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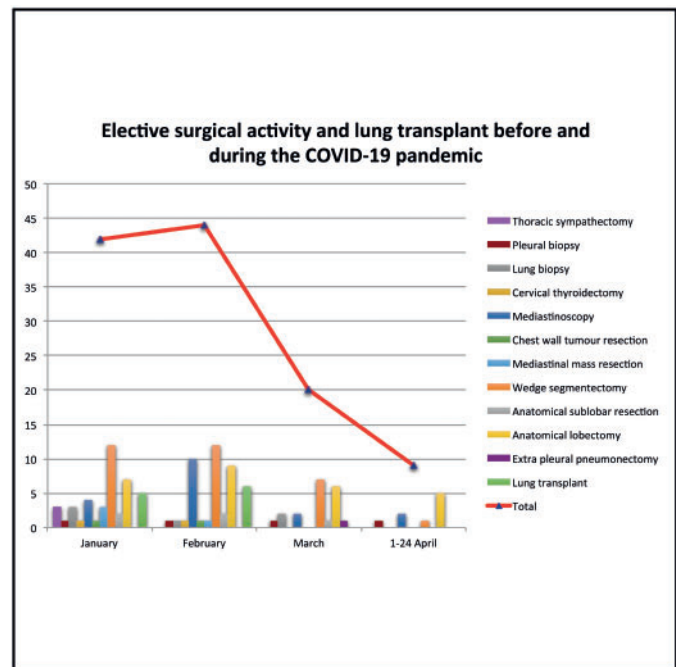
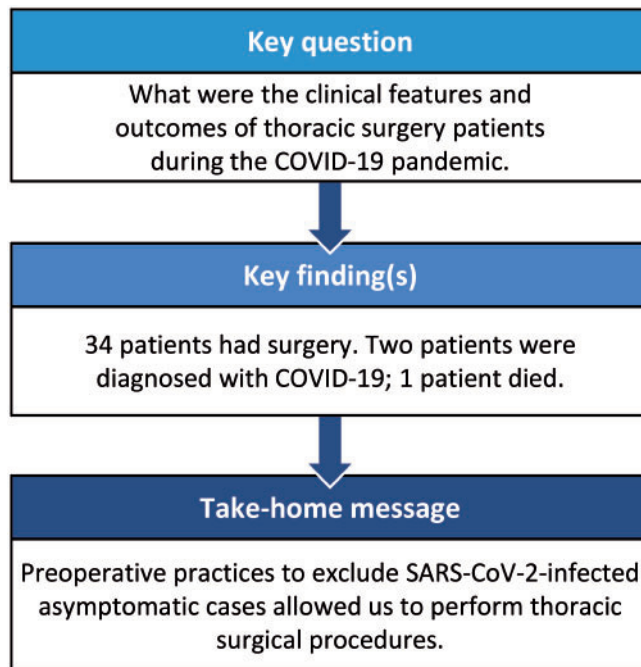
Clinical features and outcomes of thoracic surgery patients during the COVID-19 pandemic

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Abstract

OBJECTIVES: The goal of this study was to describe the clinical features and outcomes of thoracic surgery patients during the coronavirus disease 2019 (COVID-19) pandemic.

METHODS: Thirty-five patients were treated at the 12 de Octubre University Hospital in Madrid between 1 March 2020 and 24 April 2020 during the COVID-19 pandemic. Patient demographics, surgical procedures, complications, COVID-19 symptoms and outcomes were recorded. A protocol was introduced to reduce the risk of operating on patients with COVID-19, including symptom screening, a polymerase chain reaction test for severe acute respiratory syndrome coronavirus 2 and computed tomography scans of the chest. Surgical activity changed significantly during this time, from an initial period of near-normal activity, through an emergency-only period and finally a recovery period when some oncological surgical cases were restarted. Selection criteria for surgical patients are also described.

RESULTS: A total of 34 patients underwent surgery during the pandemic period. We performed 22 lung resections (11 lobectomies and 11 sublobar resections). No hospital deaths were recorded. An elective surgery patient and an emergency surgery patient were diagnosed with COVID-19 (5.88%). The former died within 30 days after surgery.

CONCLUSIONS: Severe acute respiratory syndrome coronavirus 2 represents a tremendous limitation for thoracic surgical practice. Preoperative practices to exclude asymptomatic cases infected with the virus allowed us to perform thoracic surgical procedures.

Keywords: Coronavirus disease 2019 • Novel coronavirus • Outcomes • Thoracic surgery

ABBREVIATIONS

COVID-19	Coronavirus disease 2019
CT	Computed tomography
PCR	Polymerase chain reaction
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2

INTRODUCTION

In December 2019, an outbreak of the new severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) occurred in Wuhan and spread rapidly throughout the rest of China and the world [1, 2].

According to data analysed in China, the majority of patients with COVID-19 developed mild symptoms such as fever, dyspnoea, dry cough or myalgia, which would mostly self-resolve without intervention. However, up to 20% of the patients admitted to hospitals developed severe complications such as acute respiratory distress syndrome, arrhythmias, shock, heart failure or acute renal failure, which required admission to intensive care units [3, 4].

There is little evidence regarding the risk of complications when performing thoracic surgical procedures on patients with COVID-19 [5], although it may confer greater postoperative morbidity and mortality.

Madrid has been one of the world's areas most impacted by COVID-19, with a total cumulative incidence rate in our hospital's area of 857 confirmed cases per 100 000 population [6]. Specifically, in 12 de Octubre University Hospital at the time of the pandemic's peak, a total of 1244 hospital beds and 112 intensive care unit beds were occupied by patients with COVID-19, and more than 9000 confirmed cases of COVID-19 were treated. In this context, the thoracic surgery department was forced to change its routine surgical practice to overcome this challenge.

The purpose of this article was to analyse the surgical procedures carried out in the thoracic surgery department during the pandemic in a large tertiary hospital and the possible complications associated with infection with SARS-CoV-2. We also describe the changes in our surgical activity and the selection criteria for surgical patients.

PATIENTS AND METHODS

This observational and retrospective study reviews clinical data from patients who had surgical procedures performed by members of the thoracic surgery department of the 12 de Octubre University Hospital in Madrid during the COVID-19 pandemic. The study analysed all the patients referred for surgery since the

first case of COVID-19 was confirmed in our hospital, from 1 March 2020 to 24 April 2020.

We defined 3 periods of activity during the pandemic: an initial period of near-normal activity, an emergency-only period and finally a recovery period when the surgical staff resumed performing some oncological surgical cases.

During the first period, from 1 to 19 March, we continued with our scheduled surgical activity practically without modifications. After 20 March, hospital capacity was surpassed because of the COVID-19 pandemic, which led to the limitation of surgical procedures to emergencies only. From 20 March to 5 April, the second period, only 2 operations were carried out: for pneumothorax with persistent air leak. Until this date, in our hospital, only those patients with respiratory symptoms were screened for infection with SARS-CoV-2 because of the limitations of testing resources. As a result, only 1 patient was screened and had negative test results.

After 5 April, the third period, we developed a screening protocol for patients who were asymptomatic for SARS-CoV-2 infections, described in Fig. 1, in patients who were to undergo surgery. We established several measures before and during admission as well as after the surgical procedure [7, 8]. Before admission, we questioned each patient by telephone to detect those with COVID-19 symptoms. We also requested information about their exposure and confinement status. We recommended that patients record their temperature twice a day, comply with confinement, avoid exposure to family members and go to the hospital the day of the operation with mask and gloves. In the 48 h prior to the surgical procedure, patients went to the hospital for a nasopharyngeal polymerase chain reaction (PCR) test [9] and chest computed tomography (CT).

On the day of admission, meaning 1 day before the operation, we confirmed that the patient was asymptomatic, and blood testing was requested with specific parameters for the detection of the SARS-CoV-2: C-reactive protein, creatinine kinase levels, lactate dehydrogenase levels, ferritin, D-dimer, human immunodeficiency virus and complement component serology.

After the surgical procedure, patients were treated in a COVID-free intensive care unit. Once they were moved to a hospital room, contact and droplet precautions were performed. Patients were also placed in an individual room whenever possible. Physical contact with the patient was avoided or minimized by reducing the number of professional staff during each visit and by always performing hand hygiene. Visits from family members were not allowed.

We based the criteria for surgical intervention on the guidelines of the European Society of Medical Oncology [10] and on the treatment protocols for bronchogenic cancer in our hospital [11], both of which are summarized in Table 1. Non-surgical treatment and follow-up of nodules <2 cm and of ground-glass opacifications were chosen because they were not a priority. Finally, all patients likely to have surgery were discussed in a

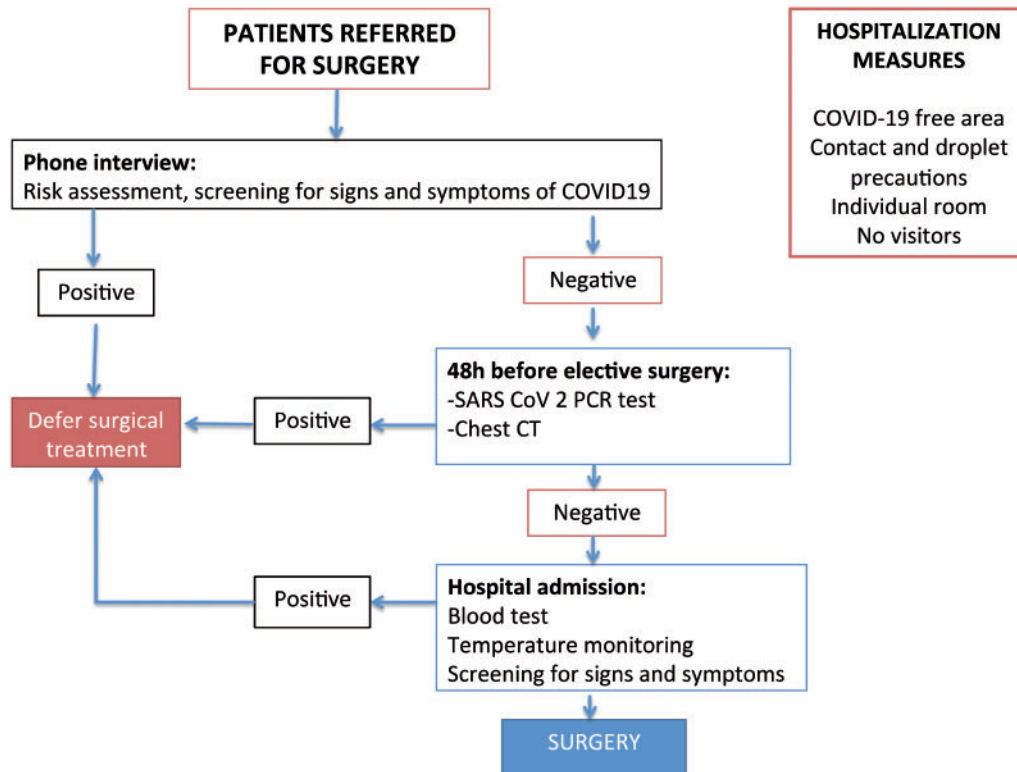


Figure 1: Algorithm of screening patients with asymptomatic SARS-CoV-2 disease referred for surgery. COVID-19: coronavirus disease 2019; CT: computed tomography; PCR: polymerase chain reaction; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2.

Table 1: Eligibility criteria for surgical intervention [10]

Priorities in thoracic surgical oncology
T2NO solid tumours naïve from treatment or after induction chemotherapy
Resectable T3/T4 solid tumours naïve from treatment or after induction chemotherapy
Resectable N1/N2 disease naïve from treatment or after induction chemotherapy
Diagnostic procedure such as mediastinoscopy/thoracoscopy/pleural biopsy for diagnostic/staging work-up
Persistent air leak
Evacuation of empyema-abscess
Drainage ± pleurodesis of pleural effusion

multidisciplinary clinical session using redefined guidelines for surgical priority.

The following variables were collected from patients who had surgery, some of which are included in Table 2: age, sex, comorbidities, ethnic origin, physical status and oncological diagnosis, procedure, postoperative complications, length of hospital stay, postoperative respiratory symptoms, time from operation to symptoms, PCR test for SARS-CoV-2, chest CT, chest X-ray, need for hospital re-admission and death within 30 days after the surgical procedure.

A postoperative follow-up consultation is normally carried out 2 weeks after discharge. During the pandemic, our institution became a COVID-19 hotspot, so to reduce exposure to the virus, we performed remote consultations by telephone [12] 1 week after discharge. We also added questions to the follow-up

telephone consultation to screen for COVID-19 respiratory symptoms. If COVID-19 symptoms were detected, we recommended that the patient go to the emergency room. Once in the emergency room, the patient was examined and if clinical suspicion of COVID-19 was high, diagnostic tests (chest radiography and PCR) were performed.

Ethics statement

This article is a description of our clinical practice and outcomes during the COVID-19 pandemic and does not constitute human subject research. According to the 12 de Octubre ethics committee for clinical research, there was no need for institutional review board approval.

RESULTS

Surgical activity during the pandemic was dramatically reduced compared to that during the months before the pandemic (Fig. 2). The number of elective surgical procedures during March was reduced to 20, 47% fewer than the previous month. No lung transplant was performed during the COVID-19 pandemic.

In total, 35 patients were referred for surgical procedures during the COVID-19 pandemic from 1 March to 24 April. One patient admitted for a lung cancer staging mediastinoscopy started to show fever and respiratory symptoms compatible with COVID-19 h before the operation. A diagnostic PCR was performed for SARS-CoV-2; the test results were positive; the surgical intervention was cancelled. The patient died of SARS-CoV-2 pneumonia.

Of the 34 patients who finally underwent thoracic surgery, 12 were women and 22 were men; the average age was 60 years. A majority (25) were patients with cancer. Among the comorbidities, the most frequent was hypertension (11) followed by dyslipidaemia (10), chronic obstructive pulmonary disease (5), diabetes (5), kidney failure (2) and cardiovascular disease (2).

Table 2: Demographics of patients who had elective surgical procedures

	N = 29 (%)
Age, average (years)	65, 17 (33–83)
Sex, n (%)	
Female	9 (31)
Male	20 (69)
Ethnic origin, n (%)	
White	28 (97)
Latin American	1 (3)
Comorbidity, n (%)	
Hypertension	11 (38)
Dyslipidaemia	10 (34)
COPD	5 (17)
Diabetes	5 (17)
Obesity	3 (10)
Chronic kidney disease	2 (7)
Cardiovascular disease	2 (7)
Physical status, ASA classification, n (%)	
I	1 (3)
II	7 (24)
III	19 (66)
IV	2 (7)
Oncological status, n (%)	25 (86.2)
Lung cancer	16 (55)
Pulmonary metastases	4 (14)
Mesothelioma	2 (7)
Mediastinal lymph nodes	3 (10)

ASA: American Society of Anesthesiology; COPD: chronic obstructive pulmonary disease.

The most frequent operations, described in Table 3, were anatomical lobectomy (11) and wedge segmentectomy (8); followed by mediastinoscopy (4), bullectomy (3), pleural biopsy (2), lung biopsy (2), extrapleural pneumonectomy (1), anatomical sublobar resection (1), and 2 emergency thoracotomies, 1 for control of thoracic trauma damage and another due to mediastinitis. The average length of stay was 4.72 days. The patients had the following postoperative complications: 1 patient had non-surgical bleeding; 1, acute renal failure; 1, pneumothorax; and 1, atrial fibrillation, all of which were resolved favourably. The patient who had thoracic trauma presented with fever and pulmonary infiltrates 7 days after the operation and was diagnosed with bilateral SARS-CoV-2 pneumonia. Two patients died within 30 days after surgery: 1 was diagnosed with COVID-19 and the other died of advanced cancer.

On 1 March, the first patient with COVID-19 was diagnosed at 12 de Octubre University Hospital. Elective surgical interventions were carried out regularly in the thoracic surgery department until 19 March: a total of 19 elective procedures, 1 urgent procedure and 1 emergency procedure. During this period, 2 patients developed symptoms of COVID-19 and had positive PCR test results. Diagnostic imaging was performed (1 chest CT and 1 chest X-ray); the results of both imaging texts were compatible with SARS-CoV-2 pneumonia [13, 14].

Given the severity of the pandemic at that time and the limited resources, our centre was forced to delay several surgical procedures. Starting 20 March, we only performed urgent or emergency surgical procedures. Only 2 procedures were carried out for pneumothorax with persistent air leak. One started with respiratory symptoms but the results of the PCR test were negative.

Starting 6 April, we added non-delayed oncological surgical procedures according to previously described criteria [7]. In total, between 6 and 24 April, only asymptomatic patients with negative PCR test results who met tumour resectability criteria, completed quarantine, and had chest CT results that were not suspicious for COVID-19 were operated on. We performed 9

Elective surgical activity and lung transplant before and during the COVID-19 pandemic

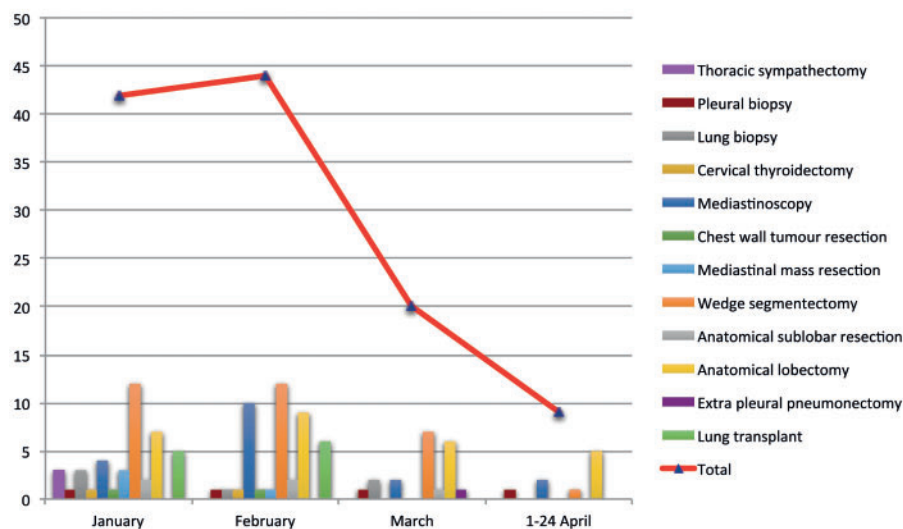


Figure 2: Elective surgical activity before and during the pandemic. COVID-19: coronavirus disease 2019.

Table 3: Outcomes of postoperative patients during the COVID-19 pandemic

Procedure	N (%)	Period		Post-screening period		Hospitalization (days)		Postoperative complications ^a		Deaths ^b	
		Prescreening period		6–24 April		All negative	Screening PCR COVID-19	Yes	Type	T	COVID+
		1–19 March	20 March–5 April	Diagnostic PCR COVID-19	Diagnostic PCR COVID-19						
Total %	34	22 (65%)	2 (6%)	10 (29%)	All negative	4.72	4	4	2	1	
Elective surgery	4 (12)	2	0	2	2	1	0	0	0	0	
Mediastinoscopy	2 (6)	1	0	1	1	5.5	1	Bleeding	1	0	
Pleural biopsy	2 (6)	2	0	0	0	4	0	0	0	0	
Lung biopsy	8 (24)	7	0	1	1	3.9	1	AKI	1	1	
Wedge segmentectomy	1 (3)	1	0	0	0	3	0	0	0	0	
Anatomical sublobar resection	11 (32)	6	0	5	5	5.3	1	AF	0	0	
Anatomical lobectomy	1 (3)	1	0	0	0	8	0	0	0	0	
Extrapleural pneumonectomy	3 (9)	1	2	0	0	8.3	0	0	0	0	
Bullectomy	1 (3)	1	0	1	1	(-) ^f	1	Pneumonia	0	0	
Urgent surgery ^d	1 (3)	0	0	0	0	(-) ^f	0	0	0	0	
Emergency surgery ^e	1 (3)	0	0	1	1	(-) ^f	0	0	0	0	
Thoracic trauma damage control	1 (3)	0	0	1	1	(-) ^f	0	0	0	0	
Mediastinitis											

^aEarly postoperative complications during hospitalization.

^bMortality within 30 days after surgery was divided in T (total mortality) and COVID+ (mortality due to COVID-19).

^cDays after surgery PCR SARS-CoV-2 test results were positive.

^dUrgent surgery: not life-threatening.

^eEmergency surgery: life-threatening.

^fStill hospitalized at the writing of this article.

AF: atrial fibrillation; AKI: acute kidney injury; COVID-19: coronavirus disease 2019; PCR: polymerase chain reaction; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2.

electives surgical procedures and 1 emergency thoracotomy procedure for mediastinitis drainage. More than 60% of the elective operations were lung resections in patients diagnosed with carcinoma. During this last period, all patients underwent the COVID-19 screening protocol; no SARS-CoV-2 infections were detected before the operation and neither of them, as of this writing, has developed the disease.

In total, 2 of the 34 patients (5.88%) who underwent surgery during the COVID-19 pandemic were diagnosed with COVID-19. One of the 2 had thoracic trauma with multiple rib fractures and right haemothorax and required an emergency thoracotomy for damage control on 15 March. On the seventh postoperative day, the patient started showing symptoms of fever and pulmonary infiltrates on a CT scan, so he was tested with SARS-CoV-2 PCR, the results of which were positive; he was diagnosed with bilateral SARS-CoV-2 pneumonia. The course of the patient's disease was difficult: he required a tracheostomy. As of this writing, the patient has been discharged from the intensive care unit but is still hospitalized. The results of the latest test for SARS-CoV-2 were negative; he has been decannulated, and he does not require oxygen therapy.

The second patient was a 79-year-old man who underwent a wedge segmentectomy of the left upper lobe on 16 March. He had a history of a right upper lobectomy, radical nephrectomy for renal carcinoma, aortic aneurysm, atrial fibrillation, hypertension and ischaemic heart disease, classified as American Society of Anesthesiologists classification IV. The patient was discharged after the operation but returned to the emergency room on the 9th postoperative day with respiratory symptoms. He was diagnosed with bilateral COVID-19 pneumonia. The patient required hospital admission and died despite treatment.

DISCUSSION

On 30 January 2020, the World Health Organization declared the Chinese outbreak of COVID-19 to be a Public Health Emergency of International Concern [15, 16]. In early February 2020, the World Health Organization based the diagnostic criteria for COVID-19 on compatible clinical features (fever and lower respiratory tract infection) associated with epidemiological risk (history of travel to Hubei province, China or close contact with confirmed COVID-19 patients within days of symptom onset) [15]. These were the criteria that we used in our hospital during February and mid-March to screen for the disease.

In Spain, at the writing of this article, there are a total of 205 905 cases confirmed by SARS-CoV-2 PCR, of which 58 819 are located in the Madrid region [17]. The 12 de Octubre University Hospital is a tertiary care hospital with more than 1300 hospital beds, of which more than 1000 were reserved for patients with COVID-19 during the worst moments of the pandemic. Clinical practice has been altered and that of the thoracic surgery department has not been an exception.

The institutional resources were altered: 3 thoracic surgeons were assigned to the hospital's COVID-19 units or to Madrid's Ifema field hospital. As specialists in pulmonary disease, we also contributed to reduce the workload in the intensive care units [18] by treating pulmonary diseases likely to require our intervention (e.g. pneumothorax, pneumomediastinum and surgical tracheostomies [19]).

Despite the preventive measures approved by our hospital, 4 doctors out of 11 (36%) from our department, 3 medical residents

and 1 attending physician have been diagnosed with COVID-19. One required hospital admission but all evolved favourably.

Due to the increased risk of surgical complications [20, 21] in those patients with asymptomatic COVID-19, we established a protocol in the thoracic surgery department designed to detect these patients prior to undergoing surgical procedures.

Our protocol includes the use of chest CT. As recently reported [13, 14], chest CT demonstrates typical radiographic features in almost all patients with COVID-19, including ground-glass opacities, multifocal patchy consolidation and/or interstitial changes with a peripheral distribution.

In our experience, none of the chest CTs performed as part of the screening protocol for COVID-19 prior to surgery identified initial signs of infection with SARS-CoV-2. This finding correlates well with the PCR tests performed, all of which had negative results.

However, at the beginning of the pandemic in our hospital, we detected in several follow-up chest CTs of oncological patients who were asymptomatic the typical radiographic features of coronavirus disease. For this reason and due to the lack of sensitivity of PCR tests and chest radiographs in identifying the initial signs of COVID-19, we decided to apply all the resources available in our hospital to screening for the disease. We also suggest that, in further and more favourable phases of the pandemic, CT screening could be omitted.

Of the 34 patients who were operated on, 2 developed COVID-19. Of these, 1 died and the other patient is still hospitalized. The operation performed on the first patient, a 79-year-old man with multiple comorbidities who had a history of a contralateral lobectomy, was a wedge segmentectomy. The other operation was a thoracotomy for damage control following thoracic trauma. It is interesting to note that both patients were operated on, on 16 and 15 March, respectively. These dates coincide with the dates of the peak incidence of COVID-19 in our region and with the declaration of the state of emergency and confinement in Spain: 14 March 2020 [22].

The coronavirus disease pandemic has impacted all areas of daily life, including medical care. The treatment of patients with lung cancer during this crisis is challenging [23, 24]. On the one hand, patients have a risk of death from cancer, which is increased if radical surgery is delayed. On the other hand, the risk of death or of serious complications from coronavirus disease and the higher lethality of the infection in immunocompromised patients have to be weighed in relation to the former. The Royal College of Surgeons of England [25] noted that patients with cancers with a high risk of progression without treatment should be operated on as resources, such as the capacity of intensive care units, permit. In some cases [10], neoadjuvant therapy may be used as a means of delaying surgery, although the risk of exposure to COVID-19 during clinic visits for chemotherapy or radiotherapy is still high.

The spread of SARS-CoV-2 has already taken on pandemic proportions, affecting over 100 countries in a matter of weeks [26]. As of April 2020, we are almost at the 4-month mark of COVID-19.

Regarding the future [27], the Spanish College of Surgeons [28] has defined 5 scenarios of the pandemic, based on the percentage of patients with COVID-19 in the hospital in relation to capacity. When the percentage becomes <5%, surgical activity could return to normal.

With this article, our goal was to offer our experience as thoracic surgeons in the epicentre of the COVID-19 pandemic in our country. We highlight that once we added preoperative asymptomatic patients to those checked with the screening protocol

for COVID-19 to the preventive measures practiced in our hospital, none of our patients presented with SARS-CoV-2 infection.

Limitations

This study has several limitations: the small sample size, the retrospective nature of the study and the limited diagnostic testing available during the early period of the pandemic.

CONCLUSION

SARS-CoV-2 represents a tremendous limitation for thoracic surgical practice. Adapting preoperative practices to exclude asymptomatic patients infected with SARS-CoV-2 allowed us to perform thoracic surgical procedures.

Conflict of interest: none declared.

Author contributions

María Salmerón Jiménez: Conceptualization; Data curation; Formal analysis; Methodology; Validation; Visualization; Writing—original draft; Writing—review & editing. **Fátima Hermoso Alarza:** Conceptualization; Data curation; Formal analysis; Methodology; Supervision; Validation; Visualization; Writing—original draft; Writing—review & editing. **Ivan Martínez Serna:** Methodology; Supervision; Visualization. **Carmen Marrón Fernández:** Methodology; Supervision; Validation. **José Carlos Meneses Pardo:** Supervision; Validation; Visualization. **José Alberto García Salcedo:** Supervision; Validation; Visualization. **Alejandro Torres Serna:** Visualization. **Mario Gustavo Manama Gama:** Visualization. **Oscar Enrique Colmenares Mendoza:** Visualization. **Vicente Díaz-Hellín Gude:** Supervision; Validation; Visualization. **Antonio Pablo Gamez García:** Conceptualization; Investigation; Methodology; Project administration; Resources; Supervision; Validation; Visualization; Writing—review & editing.

Reviewer information

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