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Clinical and Economic Impact of COVID-19 in Vascular Surgery at a Tertiary University “Hub” Hospital of Italy

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Background: Since the first cases of a novel respiratory disease were reported in December 2019, coronavirus disease (COVID-19) Emergency State (Cov-ES) caused a worldwide outbreak requiring a complete reorganization of the healthcare system and new management of its personnel; aim of this study was to analyze the clinical and financial impact of Cov-ES in the Department of Vascular Surgery at a Tertiary University “Hub” Hospital in northeast Italy.

Methods: Differences in clinical practice according to Diagnostic Related Group (DRG) and International Statistical Classification of Diseases (ICD) and Related Health Problems and the financial impact of Cov-ES were considered. Vascular procedures performed between March 2019 and December 2019 (Prepandemic) were compared to those performed in the period March–December 2020 (Pandemic). Prepandemic and pandemic reimbursements of all vascular activities and the top 3 vascular diagnoses were evaluated.

Results: Prepandemic versus pandemic era documented a decrease of vascular consultations performed (2,882 vs. 2,270, –21.2%). The number of total vascular procedures decreased from 997 to 797 (–20.1%) with a higher reduction observed in outpatient surgical activities (247 to 136, –45.0%, $P = 0.0005$) rather than inpatient surgical activities (750 vs. 661, 11.9%, $P = 0.02$). Length of hospital stay (LOS) increased from 3.3 ± 2.7 days in prepandemic to 5.3 ± 3.9 in the pandemic era ($P = 0.004$). Among patients with limb-threatening ischemia, the rate of major limb amputation was higher in the pandemic (3.3% vs. 5.4%, respectively, $P = 0.02$), and a higher rate of elective hospitalization procedures was performed as urgent/emerging setting after clinical deterioration (2.8 % vs. 6.4%, $P = 0.0002$). According to DRG classification, an increase of “complicated” limb-threatening ischemia (DRG 554) and aortic aneurysm (DRG 110) was observed prepandemic to pandemic (+84.2% and +25.0%, respectively). Total reimbursement for vascular activities between pandemic versus prepandemic was 4,646,108€ vs. 5,054,398€, respectively (–8.0%). Management of “complicated” limb-threatening ischemia (DRG 554) and aortic aneurysm (DRG 110) required a higher clinical

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and financial support that was translated into higher economic reimbursement during the pandemic (273,035€ vs. 150,005€, +82.0% and 749,250€ vs. 603,680€, +24.1%, respectively).

Conclusions: During the pandemic, the main resources were employed for the treatment of limb-threatening ischemia, aortic aneurysm, and carotid stenosis. Inpatient activities documented an increase in major limb amputation and LOS. An increased reimbursement for each vascular procedure and for all “complicated” diagnoses revealed that the more serious and resource-demanding pathology occurred in this period.

INTRODUCTION

Since the first cases of a novel respiratory disease were reported in December 2019 from China,¹ coronavirus disease (COVID-19) caused a worldwide outbreak requiring a complete reorganization of the healthcare system and new management of its personnel. In March 2020, the COVID-19 Emergency State (Cov-ES) was declared in Italy, and nonessential activities were interrupted. “Hub” hospitals were identified for specific highly specialized medical activities, and “Spoke” hospitals were identified for treatment of COVID-19 patients.² According to health authority recommendations, even the daily practice in Vascular Surgery was shifted to urgent/emergent or nondeferrable cases. The outpatient activity was reduced, and alternative modalities of clinical consultation were introduced whenever possible.³ New areas and new intensive care units (ICUs) dedicated to patients with COVID-19 were set up. As a result, many surgical elective activities were postponed or canceled. Availability of beds both in vascular wards and ICUs were missing, and the management of vascular patients was suddenly disrupted, causing a significant worsening of clinical outcomes.⁴

The redistribution of resources toward the expansion of critical care capacity and concomitant suspension of elective procedures and other clinical services placed a financial stress across all healthcare service lines. Such institutional changes have deeply modified the balance between spending and reimbursement in health medical management, and the effects of this new economic assessment have not been yet clarified in Vascular Surgery.⁵

The aim of this study was to analyze the clinical and financial impact of Cov-ES in the Department of Vascular Surgery at a Tertiary University “Hub” Hospital in northeast Italy.

METHODS

Hospital Practices and Study Setting

In response to COVID-19, starting in March 2020, the viability and access to our hospital were

completely modified (Fig. 1). Two separate checkpoints for entry, one for the patients and one for the personnel, were identified. Entrance to the hospital was allowed for individuals with a temperature <37.5°C and with personal protective equipment (PPE). Hand sanitizing gel dispensers were distributed in all common areas.

As to the organization of our Vascular Surgery Department, visits were allowed only for fragile patients after a negative nasopharyngeal swab (NPS) was obtained for the visitor. The reverse transcription-polymerase chain reaction (RT-PCR) was used to test the SARS-CoV-2 specific nucleic acid on this sample. In all other cases, any clinical information was given by telephone.

All patients received an NPS 24-48 h before the elective hospitalization and they were admitted to the “Green Zone” of the ward in case of a negative test result. A restricted area “Gray Zone” of the ward was dedicated to urgent/emergent patients while waiting for the NPS test result. In the case of a positive NPS, the patient was transferred to the Covid-area or discharged at home; in the case of a negative NPS, the patient was transferred to the “Green Zone,” where he/she was considered as Covid-free. Two operating rooms for Covid-free patients were identified, one for elective surgery and one for urgent/emergent procedures. Patients requiring emergent procedures and still awaiting test results were considered as positive and they received the surgical treatment in a Covid-dedicated operating room. Only one patient was found positive after admission in the “Green Zone,” and he was transferred to the Covid ward for further medical therapy.

Availability of beds in the ward decreased from 12 to 8, and specific personnel (nurses and caregivers) were redeployed to perform critical activities in Covid-wards. To guarantee the availability of vascular surgeons during the pandemic at all times, all vascular surgeons received at least one NPS per week and avoided precautionary quarantine in case of direct contact with a Covid-patient. Vascular consultations were mainly reserved to urgent or not deferrable

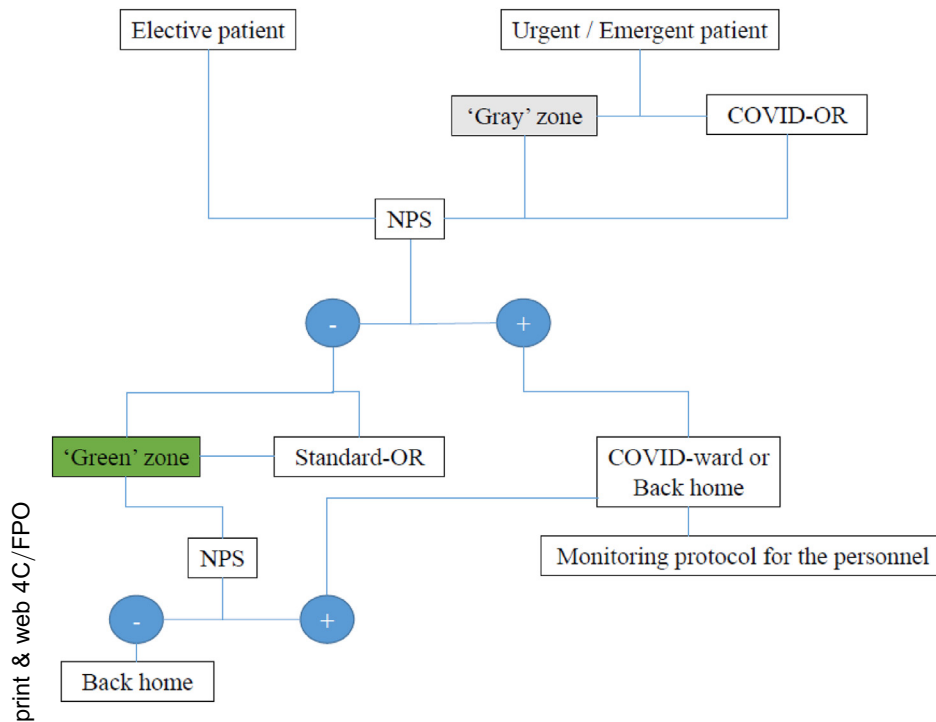


Fig. 1. Flowchart of ward organization during pandemic era. (NPS: nasopharyngeal swab; OR: operating room).

clinical questions and telehealth was never used for clinical consultation.

Our Department of Vascular Surgery at the Tertiary University “Hub” Hospital in northeast Italy consists of 3 senior and 3 junior consultants and 5 residents. It is the referral institution for approximately 1 million people. Since its foundation in 2015, the volume of outpatient and inpatient activities rapidly increased and reached a plateau in 2018 and 2019. Cov-ES imposed sudden and deep changes in the hospital assessment and our vascular practice. A retrospective analysis of a prospective database was performed to assess these changes. The differences in clinical practice according to Diagnostic Related Group (DRG) and International Statistical Classification of Diseases and Related Health Problems (ICD)⁶ and the financial impact of Cov-ES in our Department of Vascular Surgery were considered. Additionally, changes in hospital admission and vascular ward organization after Cov-ES were briefly described.

Since the beginning of the pandemic, the priority of treatment was given to patients with urgent/emergent or nondeferrable pathologies, as follows:

- Abdominal aortic aneurysm: any symptomatic or diameter ≥ 60 mm, rapid growth (≥ 0.5 cm in 6 months or ≥ 1 cm in 12 months, lesion instability on CT scan (blister, fissuring thrombus).

- Thoracic and thoracoabdominal aneurysm: any symptomatic or diameter ≥ 65 mm, rapid growth (≥ 0.5 cm in 6 months or ≥ 1 cm in 12 months, lesion instability on CT scan (blister, fissuring thrombus).
- Iliac aneurysm: any symptomatic or diameter ≥ 40 mm, rapid growth (≥ 0.5 cm in 6 months or ≥ 1 cm in 12 months, lesion instability on CT scan (blister, fissuring thrombus).
- Peripheral aneurysm: any symptomatic or diameter ≥ 30 mm, rapid growth (≥ 0.5 cm in 6 months or ≥ 1 cm in 12 months, lesion instability on CT scan (blister, fissuring thrombus).
- Aortic dissection: any acute and complicated type B aortic dissection, according to Stanford
- Limb ischemia: any acute or limb-threatening ischemia
- Carotid stenosis: any symptomatic or stenosis $\geq 80\%$, ulcerated plaque
- Miscellanea: perioperative complication, vascular trauma, hemodialysis access, oncologic surgery (indication and treatment were always defined with a multidisciplinary approach)

Clinical Evaluation

For understanding how Cov-ES modified our clinical practice, vascular procedures performed

Table I. Clinical characteristics and outcomes

Clinical characteristics & outcomes	997 vascular procedures in prepandemic (March–December 2019)	797 vascular procedures in pandemic (March–December 2020)	P
Male	692 (69.4%)	552 (69.3%)	0.9
Age (Mean ± SD, years)	75.4 ± 8.2	76.5 ± 7.2	0.4
Limb-threatening ischemia	277 (27.8%)	236 (29.6%)	0.4
Aortic aneurysm	177 (17.8%)	167 (21.0%)	0.08
Carotid stenosis	123 (12.3%)	89 (11.2%)	0.4
Other	420 (42.1%)	305 (38.3%)	0.09
Urgent/emergent	283 (28.4%)	239 (30.0%)	0.5
Urgent/emergent after being scheduled as elective	28 (2.8%)	51 (6.4%)	0.0002
COVID +	0	6 (0.8%) (one elective patient became positive before discharge)	0.006
Endovascular procedures	429 (43.0%)	358 (44.9%)	0.4
Open procedures	502 (50.3%)	396 (49.7%)	0.8
Hybrid procedures	66 (6.6%)	43 (5.4%)	0.2
Major limb amputation	33 (3.3%)	43 (5.4%)	0.02
Length of hospital stay (days)	3.3 ± 2.7	5.3 ± 3.9	0.004
30-day reintervention	36 (3.6%)	31 (3.9%)	0.7
30-day mortality	19 (1.9%)	22 (2.8%)	0.2

Differences in clinical characteristics and outcomes in prepandemic (March–December 2019) and pandemic (March–December 2020) era. Bold characters were used in case of statistically significant values.

between March and December 2019 (prepandemic) were compared to those performed in the period March to December 2020 (pandemic). The top 3 vascular diagnoses were reported and separately analyzed.

The outpatient regimen included vein surgery, vascular access procedures, and percutaneous arterial angioplasty. The inpatient regimen included all other vascular procedures.

Endovascular, hybrid, and open surgical approaches were included, both in elective and urgent settings, and clinical outcomes were compared.

Similarly, the volume of vascular consultations (ambulatory visits, advanced medications, and ultrasound duplex examinations) during the pandemic was observed and compared to the prepandemic volume.

The study was performed in accordance with the Institutional Ethics Committee rules. Individual consent for this retrospective analysis was waived. All patients signed consent to the processing of personal and clinical data to be collected prospectively in the integrated institution database. For this specific type of study, consent for publication is not

required by the local Institutional Review Board, in accordance with the Italian National Policy in the matter of Privacy Act on retrospective analysis of anonymized data.

Economic Evaluation

Since 1994, funding for all public and private providers in the Italian Health System has been based on predetermined rates for the homogeneous diagnostic group (DGR, Diagnostic Related Group), established at a regional level according to general national criteria. All pathologies are classified according to the International Statistical Classification of Diseases and Related Health Problems (ICD, REF). This mode of financing was intended to remunerate the delivered product (instead of the inputs used) proportionally to work performed. Guidelines from the Italian ministry of health about rate system of health care and the methodological definition of the DRG system has been well described elsewhere.^{7,8} In brief, the ministerial rates are fixed for all types of hospitals, and each region has the opportunity to modulate its own rates as a function of

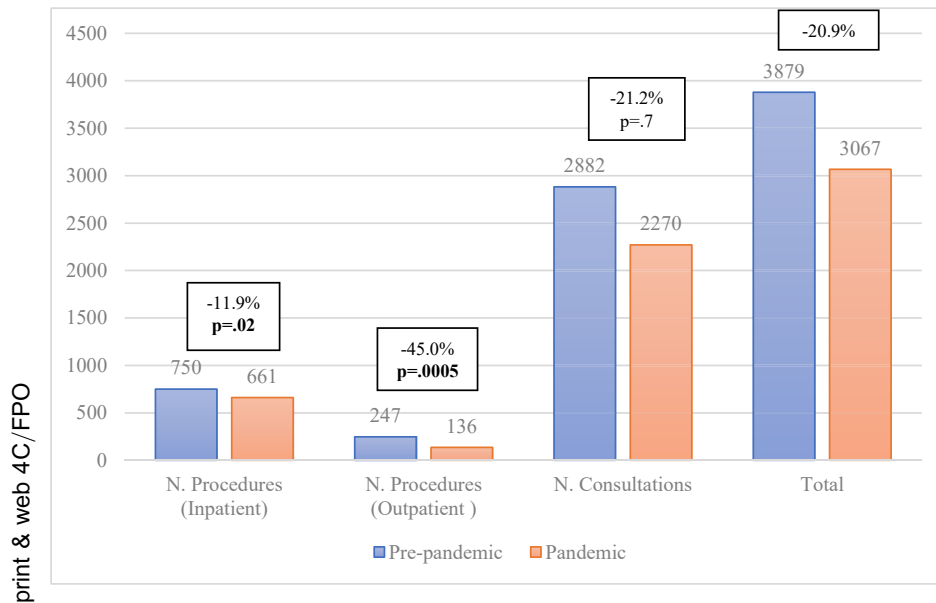


Fig. 2. Inpatient procedures, Outpatient procedures and Consultations. Differences in Inpatient procedures, Outpatient procedures and Consultations, prepandemic (March–December 2019) and pandemic (March–December 2020).

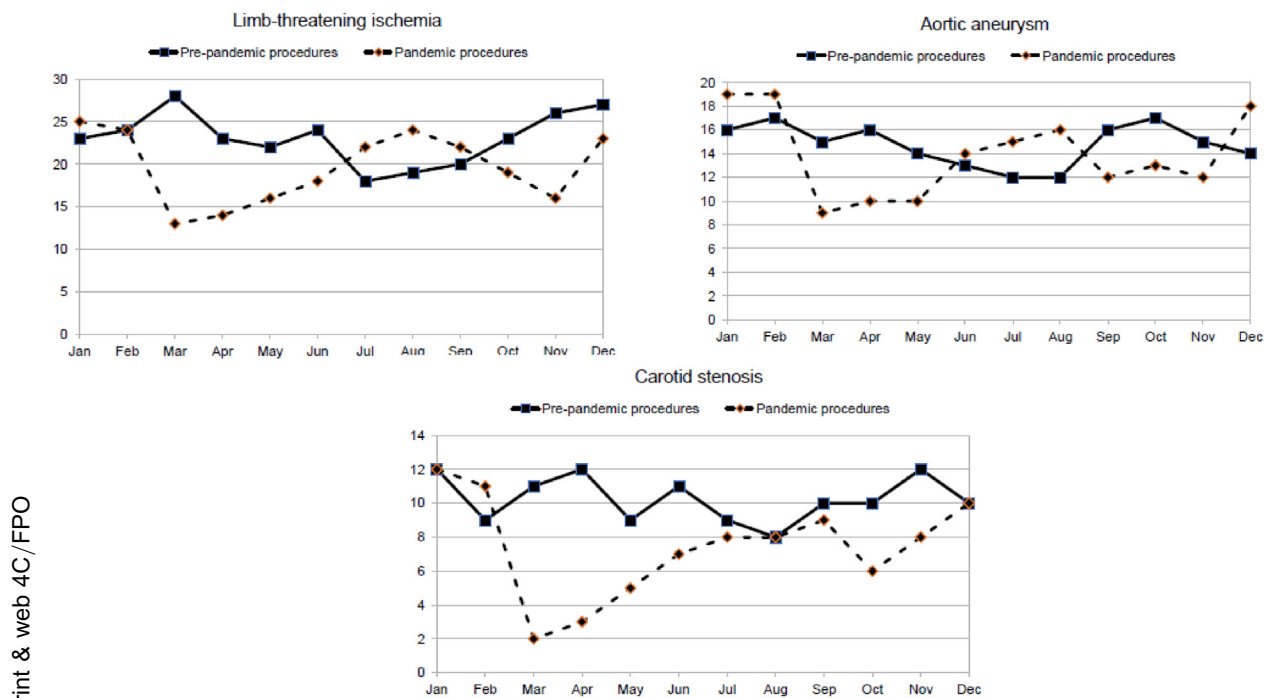


Fig. 3. Prepandemic and pandemic timeline distribution of vascular procedures.

various types of patients. For allocating each patient to a specific DRG, some information contained in the Hospital Discharge Records (HDR) was evaluated, including data about ordinary and outpatient admission. Diagnoses were divided into 17 sectors.

The principal diagnosis at discharge is the main condition treated during the hospital stay, and it requires the greatest resources. The presence of several secondary diagnoses, such as diabetes or hemorrhage, may convert the principal diagnosis

Table II. Clinical presentations of top 3 ICD diagnoses

ICD	Clinical presentation	997 pre-pandemic procedures	797 pandemic procedures	<i>P</i>
Limb-threatening ischemia (ICD 440.21, 440.22, 440.23, 440.24, 444.22)	Rutherford 1-3	142 (51.3%)	93 (39.4%)	0.007
	Rutherford 4	37 (13.4%)	42 (17.8%)	0.2
	Rutherford 5-6	98 (35.4%)	103 (43.6%)	0.05
	<i>Total</i>	277 (27.8%)	236 (29.6%)	0.4
Aortic aneurysm (ICD 441)	<55 mm	84 (47.5%)	52 (31.1%)	0.002
	55–60 mm	48 (27.1%)	51 (30.5%)	0.4
	>60 mm	45 (25.4%)	64 (38.3%)	0.01
	<i>Total</i>	177 (17.8%)	167 (21.0%)	0.08
Carotid stenosis (ICD 433.10, 433.11)	Asymptomatic	90 (73.2%)	66 (74.2%)	0.8
	Symptomatic	33 (26.8%)	23 (25.8%)	0.8
	<i>Total</i>	123 (12.3%)	89 (11.2%)	0.4

Characteristics of the top 3 diagnoses, prepandemic (March–December 2019) and pandemic (March–December 2020), according to International Statistical Classification of Diseases and Related Health Problems (ICD).

Bold characters were used in case of statistically significant values.

Italic entries represent the codes of different vascular pathologies according to the ICD classification.

from “uncomplicated” to “complicated” disease, thus improving the rate of reimbursement.

According to this classification, diseases of the circulatory system were included in Sector VII, category 390-459. Therapeutic procedures on cardiovascular system were included in Sector VII, Category 35-39.

Prepandemic and pandemic reimbursements of all vascular activities and of the top 3 vascular diagnoses were evaluated in this study.

Statistical Analysis

Qualitative variables were expressed as percentages or absolute numbers. Mean value (\pm Standard Deviation, SD) was used when result distribution was normal; otherwise, median and interquartile ranges (IQR) were preferred. The χ^2 or Fisher’s exact tests were used to analyze categorical variables. Student’s *t*-test or Mann–Witney *U*-test was used for continuous variables with or without normal distribution, respectively. $P < 0.05$ was considered significant. Analysis was performed with SPSS software (IBM, Chicago, USA).

RESULTS

Clinical Outcomes

Clinical characteristics of patients were similar between the 2 periods, and outcomes of procedures are listed in Table I. Length of hospital stay (LOS) increased from 3.3 ± 2.7 days in prepandemic to 5.3 ± 3.9 in the pandemic era ($P = 0.004$), even when the need for early reintervention and early

mortality did not statistically differ. Among patients with limb-threatening ischemia, the rate of major limb amputation was higher in the pandemic versus prepandemic (5.4% vs. 3.3%, respectively, $P = 0.02$), and a higher rate of procedures scheduled for elective hospitalization was performed as urgent/emerging setting after the clinical deterioration in the pandemic era (6.4% vs. 2.8%, $P = 0.0002$) (Table I). Prepandemic versus pandemic era documented a decrease of vascular consultations (2,882 vs. 2,270, -21.2% , $P = 0.7$) and the number of vascular procedures decreased from 997 to 797 (-20.1%) with the higher reduction in outpatient surgical activities (247 to 136, -45.0% , $P = 0.0005$) rather than in the inpatient surgical activities (750 vs. 661, -11.9% , $P = 0.02$) (Fig. 2).

Limb-threatening ischemia (ICD 440.21, 440.22, 440.23, 440.24, 444.22) (236/797, 30.8%), aortic aneurysm (ICD 441) (167/797, 21.8%) and carotid stenosis or occlusion (ICD 433.10, 433.11) (89/797, 11.2%) represented the top 3 vascular index diagnoses that underwent surgical treatment between March 2020 and December 2020 (Fig. 3). During the pandemic era, an increased rate of severe clinical presentation (Rutherford 5-6) and larger diameter (>60 mm) were observed in patients with limb ischemia (35.4% vs. 43.6%, $P = 0.05$) and abdominal aortic aneurysm (25.4% vs. 38.3%, $P = 0.01$). No statistical differences were observed in patients with carotid stenosis, both in asymptomatic and symptomatic cases (Table II). An endovascular approach was used in 299 vs. 264 (-11.7%), an open surgical approach was used in 220 vs. 191 (-13.2%), and a hybrid technique was performed

Table III. Type of procedures for top 3 ICD diagnoses

ICD	N.	577 pre-pandemic procedures in top 3 diagnoses				492 pandemic procedures in top 3 diagnoses				Difference					
		Procedures		Total		Procedures		Total		Endo		Hybrid		Total	
		Endo	Open	Hybrid	Total	Endo	Open	Hybrid	Total	Endo	Open	Hybrid	Total		
Limb- threatening ischemia (ICD 440.21, 440.22, 440.23, 440.24, 444.22)	513	167	52	58	277	154	45	37	236	-7.8%	-13.5%	-36.2%	-14.8%		
Aortic aneurysm (ICD 441)	344	115	62	-	177	96	71	-	167	-16.5%	+14.5%	-	-5.6%		
Carotid stenosis (ICD 433.10, 433.11)	212	17	106	-	123	14	75	-	89	-17.6%	-29.2%	-	-27.7%		
Total	1069	299	220	58	577	264	191	37	492	-11.7%	-13.2%	-36.2	-14.7%		

Endovascular, open surgical and hybrid procedures in the top 3 diagnoses, prepandemic (March–December 2019) and pandemic (March–December 2020), according to International Statistical Classification of Diseases and related Health Problems (ICD).

in 58 vs. 37 (-36.2%). Only in the subgroup of patients with aortic aneurysm, a higher rate of open surgical procedures was observed (+14.5%) (Table III), without statistical differences between the 2 periods. Among patients with top 3 vascular index diagnoses, a higher rate of elective procedures were performed in urgent/emergent setting after deterioration of clinical conditions during pandemic (10.3% vs. 4.8%, $P = 0.0006$), especially in case of limb-threatening ischemia (8.5% vs. 4.0%, $P = 0.002$). (Table IV).

According to DRG classification, an increase of “complicated” limb-threatening ischemia (DRG 554) and aortic aneurysm (DRG 110) was observed prepandemic to pandemic (+84.2% and +25.0%, respectively). On the contrary, diagnosis of “uncomplicated” limb-threatening ischemia (DRG 479) and aortic aneurysm (DRG 111) decreased by 22.1% and 14.6%, respectively; a similar decrease was observed in the “uncomplicated” carotid stenosis (-27.7%, DRG 534) with no cases of “complicated” diagnosis (DRG 533) during both periods (Fig. 4).

Economical Outcomes

Total reimbursement for vascular activities between pandemic and pre-pandemic was 4,646,108€ vs. 5,054,398€, respectively (-8.0%). The greatest loss of reimbursement was observed in the total outpatient activity, which decreased by 59.4% (153,952€ vs. 378,898€). Inpatient procedure loss of reimbursement was less evident (-3.9%, 4,492,156€ vs. 4,675,500), and on the contrary, the average reimbursement for procedure increased by 9.0% (6,796€ vs. 6,234€) (Table V).

The top 3 vascular diagnoses in 2020 were “limb-threatening ischemia” (ICD 440.21, 440.22, 440.23, 440.24, 444.22) with uncomplicated and complicated DRG (DRG 479 and 554, respectively), “aortic diseases” (ICD 441) with uncomplicated and complicated DRG (DRG 111 and 110, respectively), and “carotid stenosis” (ICD 433.10, 433.11) with complicated and uncomplicated DRG (DRG 534 and 533, respectively).

Management of “complicated” limb-threatening ischemia (DRG 554) and aortic aneurysm (DRG110) during the pandemic time period required a higher clinical and financial support that was translated into higher economic reimbursement during the pandemic (273,035€ vs. 150,005€, +82.0% and 749,250€ vs. 603,680€, +24.1%, respectively) (Table VI). No “complicated cases” of carotid stenosis (DRG 533) were observed during the pandemic,

Table IV. Elective procedures become urgent/emergent

ICD	577 prepandemic procedures in top 3 diagnoses	492 pandemic procedures in top 3 diagnoses	P
Limb-threatening ischemia (ICD 440.21, 440.22, 440.23, 440.24, 444.22)	23 (4.0%)	42 (8.5%)	0.002
Aortic aneurysm (ICD 441)	4 (0.7%)	8 (1.6%)	0.1
Carotid stenosis (ICD 433.10, 433.11)	1 (0.1%)	1 (0.1%)	0.9
Total	28 (4.8%)	51 (6.4%)	0.0006

Top 3 diagnoses scheduled for elective hospitalization that become urgent/emergent for worsening of clinical conditions, prepandemic (March–December 2019) and pandemic (March–December 2020).

Bold characters were used in case of statistically significant values.

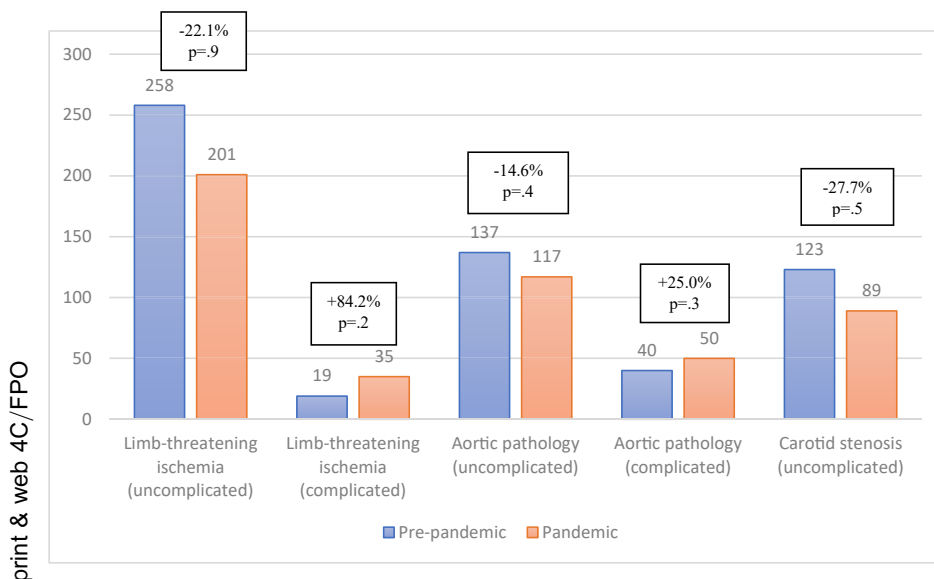


Fig. 4. Number of “uncomplicated” and “complicated” of top 3 diagnoses. Number of “uncomplicated” and “complicated” of top 3 diagnoses, prepandemic (March–December 2019) and pandemic (March–December

2020), according to International Statistical Classification of Diseases and Related Health Problems (ICD) and Diagnostic Related Group (DRG).

and the reimbursement decreased from 557.436€ to 403.348€ (–27.7%).

DISCUSSION

Coronavirus disease (COVID-19) caused a worldwide outbreak requiring a complete reorganization of the healthcare system and a new management of its personnel.⁹

Our analysis documented that our pandemic management was similar to those of the bordering regional hospitals, with 2 separate pathways for patients and the personnel. The close monitoring of the infection, as well as the COVID-dedicated ward and operating rooms, played a crucial role in preventing the spread of the contagion and

guaranteed 24/7 vascular service with only one hospitalized patient transferred to the COVID area after elective surgery. Assessment of the hospital was deeply modified: dedicated COVID areas were created, and different pathways were identified in order to separate COVID patients from COVID-free patients. According to the Public Health Authority recommendations, medical and financial resources were reallocated and personnel were re-employed in critical care areas. Several highly specialized surgical specialties, such as Vascular Surgery, suffered a significant reduction of resources,¹⁰ and precise protocols for infection prevention and control became necessary to guarantee the safety of patients and hospital personnel during their daily activities.^{11,12}

Table V. Reimbursement for all vascular procedures

Reimbursement	Prepandemic reimbursement	Pandemic reimbursement	Difference
Mean reimbursement/ procedure (Inpatient regimen)	6,234€	6,796€	+9.0%
Total reimbursement (Inpatient regimen)	4,675,500€	4,492,156€	-3.9%
Mean reimbursement/ procedure (Outpatient regimen)	1,534€	1,132€	-26.2%
Total reimbursement (Outpatient regimen)	378,898€	153,952€	-59.4%
Total reimbursement	5,054,398€	4,646,108€	-8.0%

Financial analysis and reimbursement for all vascular procedures, prepandemic (March–December 2019) and pandemic (March–December 2020).

Table VI. Reimbursement of “Uncomplicated” and “Complicated” top 3 ICD diagnoses

ICD	DRG	Prepandemic reimbursement in top 3 diagnoses	Pandemic reimbursement in top 3 diagnoses	Difference	
Limb-threatening ischemia (ICD 440.21, 440.22, 440.23, 440.24, 444.22)	“Uncomplicated”	479	1,114,044€ (258 index diagnosis)	867,315€ (201 index diagnosis)	-22.1%
	“Complicated”	554	150,005€ (19 index diagnosis)	273,035€ (35 index diagnosis)	+82.0%
Aortic aneurysm (ICD 441)	“Uncomplicated”	111	1,413,566€ (137 index diagnosis)	1,222,416€ (117 index diagnosis)	-13.5%
	“Complicated”	110	603,680€ (40 index diagnosis)	749,250€ (50 index diagnosis)	+24.1%
Carotid stenosis (ICD 433.10, 433.11)	“Uncomplicated”	534	557,436€ (123 index diagnosis)	403,348€ (89 index diagnosis)	-27.6%
	“Complicated”	533	—	—	—

Reimbursement of “Uncomplicated” and “Complicated” top 3 diagnoses, prepandemic (March–December 2019) and pandemic (March–December 2020) according to International Statistical Classification of Diseases and Related Health Problems (ICD) and Diagnostic Related Group (DRG).

Limitations of daily activities, together with the fear of the contagion, caused a delay in the diagnosis of vascular pathologies and the worsening of clinical outcomes, especially in limb-threatening ischemia patients.

In our analysis, the number of inpatient and outpatient procedures and volume of vascular consultations decreased by 11.9%, -45%, and -21.2%, respectively. It was similar to the 35% of decline in elective activity reported by Czerny et al. in their multicenter experience.¹³ Despite the decreased number of total procedures performed, the “complicated” diagnoses observed in the pandemic period were higher when compared to

the prepandemic period (+84.2% in limb-threatening ischemia and +25.0% in aortic pathology), suggesting that delayed diagnosis and the end-stage presentation of vascular pathologies after Cov-ES played a crucial role in the fate of such patients.

A higher rate of amputations during lockdown was reported by Schuivens et al.⁴ and poorer results in acute limb ischemia were described by Bellosta et al.¹⁴ Similar results were observed in our analysis, which revealed an increase of procedures for patients with Rutherford 5-6 critical limb ischemia and major limb amputations. Moreover, the worsening of clinical condition while waiting for

procedures, caused a higher rate of urgent/emergent procedures in patients that were originally scheduled for elective revascularization. The real impact of the widespread cancellation or delay of scheduled vascular operations will be better clarified at the conclusion of the available international registries, such as VASCC and COVER.^{15,16} Furthermore, the decrease of bed availability, both in the ward and in the Intensive Care Unit, together with the reduction of elective surgical activities, forced an accurate selection of patients affected by an abdominal aortic aneurysm, giving the priority cases to urgent/emergent or nondeferable patients. In such patients, an endovascular approach was often excluded due to anatomical criteria, and open surgery was preferred, justifying our increased rate of open surgery procedures and the longer hospital stay. The significant improvement of urgent/emergent interventions due to delayed diagnosis and treatment, together with the increased rate of critically ill patients, who used hospital care only if necessary and awaited the onset of the later stages of disease, has been well described in other clinical experiences.^{17,18}

On the other hand, these results appeared to be in contrast with the analysis of several high-volume centers that documented how a well-organized model of healthcare system associated with the cessation of most outpatient activities and all venous surgical procedures allowed to maintain a normal volume of elective activity during the pandemic.^{11,19} As suggested by Faggioli et al. colleagues' analysis, careful planning, and organization of dedicated vascular units had, in some instances, allowed activity to be maintained even if the problem of the treatment of asymptomatic abdominal aortic aneurysms required a number of considerations and studies. Ethical and psychological aspects should always be considered in case of postponing aortic operations, and several key factors beyond the patient's characteristics should be included for safe elective surgery in the Covid era, such as workforce availability and the clinical governance.²⁰ The short length of the observation period and the small cohort of patients were probably the main limitations of these favorable considerations and larger clinical evidence is necessary to confirm these preliminary data.

Another aim of this study was to analyze the financial impact of Cov-ES in our Department of Vascular Surgery. Fang et al.⁵ documented the reduction in activities and reimbursement across all avenues of vascular surgery services in the United States and confirmed that vascular

inpatients, although fewer, were more ill and required more care. This was in line with our results that revealed the decrease of the vascular activities by 20.1% (up to 45.0% if only outpatient regimen was considered) even if the total reimbursement decreased only by 8.0% (3.9% if only inpatient regimen was considered). According to the clinical observation that patients who present with greater illness require complex procedures and longer LOS were admitted during Cov-ES, reimbursement of each inpatient procedure increased from 6,234€ to 6,796€ (+9.0%). Furthermore, the subgroup analysis of "uncomplicated" versus "complicated" top 3 diagnoses in 2020 revealed that "complicated" limb-threatening ischemia (DRG 554) and aortic pathology (DRG 110) received a higher reimbursement than prepandemic era (+82.0% and +24.1%, respectively). This higher rate of reimbursement for each vascular procedure and "complicated" vascular diseases may be translated as an additional economic loss for the healthcare system, already stressed by direct costs of the outbreak. Mid- and long-term impacts on the Public Health System of such assessment are still unknown, and further studies are necessary to clarify these issues.

Study Limitations

This study has several limitations. First, it was an observational retrospective analysis, and statistical analysis could be influenced by the number of patients. Second, a larger inclusion of vascular diagnoses and a more precise description of the procedures performed would be necessary to clarify the real economic impact of Cov-ES in our Vascular unit. Moreover, our retrospective analysis of patients was focused on 2019–2020 and impeded the evaluation of the effects of the last update guidelines on the management of cardiovascular disease and acute limb ischemia.^{21,22} Last, this analysis included data from a single Italian regional hospital, which has economic roles slightly different from other regional centers, as described above, and a comparison between different regional hospitals would be interesting to understand if our data were in line with the national average.

CONCLUSIONS

Our analysis confirmed that Cov-ES caused a reduction of all vascular activities, especially in outpatient regimens and consultations in the Tertiary University "Hub" Hospital. During the pandemic time period defined in this study, the main resources

were employed for the treatment of limb-threatening ischemia, aortic pathologies, and carotid stenosis. A higher rate of severe clinical presentation in patients with chronic limb ischemia and larger diameter abdominal aortic aneurysms were observed. Inpatient activities documented an increase in “complicated” diagnoses (DRG 554 and DRG 110), LOS, and major limb amputation. Even if the total reimbursement of vascular activities was reduced, we observed an increase in the reimbursement for each vascular procedure and for all “complicated” pathologies, implying that treatment of pathologies considered more serious with greater resource demands was prioritized.

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