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REVIEW ARTICLE

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Management of acute and chronic aortic disease during the COVID-19 pandemic—Results from a web-based ad hoc platform

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Abstract

Background: To share the results of a web-based expert panel discussion focusing on the management of acute and chronic aortic disease during the coronavirus (COVID-19) pandemic.

Methods: A web-based expert panel discussion on April 18, 2020, where eight experts were invited to share their experience with COVID-19 disease touching several aspects of aortic medicine. After each talk, specific questions were asked by the online audience, and results were immediately evaluated and shared with faculty and participants.

Results: As of April 18, 73.3% answered that more than 200 patients have been treated at their respective settings. Sixty-four percent were reported that their hospital was well prepared for the pandemic. In 57.7%, the percentage of infected healthcare professionals was below 5% whereas 19.2% reported the percentage to

be between 10% and 20%. Sixty-seven percent reported the application of extracorporeal membrane oxygenation in less than 2% of COVID-19 patients whereas 11.8% reported application in 5%–10% of COVID-19 patients. Thirty percent of participants reported the occurrence of pulmonary embolism in COVID-19 patients. Three percent reported to have seen aortic ruptures in primarily elective patients having been postponed because of the anticipated need to provide sufficient ICU capacity because of the pandemic. Nearly 70% reported a decrease in acute aortic syndrome referrals since the start of the pandemic.

Conclusion: The current COVID-19 pandemic has—besides the stoppage of elective referrals—also led to a decrease of referrals of acute aortic syndromes in many settings. The reluctance of patients seeking medical help seems to be a major driver. The number of patients, who have been postponed due to the provisioning of ICU resources but having experienced aortic rupture in the waiting period, is still low. Further, studies are needed to learn more about the influence that the COVID-19 pandemic has on the treatment of patients with acute and chronic aortic disease.

KEYWORDS

acute and chronic aortic disease, COVID-19

1 | INTRODUCTION

Current adaptions according to the anticipated needs for intensive care capacity in patients suffering from coronavirus (COVID-19) disease have led to a near to complete stop of referral of elective cases in many in cardiovascular medicine and in particular in cardiac surgery. Acute and chronic thoracic aortic pathology has become one of the major drivers of growth in this field and the share of patients with aortic disease exceeds more than 20% in many settings.[1,2] Hence aortic disease and its treatment are of socioeconomic relevance and a complete stoppage of elective referrals is anticipated. Additionally, the reluctance of many patients to consult emergency departments despite symptoms due to the fear of acquiring COVID-19 disease during their hospital stay might have an impact too.

The aim of this manuscript is to share the results of a web-based expert panel discussion focusing on the management of acute and chronic aortic disease during the COVID-19 pandemic.

2 | METHODS

2.1 | Setting

An independent interdisciplinary scientific association focusing on continuing medical education in aortic medicine (www.aorticassociation.org) initiated a web-based expert panel discussion on April 18, 2020, where eight experts were invited to share their current experience with COVID-19 disease touching several aspects of aortic medicine. After each talk, specific questions were asked to the online audience, and results were immediately evaluated and shared with faculty and participants. Clinical data presented in this manuscript were collected according to the principles of the Declaration of Helsinki, and employed anonymized data obtained from the review of patients' charts. Patients gave their consent for the anonymous collection of their data on the standard consent sheet provided by all involved Institutions.

2.2 | Specific themes

The specific themes that were focused upon have been managed in general starting at the referral level. Examples for dealing with acute aortic syndromes were provided starting with acute type A aortic dissection, descending aortic disease as well as infrarenal aortic disease. In addition, coagulation disorders as well as specific measures at the intensive care unit (ICU) were discussed. All aspects focused on patients with suspected and confirmed disease. In addition, extracorporeal membrane oxygenation (ECMO) aspects in patients with aortic disease were discussed.

3 | MANAGEMENT IN GENERAL

3.1 | Italy, Milan, San Raffaele

The San Raffaele Hospital is in the epicenter of the Italian epidemic. The regional healthcare authorities decided to centralize surgical specialties, creating a Hub/Spoke system. Vascular surgery Hubs in Lombardia are Monzino Hospital (Milan), Poliambulanza Hospital (Brescia), Legnano Hospital (Legnano), and San Raffaele Hospital

(Milan). Starting from March 9, surgical treatment was reserved for symptomatic, urgent, or emergent disease only. A new emergency room—dedicated only to patients with cardiac and vascular diseases—has been created. All patients entering the cardiovascular emergency room are tested for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), and a chest computed tomography (CT) is performed. In case of suspect or confirmed COVID-19 in a patient requiring surgical therapy, full personal protective equipment (PPE) for the entire surgical team is available outside of the dedicated COVID-19 operating theatre. In case of general anesthesia, the surgical team waits outside the room while the patient is intubated and for another 15 min thereafter to allow clearance of the air from any aerosols origination from the intubation. Figure 1 shows the distribution of acute cases within the first 6 weeks if the epidemic.

3.2 | Italy, Bologna, Santa Orsola

The S. Orsola Hospital, University of Bologna, is located in the Emilia-Romagna region close to Lombardia and is also one of the main regional Hub centers attending the COVID-19 network. According to the initial experience with COVID-19, the department of cardiac surgery observed a significant reduction in the incidence of acute aortic syndromes since the beginning of the pandemic. Usually, 8–10 acute aortic syndromes per month are admitted while in March only two patients have been treated.

3.3 | Switzerland, Lugano, Cardiocentro

In Switzerland, it is currently forbidden by law to carry out non-urgent examinations and interventions/treatments. Physicians need to justify the urgency for every patient that is scheduled for a procedure.

3.4 | Spain, Barcelona, University Hospital

Elective cases are canceled since mid of March 2020. Both, cardiac urgencies/emergencies as well as acute aortic syndromes have decreased in numbers without altering conditions at the hospital. Preoperative evaluation is extended to ferritin testing and to paying attention to the presence of leukopenia. Such abnormal tests and/or pulmonary infiltrates—beyond pulmonary edema—raise SARS-COV-2 suspicion and motivate full PPE and FFP-3 mask use. In those patients that are COVID-19 positive or under investigation, the use of a negative pressure operating room is used if possible as well as postoperative allocation in a COVID-19 dedicated ICU (or inside a negative pressure room).

3.5 | Germany, Bavaria Ludwig-Maximilians University (LMU) Hospital, Munich

Bavaria represents the epicenter of the COVID-19 pandemic in Germany with more than 40,000 citizens infected by April 25. The regional government applied the state of emergency for the federal state on March 21, implementing social distancing and shutting down all nonessential structures. In the LMU University Hospital, the ICU capacity was doubled to over 250 beds within a short period of time by engaging personnel from operative fields (nurses and physicians), since elective surgery was prohibited by law and available resources were reallocated.

Special entry points, emergency department, ICUs, and peripheral wards were established for confirmed or suspected COVID-19 patients to reduce the possible infection of other patients in the hospital. Mouth–Nose masks became obligatory for all staff members even in the non-COVID-19 areas early on and recently also for patients. A special operating room with negative pressure was established and all patients that required surgery had to have a negative COVID-19 test if the urgency of the disease allowed it. Also here, a substantial decline of referrals of acute aortic syndromes has been observed.

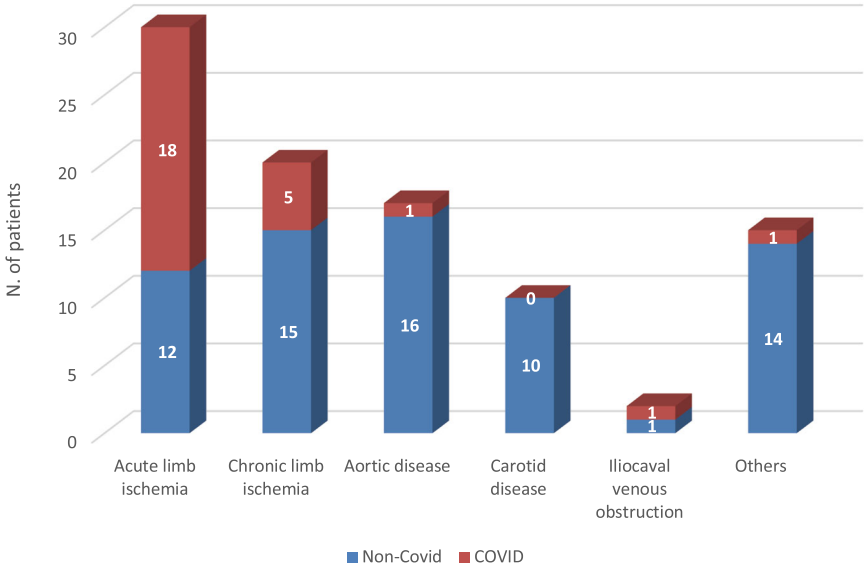

FIGURE 1 Referrals to Division of Vascular Surgery, Ospedale San Raffaele, Milan, Italy

3.6 | Surgical aspects

It has been recommended to avoid CO_2 insufflation into the operative field as this can lead to aerosolization and virus spread. Also, electrocautery should be attached to a sucker to capture smoke that can lead to aerosolization. One additional aspect of care in cardiothoracic surgery is to protect the exits of the thoracic drains that are underwater seal with continuous wall suction and bacterial filters to avoid environmental contamination.

4 | RESULTS—CLINICAL CASES

4.1 | San Raffaele, Milan

In the first 6 weeks, 94 patients were admitted to the Department of Vascular Surgery in San Raffaele. Twenty-six (28%) were positive for COVID-19. Acute limb ischemia was the most observed disease, occurring in 30 patients, of whom 18 (60%) were positive for COVID-19. In eight cases, the ischemic injury was irreversible, requiring major amputation. Chronic limb ischemia was the indication for treatment in 20 patients (COVID-19 confirmed in 25% of cases). Aortic emergencies represented 18% of the admissions (17 cases, COVID-19 confirmed in 6% of cases), including 9 cases of symptomatic abdominal aortic or iliac aneurysms, 4 cases of thoracoabdominal aortic aneurysms, 2 cases of acute type B aortic dissection (one posttraumatic, Figure 2), 1 ruptured penetrating thoracic aortic ulcer, and 1 aorto-duodenal fistula. Ten patients (11%) were admitted for symptomatic carotid stenosis (no COVID-19 patients), and all of them underwent carotid endarterectomy. The remaining 17 admissions (18%) included cases of mechanical circulatory support implantation, treatment for common femoral artery pseudoaneurysms, femoropopliteal graft infection, popliteal artery aneurysms, and iliocaval venous obstruction. Two frozen elephant trunk procedures were performed due to type A aortic dissection. Out of those remaining 17 admissions, 2 patients (12%) were positive for COVID-19.

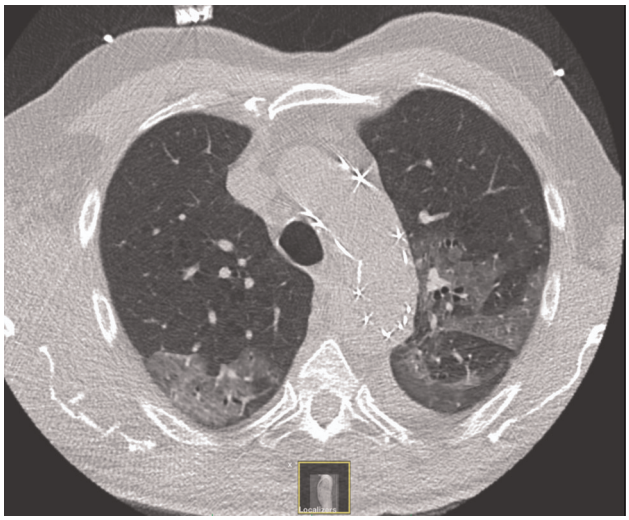

FIGURE 2 Axial view of a postoperative CTA after emergent TEVAR for traumatic type B aortic dissection, highlighting bilateral ground-glass opacity related to SARS-CoV-2 virus and the presence of a thoracic stent-graft. CTA, computed tomography angiography; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; TEVAR, thoracic endovascular aortic repair

4.2 | Santa Orsola, Bologna

A case of a 79-year-old female mirrored the currently altered frame conditions. COVID-19 was suspected without major evidence and besides the computed tomography angiography (CTA), a swab test was taken. The CTA confirmed the diagnosis of acute type A aortic dissection and hardened suspicion because of bilateral ground-glass areas at both inferior lobes suggestive of interstitial pneumonia (Figure 3). It took more than 5 h (320 min) for the patient to arrive in the operating room since her arrival in the ER to comply with all the safety protocols. The patient underwent an hemiarch and aortic valve replacement under moderate hypothermia and bilateral selective cerebral perfusion without any operative complication. All the involved sanitary were dressed with special protection devices. The first swab test in the ICU resulted in negative; however, according to the infectiologist, she was treated as a COVID-19 patient with hydroxychloroquine 400 mg (for 5 days) and azithromycin 500 mg (for 3 days) daily. Postoperative course was regular. During hospitalization, she repeated two more times the COVID-19 tests but still negative and continue to assume antibiotic treatment until normalization of chest X-ray. The patient was discharged after 13 days in a local rehabilitative hospital.

4.3 | Cardiocentro Ticino, Lugano

A 65-year-old male with a medical history of chronic renal insufficiency (on peritoneal dialysis), arterial hypertension, ischemic cardiopathy (various PTCA procedures 2004–2017), type 2 diabetes mellitus, and hyperlipidemia presented with a 55 mm penetrating atherosclerotic ulceration in segment 5. The patient was asymptomatic, COVID-negative, and would not fall into the criteria of urgency according to current Swiss regulations. However, a previous CTA, performed 3 months earlier demonstrated only a slight bulging of the descending thoracic aorta with a maximum diameter of 36 mm. Therefore, the patient had to be treated despite the restrictions in place, thoracic endovascular aortic repair was performed uneventfully and the patient could be discharged home 2 days later. This case is an illustration of how the COVID-19 pandemic affects treatment algorithms in a dramatic way, with changes driven by both medical and (in some countries) legal reasons.

4.4 | Ludwig-Maximilians University (LMU) Hospital, Munich

An 84-year-old female patient with a known history of COPD and lung fibrosis presented to another institution after experiencing

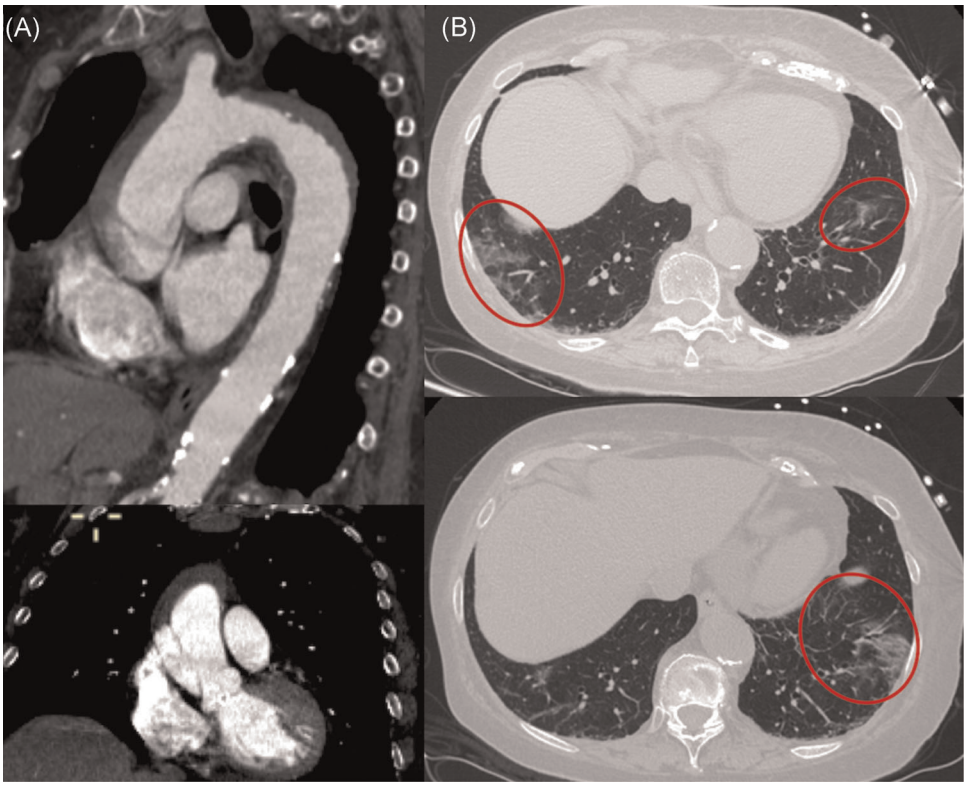

FIGURE 3 CTA of a patient with acute type A aortic dissection and suspicion of COVID-19 disease due to unspecific pulmonary infiltrates. COVID-19, coronavirus; CTA, computed tomography angiography

acute chest pain the previous night. Following her delayed presentation because of her fear of getting COVID-19 infection in the hospital, a further delay for several hours occurred in the diagnostic, because she was classified to be at risk for COVID-19 due to her previous pulmonary disease and acuteness of symptoms. The CTA performed revealed an acute type A aortic dissection. The patient was deemed unsuitable for open repair and an endovascular compassionate therapy was offered, given the patient's wish for treatment. The treatment took place after a negative COVID-19 result was confirmed, since the therapy would have otherwise been in vain.

A triple arch branched endograft (Cook Medical) planned for another patient was used and successfully implanted down to the level of the sinus of Valsalva (Figure 4). Surgery was successful and the patient recovered despite the severe pulmonary disease.

5 | COAGULATION DISORDERS IN COVID-19—FOCUS AORTA

There is increasing evidence that patients with COVID-19 can develop a hypercoagulative/prothrombotic state with possibly lethal complications. It is known that different viruses can trigger thrombocytopenia with coagulopathy, inter alia, due to the coronaviruses SARS-CoV-1 and Mers-CoV.[3]

It is also known that viruses can lead to an unbalanced provoking generation of reactive oxygen species (ROS)[4,5] with exceeding oxidative distress.[6] ROS but also virus-nucleocapsides directly can stimulate neutrophils to produce neutrophil extracellular traps (NETs).[7,8] NETs are highly thrombogenic and there is evidence, that NETs play a major role in the pathophysiology of HIT Type II.[9]

FIGURE 4 CTA after total endovascular aortic arch repair for acute type A aortic dissection. CTA, computed tomography angiography

Coagulation disorders in COVID-19 patients show striking similarities with patients that reveal a HIT Type II coagulation disorder.[10]

In addition, type I interferon (IFN) is produced by B- and T-cells in large amounts during viral infections which prime neutrophils for further NET formation.[11] There is also evidence that platelets play an important role in antiviral defense.[12] Platelet activation is frequently observed during viral infections.[13] Activated platelets form aggregates with neutrophils and stimulate NETosis.[14] Massive activation of the platelet/neutrophil axis and subsequent NET-based clearance mechanisms may represent an emergency strategy of the host in the face of systemically multiplying viruses.[15]

This reaction is followed by a drop in platelet counts, which is observed in many viral infections. The degree of platelet loss correlates with the severity of virus-induced disease and determines the clinical outcome.[16,17]

Regarding the perioperative treatment of aortic patients, several questions remain to be answered such as to the heparin strategy (fractioned or unfractioned) as well as to the dose because of the known hypercoagulative state, and finally with regard to the targeted aPTT and ACT levels. In addition, the antiaggregatory component has to be discussed as acute coronary syndromes in aortic patients (who by nature of the disease in particular in aortic dissection very rarely do have coronary artery disease) have been observed. Finally, the adjunctive value of high dose intravenous vitamin C with its antioxidant properties due to ROS-scavenging and NETosis inhibition and the potential attenuation of the inflammatory process and thereby potential risk reduction of thromboembolic complications should be discussed.

5.1 | Intensive care unit settings

Challenges for ICUs in the COVID-19 pandemic are primarily the need for a rapid increase in resources. Additional beds, ventilators, drugs, and disposables can be organized in most ICUs—at least to a certain extent. The most important resources, however, are ICU nurses, doctors, and PPE. Many ICUs recruited personnel with former ICU experience, and nurses and doctors from anesthesiology departments. Anesthesia personnel is available because regular surgery is halted in most countries.

There are different standards to protect healthcare workers in the COVID-19 pandemic. It is important that ICUs continue to use their own standards to maintain healthcare workers' trust that they and other patients are protected well. Formally, coronaviruses are transmitted by droplets/aerosols and by direct contact.[18] Therefore, surgical masks within 2 m from patients, and gowns and gloves when in direct patient contact together with meticulous hand hygiene, can avoid transmission. If aerosol-generating processes are undertaken, such as, for example, intubation or bronchoscopy, goggles, caps, and special masks are mandatory. Cohorting of patients with COVID-19 disease is especially useful to reduce nursing manpower (reduced dons and doffs of PPE). Standard hygiene procedures in ICUs must work as well as before the COVID-19 pandemic.

Also, patients with COVID-19 disease must be protected. Their lungs can be harmed by atelectasis, overdistension, and high breathing frequency—either self-inflicted if breathing spontaneously or as a result of inappropriate ventilator settings.[19] It is important to realize that ventilators used for anesthesia often do not provide all necessary information and options to ventilate complicated lung diseases such as ARDS. Furthermore, coagulation is abnormal in many patients with COVID-19 disease—sometimes, these abnormalities are cardinal symptoms of the disease.[20] Careful monitoring of coagulation and adapted anticoagulation are mandatory. Further organs involved are the heart and the kidney. Their function should also be closely monitored, given that pharmacological treatment often used in patients with COVID-19 disease may interfere with their function (e.g., vasopressors and diuretics).[21]

5.2 | ECMO specific aspects

ECMO has become a major contributor to the treatment armamentarium of COVID-19 disease. Currently, several ad hoc registries are collecting large amounts of data aiming at gaining knowledge of risk factors for the need of ECMO therapy as well as for the probability of successful weaning and finally outcome.[22] Currently, no experience in aortic patients with COVID-19 disease are available neither among this group of experts nor in the current literature.

5.3 | Specific questions

Twelve specific questions (Q) to the webinar participants were posed showing the following results. The answers (A) are summarized in groups of four in Figures 5–7.

- **Q & A 1.** How many COVID-19 patients were treated in your hospital during the pandemic? As of April 18, 73.3% answered that more than 200 patients have been treated at their respective settings.
- **Q & A 2.** Was your hospital well prepared before the first COVID-19 patient was admitted? Sixty-four percent were reported that their hospital was well prepared for the pandemic.
- **Q & A 3.** What is the percentage of infected healthcare professionals in your hospital? In 57.7%, the percentage was below 5% whereas 19.2% reported the percentage to be between 10% and 20%.
- **Q & A 4.** Was complete personal protective equipment available for all healthcare professionals caring for COVID-19 patients? Seventy-four percent reported that their settings have been/are adequately equipped regarding personal protective equipment.
- **Q & A 5.** What kind of personal protective equipment was lacking in your hospital? In 37.5%, FFP-3 masks were lacking, followed by adequate protection goggles, gloves, and gowns.
- **Q & A 6.** How many COVID-19 patients were treated with ECMO in your hospital? Sixty-seven percent reported ECMO application

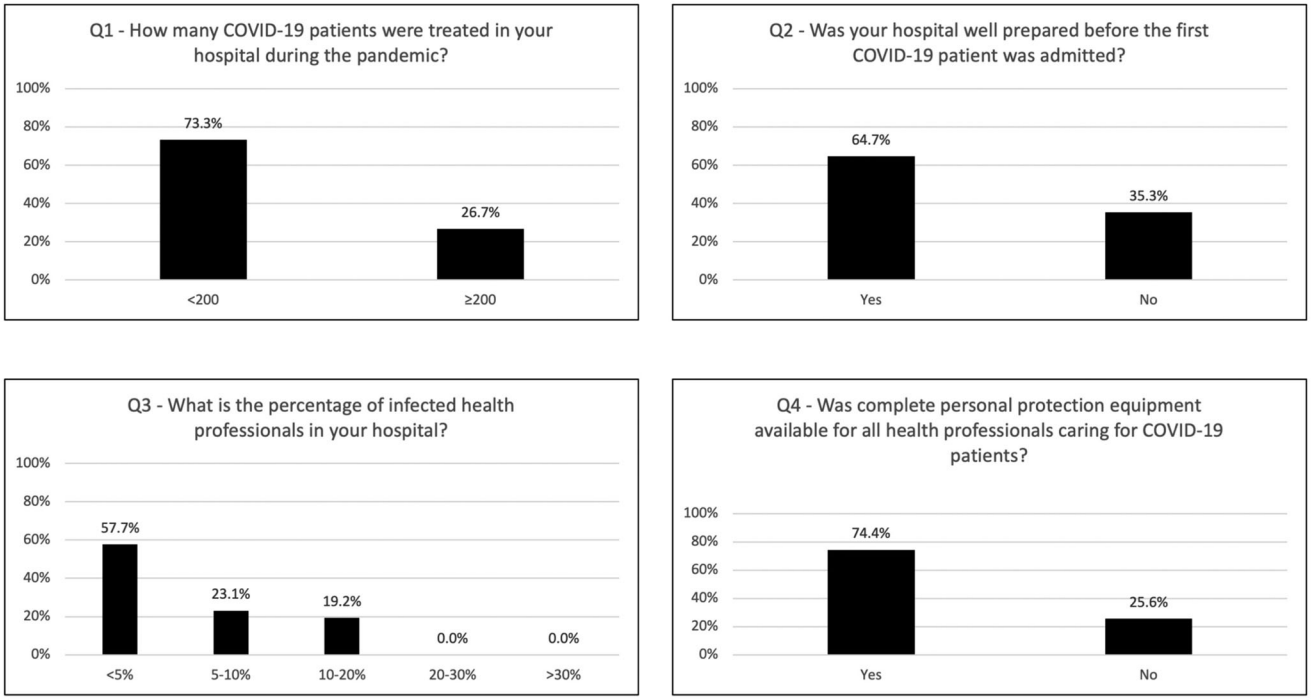

FIGURE 5 Questions and answers 1–4

in less than 2% of COVID-19 patients whereas 11.8% reported application in 5%–10% of COVID-19 patients.

- **Q & A 7.** Did you experience coagulation disorders? Thirty percent of participants reported observation of pulmonary embolism in COVID-19 patients.
- **Q & A 8.** Did you experience aortic dissection in COVID-19 patients? Nearly 19% reported to have had cases of aortic dissection in COVID-19 patients.
- **Q & A 9.** Did you experience aortic ruptures due to postponed elective cases? Three percent reported to have seen aortic

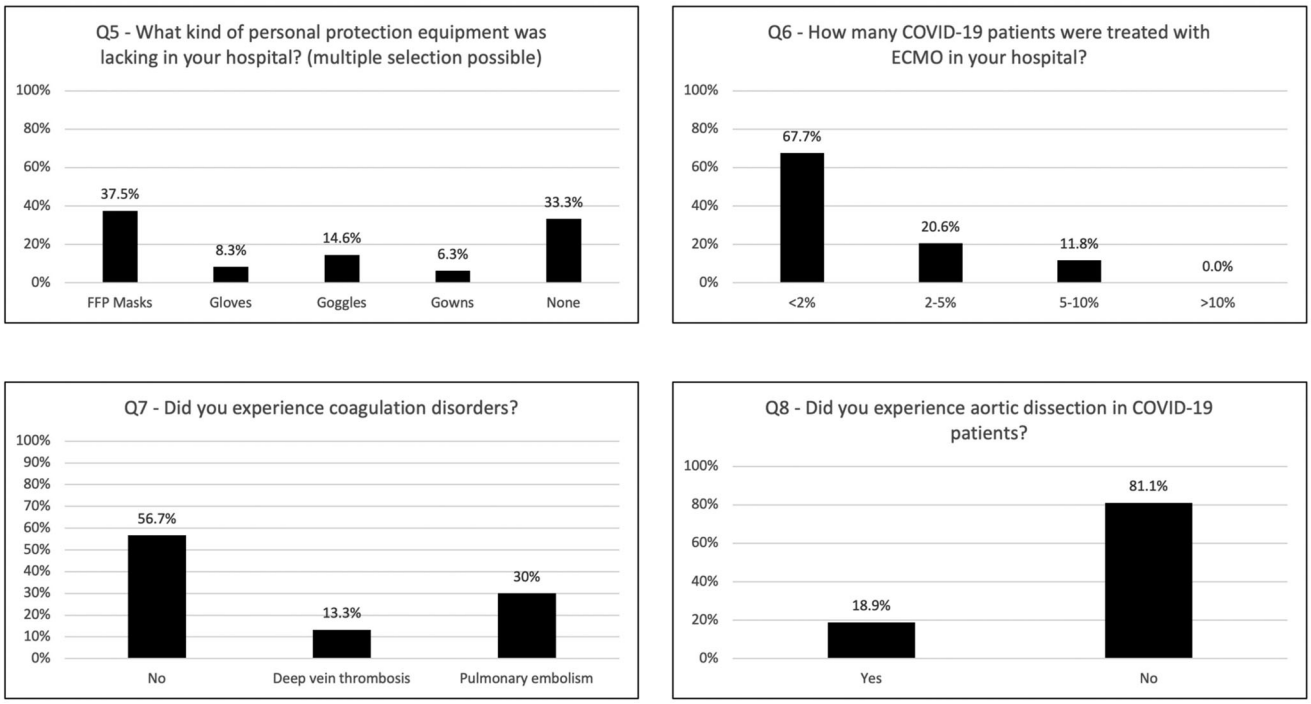

FIGURE 6 Questions and answers 5–8

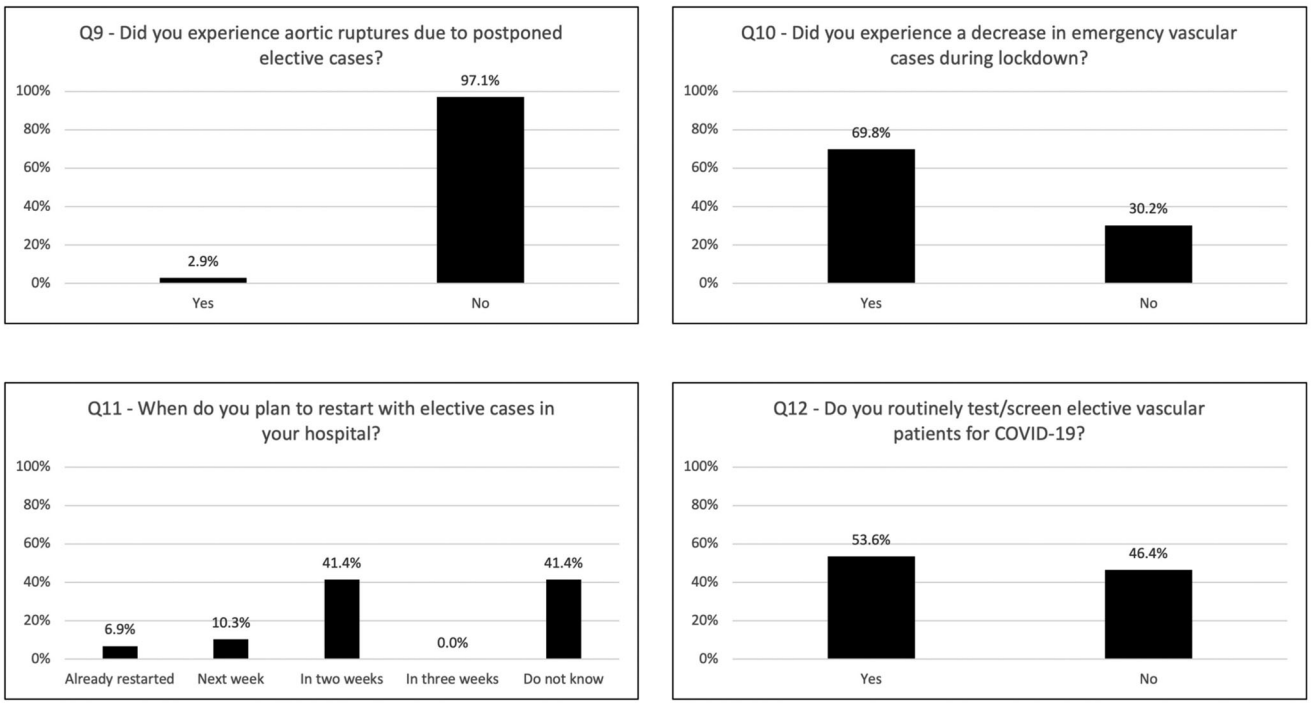

FIGURE 7 Questions and answers 9–12

ruptures in primarily elective patients having been postponed because of the anticipated need to provide sufficient ICU capacity because of the pandemic.

- **Q & A 10.** Did you experience a decrease in emergency aortic/vascular cases during lockdown? Nearly 70% reported a decrease in emergency referrals in patients with aortic disease since the start of the pandemic.
- **Q & A 11.** When do you plan to restart with elective cases in your hospital? More than 40% were able to report a planned resume of regular practice as of the beginning of May 2020.
- **Q & A 12.** Do you routinely test/screen elective aortic/vascular patients for COVID-19? More than 50% reported to apply regular screening measures in planned referrals.

5.4 | Comment

Centralization plays a key role in the COVID-19 pandemic, allocating human and material resources wisely, and improving personal safety in the healthcare environment through the appropriate use of PPEs. In the first 6 weeks of the COVID-19 pandemic, one of the central Hubs for vascular surgery in Lombardia observed a large number of patients presenting with acute limb ischemia, in most cases associated with SARS-CoV-2 infection. The settings of all other experts confirmed similar measures have been taken with a complete stop of referrals for elective cases in the majority. Eventually, the most important observation was a substantial decrease in referrals for acute aortic syndromes in all settings which is unexpected and might well be due to the reluctance of patients to consult emergency departments in fear to get infected exceeds the burden of clinical symptoms.

The clinical cases that have been shared confirm a change in patterns in particular with regard to a clear delay of treatment irrespective of setting and underlying pathology. Due to COVID-19 suspicion, it took 5 h for a patient with acute type A aortic dissection from the diagnosis in the emergency department to enter the operation room. In another case of type A aortic dissection, the delayed presentation was because of the patient's fear of contracting COVID-19 infection in the hospital, with a further delay for several hours in diagnostics, because of suspicion for COVID-19 due to her previous pulmonary disease in combination with the acuteness of symptoms. Finally, treatment was performed with a custom-made triple-branch endograft—the patient was deemed unsuitable for open surgery—which was at hand for another case that had been postponed due to the stoppage of elective cases.

Coagulation disorders in patients with COVID-19 disease have been previously reported and also this panel of experts has observed clinical conditions where a hypercoagulative state could well have been responsible for adverse events. Consequently, there was a consent that anticoagulative and antiaggregatory regimens in COVID-19 patients should be reevaluated and eventually adapted to the needs of patients with COVID-19 infetcion.[23]

ICUs are currently confronted in particular with a rapid increase in demand for resources. Cohorting of patients with COVID-19 disease is equally important as is cohorting of nursing manpower. Regarding treatment approaches, early intubation with controlled ventilation in a prone position and a restrictive fluid application strategy seems to be the most effective measure.

The specific questions posed to the participants revealed that in many hospitals more than 200 patients with COVID-19 disease have been treated and the notion of the majority was also that hospitals have been well prepared for the anticipated patient onstorm. Many settings reported infection of healthcare professionals and nearly 20% of settings reported an incidence of infection up to 20%. This finding is indicative of the obvious high contagiousity as in the same context participants have been convinced that their settings have been adequately equipped regarding PPE. In case of a lack of equipment, FFP-3 masks have been mentioned as the major source of shortage. In several settings, the treatment of pulmonary complications with an anticipated need for ECMO was expected to be higher than the actual percentage of patients requiring ECMO therapy. There are currently several ongoing efforts to document need, demand for, and outcome of ECMO therapy in COVID-19 patients. To date, no specific experience in aortic patients with COVID-19 patients requiring ECMO therapy is available.

Several participants reported coagulation disorders in particular pulmonary embolism and deep venous thrombosis in COVID-19 patients. This is in line with the known pathophysiologic mechanisms of the disease affecting the coagulation system and thereby underlying the need to rethink and adapt perioperative coagulation strategies after surgery and in particular in patients in need for substantial substitution of plasmatic and cellular coagulation, such as after major aortic surgery.[15–17]

Several participants reported patients with acute type A aortic dissection and COVID-19 infection. Fortunately, the number of patients who experienced aortic rupture due to being postponed because of the anticipated need for ICU capacity for COVID-19 patients was low. This mirrors a diligent triage but it remains clear that the need for treatment in these patient remains and an asymmetric demand will develop as soon as the referral embargo is loosened.

Participants also reported a substantial decrease in referrals for acute aortic syndromes which can only be interpreted as a reluctance of patients to seek medical help. This potentially dramatic decline will be subject of further research from this group.

Finally, there was heterogeneity with regard to the prophylactic testing or nontesting of patients before entering the hospital. Many settings report standard measures like a simple questionnaire and taking temperature for initial stratification.

Summarizing, the current COVID-19 pandemic has—besides the stop of elective case referrals—also led to a decrease of referrals of acute aortic syndromes in many settings. The reluctance of patients seeking medical help seems to be a major driver. The number of patients, who have been postponed but having experienced aortic rupture in the waiting period, is still low. Further studies are needed to learn about the context of aortic disease and the COVID-19 pandemic.

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