



Preoperative triage to detect SARS-CoV-2 infection in surgical patients: lessons learned for resuming surgery

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Abstract

Purpose To define the impact of the COVID-19 outbreak on hospital surgical activity and assess the incidence of perioperative COVID-19 within two protocolized screening pathways for elective and non-elective surgery.

Methods We conducted a prospective cohort study of adults undergoing surgery during the COVID-19 outbreak. The elective pathway included telephone surveys and a quantitative polymerase-chain-reaction test (RT-PCR) only for patients who were asymptomatic and at low risk of infection. Only patients with negative screening underwent surgery. In the non-elective pathway, preoperative screening was performed during the hospital admission.

Results Among 835 patients considered for the elective pathway, 725 had negative RT-PCR results and underwent surgery. This reflects an 83% reduction in surgical activity from 2019. Moreover, 596 patients underwent non-elective surgery, representing a 28% reduction. Preoperatively, 39 patients (6.5%) tested positive for SARS-CoV-2 and underwent surgery through the non-elective pathway, vs. none in the elective pathway ($p < 0.001$). Postoperatively, 1.4% of elective surgery patients and 2.2% of non-elective surgery patients tested positive ($p > 0.05$). Mortality was higher in non-elective surgery (0.6% vs. 2.9%, $p < 0.001$) and in patients with COVID-19 (0% vs. 14%, $p < 0.001$).

Conclusions The low incidence of COVID-19 in elective surgeries during the outbreak demonstrates the importance and effectiveness of preoperative screening, combining surveys and RT-PCR.

Keywords Perioperative · SARS-CoV-2 · COVID-19 · Nosocomial infection · Surgical

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Introduction

Subsequent to the 2019 coronavirus disease (COVID-19) being declared a pandemic by the World Health Organization (WHO) on January 30, 2020 [1], many hospitals became exclusive COVID-19 centers, thereby limiting access to health care for patients who did not have COVID-19. As a result, elective surgical activity decreased drastically worldwide, in an attempt to allocate the finite resources to COVID-19 patients [2]. However, some surgeries cannot and should not be substantially delayed.

As the first COVID-19 wave started to decline, hospitals were no longer exclusively or predominantly committed to COVID-19 patients and began considering the needs of non-COVID patients'. This situation compelled anesthesiology and surgical departments to establish pathways to detect and prevent the severe acute respiratory syndrome coronavirus-2

(SARS-CoV-2) nosocomial infection to keep healthcare providers safe. Despite limited evidence of the safety of anesthesia and surgery for COVID patients, early reports showed an increased risk of postoperative complications and mortality among patients with severe perioperative SARS-CoV-2 [3]. It remained unclear whether non-emergent surgery should be delayed in all patients with confirmed or suspected SARS-CoV-2 infection. The identification of asymptomatic and mild cases is challenging but important, since perioperative stress may exacerbate a current infection and result in fatal postoperative complications [4]. Although the incidence of asymptomatic COVID-19 ranged from 5% in the community [5] to 14% in women admitted for delivery [6], there were no such data in the general surgical population.

Strategies aimed at maintaining “COVID-free” surgical facilities have been reported, including the early detection of asymptomatic patients; however, the effectiveness of such strategies and their impact on patient outcomes remain unclear [7–9]. We conducted this study primarily to define the impact of the COVID-19 outbreak on surgical activity in a tertiary hospital caring for a population with a high prevalence of SARS-CoV-2. Second, we assessed the incidence of perioperative COVID-19 diagnosis and nosocomial infection within two COVID-19 protocolized screening pathways: for elective and non-elective surgery. Finally, we evaluated whether patients with a perioperative COVID-19 diagnosis were at increased risk of postoperative complications compared with patients who did not have COVID-19.

Methods

Study design and participants

We conducted a prospective single center cohort study of adult patients undergoing surgery at Hospital Clinic of Barcelona (Catalonia), during the first weeks of the COVID-19 outbreak in Barcelona, between March 16 and May 25, 2020. The study was approved by Hospital Clinic of Barcelona Institutional Review board (HCB/2020/0433) with individual consent waived.

The Hospital Clinic of Barcelona (HCB) is a public University Hospital with 713 beds, including 48 intensive care unit (ICU) beds, serving as a community hospital for a population of 540,000 people. On February 15, 2020, the first patient with COVID-19 was admitted to HCB. On March 16, HCB implemented a contingency plan which included the designation of a committee comprising surgeons, anesthesiologists, and nurse managers entitled to develop a prioritization strategy according to diagnoses and surgery urgency, and to perform a day-to-day case-schedule review considering the hospital COVID-19 load. During this period, only disorders that could not be deferred for more than 30 days

were approved. As part of this strategy, a screening protocol for SARS-CoV-2 infection was implemented.

Protocol

An elective pathway (Fig. 1) was designed for patients whose condition acuity allowed for the delay of surgery by at least 30 days without impacting the surgical outcome or disease process significantly, and who could be contacted before presenting for admission. First, a telephone survey was conducted by an administrative staff member 7–14 days before scheduled surgery, to postpone the procedure by at least 14 days if any clinical signs or symptoms of SARS-CoV-2 infection were suspected in the patient or their close contacts. The non-excluded patients were educated about the importance of social distancing, the consistent wearing of masks, and hand hygiene. Three days prior to surgery, a specific structured questionnaire (Supplemental Table 1) developed by the Spanish Association of Surgeons [10] was conveyed over the phone by a trained nurse, to identify patients at risk of having COVID-19 signs or symptoms. Elective surgery was postponed by at least for 14 days if patients or their immediate contacts had confirmed or suspected COVID-19. Patients who remained asymptomatic 48 h before scheduled surgery and who were evaluated as being at low risk of exposure were assessed for SARS-CoV-2 infection with a quantitative polymerase-chain-reaction test (RT-PCR) through a nasopharyngeal swab. To avoid further infection, we recommended strict isolation from when the nasopharyngeal swab was taken until hospital admission. Only patients whose screening was negative were scheduled for surgery.

The non-elective pathway (Fig. 1) was designed for patients whose indication for surgery was established only after hospital admission, if postponing surgery was medically unreasonable, or if surgery was urgent. COVID-19 screening was performed at the time of hospital admission. Patients were considered COVID-19 positive if clinical, radiological, or laboratory criteria were met (Supplemental Table 2). Patients with a negative COVID-19 test result had surgery through the “clean” path, including routine operating rooms, the post-anesthesia care unit (PACU), and surgical wards. Patients with a positive COVID test result underwent surgery on a COVID-19 path, including designated operating rooms, PACU, and surgical wards. Both paths were in the same building but in different pavilions. Moreover, health care providers worked exclusively in either one of the areas, reducing the risk of transmission. For patients with multiple surgeries during the same hospitalization, only the first operation was considered. Postoperative RT-PCR was not performed unless the patients developed signs or symptoms of COVID-19. Routine follow-up was conducted by phone 15 days after surgery.

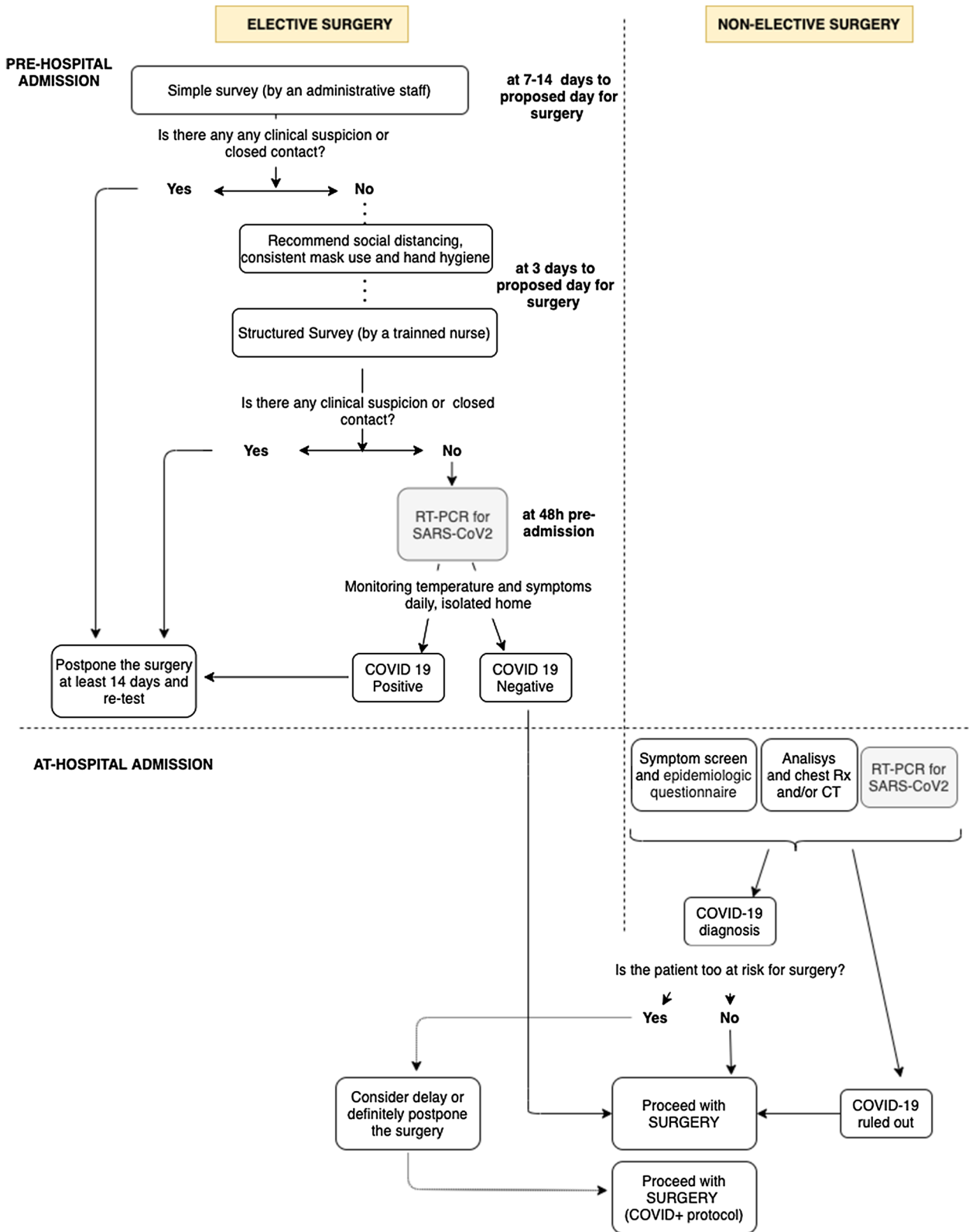


Fig. 1 Screening pathways for elective and non-elective surgery

Outcomes

Our primary outcome was to evaluate the impact of the COVID-19 outbreak on the surgical activity in a tertiary hospital caring for a population with a high prevalence of SARS-CoV-2. The secondary outcomes were the incidence of preoperative COVID-19 diagnosis according to the screening criteria (Supplemental Table 2) among patients scheduled for elective and non-elective surgery; and the incidence of postoperative COVID-19 diagnosis during the initial 15 postoperative days. The exploratory outcome was the incidence of postoperative complications and mortality among the COVID-19 positive patients.

Measurements

Qualifying patients were identified from the hospital surgical schedule database (SAP). Collected data included: demographic and morphometric information; comorbidities; surgical specialty; perioperative clinical, radiological, and laboratory findings compatible with SARS-CoV-2 infection; and postoperative complications and mortality within 15 postoperative days. We reviewed the patients' electronic medical records in SAP. Each suspected COVID-19 case was assessed independently by two adjudicators (RP and ER). Non-consensus and all positive cases were adjudicated by the senior investigator (GMP).

Statistical analysis

Elective and non-elective pathways were compared by the *T* test or chi-square test, as appropriate. Data are expressed as means \pm standard deviation and number (%), as appropriate. A Type 1 error was set at $<5\%$. For data presentation purposes only, patients are grouped according to the pandemic phases established by the Spanish government. These phases were defined according to the percentage of COVID-19-related hospital admissions among the total number of hospitalized patients: phase I, nearly normal scenario (less than 5% COVID-19-related admissions); phase II, low level alert (5–25%); phase III, medium level alert (25–50%); phase IV, high level alert (50–75%); and phase V, emergency scenario with more than 75% COVID-19-related admissions [11].

Results

In the 10-week period from March 16th to May 25th 2020, 2404 patients with COVID-19 were admitted to HCB. COVID-19 dedicated wards were progressively opened and up to 130 ICU beds were allocated according to this overflow. At peak workload, 85% of patients admitted to

the hospital were diagnosed with a COVID-19-related disease. During this period, 835 patients were considered for surgery through the elective pathway (Fig. 2). Among these patients, 30 were excluded, because they were at high risk of having COVID-19 or SAR-CoV-2 infection according to the results of the first telephone survey. An additional 18 patients were excluded later by the second structured questionnaire performed 3 days before surgery. Therefore, those 48 surgeries were postponed. Of the remaining 787 asymptomatic patients at low risk for contact (92%), 725 had a negative RT-PCR test result and underwent surgery during this period. Compared with the 4389 elective surgeries performed during the same period in 2019, this represents an 83% reduction in elective surgeries during the COVID-19 pandemic outbreak.

Six hundred patients were admitted to the hospital to undergo scheduled surgery following the non-elective pathway (Fig. 2). Of these 600 patients, 557 (93%) were negative for SARS-CoV-2. Of the 43 positive patients, 4 multimorbid orthopedic patients with COVID-19 diagnosis had their surgery postponed, because they were considered too frail. The remaining 596 patients underwent surgery on the non-elective pathway. This represents a 28% (596/833) reduction in the number of non-elective surgeries compared with the similar period in 2019. Table 1 summarizes the demographic, clinical, and surgical characteristics of the 1321 patients who underwent surgery and were included in both pathways.

During this time interval and according to the dynamic scenarios proposed by the Spanish Society of Surgeons [11], the number of surgeries performed was inversely proportional to the percentage of patients hospitalized with COVID-19-related disease (Fig. 3). We observed an exponential decrease in the number of surgical procedures moving from phase II (low level alert scenario) to phase V (emergency scenario) achieving a 35% difference between those phases. Similarly, we observed an inverse increase in surgical activity moving back from phase V to phase II (Fig. 3). Concomitantly, there was a progressive increase in perioperative COVID-19 cases, from a 3.3% incidence in phase II to an 11.6% in phase V (Fig. 3). Thirty-nine patients (6.5%) underwent surgery in the non-elective pathway despite a diagnosis of COVID-19, compared with none in the elective pathway, $p < 0.001$. Notwithstanding, 10 (1.4%) patients in the elective pathway and 12 (2.2%) in the non-elective pathway became COVID-19 positive within the first 15 postoperative days (non-significant difference). Among those, 4 (0.5%) patients who had surgery in the elective and 6 (1.1%) in the non-elective pathway were diagnosed after hospital discharge (Fig. 2). The median time from surgery to COVID-19 diagnosis was 3 (range 1–7) days.

The mortality rate was higher in the non-elective surgery group (0.6% vs. 2.9%, $p < 0.001$) (Fig. 2 and Table 2).

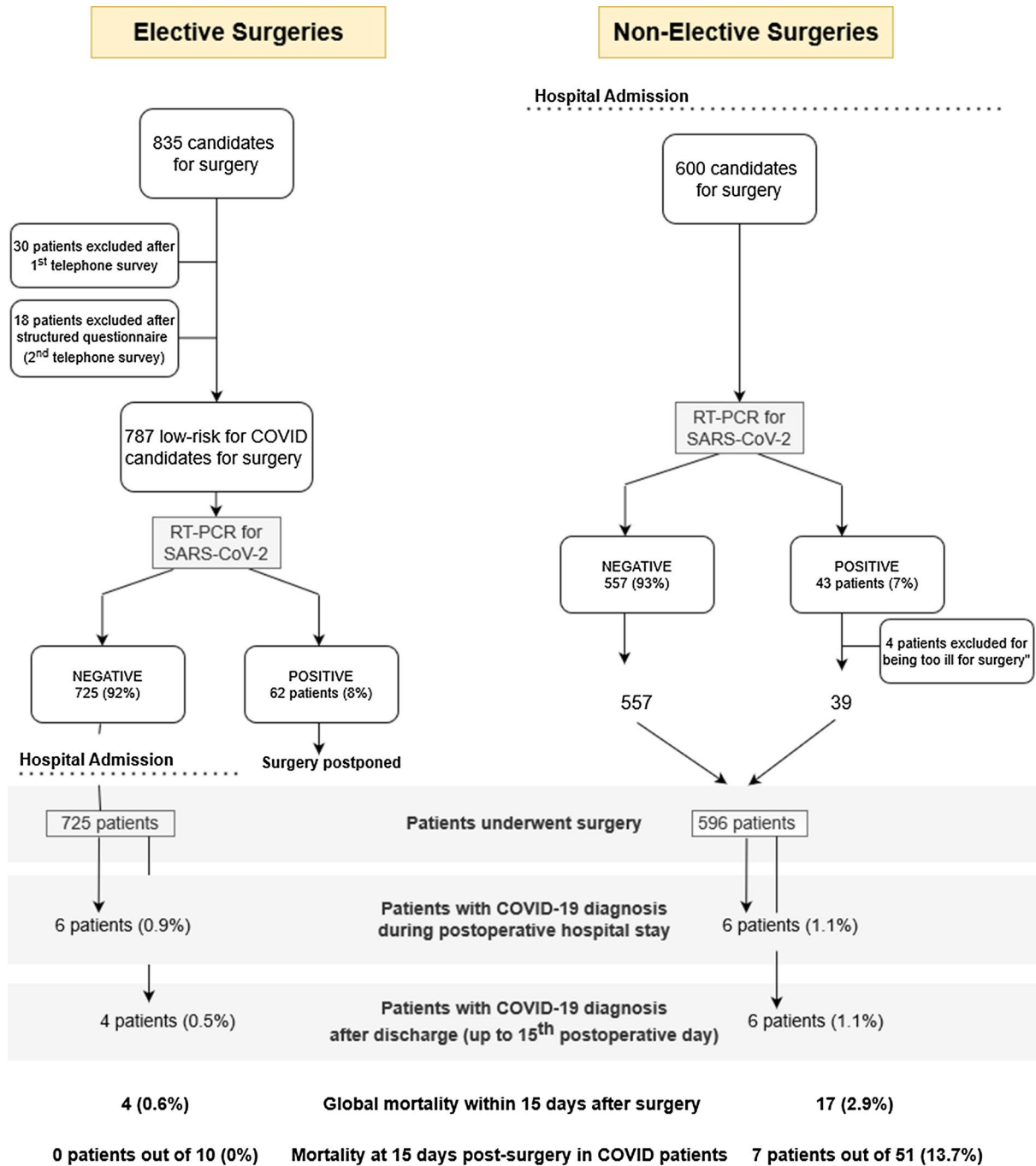


Fig. 2 Flowchart of patient candidates for elective and non-elective surgery

Seven of the 17 (41%) non-elective patients who died had a COVID-19 diagnosis. There were no deaths attributable to SARS-CoV-2 infection among the patients who underwent elective surgeries. Overall, patients with a perioperative COVID-19 diagnosis were older and had more comorbidities (Supplemental Table 3), and significantly more postoperative complications (40/61 patients, 66%) than the non-COVID-19 patients (227/1260 patients, 18%) including

higher mortality (11% vs. 1%) ($p < 0.0001$, each) (Table 2). Globally, 67% (26/39) of patients with preoperative diagnosis of COVID-19 suffered a postoperative complication. This result is not significantly different from the complication rate of 64% (14/22) observed in patients diagnosed with COVID-19 postoperatively. Among the non-elective patients only, 26 of the 33 COVID-19 positive patients who had a postoperative complication were diagnosed with COVID-19

Table 1 Clinical and demographic characteristics by surgical pathway ($n = 1321$)

	Elective ($n = 725$)	Non-elective ($n = 596$)	<i>P</i> value
Age, years	61 ± 1	53 ± 1	< 0.0001
Sex, Male/Female	344 (47)/381 (53)	204 (34)/392 (66)	< 0.0001
ASA, 1–2/3–4	479 (66)/246 (34)	411 (69)/185 (31)	ns
HTA	298 (41)	184 (31)	< 0.001
BMI, Kg/m ²	28 ± 5	27 ± 6	ns
Surgical Specialties			< 0.0001
General Surgery	157 (22)	95 (16)	
Urology-Gynecology	209 (29)	25 (4)	
Cardio-thoracic	104 (14)	22 (3)	
Vascular	21 (3)	12 (2)	
Obstetrics	21 (3)	225 (38)	
Neurosurgery	42 (6)	34 (6)	
Orthopedics -Traumatology	27 (4)	138 (23)	
Otorhinolaryngology	39 (5)	10 (2)	
Others	105 (14)	35 (6)	
Preoperative COVID-19 positive diagnosis	0 (0)	39 (6.5)	< 0.0001
Postoperative COVID-19 positive diagnosis	6 (0.9) ^b	6 (1.1) ^c	ns
Post-discharge COVID-19 positive diagnosis	4 (0.5) ^d	6 (1.1) ^e	ns
Mortality	4 (0.6)	17 (2.9)	< 0.0001
COVID-19 Mortality	0	7	

Data are expressed as means \pm SD, or n (%)

BMI body mass index, ASA American Society of Anesthesiology physical status. Others miscellaneous major surgeries

b 6 patients among the 717 assessed

c 6 patients with COVID-19 diagnosis among the 596 assessed

d 4 patients with COVID-19 diagnosis among the 692 assessed

e 6 patients with COVID-19 diagnosis among the 538 assessed

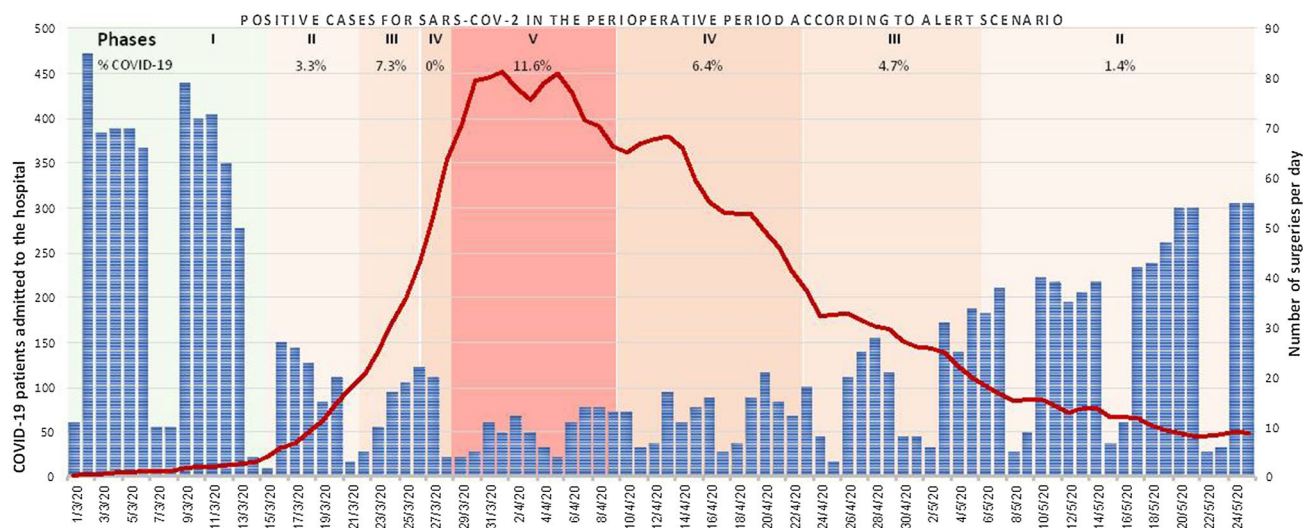


Fig. 3 Number of surgeries and COVID-19 patients admitted to the hospital and diagnosed during the perioperative period according to alert scenario. % COVID-19, percentage of cases diagnosed in the perioperative period (from admission to 15 day post-surgery) per total of surgical procedures performed in a concrete alert scenario previously defined. Phase I, almost normal scenario $< 5\%$ COVID-19-related admissions to ward and ICU; Phase II, low level alert scenario

5–25% COVID-19-related admissions; Phase III, medium level alert scenario 5–25% COVID-19-related admissions; Phase IV, high level alert scenario 50–75% COVID-19-related admissions; Phase V, emergency scenario $> 75\%$ COVID-19-related admissions. Blue columns are total of surgeries (elective and non-elective) performed per day. Red line is the total COVID-19 patients admitted to the hospital

Table 2 Incidence of postoperative complications in patients with vs. those without a perioperative COVID-19 diagnosis

A. Total surgical population (<i>n</i> = 1321)			
	COVID-19 patients (<i>n</i> = 61)	Non COVID-19 patients (<i>n</i> = 1260)	<i>P</i> value
Patients with postoperative complications, <i>n</i> (%)	40 (66)	227 (18)	< .001
COVID-Pneumonia	17 (28)	0	
Respiratory failure	14 (23)	36 (3)	
Cardiovascular	16 (26)	54 (4)	
Renal failure	13 (21)	45 (4)	
DVT/PE	6 (10)	11 (1)	
Neurological	8 (13)	34 (3)	
Surgical infection	8 (13)	41 (3)	
Urinary infection	5 (8)	35 (3)	
Septic shock	11 (18)	36 (3)	
Re-intervention	4 (7)	35 (3)	
Mortality	7 (11)	14 (1)	< .001
B. Patients who underwent non-elective surgery (<i>n</i> = 596)			
	COVID-19 patients (<i>n</i> = 51)	Non COVID-19 patients (<i>n</i> = 545)	<i>P</i> value
Patient with postoperative complications, <i>n</i> (%)	33 (65)	121 (22)	< .001
COVID-Pneumonia	12 (24)	0	
Respiratory failure	15 (29)	18 (3)	
Cardiovascular	13 (25)	29 (5)	
Renal failure	12 (24)	25 (5)	
DVT/PE	3(6)	7 (1)	
Neurological	7 (14)	24 (4)	
Surgical infection	7 (14)	22 (4)	
Urinary infection	5 (10)	26 (5)	
Septic shock	12 (24)	26 (5)	
Re-intervention	3 (6)	23 (4)	
Mortality	7 (14)	10 (2)	< .001

Data are presented as *n* (%)

DVT/PE deep venous thrombosis/pulmonary thromboembolism

before surgery, which was not different from the complication rate of 58% (7/12) among patients with a postoperative COVID-19 diagnosis.

Discussion

The growing requirement for COVID-19 dedicated wards and ICU beds during the COVID-19 outbreak reduced surgical activity worldwide [2, 12]. In HCB, during the 10 weeks of the first wave of the COVID-19 outbreak, the percentage of COVID-19 dedicated hospital beds ranged from 5% to 85% both in surgical wards and the ICU. Positivity for SARS-CoV-2 was confirmed in 56,000 people during this time in Catalonia alone. This incidence was accompanied by a marked reduction in surgical activity, especially in the emergency scenario (phase V). This marked decrease

in surgical activity was also described by the COVID collaborative group, who predicted that the global 12-week cancellation would be 82% for benign disease surgery and 38% for cancer surgery [2]. Our data suggest that these figures might be even worse with an 83% reduction in elective surgery including cancer surgery. About 3 weeks after that peak, we attempted to resume surgical activity progressively, although this process took up to 20 weeks. Moreover, surgery cancellation did not end with the first wave; the surgery rate decreased again with the recurrent waves, although only elective surgery for benign diseases was affected. Although the cumulative impact of surgery cancellations is still to be revealed, it will certainly add to the already busy waiting lists. It is worth noting that the consequences are not merely quantitative, since the surgery cancellations and longer waiting list times will negatively affect the prognosis of many patients. To avoid unnecessary delays that might affect

prognosis [12], while preventing COVID-19 nosocomial infections and protecting health care providers, we designed two dedicated perioperative pathways. The unique characteristics of SARS-CoV-2 infection, including high infectibility, long incubation period, and nonspecific symptoms at disease onset [13] contribute to the difficulty in detection of asymptomatic patients and those within the incubation period.

Contrary to dedicated ICUs, the PACU and operating rooms are semi-open spaces with complex air-filtration systems, so that containment of potential spread is nearly impossible, which presents further challenges. Previous reports on perioperative COVID pathways in orthopedic surgery [14], neurosurgery [9], and general surgery [15], also followed existing guidelines [15–17] and excluded COVID-19 elective cases to minimize the possibility of nosocomial transmission, and to reduce postoperative complications [15, 16]. Moreover, all guidelines advocate for a strict preoperative COVID-19 questionnaire [6, 9, 14, 18, 19] and RT-PCR screening [20] as the key to pathway success. However, they provide only limited evidence of the pathway effectiveness in preventing nosocomial and health care providers' infection [6, 9, 14].

The current cohort of 1321 patients is one of the largest databases evaluating perioperative SAR-CoV-2 infection during a peak period of the pandemic in a population with high COVID-19 prevalence. We demonstrated that structured preoperative screening utilizing phone questionnaires can save as many as 5% of RT-PCR tests by detecting patients at risk of having COVID-19. Considering the relatively short time from surgery to the postoperative diagnosis of COVID-19 (median 3 days), it is reasonable to assume that some of these patients were already asymptomatic carriers or within the silent incubation period and missed by the RT-PCR screening, rather than that the contracted nosocomial infection. These results contradict those of *Schlosser et al.*[7] who found no differences between universal testing and testing according to exposure risk, in two cohorts of about 60,000 patients scheduled for elective surgery. However, in that report, the rate of preoperative RT-PCR was 48% in the universal testing strategy group and 23% in the per-risk strategy group, vs. 100% in our elective surgery population. Moreover, *Schlosser et al.* did not report on postoperative follow-up, so asymptomatic patients who become positive only after surgery, because of the long incubation period, cannot be assessed. Finally, the report by *Schlosser et al.*[7] included a population with low SARS-CoV-2 prevalence, whereas our study included scheduled surgeries within a period of peak incidence of COVID-19 cases in Barcelona, which was considered severely affected by the COVID-19 pandemic.

On the non-elective pathway, the incidence of preoperative COVID-19 infection was 7%, which is similar to the incidence reported in the Barcelona population during those

weeks [21]. The similar incidence of postoperative COVID-19 diagnosis in the elective and non-elective groups further emphasizes the effectiveness of this screening protocol in detecting COVID-19 patients and in preventing nosocomial infection using designated operating rooms and PACU for COVID-19 patients.

After 2 years of the pandemic, numerous waves, and new SARS-CoV-2 variants, the situation has changed. The use of rapid antigen tests even considering their reduced sensitivity compared with RT-PCR [22] play an important role as a first-line or mass community screening test, especially in patients at lower risk of COVID-related perioperative complications, such as those undergoing outpatient procedures, those at low surgical risk, and vaccinated patients. However, more evidence is needed for decision makers. It is notable that 16% of the anesthesiologists working in the COVID-designated areas were infected during these weeks. As expected, this rate is higher than the overall 10% infection rate among health care providers reported by the Spanish government, presumably since our anesthesiologists were more exposed to high-risk aerosol-generating procedures than were health care providers working in wards or emergency departments. To prevent further infections, we prioritized training for the correct use of personal protective equipment with the appropriate space for dressing and undressing, implemented weekly COVID19 screening for professionals in the front-line, and limited the number of people allowed in common areas without masks, for example, at meal break times.

Finally, previous reports described nearly double the incidence of postoperative complications and higher mortality of COVID-19 patients [3, 12, 23]. However, our sample size was small and our populations were not comparable (Supplemental Table 3). Interestingly, the rate of complications was similar in patients with COVID-19 diagnosed preoperatively and those diagnosed postoperatively, again highlighting the importance of preoperative screening for minimizing viral spread and reducing the risk of postoperative complications.

Limitations

The main limitation of the current report was its single-center origin, in a tertiary hospital during the pandemic peak, making the results difficult to generalize for populations with lower COVID-19 prevalence. Furthermore, the 2% incidence of postoperative new SARS-CoV-2 infections might be underreported given that only patients presenting with clinical suspicion were tested postoperatively. Thus, asymptomatic patients might have not been detected. Finally, we were underpowered to detect an association between postoperative complications and SARS-CoV-2 infection.

Despite these limitations, this report provides valuable information about the impact of the COVID-19 pandemic

peak on surgical activity. The low incidence of postoperative COVID-19 diagnosis in elective surgeries (1.4%) during the first weeks of the outbreak reinforces the use of these pathways and demonstrates the efficacy of systematic preoperative screening for SARS-CoV-2 infection, including not only RT-PCR, but also structured questionnaire-based screening.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s00595-022-02610-8>.

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Declarations

Conflict of interest We have no conflicts of interest to declare.

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