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Re-organization of the Vascular Surgery Department During the Acute Phase of the COVID19 Outbreak: Lessons Learned and Future Perspectives

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Introduction: Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection represents a serious threat to public health because it leads to a wide spectrum of clinical manifestations. The region Lombardia (Italy) has suffered from severe problems during the acute phase of the outbreak in Italy (March–April 2020). The aim of our analysis is to report the experience of the Department of Vascular Surgery of Pavia, including the learned lessons and future perspectives, considering that the COVID-19 outbreak is in its acute phase in other continents.

Material and methods: Single-center, retrospective, observational study based on extracted data from the medical records of all consecutive COVID-19 patients observed in our Vascular Department between March 1st and April 30th, 2020. We reviewed the records for demographic information, comorbidities, laboratory tests, and anticoagulation treatment at the time of hospital admission.

Results: We observed an important reduction in elective and urgent interventions compared to the same period of the previous year; in parallel, we observed an increase in the diagnosis of deep vein thrombosis (DVT) in hospitalized patients, especially with severe infection. In our department, four infections were reported among health workers.

Conclusions: The impact of the COVID19 pandemic on health-care delivery has been massive. A wave of vascular-related complications is expected. Regular SARS-CoV-2 screening, adequate protection, and quick reorganization of health-care resources are still needed.

INTRODUCTION

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection represents a serious threat to public health because it leads to a wide spectrum of clinical manifestations, which include fever, chills, fatigue, myalgia, headache, sore throat, ageusia, anosmia, and diarrhea, up to the development of respiratory symptoms for pneumonia, which may progress to acute respiratory distress syndrome (ARDS), multiorgan failure, and death. On July 9th, 2020, in Italy, more than 34,000 deaths from COVID-19 have been diagnosed. The region Lombardia has suffered from severe problems during the acute phase of the outbreak (March–April 2020), with 16,000 diagnosed COVID-19–related deaths (49% of the COVID-19–

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related deaths in Italy). In the area surrounding Pavia, during the same period of time, out of the documented 4,200 deaths, 1,225 were related to COVID-19 infection, with a mortality rate of 181/100,000 inhabitants and an increase in deaths of 138% in comparison to the same period of the previous year. Mean age of the patients dying from the disease was 81 years, and 70% were aged more than 75 years.^{1–3} The COVID-19 pandemic has led to an extensive modification of our national and regional health system because of the need to preserve caregivers, save resources, and maintain the availability of beds for intensive care units (ICUs) while simultaneously preventing the risk of the infection from SARS-CoV-2.

The aim of our analysis was to report the experience of the Department of Vascular Surgery of Pavia, including learned lessons and future perspectives, considering that the COVID-19 outbreak is in its acute phase in other countries, and that a new acute phase is returning to Italy.

MATERIAL AND METHODS

This is a single-center, retrospective, observational study based on extracted data from the medical records of all consecutive patients with a diagnosis of COVID-19 observed in our Vascular Department either for vascular pathologies or evaluated in consultation at other departments (Internal Medicine, Infectious Disease, ICUs, and Respiratory Disease) of the Fondazione IRCCS Policlinico San Matteo (Pavia, Lombardia, Italy), between March 1st and April 30th, 2020. All patients had a confirmed diagnosis of COVID-19 by real-time polymerase chain reaction (RT-PCR) in respiratory samples.

We reviewed the records of all COVID-19 patients for demographic information, comorbidities, laboratory tests, and anticoagulation treatment at the time of hospital admission. The outcome considered are: 1) the number of vascular procedures performed during the lockdown period in comparison to the previous year, 2) the number and type of consultation for patients with suspected deep vein thrombosis (DVT) related to COVID 19 infection during the lock down period in comparison to the previous year, and 3) the COVID-19 contamination rates between patients and health workers.

Statistical analysis. We used the Statistical Package for Social Sciences software (SPSS Inc., Chicago, IL, USA) version 14.0 for Windows to prepare the database and perform descriptive analysis. The results

are presented in tables. Categorical variables are expressed as frequencies and percentages. Continuous variables with normal distribution are expressed as mean and standard deviation, and those with nonnormal distribution as median and interquartile range. The Student's *t*-test and chi-square test were used when appropriate.

RESULTS

Vascular procedures in the lockdown period. Table I shows the number of vascular procedures performed in our department during the lockdown period in comparison to the previous year. We registered an actual reduction of the 100% of the elective procedures, compared with a 31% reduction of the urgent procedures. Only emergency procedures, which cannot be deferred or transported to a COVID-free hub, were performed, totally postponing elective procedures. Endovascular surgery, performed under loco-regional anesthesia, was preferred when possible (41% vs 31% in the same period of time), avoiding the need for endotracheal intubation and potentially for intensive care beds.

Consultation for patients with DVT related to COVID-19 infection. The number of requests for in-hospital consultation for patients with suspected DVT increased by more than 100% in comparison with the previous year. During this period of time, 32 hospitalized patients with severe COVID-19 infection (fever and pulmonary complications requiring assisted ventilation) were diagnosed with DVT on the basis of ultrasound imaging. Table II shows the hemostatic and inflammatory parameters in patients with DVT and critical conditions. Mortality was higher in the group of patients aged more than 70 years, with significant alteration of at least two hemostatic parameters associated to increased C-reactive protein (CRP). Significantly, prolonged prothrombin time (PT, $P < 0.05$) and augmented D-dimer levels ($P < 0.001$) were associated to an increased mortality rate. Persistence of high levels of CRP and abnormalities of the hemostatic parameters, despite aggressive therapy, were associated also with increased mortality rates.

Contamination rates for patients and health workers. More than 200 health workers have died in the acute phase of the pandemic in Italy who were COVID-19 positive. In the last 30 days (June 20–July 20, 2020), out of 2,762 (in tutta Italia solo questi) identified patients who were infected in Italy by screening tests, 78 (2%) were health workers. In our department, four infections were

Table I. Operative vascular procedures at the vascular surgery department of Fondazione IRCCS Policlinico San Matteo of Pavia

Procedure	March 1–April 30, 2020		March 1–April 30, 2019	
	Emergency	Elective	Emergency	Elective
AAA				
EVAR	2	0	4	12
OPEN	0	0	5	18
CAROTID				
CAS	0	0	0	3
CEA	0	0	5	27
PAD				
PTA/STENT	9	0	8	18
OPEN	6	0	6	12
ACUTE THROMBOSIS	6	0	8	0
AMPUTATION	4	0	3	9

AAA, abdominal aortic aneurysm; EVAR, endovascular aortic repair; CAS, carotid artery stenting; CEA, carotid endarterectomy; PAD, peripheral arterial disease; PTA, percutaneous transluminal angioplasty.

reported among health workers, with light/mild clinical manifestations.

DISCUSSION

The most common initial attitude in all countries has been an under-evaluation of the contamination rate. A general lockdown with severe social isolation rules for the general population and for health workers was introduced in March in Italy, when the high diffusion and virulence of the virus were evident. The dangerous characteristics of the virus were clearly related to the highest number of COVID-19 patient admissions, often requiring respiratory intensive cares, which unexpectedly overwhelmed the capacity of ICUs, and revealed the inadequacy of the national health system. After initial organizational problems, hospitals were divided in sections devoted only to COVID-19 patients. Admissions to hospitals were reduced, avoiding nonurgent conditions and deferrable elective interventions. Reduced admissions to hospitals were a consequence from imposed government rules, as well as from a generalized fear for possible contacts and contamination.^{4,5}

Health workers had a specific training about preventive measures, equipment, sanitation. When feasible, selected, more experienced health workers were devoted only to COVID-19 patients. Swab test for COVID-19 was performed every two days for all the health patients candidate to surgery.

Surgery for COVID-19 patients was performed in dedicated operating rooms. Similarly, ICU was

divided for COVID-19 positive and negative patients. Telecommunication was the most common used method for conferences, clinical meetings, teaching sessions with residents. Outpatient visits were reduced to minimum. Patients in the community had the possibility for reliable, easy phone contacts with expert doctors or nurses who gave the most appropriate recommendations. When needed, an ambulance was sent to visit the patient at home. Family doctors could easily communicate with staff members through a dedicated phone line.⁶

Patients who were told, before the acute phase of the outbreak, that there was an indication for surgery to treat their vascular problems (aneurysm, carotid occlusive disease) were thoroughly explained about the pros and contras to have surgery in this period, and the risk to have their surgery deferred. Most patients decided to have their surgery deferred. Their decision was influenced only in part by the government isolation rules. A major role was played by the information provided by the media.^{7–10}

It is very difficult to determine the reasons why the outbreak was so severe in Lombardia and other northern regions in comparison to other Italian regions. High density population, international exchanges, high air pollution, specific climatic conditions might have had a role in this unexpected, sudden, overwhelming outbreak. In this scenario, many generally accepted evidence-based indications to surgery should be re-evaluated taking in mind several specific matters, like as the prevention of contamination for patients and health workers. The fear for contamination has brought the general

Table II. Mortality in hospitalized COVID-19 patients with DVT (laboratory values refer to the time of diagnosis)

Parameter	Mortality (9 patients)	No mortality (23 patients)	
Sex (M/F)	8/1	16/7	
Age (mean; range)	71.2 (62–83)	58.8 (30–94)	<i>P</i> < 0.05
Comorbidities (mean)	4 (3–5)	3 (2–4)	
Oxygen Therapy			
High flow	-	4	
Noninvasive mechanical ventilation	4	7	
Invasive mechanical ventilation	5	12	
Thrombosis Localization			
Lower limb proximal	5	7	
Lower limb distal	2	10	
Upper limb	2	6	
Evidence pulmonary embolism	4	4	
Padua score (mean, range)	3.6 (3–4)	3.2 (3–4)	
Platelet (mean:range)	272 (112–669)	242 (139–324)	
Fibrinogen	418 (122–657)	397 (172–717)	
PT	57.6 (37–74)	75.7 (36–118)	<i>P</i> < 0.05
aPTT	25 (20–34)	25 (20–43)	
D-dimers	25,270 (10,800–35,000)	14,430 (985–35,000)	<i>P</i> < 0.001
LDH	482 (276–778)	437 (250–876)	
Creatinine kinase	362 (15–2,264) (100)	124 (15–842) (78)	
CRP	26.3 (1.4–100)	16.7 (0.1–33.6)	<i>P</i> < 0.05
WBC	10.4 (1.4–21.3)	10.6 (3.7–18)	

CRP, C-reactive protein (mg/dL); Platelet ($\times 10^3$ /mCL); PT, prothrombin time (%); aPTT, activated thromboplastin time (%); D-dimers (mcg/L); LDH, lactate dehydrogenase (mU/mL); Creatinine kinase (mU/mL); WBC (white blood count).

population to avoid medical facilities and medical consultation. Only people with unbearable symptoms in the pandemic have asked for medical help. We are looking at a new form of physician–patient relationship. COVID-19 has forced widespread adoption of remote encounters by video applications, patient portals, or phone calls.¹¹ In patients with major, life-threatening complications requiring surgical intervention, a careful assessment of risk and benefits is always required, but in the pandemic period, the possibility of contamination should be added to the usual considerations. In almost all hospitals, visits from relatives are not allowed, so the patient undergoing major surgery should expect a significant isolation time with inevitable negative psychological consequences. Endovascular surgery, which can be performed under loco-regional anesthesia, avoiding general anesthesia with endotracheal intubation, reduced post-operative pain, and ICU permanence was preferred. The possibility to defer the standard,

more effective surgical operation at later times, after having resolved the emergency situation by a less-risky endovascular procedure, is a reasonable clinical perspective.^{12–14}

In regions where the pandemic has a low diffusion, the health-care workforce is intact, and hospital beds and equipment, including ventilators, are available, surgeons may propose more conventional surgical indications. In regions with a high diffusion of the pandemic, in the acute phase where the workforce has limited capacity and the health-care system is overwhelmed with COVID-19 cases and has no surplus capacity with respect to hospital and ICU beds, equipment, staff, surgeons must accept compromises and to choose a treatment that has no short-term complications, requires less organizational efforts, with reduced possibilities of contamination and pulmonary complications, rather than a treatment that has been always considered more effective in the medium and long term.^{5,6,15–21}

CONCLUSIONS

It may sound unethical, but from this critical condition, we can get the stimuli to perfect a new vision of surgery. After this crisis, the improvement in telemedicine will remain and may represent the basis for future patient–physician relationship. Follow-up visit and diffuse screening programs, even in people in distant regions and countries, will be more frequent, without major inconvenience. Medical and surgical complications in vascular patients will be more carefully evaluated, including a diffuse analysis and definition of quality of life for patients and their families. The possibility of prolonged hospital stay, including significant time in the ICU, will be at the center of the surgical evaluation. Costs of treatment will be another aspect of the evaluation, considering that in the pandemic, we found ourselves inevitably short of resources.

In this period, episodes of heroism and solidarity were common, representing a driving force for all the health workers, as well as for the patients. Most of the health workers were on duty for more than 100 hours per week, and many of them remained in the hospital full time during all the acute phase of the outbreak for several reasons, including the fear to transmit the infection to their family members. In two days, 20,000 voluntary applications were made from all over Italy. A big thank to these people who made this possible!

REFERENCES

1. Epicentro. Istituto Superiore Sanità Italy. Statistics COVID19. Available at: www.epicentro.iss.it; 2020.
2. Sterpetti AV. Lessons learned during the COVID 19 virus pandemic. *J Am Coll Surg* 2020;230:1092–3.
3. Onder G, Rezza G, Brusaferro S. Case-fatality rate and characteristics of patients dying in relation to COVID-19 in Italy. *JAMA* 2020;323:1775–6.
4. Rush VW, Wexner SD. The American College of Surgeons responds to COVID-19. *J Am Coll Surg* 2020;231:490–6.
5. Lancaster EM, Sosa JA, Sammann A, et al. Wick EC rapid response of an academic surgical department to the COVID-19 pandemic: implications for patients, surgeons, and the community. *J Am Coll Surg* 2020;230:1064–73.
6. Arici V, Perotti C, Calliada F, et al. Autologous immunomagnetically selected CD133+ stem cells in the treatment of no-option critical limb ischemia: clinical and contrast enhanced ultrasound assessed results in eight patients. *J Transl Med* 2015;13:342.
7. Arici V, Quaretti P, Bozzani A, et al. Neck-targeted, stand-alone coiling for successful treatment of type 1A endoleak following endovascular repair. *Vasc Endovascular Surg* 2014 Jan;48:61–4.
8. Perotti C, Arici V, Cervio M, et al. Allogeneic lethally irradiated cord blood mononuclear cells in no-option critical limb ischemia: a “box of rain”. *Stem Cells Dev* 2013;22:2806–12.
9. Smith WR, Atala AJ, Terlecki RP, et al. Implementation guide for rapid integration of an outpatient telemedicine program during COVID-19 pandemic. *J Am Coll Surg* 2020;231:216–222.e2.
10. Ackermann M, Verleden SE, Kuehnel M, et al. Pulmonary vascular endothelialitis, thrombosis, and angiogenesis in COVID-19. *N Engl J Med* 2020;383:120–8.
11. Bikdeli B, Madhavan MV, Jimenez D, et al. COVID-19 and thrombotic or thromboembolic disease: implications for prevention, antithrombotic therapy, and follow-up: JACC state-of-the-art review. *J Am Coll Cardiol* 2020;75:2950–73.
12. Spyropoulos AC, Weitz JI. Hospitalized COVID-19 patients and venous thromboembolism: a perfect storm. *Circulation* 2020;142:129–32.
13. McFadyen JD, Stevens H, Peter K. The emerging threat of (micro)thrombosis in COVID-19 and its therapeutic implications. *Circ Res* 2020;127:571–87.
14. Bozzani A, Arici V, Franciscone MM, et al. Severe acute respiratory syndrome Coronavirus 2 infection and the upper limb deep vein thrombosis risk. *Ann Vasc Surg* 2020;66:11–3.
15. Bozzani A, Tavazzi G, Arici V, et al. Acute deep vein thrombosis in COVID 19 hospitalized patients. Risk factors and clinical outcomes. *Phlebology* 2020;. <https://doi.org/10.1177/0268355520958598>. 268355520958598. online ahead of print.
16. Bozzani A, Arici V, Tavazzi G, et al. Acute arterial and deep venous thromboembolism in COVID-19 patients. *Surgery* 2020;168:987–92.
17. Vogler TO, Moore EE, Moore HB, et al. Fibrinolysis shutdown correlation with thromboembolic events in severe COVID-19 infection. *J Am Coll Surg* 2020;231:193–203.e1.
18. Prachand VN, Milner R, Angelos P, et al. Medically necessary, time-sensitive procedures: scoring system to ethically and efficiently manage resource scarcity and provider risk during the COVID-19 pandemic. *J Am Coll Surg* 2020;231:281–8.
19. Arici V, Bozzani A, Odero A. Successful endovascular treatment of a bronchial artery aneurysm refractory to transcatheter embolization. *Ann Vasc Surg* 2013;27:802.e13–5.
20. Bozzani A, Arici V, Ragni F. Thoracic aorta coarctation in the adults: open surgery is still the gold standard. *Vasc Endovascular Surg* 2013 Apr;47:216–8.
21. Bozzani A, Arici V, Bonalumi G, et al. Descending thoracic aorta remodeling after multilayer stent release. *Ann Vasc Surg* 2015;29. 1018.e9–1018.e11.