Outcomes After Vascular Surgery Procedures in Patients with COVID-19 Infection: A National Multicenter Cohort Study (COVID-VAS)

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Objectives: To analyze the outcome of vascular procedures performed in patients with COVID-19 infection during the 2020 pandemic.

Methods: This is a multicenter, prospective observational cohort study. We analyzed data from 75 patients with COVID-19 infection undergoing vascular surgery procedures in 17 hospitals across Spain and Andorra between March and May 2020. The primary end point was 30-day mortality. Clinical Trials registry number NCT04333693.

Results: The mean age was 70.9 (45–94) and 58 (77.0%) patients were male. Around 70.7% had postoperative complications, 36.0% of patients experienced respiratory failure, 22.7% acute

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renal failure, and 22.7% acute respiratory distress syndrome (ARDS). All-cause 30-days mortality rate was 37.3%. Multivariate analysis identified age $>$65 years ($P = 0.009$), American Society of Anesthesiologists (ASA) classification IV ($P = 0.004$), preoperative lymphocyte count $<$0.6 ($\times 10^9$/L) ($P = 0.001$) and lactate dehydrogenase (LDH) $>$500 (UI/L) ($P = 0.004$), need for invasive ventilation ($P = 0.043$), postoperative acute renal failure ($P = 0.001$), ARDS ($P = 0.003$) and major amputation ($P = 0.009$) as independent variables associated with mortality. Preoperative coma ($P = 0.001$), quick Sepsis Related Organ Failure Assessment (qSOFA) score $\geq$2 ($P = 0.043$), lymphocytes $<$0.6 ($\times 10^9$/L) ($P = 0.019$) leucocytes $>$11.5 ($\times 10^9$/L) ($P = 0.007$) and serum ferritin $>$1800 mg/dL ($P = 0.004$), bilateral lung infiltrates on thorax computed tomography ($P = 0.025$), and postoperative acute renal failure ($P = 0.009$) increased the risk of postoperative ARDS. qSOFA score $\geq$2 was the only risk factor associated with postoperative sepsis ($P = 0.041$).
Conclusions: Patients with COVID-19 infection undergoing vascular surgery procedures showed poor 30-days survival. Age $>$65 years, preoperative lymphocytes $<$0.6 (x10^9/L) and LDH $>$500 (UI/L), and postoperative acute renal failure, ARDS and need for major amputation were identified as prognostic factors of 30-days mortality.

INTRODUCTION

The outbreak of coronavirus 2019 (COVID-19), an emerging infectious syndrome caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) virus, constitutes the greatest public health emergency of this century. On January 30, 2020, the World Health Organization announced that the COVID-19 epidemic was a public health emergency of international concern. COVID-19 has contributed to an enormous adverse impact globally. While the population continues to be affected by the whole spectrum of preexisting diseases, hospitals were swamped with a massive number of COVID-19 patients, so in this context, the majority of surgical departments were forced to reschedule their activity giving priority to urgent or emergent and nondeferrable cases. Our knowledge of COVID-19 is still rapidly evolving but, to date, we do not yet know the complete impact of this pandemic regarding vascular surgery. Patients with vascular diseases are especially prone to the development of complications if infected by COVID-19.[1]

The COVID-19 pandemic has significantly altered the practice of medicine, has perturbed the functioning of healthcare systems around the world and led to changes in elective surgical care. On March 14, 2020, Spain experienced drastic changes in our health practice in accordance to the Ministry of Health, Consumption and Social Welfare Guidelines' indications. This fact involved postponing all elective cases, with the exception for immediate life- or limb-threatening processes. But, since March, many of the postponed elective and semi-acute operations had to be performed later on, in April or May. The COVID-19 pandemic has affected the globe with Spain leading many updates of incidence and mortality. By June 1, 2020, 239,638 confirmed cases of patients infected by COVID-19 and 27,127 deaths were published in Spain,[2] the third European country in confirmed cases (after Russia and United Kingdom) and the sixth in the world (led by United Sates and Brazil).

In this article, we will focus on the detailed clinical outcomes when performing vascular surgery procedures for COVID-19 patients. The most important real-world registry is the CovidSurg Cohort Study (Outcomes of surgery in COVID-19 infection: international cohort study),[3] this international multicenter cohort study aims to assess the outcomes of any type of surgery (including obstetrics) in patients with COVID-19 infection. The primary aim of the present prospective multicenter study was to describe the treatment, outcome, and prognostic factors for patients with COVID-19 infection undergoing vascular surgery procedures. We analyzed data from a prospective database of patients treated in Spanish centers.

MATERIAL AND METHODS

Study Design

This prospective, multicenter, nationwide, observational, open-cohort study included all patients with COVID-19 infection who underwent vascular surgery at 17 voluntary vascular centers, between March and May 2020. This study was supported by the Vascular Investigation Network of the Spanish Society for Angiology and Vascular Surgery (RIV-SEACV). The study, which received no financial support from industry, was performed in agreement with the Declaration of Helsinki and was approved by the institutional review board at each participating site (PI 20-1731, Valladolid East Ethics Committee for Clinical Investigation). In accordance with institutional and local regulatory

policies, all patients who underwent procedures within this study signed a written informed consent. This trial is registered within the Clinical Trials registry, number NCT04333693.

Data entry was managed by physicians involved in direct patient care and was collected in a prospectively maintained database. Data was collected and stored online through a secure server running the SEACV web application. This secure server allows collaborators to enter and store data in a secure system. A designated collaborator at each participating site was provided with project server login details, allowing them to securely submit data on to the system. Only anonymized data were uploaded to the database. No patient-identifiable data were collected. Data collected pertained comorbidities, physiological state, treatment/operation, and outcome. The quick Sepsis Related Organ Failure Assessment (qSOFA) and the Severity Score for Community-Acquired Pneumonia (CURB-65) were calculated based on the individual data points entered.

Study Population

The inclusion criteria were adults (age ≥18 years) undergoing any type of vascular surgery procedure in an operating theater, this includes open surgery, endovascular surgery, and hybrid procedures. COVID-19 infection was confirmed with laboratory tests either before or after surgery. Urgent and emergent surgeries were included. Urgent surgery was defined as the ones that could wait until the patient was medically stable, but should have generally been done within 2 days. However, emergent surgery was defined as the cases that had to be performed without delay, and the patient had no choice other than immediate surgery if permanent disability or death was to be avoided. Patients who met the inclusion criteria would be included regardless of surgical indication (aneurysm, limb or visceral ischemia, carotid stenosis, and vascular trauma), anesthetic type (local, regional, and general), procedure type, or surgical approach.

Demographic, risk factors, preoperative status (analytical and hemodynamic monitoring values), thoracic X-ray or thoracic computed tomography scan results, surgical characteristics, COVID-19 treatments (antibiotics, antivirals, chloroquine and related drugs, corticosteroids, intravenous immunoglobulins, interferon, interleukin-6 receptor antagonist), postoperative outcome (dialysis, support ventilation or mechanical ventilation), hospital stay, and ICU admission and prognosis were obtained. Preoperative comorbidities included smoking, asthma,[4] cancer history, chronic renal failure (creatinine level >150 mmol/L), chronic obstructive pulmonary disease (COPD), chronic heart failure, dementia, diabetes mellitus (oral hypoglycemic medications and/or insulin), hypertension (>140/90 mm Hg; antihypertensive medication), ischemic heart disease, peripheral arterial disease, and stroke (ischemic or hemorrhagic stroke). Postoperative complications considered were acute renal failure (defined according to KDIGO clinical practice guidelines),[5] acute respiratory distress syndrome (ARDS, defined by the Kigali modification),[6] bleeding requiring transfusion, cardiac failure requiring cardiopulmonary resuscitation, coma >24 h, acute myocardial infarction (elevation of hypersensitive troponin I and creatine kinase-MB or new abnormalities were shown in electrocardiography and echocardiography), arrhythmia, deep vein thrombosis, pulmonary embolism, pneumonia, respiratory failure, sepsis, septic shock, cerebrovascular accident, surgical site infection, wound dehiscence, urinary tract infection, treated vessel thrombosis, and major (transfemoral or transtibial) or minor amputation (any toe or forefoot amputation). CURB-65 and q-SOFA (quick Sepsis Related Organ Failure Assessment) scores were also obtained.[7,8] Two research investigators independently reviewed the data collection to verify data accuracy (ESN, JDH). Any missing or uncertain records were collected and clarified by direct communication with the participating center.

End Points

The primary end point of this analysis was to determine 30-day mortality in patients with COVID-19 infection who underwent vascular surgery. Seven-day mortality, 30-day reintervention, respiratory failure, ARDS, and sepsis were also analyzed as secondary end points.

Statistical Analysis

Normally distributed continuous variables are summarized with mean and standard deviation and compared using independent group *t*-tests when the data were normally distributed; otherwise, the Mann-Whitney test was used. Continuous variables were tested for normality using the Shapiro-Wilk's test. Categorical variables were expressed as frequencies and percentages and compared by Pearson's chi-square or Fisher's exact test.

For the binary outcomes concerning mortality within 30 days of surgery, univariate and multivariate logistic regressions were used. In the multivariate models, patient characteristics, comorbidities, vascular disease diagnosis, COVID-19 treatments, and postoperative complications were used as covariables. Univariate and multivariate logistic regression analyses were performed, and odds ratios (ORs) with 95% confidence intervals (CIs) were reported. Two sided *P*values<0.05 were considered statistically significant throughout. All the analyses were performed with the SPSS statistical software package (version 20.0; IBM Corporation, Somers, NY, USA).

RESULTS

Patients

A total of 75 cases with COVID-19 infection undergoing vascular surgery were enrolled in the present study. Among them, 47 cases (62.7%) were confirmed COVID-19 preoperatively by positive SARS-CoV-2 nucleic acid test, whereas 28 cases (37.3%) were considered as suspected COVID-19 as diagnosed by clinical manifestations, exposure history and X-ray or CT examination and were confirmed postoperatively by nucleic acid test. Only 9 patients (12%) were previously admitted because of CODIV-19 related complications (pneumonia or ARDS). The clinical characteristics of patients are shown in Table I. The most prevalent comorbidity was hypertension (75%), followed by diabetes mellitus (57%) and smoking (57%). Statin and antiplatelet drugs usage was frequent (65.3% and 53.3%, respectively).

During the study period, 43 (57.4%) vascular procedures for revascularization of the limbs were performed (41 lower limbs and 2 upper limbs), 2 (2.6%) for aneurysms (one abdominal and one thoracic aneurysm), and 4 (5.3%) for vascular trauma. Twenty-six (34.7%) patients underwent vascular surgery for other pathologies. The most frequent American Society of Anesthesiologist (ASA) classification was category 3 (63.1%). Local anesthesia (10.7%), regional anesthesia (53.3%), and general anesthesia (36.0%) were the anesthetic methods used in the surgery procedures. Sixty-four cases (85.3%) required open surgery, 8 (10.7%) endovascular techniques, and 3 (4.0%) hybrid procedures. The most frequent surgical type was urgent surgery (56.0%), followed by emergent (44.0%) surgery. Preoperative clinical status and lab test values are included in Table II and Table III.

Postoperative Outcomes

The 30-days mortality was 37.3%. Seventeen (22.7%) patients died in the first 7 days after surgery and 11 (14.7%) between 8 and 30 days postoperatively. Thirty days adverse events occurred in 53 (70.7%) patients. The most frequent associated postoperative complications were respiratory failure (36.0%), acute renal failure (22.7%), and ARDS (22.7%). Seventeen patients required lower limb amputation (4.0% minor amputation and 17.3% mayor amputation) (Table IV).

After adjustment for potential confounding variables, multivariate analysis indicated that age >65 years was associated with almost 7 times higher of risk mortality (OR 7.17, 95% CI: 1.50–34.21, $P = 0.009$) and ASA-IV classification with almost 5 times (OR 4.71, 95% CI: 1.47–15.07, $P = 0.004$). Other predictors of mortality were lymphocytes <0.6 ($\times 10^9$/L) (OR 11.12, 95% CI: 2.17–56.88, $P = 0.001$) and LDH >500 (UI/L) (OR 9.75, 95% CI: 1.18–52.85, $P = 0.004$), treatment requiring azithromycin (OR 4.27, 95% CI: 1.54–11.84, $P = 0.014$) lopinavir (OR 3.73, 95% CI: 1.38–10.04, $P = 0.018$) or invasive ventilation (OR 3.15, 95% CI: 1.08–9.24, $P = 0.043$) and postoperative acute renal failure (OR 5.92, 95% CI: 1.91–18.40, $P = 0.001$), ARDS (OR 4.42, 95% CI: 1.41–13.88, $P = 0.003$) and major amputation (OR 4.83, 95% CI: 1.63–8.49, $P = 0.009$).

For the association between variables and 7-days mortality, lymphocytes <0.6 ($\times 10^9$/L) (OR 9.72, 95% CI: 2.35–40.17, $P = 0.002$) and LDH >500 (UI/L) (OR 1.92, 95% CI: 1.30–2.84, $P = 0.001$), therapy requiring lopinavir (OR 4.95, 95% CI: 1.43–17.06, $P = 0.008$) or invasive ventilation (OR 3.80, 95% CI: 1.20–12.08, $P = 0.028$), and postoperative acute renal failure (OR 7.78, 95% CI: 2.34–25.80, $P = 0.001$), were significantly associated with an increased risk.

The need for tocilizumab (OR 6.48, 95% CI: 1.88–22.32, $P = 0.004$) postoperative bleeding (OR 9.50, 95% CI: 1.95-46.18, $P = 0.001$), wound dehiscence (OR 10.55, 95% CI: 1.12–64.80, $P = 0.013$), treated vessel thrombosis (OR 12.76, 95% CI: 2.68–59.92, $P = 0.001$), and major amputation (OR 38.00, 95% CI: 7.82–184.72, $P = 0.000$), were significantly associated with an increased risk of 30 days reintervention.

Preoperative coma (OR 9.42, 95% CI: 2.51–35.34, $P = 0.001$), qSOFA score ≥2 (OR, 95% CI: 1.12–28.35, $P = 0.043$), lymphocytes <0.6 ($\times 10^9$/L) (OR 5.24, 95% CI: 1.35–20.31, $P = 0.019$) leucocytes >11.5 ($\times 10^9$/L) (OR 4.80, 95% CI: 1.47–

Table I. Demographic and comorbidity characteristics. Preoperative treatments and vascular pathologies. Outcome of univariate analysis regarding the primary endpoint, 30-day mortality

	%	Univariate analysis P
Age (range)	70.9 (45–94)	0.027*
Age >65 years		0.006*
Gender (male)	77%	
ASA scale		
I	1.5%	0.411
II	7.7%	0.640
III	63.1%	0.074
IV	27.7%	0.007*
Smoking	50.7%	0.929
Asthma	6.7%	0.898
Cancer history	18.7%	0.172
Chronic renal failure	12.0%	0.071
COPD	33.3%	0.736
Chronic heart failure	12.0%	0.791
Dementia	4.0%	0.552
Diabetes mellitus	50.7%	0.698
Hypertension	76.0%	0.336
Ischaemic heart disease	24.0%	0.687
Peripheral arterial disease	44.0%	0.197
Stroke	5.3%	0.290
Dislypemia	28.0%	0.655
Preoperative treatments:		
ACE inhibitors	21.3%	0.571
Angiotensin II receptor blockers	32.0%	0.623
Diuretics	28.0%	0.027
Beta-blockers	29.3%	0.092
Calcium channel blockers	17.3%	0.062
Anticoagulants	26.7%	0.773
Antiplatelets	53.3%	0.610
Statins	65.3%	0.883
Corticoids	4.0%	0.884
Immunosuppressive drugs	1.3%	0.437
Vascular pathology		
Aneurysm	2.6%	0.373
Carotid stenosis	0%	-
Limb ischemia	57.4%	0.526
Vascular trauma	5.3%	0.626
Others	34.7%	0.793

*Statistically significant.

15.73, $P = 0.007$) and serum ferritin >1800 mg/dL (OR 2.00, 95% CI: 1.14–3.52, $P = 0.004$), bilateral lung infiltrates on thorax computed tomography (OR 5.67, 95% CI: 1.54–22.09, $P = 0.025$), the need for treatment with azithromycin (OR 4.096; 95% CI: 1.32–12.69, $P = 0.011$), lopinavir (OR 4.95, 95% CI: 1.43–17.06, $P = 0.008$), corticosteroids (OR 3.75, 95% CI: 1.22–11.55, P 0.017), beta interferon (OR: 5.63, CI: 95%: 1.31–24.12, $P = 0.024$) or tocilizumab therapy (OR 4.84, 95% CI: 1.48-15.88, $P = 0.017$) and postoperative acute renal failure (OR 5.40, 95% CI: 1.67–17.42, $P = 0.009$) increased the risk of postoperative ARDS.

For the analyses of the association between studied variables and postoperative respiratory failure, treatment requiring azithromycin (OR 3.62; 95% CI: 1.32–9.96, $P = 0.011$) or tocilizumab therapy (OR 4.81, 95% CI: 1.53–15.19, $P = 0.005$) and postoperative acute renal failure (OR 6.50, 95% CI: 2.08–20.34, $P = 0.001$), were significantly

Table II. Preoperative clinical status and lab test values. LDH: lactic acid dehydrogenase

	Mean±SD	*Univariate analysis P*
Confusion	17.3%	*0.062*
Breathing rate (bmp)	25.0±15.5	*0.498*
Heart rate (bmp)	86.9±17.4	*0.100*
Systolic blood pressure (mm Hg)	143.0±130.7	*0.458*
Diastolic blood pressure (mm Hg)	76.7±14.8	*0.915*
Peripheral oxygen saturation (%)	94.5±5.0	*0.075*
Inspired oxygen fraction (%)	35.8±37.3	*0.498*
Hemoglobin (g/dL)	11.9±2.5	*0.910*
Leukocytes (x10^9/L)	12.5.25±8.2	*0.895*
Neutrophils (x10^9/L)	9.2±5.9	*0.481*
Lymphocytes (x10^9/L)	1.4±1.4	*0.569*
Platelets (x10^9/L)	273.3±238.5	*0.626*
D-dimer (ng/mL)	9434.37±16564.8	*0.569*
C-reactive protein (mg/L)	485.5±706.1	*0.767*
Serum albumin (mg/dL)	2.95±0.6	*0.248*
Urea (mg/dL)	97.1±166.1	*0.522*
Creatinine (mg/dL)	1.5±1.4	*0.692*
Serum ferritin (mg/dL)	2009.1±1954.5	*0.199*
LDH (UI/L)	757.3±838.2	*0.192*
IL-6 (pg/mL)	1485.6±1556.6	*0.340*
Venous blood gasometry:	30.7%	
O_2 saturation (%)	65.2±57.8	*0.757*
Lactate concentration (mmol/L)	11.6±10.7	*0.742*
Bicarbonate (HCO_3) (mm/L)	24.8±5.9	*0.537*
Partial pressure of oxygen (PaO_2) (mm Hg)	72.2±52.0	*0.506*
Partial pressure of carbon dioxide ($PaCO_2$) (mm Hg)	42.9±14.2	*0.744*
CURB-65 score		
0	12.0%	*0.141*
1	38.7%	*0.685*
2	38.7%	*0.565*
3	5.3%	*0.626*
4	4.0%	*0.552*
5	1.3%	*0.373*
qSOFA score		
0	68.0%	*0.296*
1	21.3%	*0.550*
2	9.3%	*0.525*
3	1.3%	*0.373*
Thorax X-ray	89.3%	
Normal	38.8%	*0.161*
Lung consolidation	1.5%	*0.437*
Unilateral lung infiltrate	1.5%	*0.706*
Bilateral lung infiltrates	49.3%	*0.063*
Others	7.5%	*0.643*
Thorax computed tomography	72.0%	
Normal	59.3%	*0.983*
Lung consolidation	0%	-
Unilateral lung infiltrate	1.9%	*0.403*
Bilateral lung infiltrates	24.1%	*0.270*
Others	14.8%	*0.449*

IL, interleukin. Outcome of univariate analysis regarding the primary endpoint, 30-day mortality.
*Statistically significant.

Table III. COVID-19 treatment. Outcome of univariate analysis regarding the primary endpoint, 30-day mortality

	%	Univariate analysis P
Antibiotic		
Azithromycin	33.3%	0.004*
Antiviral	48%	
Lopinavir	4.0%	0.884
Lopinavir+Ritonavir	41.3%	0.002*
Lopinavir+Ritonavir+Remdesivir	1.3%	0.437
Lopinavir+Darunavir	1.3%	0.627
Lopinavir (single or combination)	48.0%	0.008
Chloroquine/hydroxychloroquine	68%	0.623
Chloroquine	5.3%	0.626
Hydroxychloroquine	62.7%	0.823
Corticosteroids	34.7%	0.392
Intravenous immunoglobulins	0%	-
Beta interferon	12.0%	0.281
Interleukin-6 receptor antagonist (Tocilizumab)	22.7%	0.709
Dialysis		
No	94.7%	0.626
<30 postoperative days	1.3%	0.373
>30 postoperative days	0%	-
Preoperative treatment	4.0%	0.884
Respiratory support	68.0%	0.011*
Low-flow oxygen therapy	22.7%	0.843
High-flow oxygen therapy	20.0%	0.403
Noninvasive ventilation	0%	-
Invasive ventilation	25.3%	0.032*
1–23 h	4.0%	0.884
24–47 h	1.3%	0.373
48–71 h	5.3%	0.017*
72–167 h	1.3%	0.373
>167 h	13.3%	0.851
ECMO ventilation	0%	-

ECMO Extracorporeal membrane oxygenation.
*Statistically significant.

associated with increased risk. qSOFA score ≥ 2 was the only variable significantly associated with postoperative sepsis (OR 13.20, 95% CI: 1.52–114.52, $P = 0.041$).

DISCUSSION

The COVID-19 pandemic has overwhelmed healthcare systems across the world, and has also affected specialized practices such as vascular surgery. Since the Spanish government declared the state of alarm on March 14, 2020, we have instituted significant changes to our routine vascular surgical activities. The majority of centers experienced a reduction in or cessation of patient services and elective cases while continuing emergency surgery in accordance with the recommendations provided by the Spanish Ministry of Health, to preserve hospital resources such as intensive care unit beds. In the same way as in Portugal we have seen a significant decrease in the number of vascular urgent and emergent cases, which is probably due to the population confinement measures and to patients being afraid to go to medical centers.[9] Also, many health care systems and hospitals have converted existing outpatient clinic visits to telehealth visits. A risk-benefit assessment of every vascular patient undergoing surgery should be performed during the COVID-19 pandemic based on the urgency of the surgery and the risk of the viral illness and transmission. There is minimal evidence regarding emergency surgical care in the COVID-19 era. The effects of perioperative physiological stress on predisposition to or recovery from COVID-19 are not known, but it is assumed that relative immunocompromise after surgical

Table IV. Postoperative complications. Outcome of univariate analysis regarding the primary endpoint, 30-day mortality

	%	*Univariate analysis P*
30-days mortality	37.3%	
Mortality type		
Intraoperative	0%	
1–7 postoperative days	22.7%	
8–30 postoperative days	14.7%	
Reintervention	20.0%	*0.121*
ICU stay (SD, range)	4.1 ± 10.9 (0–58)	*0.866*
Hospital stay	19.1 ± 18.5 (0–98)	*0.020**
Postoperative complications	70.7%	
Acute renal failure	22.7%	*0.001**
ARDS	22.7%	*0.008**
Bleeding	10.7%	*0.992*
Cardiac failure	1.3%	*0.373*
Coma	9.3%	*0.751*
Acute myocardial infarction	6.7%	*0.645*
Arrhythmia	5.3%	*0.626*
Deep vein thrombosis	0%	-
Pulmonary embolism	2.7%	*0.707*
Pneumonia	21.3%	*0.571*
Respiratory failure	36.0%	*0.146*
Sepsis	5.3%	*0.144*
Septic shock	4.0%	*0.552*
Cerebrovascular accident	2.7%	*0.707*
Surgical site infection	2.%	*0.208*
Wound dehiscence	8.0%	*0.078*
Urinary tract infection	4.0%	*0.884*
Treated vessel thrombosis	12.0%	*0.791*
Minor amputation	4.0%	*0.289*
Major amputation	17.3%	*0.001**

ARDS, acute respiratory distress syndrome.
*Statistically significant.

intervention worsens the prognosis of those who contract COVID-19 perioperatively. There is no doubt about the effect that COVID-19 can have on cardiovascular-related department's service operation and performance. The consequences of the COVID-19 infection will affect vascular surgery worldwide for a long time, and probably longer than expected several months ago. Currently, the data on the clinical characteristics and outcomes of patients with COVID-19 infection undergoing vascular surgery are limited. Therefore, for the time being, no treatment protocol is available.

The experience from Singapore published by Tan et al.,[10] described 6 types of elective operations that would be carried out during the COVID-19 pandemic: limb salvage surgery (bypass or endovascular approach), aortic aneurysm surgery, vascular oncology surgery, major and minor amputations, creation, and salvage of arteriovenous fistula. In our series, lower limb revascularization (54.7%) was the most common diagnosis for surgery, followed by vascular trauma (5.3%). Whenever possible, Spanish vascular surgeons have opted for an approach that shortened the length of stay: use of local or regional anesthesia, endovascular aneurysm repair and percutaneous approach. The need for intensive care has been considered a "critical key" for vascular surgery patients. Therefore, endovascular favored over open repair whenever possible to shorten hospital and ICU stay could improve the treatment of our patients. Nevertheless, the endovascular approach could be possible in only 8 patients (10.7%) and the local or regional anesthesia in 48 patients (64.0%). This fact could be explained because lower limb revascularization (54.7%), and specifically thromboembolectomy, was the most frequent surgical procedure and is related

with the reported high incidence of cardiovascular complications associated with COVID-19 infection, including systemic arterial embolism.[11] Sena and Gallelli reported an incremented incidence of patients with severe critical limb ischemia undergoing amputation surgery during the COVID-19 pandemia.[12] A study published in 2021 with 49 patients of the New York Metro area with acute arterial thromboembolism, reported 10% of primary amputation, 18% of limb loss and 46% of intrahospital mortality.[13] In our series, 17 (22.7%) patients required some type of amputation during hospital stay. Several studies have reported associated coagulopathy disorders in COVID-19 patients. These reports have highlighted a coexisting hypercoagulable state in patients with COVID-19, which may be associated with higher limb ischemia and mortality.[14,15] Bellosta et al.[16] in Italy, reported the high rate of clinical and technical failure of limb revascularization for acute ischemia (70.6% of successful revascularization and 40% of mortality). This seems to support a hypercoagulable state triggered by this viral infection. Meanwhile Abdallah in Paris reported the observation of a rising number of acute arterial events in COVID-19 patients with no prior vascular history.[17]

Wynants et al.[18] published a systematic review of prediction models for prognosis of COVID-19 infection. Prognostic models for patients with diagnosis of COVID-19 included age and lymphocyte count as mortality predictors. In our series age >65 years and preoperative lymphocyte count <0.6 ($\times 10^9$/L) were found as major mortality factors. Zhou et al.,[19] in their retrospective, multicenter cohort study including 191 patients found older age (OR 1.10 per year increase) associated with in-hospital death. Further, this investigation also suggested also suggested higher SOFA score and D-dimer elevation on admission as mortality risk factors. In our investigation qSOFA score ≥2 was associated with postoperative ARDS incidence (OR 5.64) but not with mortality. Very high levels of D-dimer (9434.37 ± 16564.8 ng/mL) were found in our series, but no relation with mortality, postoperative complications or reoperation was found. Nevertheless D-dimer has been described as a predictor of disease deterioration in several studies.[20] Other laboratory examinations such as leucopenia, leukocytosis, aspartate amino transferase, creatinine, hypersensitive cardiac troponin, ferritin, procalcitonine and LDH have been proposed as risk factors for complications and mortality.[21–23] Preoperative LDH>500 (UI/L) constituted in our report a significant predictor of 7 days (OR 1.92) and 30 days mortality (OR

9.75), meanwhile serum ferritin>1800 mg/dL (OR 2.00) was found as an independent risk factor for postoperative ARDS. This finding could reflect the inflammatory storm induced by the immune response against the COVID-19 infection.

The initial clinical sign for the detection of COVID-19 is pneumonia, however, other organ damages have been reported.[24,25] In our study, postoperative acute renal injury has been significantly related with 7 days ($P = 0.001$) and 30 days ($P = 0.001$) mortality, ARDS ($P = 0.009$) and respiratory failure ($P = 0.001$). Pei et al.,[24] published a retrospective single-center study with 333 hospitalized patients with COVID-19 pneumonia with acute renal injury incidence of 75.4%. Patients with renal involvement had higher overall mortality compared with those without renal involvement (11.2% vs. 1.2%). Pathology from autopsies of patients with COVID-19 with renal function impairment suggested acute tubular necrosis as the major form of intrarenal acute renal injury.[26] Meanwhile, in our series, postoperative acute renal failure is one of the most important factors for 7 days mortality (OR: 7.78, 95% CI: 2.34–25.80).

There is no specific treatment for COVID-19, so treatment is symptomatic, and oxygen support represents the major treatment intervention for patients with severe infection. Management is based mainly on supportive therapy and on treating the symptoms and trying to prevent respiratory failure. High-flow oxygen has been usually used but some patients developed ARDS and warranted intubation with mechanical ventilation. The group of patients that required therapy with invasive ventilation was associated with a mortality almost 3 times higher at 7 and 30-days follow-up (OR 3.80, and OR 3.15, respectively).

Various therapeutic agents are being explored for pharmacological treatment of COVID-19. Furthermore, in critically ill patients several combinations had been employed. ARDS presentation was related with treatment with azithromycin ($P = 0.011$), lopinavir ($P = 0.008$), beta-interferon ($P = 0.024$), corticosteroids ($P = 0.017$) or tocilizumab ($P = 0.017$), and azithromycin ($P = 0.011$) and tocilizumab ($P = 0.005$) in cases with respiratory failure. The efficacy of azithromycin in COVID-19 infection has been described with the use in combination with cloroquine/hydroxychloroquine with contradicting results.[27,28]

Our study found 30 days mortality of 37.3%. A report published from Lombardy with 116 patients treated for several vascular pathologies

demonstrated a mortality rate of 2.6%.[29] This difference could be explained because the surgeries performed were not similar, in Lombardy the clinical diagnosis were chronic limb ischemia (20.7%), aortic emergencies (18.1%), symptomatic carotid stenosis (14.7%), whereas in our study, the most popular diagnosis were limb ischemia (57.4%), vascular trauma (5.3%), and aneurysm related pathology (2.6%). Nevertheless, we agree that during the pandemic months, all vascular centers have treated more severe and complex cases of peripheral arterial disease and more serious gangrenes than the previous year.[13,29,30]

This prospective, nationwide, observational study has several limitations. First, the small number of patients included so far. Interpretation of our findings might be limited by the sample size, however, by including patients in 17 referral centers in Spain and Andorra, we believe our study population is representative of cases with COVID-19 infection undergoing vascular surgery. Second, various external factors may have influenced the results. The global scientific community has stood up to the highest standards, unfortunately, the same cannot be said for the organization of healthcare, especially in our country. Many hospitals struggle with personal protective equipment, ventilators and shortages of drugs, putting both patients and staff at risk.[31]

CONCLUSIONS

In conclusion, despite the very few patients undergoing vascular surgery procedures in Spain and Andorra during the COVID-19 pandemic, the short-term mortality has been significantly high. Clinical characteristics such as age >65 years and ASA classification grade IV, laboratory examinations such as preoperative lymphocyte count <0.6 ($\times 10^9$/L) and LDH levels >500 (UI/L) and postoperative complications such as acute renal failure, ARDS, and need for major amputation, have been described as independent negative survival risk factors. qSOFA score ≥ 2 was significantly associated with increased risk of postoperative ARDS and sepsis.

REFERENCES

1. Preliminary estimates of the prevalence of selected underlying health conditions among patients with coronavirus disease 2019 - United States, February 12-March 28, 2020. MMWR Morb Mortal Wkly Rep 2020;69:382–6.
2. Update number 123 of coronavirus disease (COVID-10). 06/01/2020. Spanish Ministry of Health, Consumption and Social Welfare. Available at: https://www.mscbs.gob. es/profesionales/saludPublica/ccayes/alertasActual/nCov/situacionActual.htm
3. CovidSurg. NIHR Global Health Research Unit on Global Surgery. Available at: https://globalsurg.org/covidsurg/.
4. National Asthma Education and Prevention Program: Expert panel report III: Guidelines for the diagnosis and management of asthma. Bethesda, MD: National Heart, Lung, and Blood Institute, 2007. (NIH publication no. 08-4051) Available at: www.nhlbi.nih.gov/guidelines/asthma/asthgdln.htm (Accessed on April 03, 2020).
5. Kellum JA, Lameire N, Group KAGW. Diagnosis, evaluation, and management of acute kidney injury: a Kdigo summary (Part1). Crit Care 2013;17:204.
6. Riviello ED, Kiviri W, Twagirumugabe T, et al. Hospital incidence and outcomes of the acute respiratory distress syndrome using the Kigali Modification of the Berlin Definition. Am J Respir Crit Care Med 2016;193:52–9.
7. Lim WS, van der Eerden MM, Laing R, et al. Defining community acquired pneumonia severity on presentation to hospital: an international derivation and validation study. Thorax 2003;58:377–82.
8. Singer M, Deutschman CS, Seymour CW, et al. The third international consensus definitions for sepsis and septic shock (Sepsis-3). JAMA 2016;315:801–10.
9. Gouveia E Melo R, Mendes Pedros L. Vascualr surgery department adjustments in the era of the COVID-19 pandemic. J Vasc Surg 2020;72:375–6.
10. Tan LGW, Chandrasekar S, Lo ZJ, et al. Early experience in the COVID-19 pandemic from a vascular surgery unit in a Singapore tertiary hospital. J Vasc Surg 2020;17:12–15.
11. Klok FA, Kruip MJHA, van der Meer NJM, et al. Incidence of thrombotic complications in critically ill ICU patients with COVID-19. Thromb Res 2020;191:145–7.
12. Sena G, Gallelli G. An increased severity of peripheral arterial disease in the covid-19 era. J Vasc Surg 2020;72:758.
13. Etkin Y, Conway AM, Silpe J, et al. Acute arterial thromboembolism in patients with COVID-19 in the New York city area. Ann Vasc Surg 2021;70:290–4.
14. Tang N, Li D, Wang X, et al. Abnormal coagulation parameters are associated with poor prognosis in patients with novel coronavirus pneumonia. J Thromb Haemost 2020;18:844–7.
15. Zhang Y, Xiao M, Zhang S, et al. Coagulopathy and antiphospholipid antibodies in patients with Covid-19. N Engl J Med 2020;23:382 e38.
16. Bellosta R, Luzzani L, Natalini G, et al. Acute limb ischemia in patients with COVID-1o pneumonia. J Vasc Surg 2020;29 S0741-5214(20)31080-6.
17. Abdallah IB. Early experience in Paris with the impact of the COVID-19 pandemic on vascular surgery. J Vasc Surg 2020;72:373.
18. Wynants L, Van Calster B, Collins GS, et al. Prediction models for diagnosis and prognosis of covid-19 infection: systematic review and critical appraisal. BMJ 2020;7:369 m1328.
19. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet 2020;28(395):1054–62.
20. Zheng Z, Peng F, Xu B, et al. Risk factors of critical & mortal COVID-19 cases: a systematic literature review and meta-analysis. J Infect 2020;81:e16–25.
21. Pascarella G, Strumia A, Piliego C, et al. COVID-19 diagnosis and management: a comprehensive review. J Intern Med 2020;29. doi:10.1111/joim.13091.
22. Huang C, Wang Y, Li X, et al. Clinical features of patients

infected with 2019 novel coronavirus in Wuhan, China. Lancet 2020;395:497–506.

23. Velavan TP, Meyer CG. The COVID-19 epidemic. Trop Med Int Health 2020;25:278–80.

24. Chan JF, Yuan S, Kok KH, et al. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: A study of a family cluster. Lancet 2020;395:514–23.

25. Pei G, Zhang Z, Peng J, et al. Renal involvement and early prognosis in patients with COVID-19 pneumonia. J Am Soc Nephrol 2020;31:1157–65.

26. Yang X, Jin Y, Li R, et al. Prevalence and impact of acute renal impairment on COVID-19: a systematic review and meta-analysis. Crit Care 2020;18:356.

27. Gautret P, Lagier JC, Parola P, et al. Hydroxychloroquine and azithromycin as a treatment of COVID-19: results of an open-label non-randomized clinical trial. Int J Antimicrob Agents 2020 105949.36.

28. Luo P, Liu Y, Qiu L, et al. Tocilizumab treatment in COVID-19: a single center experience. J Med Virol 2020;92:814–18.

29. Montanari F, Tinelli G, Tshomba Y. Management of vascular surgical urgencies during COVID-19 pandemic. Ann Vasc Surg 2021;70:295–6.

30. Mascia D, Kahlberg A, Melloni A, et al. Single-center vascular hub experience after 7 weeks of COVID-19 pandemic in Lombardy (Italy). Ann Vasc Surg 2020;69:90–9.

31. Björck M, Boyle JR, Dick F. The need of research initiatives amidst and after Covid-19 pandemic: a message from the editors of the European Journal of Vascular and Endovascular Surgery. Eur J Vasc Endovasc Surg 2020;59:695–6.