Mortality and pulmonary complications in emergency general surgery patients with COVID-19: A large international multicenter study

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OBJECTIVES:	The outcomes of emergency general surgery (EGS) patients with concomitant COVID-19 infection remain unknown. With a multicenter study in 361 hospitals from 52 countries, we sought to study the mortality and pulmonary complications of COVID-19 patients undergoing EGS.
METHODS:	All patients 17 years or older and diagnosed preoperatively with COVID-19 between February and July 2020 were included. Emergency general surgery was defined as the urgent/emergent performance of appendectomy, cholecystectomy, or laparotomy. The main outcomes were 30-day mortality and 30-day pulmonary complications (a composite of acute respiratory distress syndrome, unexpected mechanical ventilation, or pneumonia). Planned subgroup analyses were performed based on presence of preoperative COVID-related respiratory findings (e.g., cough, dyspnea, need for oxygen therapy, chest radiology abnormality).
RESULTS:	A total of 1,045 patients were included, of which 40.1% were female and 50.0% were older than 50 years; 461 (44.1%), 145 (13.9%), and 439 (42.0%) underwent appendectomy, cholecystectomy, and laparotomy, respectively. The overall mortality rate was 15.1% (158 of 1,045 patients), and the overall pulmonary complication rate was 32.9% (344 of 1,045 patients); in the subgroup of laparotomy patients, the rates were 30.6% (134 of 438 patients) and 59.2% (260 of 439 patients), respectively. Subgroup analyses found mortality and pulmonary complication risk to be especially increased in patients with preoperative respiratory findings.
CONCLUSION:	COVID-19 patients undergoing EGS have significantly high rates of mortality and pulmonary complications, but the risk is most pronounced in those with preoperative respiratory findings. (*J Trauma Acute Care Surg.* 2022;93: 59–65. Copyright © 2022 Wolters Kluwer Health, Inc. All rights reserved.)
LEVEL OF EVIDENCE:	Prognostic and Epidemiologic; Level IV.
KEY WORDS:	COVID-19; COVIDSurg; emergency surgery; mortality; pulmonary complications.

The COVID-19 pandemic continues to cause major disruptions to the delivery of surgical services globally. To prevent the transmission of respiratory syndrome coronavirus 2 (SARS-CoV-2) and to divert available resources toward the care of patients with SARS-CoV-2, it is estimated that more than 28 million elective surgeries were canceled in the early phases of the pandemic worldwide and more as the pandemic persisted.[1–3] However, the majority of emergency general surgery (EGS) procedures could not be postponed or canceled, especially when nonoperative alternatives were deemed unacceptable or inferior in efficacy or safety. Surgeons in general and acute care surgeons in specific were faced every day with the challenge to balance the patients' need for surgical management of their acute disease and the potential risks associated with concomitantly having or contracting perioperative SARS-CoV-2 infection.[4] In light of early reports detailing a wide spectrum of extrapulmonary thromboembolic COVID-19 manifestations and raising concerns over the risks of surgical intervention in COVID-19 patients,[5–10] major surgical societies provided pragmatic guidelines for triaging EGS patients that take into consideration patient- and disease-related factors as well as hospital resource availability.[11]

In its first international multicenter study conducted among 1,128 surgical patients with SARS-CoV-2 infection, the COVIDSurg group identified a markedly increased risk of mortality and postoperative pulmonary complications in all patients undergoing surgery with a perioperative diagnosis of COVID-19. Those rates were significantly higher than those reported in even the highest-risk surgical patients in prepandemic studies.[1] Similarly, the increased risk of mortality and morbidity among surgical patients with SARS-CoV-2 infection was demonstrated in Italy and the Netherlands.[12,13] However, specific data on the postoperative outcomes of EGS patients with preoperative COVID-19 remain unclear. In addition, it also remains unclear whether the presence or absence of preoperative signs or symptoms of COVID-19 affects the outcome and impacts the prognosis in patients with COVID-19. In this study, we sought to (1) determine the rates of 30-day mortality and pulmonary complications of EGS patients with preoperative SARS-CoV-2 infection and (2) compare the clinical outcomes of patients with and without preoperative respiratory findings of COVID-19 in this same cohort.

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PATIENTS AND METHODS

Setting and Ethical Oversight

This study is reported in compliance with the Strengthening the Reporting of Observational Studies in Epidemiology guidelines for observational cohort studies (Supplemental Digital Content, Supplementary Table S1, http://links.lww.com/TA/C366)[14] and is a secondary analysis of the COVIDSurg Cohort Study. COVIDSurg prospectively enrolled consecutive patients from February to July 2020; it was led by the University Hospital Birmingham, United Kingdom, and registered as a clinical audit (registration number CARMS-15986).[15] All participating centers, including the Massachusetts General Hospital as the lead US center, received ethical approval from their respective institutional review board offices and signed a data use agreement with the UK-based leading center. Supplemental Digital Content (Supplementary Table S2, http://links.lww.com/TA/C367) details the number of patients contributed to the study by each participating country. Patients 17 years or older who were diagnosed SARS-CoV-2 infection up to 7 days before EGS based on quantitative reverse transcription–polymerase chain reaction testing, pathognomonic chest computed tomography (CT) scan, or clinical diagnosis were included. Patients diagnosed with SARS-CoV-2 postoperatively were excluded from this analysis. The index operation was identified as the one performed closest to the time the SARS-CoV-2 infection was confirmed. For the purpose of this study, EGS was defined as urgent or emergent appendectomy, cholecystectomy, or laparotomy for any indication (e.g., bowel obstruction, or perforation). Both open and laparoscopic procedures were included.

Data Collection

The medical records of each included patient were systematically reviewed to identify the following information: (1) demographics (age and sex), (2) American Society of Anesthesiologists (ASA) physical status classification, (3) comorbidities (e.g., asthma, chronic obstructive pulmonary disease, chronic kidney disease, and coronary artery disease), (4) Revised Cardiac Risk Index,[16] (5) method diagnosis of SARS-CoV-2 (reverse transcription–polymerase chain reaction, CT, clinical), (6) clinical symptoms at the time of hospital admission (e.g., cough, diarrhea, fever, and hemoptysis) as obtained from the History and Physical, (7) preoperative vital signs (e.g., respiratory rate, heart rate, and systolic blood pressure), (8) preoperative respiratory support (none, supplemental oxygen, or mechanical ventilation), and (9) operative characteristics (primary procedure, type of anesthesia).

Outcomes

The main outcomes were 30-day mortality and 30-day pulmonary complications (a composite of acute respiratory distress syndrome, unexpected postoperative mechanical ventilation, or pneumonia). Unexpected postoperative ventilation was defined as the need for noninvasive or invasive ventilation or extracorporeal membrane oxygenation after initial extubation following surgery or failure to extubate as planned after surgery.

Statistical Analyses

Descriptive statistics were used for patient characteristics and discharge outcomes. Continuous variables are presented as mean and SD for those with normal distribution or median and interquartile range for nonnormal distributions. Bivariate analysis was performed using parametric (t tests) or nonparametric tests (Wilcoxon rank-sum) depending on their distribution for continuous variables and Pearson χ^2 tests or Fisher's exact tests for categorical variables as applicable. Univariate and multivariable analyses were used to identify independent predictors of 30-day mortality and 30-day pulmonary complications. Explanatory variables were selected a priori based on clinical relevance (age, sex, ASA, body mass index, number of comorbidities, respiratory comorbidity, respiratory rate, heart rate, systolic blood pressure, white blood cell count, smoking status, preoperative respiratory findings, and surgical procedure). A two-sided p value of <0.05 was considered statistically significant. The statistical software STATA, version 15.1 (StataCorp, College Station, TX), was used to analyze the data.

Subgroup Analyses: Patients With and Without Preoperative Respiratory Findings of COVID-19

Subgroup analyses were performed according to the presence of preoperative respiratory findings or not. This was based on respiratory symptoms at the time of hospital admission (dyspnea, cough, hemoptysis, sputum production), abnormal preoperative imaging (chest x-ray or chest CT scan), or preoperative oxygen requirement (supplemental oxygen or mechanical ventilation).

RESULTS

Patient Characteristics and Overall Outcomes

A total of 1,045 patients were included, of which 40.1% were female (n = 419) and 50.0% were older than 50 years (n = 523). More than half of the patients had preoperative respiratory findings of COVID-19 (n = 647, 61.9%). These included specifically preoperative respiratory symptoms (n = 298, 28.5%), abnormal chest x-ray (n = 335, 32.1%), abnormal chest CT scan (n = 438, 41.9%), need for supplemental oxygen therapy (n = 280, 27.6%), and/or the need for mechanical ventilation (n = 146, 14.4%). Regarding the specific surgical procedures performed, 44.1% of patients underwent an appendectomy (n = 461), 13.9% a cholecystectomy (n = 145), and 42.0% a laparotomy (n = 439). The overall rate of 30-day mortality was 15.1% (n = 158), and that of pulmonary complications was 32.9% (n = 344). Supplemental Digital Content (Supplementary Table S3, http://links.lww.com/TA/C367) describes the rates of nonpulmonary complications by surgical procedure.

Univariate Analyses for Mortality and Pulmonary Complications

Tables 1 and 2 summarize the results of the univariate analyses for mortality and pulmonary complications. In summary, compared with survivors, nonsurvivors were more likely to be older than 50 years, more often had an ASA of 3 or more, more often had a body mass index more than 30 kg/m^2, and more often had at least one respiratory comorbidity. They were also more likely to be bradycardic, hypotensive, or hypertensive preoperatively and more likely to have at least one preoperative respiratory finding of COVID-19. They more frequently underwent a laparotomy and more often developed at least one pulmonary complication. When compared with patients who did not develop postoperative

TABLE 1. Characteristics and Outcomes of Survivors Versus Nonsurvivors

Characteristic	Total Cohort (n = 1,045)	Survivors (n = 887)	Nonsurvivors (n = 158)	*p*
Age, n (%), y				<0.001
17–29	219 (21.0)	217 (24.5)	2 (1.3)	
30–49	303 (29.0)	276 (31.1)	27 (17.1)	
50–69	318 (30.4)	244 (27.5)	74 (46.8)	
≥70	205 (19.6)	150 (16.9)	55 (34.8)	
Missing	0	0	0	
Sex, n (%)				0.41
Female	419 (40.1)	351 (39.6)	68 (43.0)	
Male	626 (59.9)	536 (60.4)	90 (57.0)	
Missing	0	0	0	
ASA classification, n (%)				<0.001
I	233 (22.4)	230 (26.0)	3 (1.9)	
II	436 (41.9)	400 (45.1)	36 (22.8)	
III	210 (20.2)	164 (18.5)	46 (29.1)	
IV	124 (11.9)	76 (8.6)	48 (30.4)	
V	38 (3.7)	15 (1.7)	23 (14.6)	
Missing	4	2	2	
BMI group, n (%)				<0.001
Underweight: BMI <18.5 kg/m^2	21 (2.2)	17 (2.1)	4 (2.7)	
Normal: BMI 18.5–24.9 kg/m^2	398 (41.1)	359 (43.6)	39 (26.7)	
Overweight: BMI 25–29.9 kg/m^2	336 (34.7)	290 (35.2)	46 (31.5)	
Obese: BMI 30–39.9 kg/m^2	193 (19.9)	143 (17.4)	50 (34.2)	
Morbid obesity: BMI ≥40 kg/m^2	21 (2.2)	14 (1.7)	7 (4.8)	
Missing	76	64	12	
No. comorbidities, n (%)				<0.001
No comorbidities	317 (30.3)	219 (24.7)	98 (62.0)	
One comorbidity only	301 (28.8)	264 (29.8)	37 (23.4)	
≥2 comorbidities	427 (40.9)	404 (45.5)	23 (14.6)	
Missing	0	0	0	
Respiratory comorbidity (COPD or asthma), n (%)	115 (11.0)	77 (8.7)	38 (24.1)	<0.001
Missing	0	0	0	
Revised Cardiac Risk Index, median (IQR)	1 (1–1)	1 (1–1)	1 (1–2)	<0.001
Missing	0	0	0	
RR ≥20, n (%)	303 (29.6)	217 (25.0)	86 (55.8)	<0.001
Missing	22	18	4	
HR, n (%)				<0.001
50–100	747 (72.3)	667 (76.1)	80 (51.3)	
<50	277 (26.8)	203 (23.1)	74 (47.4)	
≥100	9 (0.9)	7 (0.8)	2 (1.3)	
Missing	12	10	2	
SBP, n (%)				<0.001
90–140	762 (74.0)	665 (75.9)	97 (63.0)	
≥140	194 (18.8)	163 (18.6)	31 (20.1)	
<90	74 (7.2)	48 (5.5)	26 (16.9)	
Missing	15	11	4	
WBCs, n (%)				0.28
4–13	458 (43.9)	390 (44.0)	68 (43.3)	
<4	532 (51.0)	455 (51.4)	77 (49.0)	
≥13	53 (5.1)	41 (4.6)	12 (7.6)	
Missing	2	1	1	
Preoperative respiratory findings of COVID-19, n (%)	647 (61.9)	501 (56.5)	146 (92.4)	<0.001
Preoperative respiratory symptoms	298 (28.5)	215 (24.2)	83 (52.5)	<0.001
Missing	0	0	0	
Preoperative CXR				<0.001
Not performed	440 (42.1)	387 (43.6)	53 (33.5)	
Performed — abnormal	335 (32.1)	247 (27.8)	88 (55.7)	
Performed — normal	270 (25.8)	253 (28.5)	17 (10.8)	
Missing	0	0	0	
Preoperative CT scan				
Not performed	505 (48.3)	460 (51.9)	45 (28.5)	<0.001
Performed	540 (51.7)	427 (48.1)	113 (71.5)	
Normal	102 (9.8)	93 (10.5)	9 (5.7)	0.062
Consolidation	110 (10.5)	82 (9.2)	28 (17.7)	0.001
Ground-glass opacity	268 (25.6)	206 (23.2)	62 (39.2)	<0.001
Pulmonary infiltrates	164 (15.7)	113 (12.7)	51 (32.3)	<0.001
Other	61 (5.8)	44 (5.0)	17 (10.8)	0.004
Missing	0	0	0	
Preoperative respiratory support				<0.001
None	588 (58.0)	555 (64.8)	33 (20.9)	
Supplemental oxygen	280 (27.6)	226 (26.4)	54 (34.2)	
Mechanical ventilation	146 (14.4)	75 (8.8)	71 (44.9)	
Missing	31	31	0	
Procedure, n (%)				
Appendectomy	461 (44.1)	452 (51.0)	9 (5.7)	<0.001
Cholecystectomy	145 (13.9)	130 (14.7)	15 (9.5)	0.084
Laparotomy	439 (42.0)	305 (34.4)	134 (84.8)	<0.001
30-d Outcomes				
Mortality, n (%)	158 (15.1)	—	158 (100.0)	—
Respiratory complications, n (%)	344 (32.9)	206 (23.2)	138 (87.3)	
ARDS	143 (13.7)	54 (6.1)	89 (56.3)	<0.001
Unexpected postoperative ventilation	250 (23.9)	135 (15.2)	115 (72.8)	<0.001
Pneumonia	157 (15.0)	105 (11.8)	52 (32.9)	<0.001
Missing	0	0	0	

ARDS, acute respiratory distress syndrome; BMI, body mass index; COPD, chronic obstructive pulmonary disease; CXR, chest x-ray; HR, heart rate; IQR, interquartile range; RR, respiratory rate; SBP, systolic blood pressure; WBC, white blood cell.

pulmonary complications, patients who did were more likely to be older than 50 years, more often had an ASA of 3 or more, and more often had at least one respiratory comorbidity. They were also more often bradycardic, hypotensive, or hypertensive; more often had at least one preoperative respiratory finding of COVID-19; and more often underwent a laparotomy. They were also more likely to die within 30 days of surgery.

Multivariable Analyses for Mortality and Pulmonary Complications

Table 3 shows the multivariable analyses for mortality and pulmonary complications. In summary, the main independent predictors of 30-day mortality were age 50 to 69 years and ≥70 years (odds ratio [OR] [95% confidence interval (CI)],

TABLE 2. Characteristics and Outcomes of Patients With or Without Pulmonary Complications

Characteristic	No Pulmonary Complications (n = 701)	Pulmonary Complications (n = 344)	*p*
Age, n (%), y			<0.001
17–29	199 (28.4)	20 (5.8)	
30–49	230 (32.8)	73 (21.2)	
50–69	160 (22.8)	158 (45.9)	
≥70	112 (16.0)	93 (27.0)	
Missing	0	0	
Sex, n (%)			0.061
Female	295 (42.1)	124 (36.0)	
Male	406 (57.9)	220 (64.0)	
Missing	0	0	
ASA classification, n (%)			<0.001
I	212 (30.3)	21 (6.2)	
II	341 (48.7)	95 (27.9)	
III	119 (17.0)	91 (26.7)	
IV	23 (3.3)	101 (29.6)	
V	5 (0.7)	33 (9.7)	
Missing	1	3	
BMI group, n (%)			<0.001
Underweight: BMI <18.5 kg/m^2	13 (2.0)	8 (2.6)	
Normal: BMI 18.5–24.9 kg/m^2	305 (46.3)	93 (30.0)	
Overweight: BMI 25–29.9 kg/m^2	235 (35.7)	101 (32.6)	
Obese: BMI 30–39.9 kg/m^2	94 (14.3)	99 (31.9)	
Morbid obesity: BMI ≥40 kg/m^2	12 (1.8)	9 (2.9)	
Missing	42	34	
No. comorbidities, n (%)			<0.001
No comorbidities	136 (19.4)	181 (52.6)	
One comorbidity only	199 (28.4)	102 (29.7)	
≥2 comorbidities	366 (52.2)	61 (17.7)	
Missing	0	0	
Respiratory comorbidity (COPD or asthma), n (%)	51 (7.3)	64 (18.6)	<0.001
Missing	0	0	
Revised Cardiac Risk Index, median (IQR)	1 (1–1)	1 (1–2)	<0.001
Missing	0	0	
RR ≥ 20, n (%)	113 (16.4)	190 (56.9)	<0.001
Missing	12	14	
HR, n (%)			<0.001
50–100	560 (80.7)	187 (55.2)	
<50	127 (18.3)	150 (44.2)	
≥100	7 (1.0)	2 (0.6)	
Missing	7	5	
SBP, n (%)			<0.001
90–140	549 (79.0%)	213 (63.6%)	
≥140	116 (16.7%)	78 (23.3%)	
<90	30 (4.3%)	44 (13.1%)	
Missing	6	9	
WBCs, n (%)			0.047
4–13	325 (46.4)	133 (38.9)	
<4	345 (49.2)	187 (54.7)	
≥13	31 (4.4)	22 (6.4)	
Missing	0	2	
Preoperative respiratory findings of COVID-19, n (%)	323 (46.1)	324 (94.2)	<0.001
Preoperative respiratory symptoms	93 (13.3)	205 (59.6)	<0.001
Missing	0	0	
Preoperative CXR			<0.001
Not performed	351 (50.1)	89 (25.9)	
Performed — abnormal	120 (17.1)	215 (62.5)	
Performed — normal	230 (32.8)	40 (11.6)	
Missing	0	0	
Preoperative CT scan			
Not performed	410 (58.5)	95 (27.6)	<0.001
Performed	291 (41.5)	249 (72.4)	
Normal	91 (13.0)	11 (3.2)	<0.001
Consolidation	43 (6.1)	67 (19.5)	<0.001
Ground-glass opacity	111 (15.8)	157 (45.6)	<0.001
Pulmonary infiltrates	60 (8.6)	104 (30.2)	<0.001
Other	31 (4.4)	30 (8.7)	0.005
Missing	0	0	
Preoperative respiratory support			<0.001
None	519 (77.3)	69 (20.1)	
Supplemental oxygen	146 (21.8)	134 (39.1)	
Mechanical ventilation	6 (0.9)	140 (40.8)	
Missing	30	1	
Procedure, n (%)			
Appendectomy	412 (58.8)	49 (14.2)	<0.001
Cholecystectomy	110 (15.7)	35 (10.2)	0.015
Laparotomy	179 (25.5)	260 (75.6)	<0.001
30-day outcomes			
Mortality, n (%)	20 (2.9)	138 (40.1)	<0.001
Respiratory complications, n (%)	—	344 (100.0)	—
ARDS	—	143 (41.6)	—
Unexpected postoperative ventilation	—	250 (72.7)	—
Pneumonia	—	157 (45.6)	—
Missing	0	0	

ARDS, acute respiratory distress syndrome; BMI, body mass index; COPD, chronic obstructive pulmonary disease; CXR, chest x-ray; HR, heart rate; IQR, interquartile range; RR, respiratory rate; SBP, systolic blood pressure; WBC, white blood cell.

5.3 [1.14–24.63] and 5.67 [1.17–27.48], respectively), undergoing a laparotomy (OR [95% CI], 5.74 [2.52–13.08]), and ASA grades 4 and 5 (OR [95% CI], 6.95 [1.4–34.45] and 18.08 [3.22–101.49], respectively).

The main independent predictors of pulmonary complications were the presence of preoperative respiratory findings of COVID-19 (OR [95% CI], 6.03 [3.44–10.6]), ASA grade 4 (OR [95% CI], 4.67 [1.87–11.66]), and undergoing a laparotomy (OR [95% CI], 3.24 [1.97–5.32]).

Subgroup Analyses: Patients With and Without Preoperative Respiratory Findings of COVID-19

Table 4 summarizes the results of the sensitivity analyses in patients with and without preoperative respiratory findings of COVID-19. Compared with those without, patients with

TABLE 3. Multivariable Analyses for Predictors of 30-Day Mortality and 30-Day Pulmonary Complications

	30-d Mortality		30-d Pulmonary Complications	
Characteristic	**OR (95% CI)**	***p***	**OR (95% CI)**	***p***
Procedure				
Appendectomy	Ref.		Ref.	
Cholecystectomy	2.02 (0.75–5.45)	0.162	1.33 (0.71–2.51)	0.377
Laparotomy	5.74 (2.52–13.08)	<0.001	3.24 (1.97–5.32)	<0.001
Age, y				
17–29	Ref.		Ref.	
30–49	3.22 (0.68–15.2)	0.14	1.03 (0.52–2.05)	0.924
50–69	5.3 (1.14–24.63)	0.033	1.16 (0.57–2.35)	0.686
≥70	5.67 (1.17–27.48)	0.031	0.71 (0.31–1.61)	0.413
Female sex	1.29 (0.82–2.03)	0.263	0.9 (0.61–1.32)	0.578
ASA classification				
I	Ref.		Ref.	
II	3.37 (0.73–15.6)	0.121	0.93 (0.46–1.89)	0.842
III	4.28 (0.88–20.69)	0.071	1.27 (0.57–2.83)	0.558
IV	6.95 (1.4–34.45)	0.018	4.67 (1.87–11.66)	0.001
V	18.08 (3.22–101.49)	0.001	4.48 (1.21–16.64)	0.025
BMI group, n (%)				
Underweight: BMI <18.5	Ref.		Ref.	
Normal: BMI 18.5–24.9	0.95 (0.25–3.59)	0.937	1.38 (0.41–4.66)	0.605
Overweight: BMI 25–29.9	1.28 (0.34–4.87)	0.715	2.25 (0.66–7.68)	0.196
Obese: BMI 30–39.9	1.34 (0.35–5.08)	0.665	3.01 (0.87–10.49)	0.083
Morbid obesity: BMI ≥40	2.38 (0.42–13.6)	0.33	1.29 (0.26–6.52)	0.757
No. comorbidities				
No comorbidities	Ref.		Ref.	
One comorbidity only	0.64 (0.37–1.12)	0.116	0.7 (0.43–1.15)	0.161
≥2 comorbidities	0.91 (0.44–1.89)	0.81	0.55 (0.28–1.07)	0.078
Respiratory comorbidity (COPD or asthma)	1.66 (0.93–2.98)	0.089	1.45 (0.8–2.6)	0.217
RR ≥20	1.62 (1.02–2.59)	0.042	2.59 (1.74–3.87)	<0.001
HR				
50–100	Ref.		Ref.	
<50	1.37 (0.86–2.19)	0.189	1.34 (0.87–2.06)	0.189
≥100	2.22 (0.32–15.48)	0.421	0.24 (0.03–2.1)	0.197
SBP				
90–140	Ref.		Ref.	
≥140	0.76 (0.44–1.31)	0.325	1.1 (0.69–1.75)	0.677
<90	1.23 (0.64–2.36)	0.535	1.11 (0.56–2.2)	0.77
WBCs				
4–13	Ref.		Ref.	
<4	0.82 (0.52–1.29)	0.385	1.23 (0.83–1.83)	0.307
≥13	0.87 (0.37–2.01)	0.736	0.87 (0.4–1.92)	0.734
Smoker	1.7 (0.9–3.22)	0.102	1.66 (0.95–2.93)	0.077
Preoperative respiratory findings of COVID-19	1.63 (0.79–3.34)	0.185	6.03 (3.44–10.6)	<0.001

BMI, body mass index; COPD, chronic obstructive pulmonary disease; HR, heart rate; Ref., reference; RR, respiratory rate; SBP, systolic blood pressure; WBC, white blood cell.

preoperative respiratory findings of COVID-19 had a significantly higher mortality (22.6% vs. 3.0%, $p < 0.001$). When analyzed at the individual procedure level, the same finding was noted specifically for patients undergoing cholecystectomy (19.2% vs. 0.0%, $p < 0.001$) and laparotomy (33.0% vs. 14.3%, $p = 0.001$), but not appendectomy (2.7% vs. 1.5%, $p = 0.385$). When examining pulmonary complications, patients with preoperative respiratory findings also had a higher rate of pulmonary complications (50.1% vs. 5.0%, $p < 0.001$), and the finding was true for all three procedures: appendectomy (21.5% vs. 3.3%, $p < 0.001$), cholecystectomy (41.0% vs. 4.5%, $p < 0.001$), and laparotomy (65.8% vs. 14.3%, $p < 0.001$).

DISCUSSION

In this large, international, multicenter, prospective study, we show that both mortality and pulmonary complication rates of patients with SARS-CoV-2 infection undergoing EGS are

TABLE 4. Subgroup Analyses for 30-Day Mortality and 30-Day Pulmonary Complications, by Presence of Preoperative Respiratory Findings

	All Patients, n (%)	No Preoperative Respiratory Findings, n (%)	Preoperative Respiratory Findings, n (%)	*p*
30-d Mortality				
All procedures	158 (15.1)	12 (3.0)	146 (22.6)	<0.001
Appendectomy	9 (2.0)	4 (1.5)	5 (2.7)	0.385
Cholecystectomy	15 (10.3)	0 (0.0)	15 (19.2)	<0.001
Laparotomy	134 (30.6)	8 (14.3)	126 (33.0)	0.001
30-d Pulmonary complications				
All procedures	344 (32.9)	20 (5.0)	324 (50.1)	<0.001
Appendectomy	49 (10.6)	9 (3.3)	40 (21.5)	<0.001
Cholecystectomy	35 (24.1)	3 (4.5)	32 (41.0)	<0.001
Laparotomy	260 (59.2)	8 (14.3)	252 (65.8)	<0.001

Preoperative respiratory findings are defined as presence of preoperative respiratory symptoms (dyspnea, cough, hemoptysis, sputum production), abnormal preoperative imaging (chest x-ray or CT scan), or preoperative oxygen requirement (supplemental oxygen or mechanical ventilation).

significantly elevated. As importantly, the risk was particularly high in patients with preoperative respiratory findings of COVID-19 such as cough, dyspnea, or imaging findings. Based on those findings, we strongly suggest that surgeons should seriously weigh the elevated risks associated with concomitant SARS-CoV-2 infection against the risks of postponing surgery and adopting alternatives to operative management, when feasible. This is especially important in patients with preoperative respiratory findings of COVID-19.

While our study lacks controls, the mortality we report among EGS patients with preoperative respiratory findings of COVID-19 is considerably higher than prepandemic baseline rates for EGS. A multicenter study conducted across 58 countries from high, middle, or low Human Development Index reported a 30-day mortality rate of 14.9% in patients undergoing emergency laparotomy.[17] This finding approaches the rate that we identified among asymptomatic SARS-CoV-2 patients (14.3%) but is less than half the mortality rate we report in patients with preoperative respiratory findings of COVID-19 (33.0%). Mortality was similar in cholecystectomies performed among prepandemic and asymptomatic SARS-CoV-2 patients (1.1% vs. 0.0%, respectively) but was much higher among patients with preoperative respiratory findings of COVID-19 (19.2%).[17] When it comes to appendectomies, postoperative mortality was higher among patients with or without respiratory findings of COVID-19 when compared with prepandemic rates (2.7% and 1.5% vs. 0.2%, respectively).[17]

In addition to a high mortality rate, more than half of the patients with preoperative respiratory findings of COVID-19 developed serious pulmonary complications following EGS; more than two thirds of the patients undergoing emergency laparotomy with respiratory findings of COVID-19 developed pulmonary complications postoperatively. These rates are much higher than those reported in non-SARS-CoV-2 patients, which were reported to be as low as 8.5% in a multicenter prospective cohort study across seven US hospitals.[18] Notably, the risk of pulmonary complications was high even in the cohort of patients with preoperative respiratory findings of COVID-19 undergoing the lower risk appendectomies and cholecystectomies.

Based on our findings, we recommend that surgeons seriously weigh the risks associated with surgery against the risks of delayed operative management and consider nonoperative alternatives (e.g., antibiotics for acute appendicitis), especially for patients with preoperative respiratory findings. In addition, the recently developed COVIDSurg mortality score can serve as a practical and reliable adjuvant to estimate personalized mortality risk for patients with perioperative SARS-CoV-2 infection.[19]

Our study has several limitations that we need to caution the reader about. First, our data were collected during the first wave of the pandemic, and none of the patients included in this study had been vaccinated against COVID-19 or were infected with a recent COVID-19 variant (Delta, Omicron). The constantly changing nature of the disease might limit generalizability of our findings to the current patient population. The COVIDSurg group has launched a new collaborative effort (COVIDSurg3) to collect data during the vaccination and Omicron era. We plan to compare the findings of the current study to the data of COVIDSurg3 when data collection is completed. Second, in the absence of data on SARS-CoV-2 patients who underwent non-operative management for similar diagnoses, we cannot confirm with certainty whether the high mortality and pulmonary complications were precipitated by the surgical intervention itself and cannot report the mortality and pulmonary complications of patients who underwent nonoperative management instead. Third, the use of CT scan to diagnose some patients with SARS-CoV-2 infection likely led to the inclusion of patients who are already experiencing pulmonary problems, which might skew estimates of pulmonary complication rates for SARS-CoV-2 patients receiving surgery. Fourth, we did not evaluate whether the indication for EGS was related to COVID-19 or not (e.g., COVID-related bowel ischemia), as the relationship was and remains difficult to pinpoint with certainty. Fifth, we only included emergent appendectomies, cholecystectomies, and laparotomies. Other laparoscopic and nonlaparoscopic emergent surgeries were excluded, which might limit the generalizability of our findings to the entire EGS population.

CONCLUSION

COVID-19 patients undergoing EGS have significantly higher rates of mortality and pulmonary complications when compared with the prepandemic baseline risk. This is especially true for patients with preoperative respiratory clinical or radiological findings of SARS-CoV-2. Such information is crucial for the bedside clinician and surgeon who is bedside counseling the EGS patient with COVID-19 on the risks and benefits of surgery compared with any viable nonoperative alternatives in management. In recognition of the limitations of the current study, the results should not be interpreted as a recommendation against an operation in appropriate emergency surgery patients. Further studies are needed to determine the impact of new therapeutics and vaccination on outcomes of EGS patients infected with recent COVID-19 variants.

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DISCLOSURE

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