbidities, malignancy, COVID-19 infection status, date of surgery, urgency, type and complexity of surgery, 30-day postoperative follow-up) were excluded.

Statistical analysis

Sample size

Owing to the design of the study and the nature of the aim, no formal calculation of sample size was undertaken. The sample size was the number of patients fulfilling the inclusion criteria.

Statistical procedures

Baseline characteristics were summarized by cohort using standard descriptive statistics. A comparison of the raw and adjusted cumulative incidence (and its 95 per cent confident interval) was made between cohorts 1 and 2, and between cohorts 2 and cohort 3. A mixed-effects logistic regression model was used to estimate the odds ratio (OR) to quantify the effect on each outcome. Mixed effects were used to account for centre effects. The adjustment factors used in the model were: sex, age (linear and quadratic term), functional status, chronic obstructive pulmonary disease

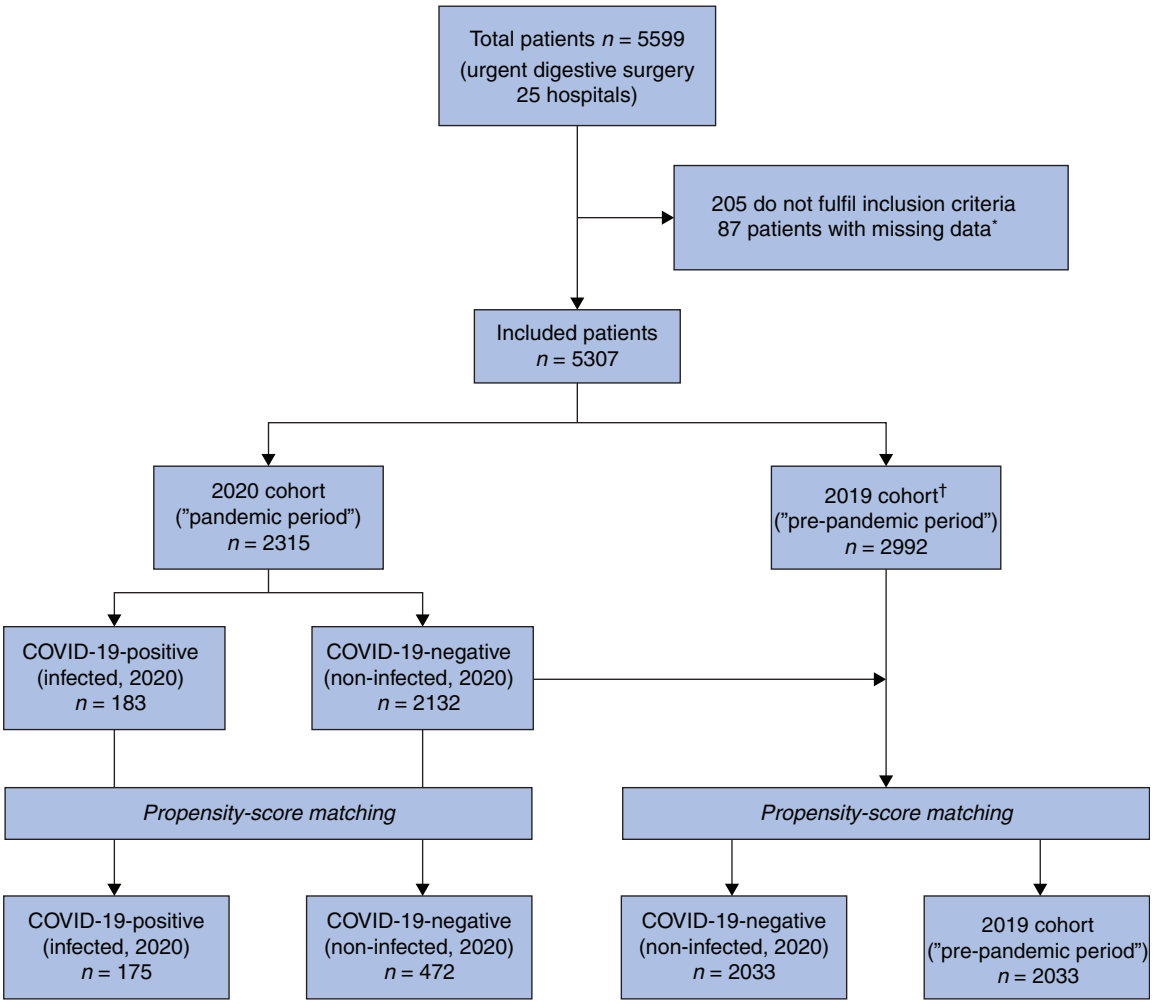

Fig. 1 Study flow diagram

*Excluded patients: those lacking any of the following data: date of surgery, age, gender, functional status, previous pathologies, malignancy, urgency, complexity of surgery, 30-day and 90-day outcomes. †Three hospitals did not provide all consecutive patients from control cohort (2019).

Table 1 Demographics, co-morbidities, and clinical, analytical and surgical variables in the study population

	2020 cohort			
	COVID-19-positive (*n* = 183)	COVID-19-negative (*n* = 2132)	Total (n = 2315)	2019 cohort (*n* = 2992)
Sex				
M	113 (61.7)	1272 (59.7)	1385 (59.8)	1754 (58.6)
F	70 (38.3)	860 (40.3)	930 (40.2)	1238 (41.4)
Age (years)*	63 (48–73)	56 (40–72)	56 (41–72)	57 (40–72)
BMI (kg/m^2)†	27.9 (5.6)	27.2 (5.6)	27.3 (5.6)	27.3 (5.9)
BMI classification				
Underweight	1 (0.7)	35 (2.7)	36 (2.5)	48 (2.7)
Normal weight	43 (30.7)	465 (36.1)	508 (35.6)	604 (33.9)
Overweight	58 (41.4)	442 (34.3)	500 (35.0)	684 (38.4)
Obesity	38 (27.1)	346 (26.9)	384 (26.9)	447 (25.1)
ASA fitness grade				
I	34 (18.7)	612 (28.9)	646 (28.1)	875 (29.4)
II	66 (36.3)	876 (41.4)	942 (41.0)	1149 (38.7)
III	59 (32.4)	523 (24.7)	582 (25.3)	784 (26.4)
IV	22 (12.1)	104 (4.9)	126 (5.5)	155 (5.2)
V	1 (0.6)	3 (0.1)	4 (1.2)	9 (0.3)
Functional status‡				
Independent	155 (84.7)	1930 (90.5)	2085 (90.1)	2727 (91.1)
Partially dependent	26 (14.2)	187 (8.8)	213 (9.2)	236 (7.9)
Fully dependent	2 (1.1)	15 (0.7)	17 (0.7)	29 (0.9)
Respiratory system§				
Normal	158 (86.3)	1910 (89.6)	2068 (89.4)	2737 (91.5)
Dyspnoea with exercise	14 (7.7)	161 (7.6)	175 (7.6)	182 (6.1)
Limiting dyspnoea	7 (3.8)	53 (2.5)	60 (2.6)	61 (2.0)
Dyspnoea at rest	4 (2.2)	7 (0.3)	11 (0.5)	10 (0.3)
Cardiac system				
Normal (no failure)	137 (74.9)	1681 (79.0)	1818 (78.6)	2254 (75.3)
Diuretics, digoxin, antianginal or antihypertensive drugs	38 (20.8)	391 (18.4)	429 (18.6)	630 (21.1)
Peripheric oedema, warfarin, incipient cardiomegaly	5 (2.7)	53 (2.5)	58 (2.5)	97 (3.2)
Raised jugular venous pressure, cardiomegaly	3 (1.6)	4 (0.2)	7 (0.3)	11 (0.4)
Co-morbidities				
Arterial hypertension¶	79 (43.2)	709 (33.3)	788 (34.0)	1030 (34.4)
Diabetes¶	40 (21.9)	268 (12.6)	308 (13.3)	416 (13.9)
Active smoker	27 (14.8)	377 (17.7)	404 (17.5)	523 (17.5)
COPD	19 (10.4)	180 (8.4)	199 (8.6)	196 (6.6)
Cardiovascular disease#	31 (16.9)	245 (11.5)	276 (11.9)	397 (13.3)
Preoperative Glasgow Coma Score ≤8	16 (8.7)	16 (0.8)	32 (1.4)	21 (0.7)
Preoperative analytical data†				
Urea (mmol/l)	8.8(8.4)	6.9(5.4)	7.1(5.7)	7.3(13.5)
Alanine aminotransferase (units/l)	53.2(161)	43.9(142)	44.8(143)	36.7(79.4)
Haemoglobin (g/dl)	11.7(3.8)	11.5(4.7)	11.5(4.7)	11.7(4.6)
Leucocytes (× 10^9/l)	13.4(6.8)	13.0(5.9)	13.0(6.0)	12.6(5.7)
Neutrophils (× 10^9/l)	12.6(12.6)	11.7(11.3)	11.8(11.4)	13.0(15.1)
Lymphocytes (× 10^9/l)	1.5(1.3)	1.9(2.5)	1.9(2.4)	2.2(3.6)
Platelets (× 10^9/l)	254(112)	252(96.9)	252(98.1)	255(101)
NLR	11.9(10.5)	10.1(12.5)	10.3(12.3)	9.7(10.1)
PLR	272(207)	228(212)	231(212)	230(249)
SII (× 10^9/l)	2948(2937)	2619(3720)	2644(3666)	2496(3361)
C-reactive protein (mg/l)	143(268)	101(147)	105(161)	105(183)
Prothrombin time (%)	78.6(23.9)	79.5(25.4)	79.4(25.3)	75.5(29.6)
Prothrombin time (Quick value)	1.2(0.2)	1.2(0.3)	1.2(0.3)	1.3(1.1)
Prothrombin time (s)	13.1(1.4)	13.9(4.7)	13.8(4.4)	13.8(7.8)
ICU admission before urgent surgery	27 (14.8)	70 (3.3)	97 (4.2)	132 (4.4)
Clinical priority**				
Urgent	164 (89.6)	2030 (95.2)	2194 (94.8)	2810 (93.9)
Emergency	19 (10.4)	102 (4.8)	121 (5.2)	182 (6.1)
Surgical approach				
Open	108 (60.0)	1111 (52.4)	1219 (53.0)	1655 (55.5)
Laparoscopic	72 (40.0)	1008 (47.6)	1080 (47.0)	1327 (44.5)
Malignancy				
None	160 (87.4)	1983 (93.0)	2143 (92.6)	2789 (93.2)
Localized tumour	15 (8.2)	86 (4.0)	101 (4.4)	126 (4.2)
Metastasis (nodal or disseminated neoplasia)	8 (4.4)	63 (2.9)	71 (3.1)	77 (2.6)
Peritoneal exudate (intraoperative)				
None	67 (36.8)	979 (45.9)	1046 (45.2)	1513 (50.6)
Serous	47 (25.8)	492 (23.1)	539 (23.3)	615 (20.6)

(continued)

Table 1. (continued)

	2020 cohort			
	COVID-19-positive ($n = 183$)	COVID-19-negative ($n = 2132$)	Total ($n = 2315$)	2019 cohort ($n = 2992$)
Localized purulent	39 (21.4)	435 (20.4)	474 (20.5)	551 (18.4)
Diffuse purulent	29 (15.9)	225 (10.6)	254 (11.0)	313 (10.5)
Introperative blood loss (ml)				
< 100	135 (73.8)	1859 (87.2)	1994 (86.2)	2542 (85 0.0)
101–500	37 (20.2)	226 (10.6)	263 (11.4)	336 (11.2)
501–1000	8 (4.4)	27 (1.3)	35 (1.5)	47 (1.6)
> 1000	3 (1.6)	19 (0.9)	22 (0.9)	65 (2.2)
Surgical complexity††				
Minor	35 (19.1)	477 (22.4)	512 (22.1)	773 (25.8)
Moderate	74 (40.4)	1063 (49.9)	1137 (49.1)	1393 (46.6)
Major/major +	74 (40.4)	592 (27.8)	666 (28.8)	826 (27.6)
Surgical prognostic scores (%)†				
P-POSSUM mortality	9.0(18.5)	4.2(10.2)	4.6(11.2)	4.3(9.9)
LUCENTUM logistic regression morbidity	28.1(19.5)	22.7(17.7)	23.1(17.9)	22.4(17.8)

Values in parentheses are percentages unless indicated otherwise; values are *median (i.q.r.) and †mean(s.d.). ‡Ability to perform activities of daily living, as categorized by Scarborough *et al.*[28]. §Normal: no dyspnea and chest X-ray with no signs of chronic obstructive pulmonary disease (COPD); dyspnoea with exercise: dyspnoea with exercise and/or chest X-ray with minimal signs of COPD; limiting dyspnoea: limiting dyspnoea (1 landing) and/or chest X-ray with moderate signs of COPD; dyspnoea at rest: dyspnoea at rest (30 breaths/min or more) and/or chest X-ray with fibrosis or consolidation. ¶Defined by patient needing specific pharmacological treatment. #Antecedent of ischaemic heart disease, transient ischaemic attack, stroke or peripheral artery disease. **Emergency, needed in less than 2 h after admission; urgent, needed during the first 24 h[29]. ††Complexity of surgical procedures as defined originally in the POSSUM score[29]—minor: hernia/eventration repair, perineal surgery, pilonidal sinus; moderate: cholecystectomy, appendicectomy; major: gastrointestinal perforation suture, intestinal resection, colectomy, main bile duct surgery, gastrectomy, lysis of adhesions, internal hernia repair, enterolithotomy, splenectomy or minor liver trauma, exploratory laparotomy/laparoscopy, surgical control of intra-abdominal bleeding; major+: pancreatectomy or pancreatic necrosectomy, damage control surgery (owing to trauma, bleeding, ischaemia or peritonitis). NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; SII, systemic immune-inflammation index (neutrophil × platelet/lymphocyte counts); P-POSSUM, Portsmouth POSSUM; LUCENTUM, aLicante sUrgical Community Emergencies New Tool for the enUmeration of Morbidities.

(COPD), hypertension, malignancy, need for ICU before surgery, clinical priority, and surgical complexity.

A propensity score matching analysis was undertaken using a logistic regression model, in which COVID-19 status or year was regressed on observed baseline characteristics. Variables taken into account were selected prospectively because of their clinical relevance[26]: age, sex, functional status, smoking status, hypertension, COPD, diabetes, cardiovascular disease, malignancy, clinical priority, surgical complexity, need for ICU before surgery, and centre. Participants with similar propensity score values were matched 1 : 3 for comparison of cohort 1 *versus* cohort 2, and 1 : 1 for comparison of cohort 2 *versus* cohort 3. In matched cohorts, to identify any imbalance between groups, the standardized mean difference in observed baseline characteristics was estimated and plotted. A mixed-effects logistic regression model was used to estimate the OR to quantify the effect on each outcome. Mixed effects were used to account for centre effects. Variables remaining imbalanced between groups after matching were added to the logistic model for the purpose of adjustment. For sensitivity assessment, a stratified analysis by centre was predefined in the statistical analysis plan. Analysis was performed using R version 3.6.3 (https://www.R-project.org/).

Results

Some 5599 patients were registered, of whom 5307 (183 COVID-19-positive and 2132 COVID-19-negative during the pandemic; 2992 treated before the pandemic) fulfilled inclusion and data quality criteria (*Fig. 1*). The median number of procedures performed per centre per month was 16.8 (i.q.r. 3.9–44.0) in 2019 and 13.0 (5.5–30.9) in 2020, of which 1.3 (0.8–2.5) involved patients infected with COVID-19. The diagnosis of COVID-19 infection was confirmed before surgery in 112 patients (61.2 per cent) and afterwards in 71 (38.8 per cent), by RT–PCR in 164 patients (89.6 per cent), and by clinical and radiological findings in 19 (10.4 per cent).

Patient characteristics

Patients treated during pandemic: COVID-19-positive versus *-negative*

Patients who tested positive for COVID-19 were older, more overweight, with higher ASA grades, worse functional status (more dependence), and more basal co-morbidities, including respiratory pathology, COPD, heart failure, arterial hypertension, diabetes, and cardiovascular disease (*Table 1*). They were more often admitted to ICU before surgery, with a lower preoperative Glasgow Coma Score, submitted to emergency surgery, with greater surgical complexity, affected by malignant pathology, and with diffuse peritonitis. These patients also had a lower lymphocyte count, higher C-reactive protein values, higher urea and alanine aminotransferase levels, higher inflammatory indices (NLR, PLR, and SII), and higher surgical prognostic scores (P-POSSUM and LUCENTUM).

Patients without COVID-19: during versus *before pandemic*

Patients without COVID-19 infection from the two intervals had similar age, BMI, ASA grade, functional status, and baseline co-morbidities. There were no significant differences either in need for ICU before surgery, priority and complexity of operations, malignancy, extent of peritonitis, analytical variables or surgical prognostic scores.

Table 2 Study outcomes

	2020 cohort			
	COVID-19-positive (*n* = 183)	COVID-19-negative (*n* = 2132)	Total (n = 2315)	2019 cohort (*n* = 2992)
30-day mortality	23 (12.6)	98 (4.6)	121 (5.2)	97 (3.2)
90-day mortality†	29 (17.4)	119 (6.2)	148 (7.1)	139 (4.7)
Patients with 30-day postoperative complications	76 (41.5)	509 (23.9)	585 (25.3)	754 (25.2)
Failure-to-rescue (%)‡	30.3	19.3	20.7	12.9
Type of complication (≥ 1 of the following)				
Pulmonary§	32 (17.5)	119 (5.6)	151 (6.5)	165 (5.5)
Thromboembolic¶	11 (6.0)	38 (1.8)	49 (2.1)	38 (1.3)
Other medical	33 (18.0)	210 (9.9)	243 (10.5)	304 (10.2)
Surgical	46 (25.1)	328 (15.4)	374 (16.2)	521 (17.4)
Clavien–Dindo grade				
I	5 (2.7)	51 (2.4)	56 (2.4)	126 (4.2)
II	27 (14.8)	206 (9.7)	233 (10.1)	263 (8.8)
IIIA	3 (1.6)	40 (1.9)	43 (1.9)	69 (2.3)
IIIB	5 (2.7)	64 (3.0)	69 (2.9)	101 (3.4)
IVA	5 (2.7)	26 (1.2)	31 (1.3)	42 (1.4)
IVB	8 (4.4)	24 (1.1)	32 (1.4)	57 (1.9)
V	23 (12.6)	98 (4.6)	121 (5.2)	97 (3.2)
Patients with severe complications#	44 (24.0)	252 (11.8)	296 (12.8)	365 (12.2)
Need for postoperative ICU for ≥24 h	55 (30.1)	241 (11.3)	296 (12.8)	389 (13.0)
Duration of hospital stay (days)*	7 (3–18)	4 (2–8)	4 (2–8)	4 (2–9)
30-day readmission	16 (10.2)	135 (6.7)	151 (6.9)	190 (6.6)
30-day surgical reintervention	11 (6.9)	110 (5.4)	121 (5.5)	153 (5.3)

Values in parentheses are percentages unless indicated otherwise; *values are median (i.q.r.). †Considered only for patients with registered 90-day follow-up (91.3, 90.3, 90.4, and 98.5 per cent of patients in 2020 COVID-19-positive, 2020 COVID-19-negative, 2020 total, and 2019 cohorts respectively). ‡Calculated as 30-day deaths as a percentage of patients with 30-day complications. §Pulmonary complications: respiratory infection or pneumonia, defined as purulent expectoration with positive bacteriological/virological culture, with or without changes in chest X-ray, or fever associated with pulmonary consolidation in chest X-ray; respiratory failure, defined as dyspnoea requiring ventilator urgent support and/or arterial partial pressure of oxygen below 60mmHg and arterial partial pressure of carbon dioxide above 45mmHg without oxygen assistance; and pleural effusion/pulmonary atelectasis. ¶Deep venous thrombosis and/or pulmonary embolism; acute myocardial infarction, stroke, acute limb ischemia, acute mesenteric ischaemia. #Clavien–Dindo grade IIIA or higher.

Outcomes

Patients treated during pandemic: COVID-19-positive versus *-negative*

Patients who tested positive for COVID-19 had a higher unadjusted mortality at 30 days (12.6 *versus* 4.6 per cent), higher FTR, more complications, more severe complications, longer hospital stay, and higher rates of readmission and reintervention (*Table 2*, *Tables S2 and S3*). Based on propensity scores, 175 COVID-19-positive patients were matched with 472 COVID-19-negative patients (*Fig. 2* and *Table S4*). There were no statistically significant differences in mortality at 30 days, FTR, and rates of readmission or reintervention in the propensity score-matched analysis. Patients with COVID-19 had a higher 90-day mortality rate (17.0 *versus* 9.9 per cent; $P = 0.027$), more complications (especially pulmonary), more severe complications, a greater need for postoperative ICU admission, and longer hospital stay.

Patients without COVID-19: during versus *before pandemic*

Patients treated during the pandemic had higher 30-day mortality rates (4.6 *versus* 3.2 per cent) and FTR (19.3 *versus* 12.9 per cent); there were no significant differences in complication rates, duration of hospital stay, or rates of readmission and reintervention. The propensity score-matched analysis included 2032 COVID-19-negative patients treated during the pandemic and 2032 before the pandemic (*Fig. 3* and *Table S5*). Patients treated during the pandemic had a significantly higher FTR rate (OR 1.56, 95 per cent c.i. 1.10 to 2.19) and a tendency towards a higher 30-day mortality rate, although this did not reach statistical significance (OR 1.35, 0.98 to 1.90). Complication rates, type and severity, hospital stay, and rates of readmission and reintervention were similar.

Discussion

The multicentre COVID-CIR study of patients undergoing emergency general and gastrointestinal surgery found that COVID-19 infection was associated with high postoperative complication and mortality rates. Propensity score analysis provided some insight into the impact of COVID-19 infection, and the effect of lockdown and hospital collapse on the outcomes of emergency general and gastrointestinal surgery.

The 30-day mortality rate among patients infected with COVID-19 was greater than that in contemporary patients who did not have COVID-19 (12.6 *versus* 4.6 per cent). The mortality rates are actually similar to those observed in non-surgical patients hospitalized with COVID-19 infection in Spain (10.6 per cent)[32]. A prompt international cohort study (COVIDSurg)[11] of patients infected with COVID-19 who had surgery in different specialties with no control comparisons reported an overall 30-day mortality rate of 23.8 per cent. Other cohort studies[7,11–13,21,33–35] showed great heterogeneity in mortality, with rates varying from 4.3 to 42.8 per cent. Based on these data, most studies concluded that concomitant COVID-19 infection worsens the outcomes for surgical patients, and so recommended delaying or avoiding surgery whenever possible in the presence of active COVID-19 infection[11,20,36]. However, multicentre studies potentially suffer from selection bias, operating on patients who may present the highest risk during the pandemic. The present study is based on a large cohort of consecutive patients who had emergency surgery in a single surgical specialty. The National

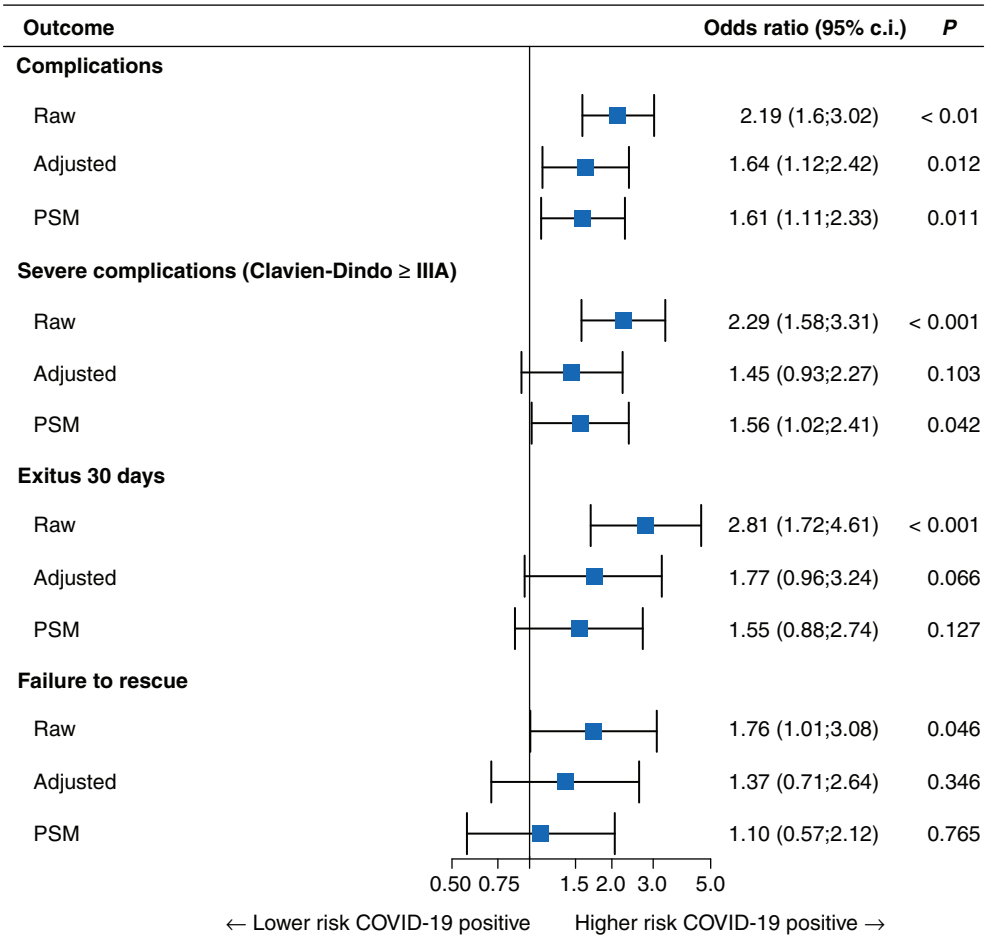

Fig. 2 Forest plot of raw, adjusted, and propensity score-matched outcomes of COVID-19-positive *versus* COVID-19-negative patients treated in 2020 during the pandemic

Odd ratios are shown with 95 per cent confidence intervals. PSM, propensity score-matched.

Emergency Laparotomy Audit of England and Wales (NELA) group[37] recently conducted an analysis of outcomes using a population-based register, and reported a 30-day mortality rate of 12.5 per cent for emergency laparotomy in patients testing positive for COVID-19, somewhat lower than that reported by the COVIDSurg group. Raw postoperative outcomes associated with COVID-19 infection should be evaluated with caution, as COVID-19-positive patients in the present and previous studies were mostly aged 70 years or older (50–66 per cent), had an ASA grade of III–IV (60–91 per cent), and had two or more co-morbidities (61–67 per cent)[11,12,14]. This underlines the need for meticulous benchmarking. Three previous studies comparing outcomes of contemporaneous surgical patients with and without COVID infection reached contradictory conclusions: in two studies[13,14], COVID-19 infection was associated with poorer postoperative outcomes, whereas in the other[38] it was not. In the present study, the difference in mortality between matched COVID-positive and COVID-negative cohorts was not statistically significant, suggesting that poor postoperative outcomes could have more to do with baseline characteristics and the preoperative state of the patient rather than a specific risk-multiplying effect of COVID-19. In fact, the prognostic surgical score values of patients infected with COVID-19 made their poor outcomes predictable[39]. Not all emergency operations can be avoided without considerable risk to the life of the patient. Procedure-specific mortality provided in this study could help in surgeons' decision-making.

During the pandemic, 22.6 per cent fewer emergency operations were performed compared with the same period in 2019, probably related to a reduction in emergency department attendances, ranging between 22 and 60 per cent in previous Spanish studies[6,7,21,40]. Delay in consultation could potentially result in more evolved acute diseases and worse postoperative prognosis[7,23]. However, in the present study, patients who were negative for COVID-19 operated on in 2019 *versus* 2020 had similar inflammatory parameters and indices, extent of peritonitis, intraoperative blood loss, surgical prognostic score values, and complication rates. Therefore, the high mortality rate among COVID-19-negative patients treated during the pandemic in this study cannot be definitely attributed to the effect of lockdown.

In this study, COVID-19-negative patients operated on during the pandemic had a significantly higher risk of death as a consequence of postoperative complications (FTR) than those who had surgery before the pandemic. FTR in surgical patients is already known to be associated with a delay in the detection of morbidity and therapeutic escalation[31]. Several hospital-related risk indicators, such as outdated communication technology, nurse understaffing, hierarchy barriers, and communication errors, have been identified as root causes of inability of surgical services to stop the transition from an initial complication to a progressive cascade of adverse events leading to death[31]. All these factors are likely to have been altered as a result of hospital collapse during the pandemic in Spain. The NELA group[37] reported that the 30-day

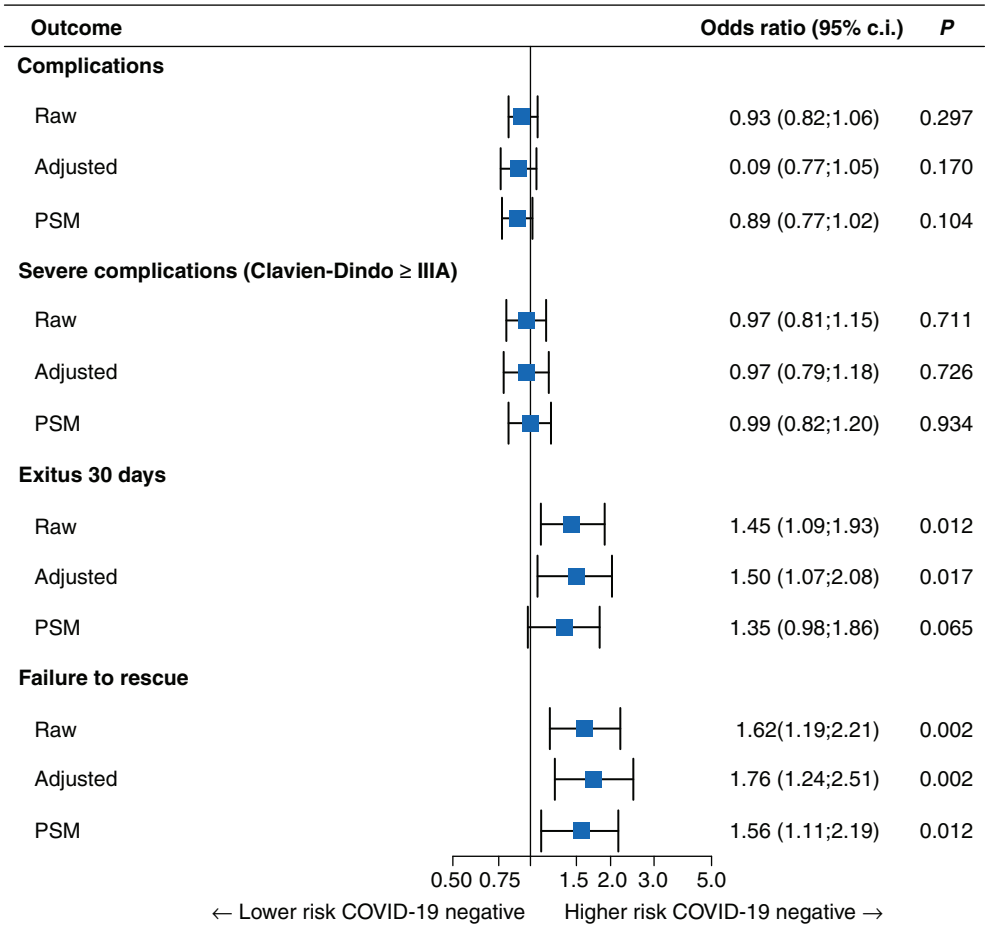

Fig. 3 Forest plot of raw, adjusted, and propensity score-matched outcomes of COVID-19-negative patients treated in 2020 during the pandemic *versus* patients treated in 2019 before the pandemic

Odd ratios are shown with 95 per cent confidence intervals. PSM, propensity score-matched.

postoperative mortality rate for emergency laparotomies in England and Wales was 9.0 per cent before and 7.2 per cent during the COVID-19 pandemic, whereas in the present study it changed from 10.9 to 14.7 per cent (*Table S2*). Therefore, reducing avoidable deaths during present and future pandemics will require improving coordination and increasing resources for public healthcare[24,41].

This study has some limitations. It involves only one country, which could limit the generalizability of the results. However, it represents a largely homogeneous population base that can minimize selection bias. The retrospective design is a further limitation, minimized by data quality control and exclusion of patients with missing data on relevant variables. In 10.4 per cent of patients considered positive for COVID-19, the diagnosis was not based on nasopharyngeal RT–PCR, but on clinical and radiological findings, especially in the initial phase of the pandemic, when COVID-19 diagnostic protocols had not yet been standardized. Other studies have documented a similar proportion of COVID-19 diagnoses based on clinical and radiological findings, with comparable outcomes to those of patients with laboratory-confirmed COVID-19[11]. Finally, it must be remembered that propensity score adjustment cannot balance for unknown or known unmeasured confounding variables; however, it is plausible that matching would appropriately correct for the impact of baseline variables in the model.

This large multicentre propensity-score matched study suggests that COVID-19-infected patients submitted to emergency general and digestive surgeries were at increased risk of postoperative complications and mortality, probably more in relation to their basal comorbidities and the severity of disease at presentation than to a specific effect of COVID-19 infection. Predicted increase in mortality should be balanced against the risk of delaying surgery in each individual case. Moreover, COVID-19-negative patients operated on during the pandemic presented higher-than-expected failure-to-rescue. Therefore, the consequences of hospital collapse during the COVID-19 pandemic should not be minimized.

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Supplementary material

Supplementary material is available at *BJS* online.

Acknowledgements

The authors are grateful to J. M. Valderas (Chair in Health Services and Policy, University of Exeter Medical School, Exeter, UK) and C. Jericó (Department of Internal Medicine, Hospital Moisès Broggi, Sant Joan Despí, Barcelona, Spain) for their thorough review of this manuscript; and A. Aguilar and J. Hothersall for English language assistance. This study, including its analysis plan, was registered at ClinicalTrials.gov (NCT04479150) before data collection and analysis were performed. The preregistration adheres to the disclosure requirements of the institutional registry. The data sets generated and analysed during the present study are not publicly available but are available from the corresponding author on reasonable request . *Disclosure*. The authors declare no conflict of interest.

Funding

This study was supported by a grant from the Catalan Surgical Society.

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