

## Article

# How the First Year of the COVID-19 Pandemic Impacted Patients' Care in the Vascular Surgery Divisions of the Southern Regions of the Italian Peninsula

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**Abstract: Background:** To investigate the effects of the COVID-19 lockdowns on the vasculopathic population. **Methods:** The Divisions of Vascular Surgery of the southern Italian peninsula joined this multicenter retrospective study conducted through cross-sectional survey. Each received a 13-point questionnaire, investigating the hospitalization rate of vascular patients in the first 11 months of the COVID-19 pandemic and in the preceding 11 months. **Results:** 27 out of 29 Centers were enrolled. April-December 2020 (7092 patients) vs 2019 (9161 patients): post-EVAR surveillance, treatment for Rutherford category 3 peripheral arterial disease, and asymptomatic carotid stenosis revascularization significantly decreased [1484 (16.2%) vs 1014 (14.3%),  $p=0.0009$ ; 1401 (15.29%) vs 959 (13.52%),  $p=0.0006$ ; and 1558 (17.01%) vs 934 (13.17%),  $p<0.0001$ , respectively]; while revascularization or major amputations for chronic limb-threatening ischemia, and urgent revascularization for symptomatic carotid stenosis significantly increased [1204 (16.98%) vs 1245 (13.59%),  $p<0.0001$ ; 355 (5.01%) vs 358 (3.91%),  $p=0.0007$ ; and 153 (2.16%) vs 140 (1.53%),  $p=0.0009$ , respectively]. **Conclusions:** The suspension of elective activities during the COVID-19 pandemic caused a significant reduction in asymptomatic carotid stenosis revascularization, treatment for Rutherford 3 peripheral arterial disease, post-EVAR surveillance. Contestually, we observed a significant increase in urgent revascularization for symptomatic carotid stenosis, and revascularization or major amputations for chronic limb-threatening ischemia.

**Keywords:** COVID-19; carotid stenosis; abdominal aortic aneurysm; chronic limb-threatening ischemia; amputation; deep venous thrombosis

## 1. Introduction

The Coronavirus disease 2019 (COVID-19) pandemic has changed lifestyles and working activities worldwide. Following the publication of the Italian government decree in March 2020, three-month strict lockdown measures were implemented countrywide to avoid social contact. Hospital-related routines were interrupted to give priority to the management of COVID-19 cases; in particular, outpatient and elective surgery were postponed.

Similar prevention and public health interventions were implemented from the second half of September up to the beginning of December 2020 in response to the second wave of the pandemic. Furthermore, except for situations of proven urgency, the quality of diagnostic and therapeutic care of General Medicine in Southern Italy was impacted negatively during the lockdowns, affecting the diagnosis, management and surveillance of the vascular patients.

This study was conducted to assess the eventual impact of suspension of elective vascular surgery on the incidence rates of complications caused by common vascular conditions compared to the pre-pandemic period.

## 2. Materials and Methods

A multicenter retrospective cross-sectional study was carried out: the majority of public vascular surgery wards, or accredited with the National Health System (NHS),

located in the south of the Italian peninsula were enrolled (i.e., the regions of Campania, Molise, Basilicata, Puglia, Calabria; population: 12,646,486; area: 62,809 km<sup>2</sup>, figure 1).



**Figure 1.** The five regions of the southern Italian peninsula (reproduced with permission from Atlante Geografico Mondiale. Milan, Italy: Touring Club Italiano, 2021).

Even though healthcare policies are issued at a regional level in Italy, the above-mentioned regions implemented similar COVID-19 restrictions.

Twenty-seven vascular surgery divisions joined the study; only two centers (one public and one private) declined to participate due to the lack of human resources for data collection. A 13-item questionnaire was provided, asking the number of patients that underwent:

- 1) open repair or endovascular aneurysm repair (EVAR) for asymptomatic abdominal aortic aneurysm (AAA);
- 2) open repair or EVAR for primary ruptured or symptomatic AAA;
- 3) duplex or computed-tomography scans performed for post-EVAR surveillance;
- 4) Previous EVAR treated again (in an open or endovascular fashion) for recurring symptomatic or ruptured AAA, or for endoleak at risk of AAA rupture (type 1, 3, or 2 with sac expansion);
- 5) open, or endovascular treatments for thrombotic, non-embolic, acute lower limb ischemia;
- 6) treatments for Rutherford category 3 peripheral arterial disease (R3-PAD), in socially active patients with very short distance intermittent claudication (less than 50 mt. on the flat), not responsive to best medical therapy, and asking for a resolute treatment to improve their life-style;
- 7) open or endovascular revascularizations for chronic limb-threatening ischemia (CLTI);
- 8) CLTI patients who have had a thigh or leg amputated;
- 9) open or endovascular revascularizations for asymptomatic severe internal carotid artery (ICA) stenosis;

- 10) Asymptomatic severe ICA stenosis on surgical waiting list, complicated to total obstruction (with or without neurological symptoms);
- 11) symptomatic ICA stenosis operated in urgency;
- 12) conservative or surgical treatments for venous ulcers;
- 13) diagnosis of deep vein thrombosis (DVT), also from requests of consultation from the emergency room or any medical/surgical divisions.

The aim was to compare these vascular surgery activities before (11 months pre-COVID-19) and during the COVID-19 pandemic (11 months since the beginning of the pandemic).

Indications for carotid, AAA, CLTI, and venous surgery, as well as the diagnosis of vascular diseases, are those reported in the current, well-known, international guidelines.

Informed consent for the present study was waived because of the retrospective and aggregated nature of the study analysis. Being an observational study, according to the Italian law, a mandatory approval is not needed.

Clinical characteristics were described with absolute and relative (percentage) frequencies. Qualitative variables were compared using the chi-square test. Percentage differences for the collected variables (delta) between pre-COVID-19 and COVID-19 periods were computed. A two-tailed p-value <0.05 was considered statistically significant. All statistical analyses were carried out using the STATA software version 17 (StataCorp LLC, TX, USA).

### 3. Results

Information on 19,603 cases was collected: 11,129 (56.8%) during the pre-COVID period (Table 1a), 8,474 (43.2%) during the COVID-period (Table 1b).

**Table 1a.** Summary of the responses to the questionnaire: the pre-COVID period.

Time period→ Questions ↓	April 2019	May 2019	June 2019	July 2019	August 2019	September 2019	October 2019	November 2019	December 2019	January 2020	February 2020
#1	99	108	93	94	45	102	125	120	105	102	90
#2	184	182	192	159	77	173	197	175	145	162	155
#3	16	12	14	10	6	16	11	10	11	11	10
#4	171	180	152	153	88	162	166	179	150	175	128
#5	47	45	53	51	40	53	53	58	55	59	49
#6	57	71	67	68	53	58	85	75	54	67	52
#7	87	90	82	77	76	79	97	86	79	96	77
#8	162	180	188	183	99	189	190	207	160	164	158
#9	16	21	12	12	15	19	18	30	32	18	17
#10	46	169	165	145	108	151	159	166	136	141	136
#11	44	48	45	41	40	36	38	32	34	34	37
#12	0	1	2	0	0	2	1	0	1	0	1
#13	18	9	14	15	8	20	20	22	14	16	13

**Table 1b.** Summary of the responses to the questionnaire: the COVID period.

Time period→ Questions ↓	March 2020	April 2020	May 2020	June 2020	July 2020	August 2020	September 2020	October 2020	November 2020	December 2020	January 2021
#1	69	53	58	73	81	52	97	109	87	81	85
#2	67	50	69	115	131	76	149	149	142	133	144
#3	5	5	8	11	10	8	14	9	8	7	6
#4	79	47	78	125	118	80	153	147	113	98	92
#5	41	44	37	45	37	42	47	42	38	38	44
#6	32	25	47	61	68	41	67	48	61	43	61
#7	63	67	71	91	86	71	86	85	68	70	76
#8	66	52	90	124	124	66	126	144	115	93	87
#9	14	14	22	21	18	16	24	23	15	18	15
#10	90	89	121	138	152	92	160	171	142	139	142
#11	31	43	36	41	44	36	44	38	42	31	44
#12	4	0	0	1	0	0	1	1	2	0	0
#13	12	12	19	11	21	15	16	18	23	18	13

Imaging for post-EVAR surveillance, treatment for R3-PAD, and asymptomatic ICA stenosis revascularization significantly decreased (16.2% vs 14.3%,  $p=0.0009$ ; 15.29% vs 13.52%,  $p=0.0006$ ; 17.01% vs 13.17%,  $p<0.0001$ , respectively) during the COVID-19 period from April to December 2020, compared to the same time-period of the previous pre-pandemic year. During the COVID-19 period open repair or EVAR for primary ruptured or symptomatic AAA, open or endovascular revascularization for CLTI, major amputations for CLTI, urgent revascularization for symptomatic ICA stenosis, and the diagnosis of DVT significantly increased (2.41% vs 1.91%,  $p=0.03$ ; 16.98% vs 13.59%,  $p<0.0001$ ; 5.01% vs 3.91%,  $p=0.0007$ ; 2.16% vs 1.53%,  $p=0.0009$ ; 9.8% vs 8.22%,  $p=0.0004$ , respectively, table 2).

**Table 2.** Summary of the responses to the questionnaire for the COVID period from April to December 2020, compared with the non-COVID period from April to December 2019.

	Activities	April/December 2019 (no COVID) (n= 9161) n (%)	April/December 2020 (COVID) (n= 7092) n (%)	p-value	Delta %
#1	Open repair / EVAR for asymptomatic AAA	891 (9.73)	691 (9.74)	1.00	-22.45
#2	Open repair / EVAR for primary ruptured or symptomatic AAA	175 (1.91)	171 (2.41)	0.03	-2.29
#3	Post-EVAR surveillance	1484 (16.2)	1014 (14.3)	0.0009	-31.67
#4	Previous EVAR treated again for recurring symptomatic or ruptured AAA, or endoleak type 1, 3, or 2 with sac expansion	106 (1.16)	80 (1.13)	0.55	-24.53
#5	Treatment for thrombotic acute lower limb ischemia	455 (4.97)	370 (5.22)	0.57	-18.68
#6	Treatment for R3-PAD	1401 (15.29)	959 (13.52)	0.0006	-31.55
#7	Revascularizations for CLTI	1245 (13.59)	1204 (16.98)	<0.0001	-3.29
#8	Major amputations for CLTI	358 (3.91)	355 (5.01)	0.0007	-0.84
#9	Revascularizations for asymptomatic severe ICA stenosis	1558 (17.01)	934 (13.17)	<0.0001	-40.05
#10	Asymptomatic severe ICA stenosis on surgical waiting list complicated to total obstruction	7 (0.08)	5 (0.07)	0.91	-28.57
#11	Symptomatic ICA stenosis operated in urgency	140 (1.53)	153 (2.16)	0.0009	9.29
#12	Treatment for venous ulcers	588 (6.42)	461 (6.5)	0.80	-21.60
#13	Diagnosis of deep vein thrombosis	753 (8.22)	695 (9.8)	0.0004	-7.70

EVAR, endovascular aneurysm repair; AAA, abdominal aortic aneurysm; R3-PAD, Rutherford category 3 peripheral arterial disease; CLTI, chronic limb-threatening ischemia; ICA, internal carotid artery.

When only April 2019 and April 2020 were compared, the significant decrease in imaging for post-EVAR surveillance, treatment for R3-PAD, and asymptomatic ICA stenosis revascularization was confirmed (19.43%, vs 9.98%  $p<0.0001$ ; 18.06% vs 9.38%,  $p<0.0001$ ; 17.11% vs 10.38%,  $P: 0.0006$ , respectively), as well as the significant increase in open or endovascular revascularization for CLTI, major amputations for CLTI, and the diagnosis of DVT (17.76% vs 4.86%,  $p<0.0001$ ; 8.58% vs 4.65%,  $p=0.002$ ; 13.37% vs 9.19%,  $p=0.01$ , respectively). Furthermore, a significant decrease in the number of patients requiring further treatment after EVAR (1.69% vs 1%,  $p=0.006$ ) and a significant increase of patients treated for acute, thrombotic lower limb ischemia was found (8.78% vs 4.96%,  $p=0.005$ , table 3).



**Table 3.** Summary of the responses to the questionnaire for the COVID month of April 2020, compared with the non-COVID month of April 2019.

	Activities	April 2019 (no COVID) (n= 947) n (%)	April 2020 (COVID) (n= 501) n (%)	p- value	Delta %
#1	Open repair / EVAR for asymptomatic AAA	99 (10.45)	53 (10.58)	0.91	-46.46
#2	Open repair / EVAR for primary ruptured or symptomatic AAA	16 (1.69)	14 (2.79)	0.16	-12.50
#3	Post-EVAR surveillance	184 (19.43)	50 (9.98)	<0.0001	-72.83
#4	Previous EVAR treated again for recurring symptomatic or ruptured AAA, or endoleak type 1, 3, or 2 with sac expansion	16 (1.69)	5 (1)	0.006	-68.75
#5	Treatment for thrombotic acute lower limb ischemia	47 (4.96)	44 (8.78)	0.005	-6.38
#6	Treatment for R3-PAD	171 (18.06)	47 (9.38)	<0.0001	-72.51
#7	Revascularizations for CLTI	46 (4.86)	89 (17.76)	<0.0001	93.48
#8	Major amputations for CLTI	44 (4.65)	43 (8.58)	0.002	-2.27
#9	Revascularizations for asymptomatic severe ICA stenosis	162 (17.11)	52 (10.38)	0.0006	-67.90
#10	Asymptomatic severe ICA stenosis on surgical waiting list complicated to total obstruction	0 (0)	0 (0)	-	-
#11	Symptomatic ICA stenosis operated in urgency	18 (1.9)	12 (2.4)	0.52	-33.33
#12	Treatment for venous ulcers	57 (6.02)	25 (4.99)	0.43	-56.14
#13	Diagnosis of deep vein thrombosis	87 (9.19)	67 (13.37)	0.01	-22.99

EVAR, endovascular aneurysm repair; AAA, abdominal aortic aneurysm; R3-PAD, Rutherford category 3 peripheral arterial disease; CLTI, chronic limb-threatening ischemia; ICA, internal carotid artery.

The comparison between May-June 2019 and May-June 2020 highlighted similar decreases in imaging for post-EVAR surveillance and asymptomatic ICA stenosis revascularization (17.04% vs 12.16%,  $p=0.0001$ , and 16.77% vs 14.14%,  $p=0.03$ , respectively), and increases in open repair or EVAR for primary ruptured or symptomatic AAA, urgent revascularization for symptomatic ICA stenosis, and the diagnosis of DVT (2.84% vs 1.5%,  $p=0.006$ ; 1.98% vs 1.05%,  $p=0.01$ ; 10.71% vs 7.84%,  $p=0.002$ , respectively, table 4).

**Table 4.** Summary of the responses to the questionnaire for the COVID months of May-June 2020, compared with the non-COVID months of May-June 2019.

	Activities	May-June 2019 (no COVID) (n= 2195) n (%)	May-June 2020 (COVID) (n= 1513) n (%)	p- value	Delta %
#1	Open repair / EVAR for asymptomatic AAA	201 (9.16)	131 (8.66)	0.60	-34.83
#2	Open repair / EVAR for primary ruptured or symptomatic AAA	33 (1.5)	43 (2.84)	0.006	30.30
#3	Post-EVAR surveillance	374 (17.04)	184 (12.16)	0.0001	-50.80
#4	Previous EVAR treated again for recurring symptomatic or ruptured AAA, or endoleak type 1, 3, or 2 with sac expansion	26 (1.18)	19 (1.26)	0.79	-26.92
#5	Treatment for thrombotic acute lower limb ischemia	98 (4.46)	82 (5.42)	0.21	-16.33
#6	Treatment for R3-PAD	332 (15.13)	203 (13.42)	0.15	-38.86
#7	Revascularizations for CLTI	334 (15.22)	259 (17.12)	0.12	-22.46
#8	Major amputations for CLTI	93 (4.24)	77 (5.09)	0.20	-17.20
#9	Revascularizations for asymptomatic severe ICA stenosis	368 (16.77)	214 (14.14)	0.03	-41.85
#10	Asymptomatic severe ICA stenosis on surgical waiting list complicated to total obstruction	3 (0.14)	1 (0.07)	1.00	-66.67
#11	Symptomatic ICA stenosis operated in urgency	23 (1.05)	30 (1.98)	0.01	30.43
#12	Treatment for venous ulcers	138 (6.29)	108 (7.14)	0.34	-21.74
#13	Diagnosis of deep vein thrombosis	172 (7.84)	162 (10.71)	0.002	-5.81

EVAR, endovascular aneurysm repair; AAA, abdominal aortic aneurysm; R3-PAD, Rutherford category 3 peripheral arterial disease; CLTI, chronic limb-threatening ischemia; ICA, internal carotid artery.

July-August 2019 vs July-August 2020 showed the same significant decrease in asymptomatic carotid stenosis revascularization (16.96% vs 12.79%,  $p=0.001$ ), as well as the same significant increase in urgent revascularization for symptomatic ICA stenosis (2.42% vs 1.38%,  $p=0.04$ , table 5).



**Table 5.** Summary of the responses to the questionnaire for the COVID months of July-August 2020, compared with the non-COVID months of July-August 2019.

	Activities	July-August 2019 (no COVID) (n=1663) n (%)	July-August 2020 (COVID) (n=1485) n (%)	p-value	Delta %
#1	Open repair / EVAR for asymptomatic AAA	139 (8.36)	133 (8.96)	0.55	-4.32
#2	Open repair / EVAR for primary ruptured or symptomatic AAA	27 (1.62)	34 (2.29)	0.15	25.93
#3	Post-EVAR surveillance	236 (14.19)	207 (13.94)	0.81	-12.29
#4	Previous EVAR treated again for recurring symptomatic or ruptured AAA, or endoleak type 1, 3, or 2 with sac expansion	16 (0.96)	18 (1.21)	0.59	12.50
#5	Treatment for thrombotic acute lower limb ischemia	91 (5.47)	79 (5.32)	0.80	-13.19
#6	Treatment for R3-PAD	241 (14.49)	198 (13.33)	0.33	-17.84
#7	Revascularizations for CLTI	253 (15.21)	244 (16.43)	0.36	-3.56
#8	Major amputations for CLTI	81 (4.87)	80 (5.39)	0.53	-1.23
#9	Revascularizations for asymptomatic severe ICA stenosis	282 (16.96)	190 (12.79)	0.001	-32.62
#10	Asymptomatic severe ICA stenosis on surgical waiting list complicated to total obstruction	0 (0)	0 (0)	-	-
#11	Symptomatic ICA stenosis operated in urgency	23 (1.38)	36 (2.42)	0.04	56.52
#12	Treatment for venous ulcers	121 (7.28)	109 (7.34)	1.00	-9.92
#13	Diagnosis of deep vein thrombosis	153 (9.2)	157 (10.57)	0.19	2.61

EVAR, endovascular aneurysm repair; AAA, abdominal aortic aneurysm; R3-PAD, Rutherford category 3 peripheral arterial disease; CLTI, chronic limb-threatening ischemia; ICA, internal carotid artery.

There was a constant significant decrease in asymptomatic ICA stenosis revascularization (17.07% vs 13.72%,  $p=0.002$ ) in September-October 2019 vs September-October 2020 (Table 6).

**Table 6.** Summary of the responses to the questionnaire for the COVID months of September-October 2020, compared with the non-COVID months of September-October 2019.

	Activities	September/ October <b>2019</b> (no COVID) (n= 2220) n (%)	September/ October <b>2020</b> (COVID) (n= 1968) n (%)	p-value	Delta %
#1	Open repair / EVAR for asymptomatic AAA	227 (10.23)	206 (10.47)	0.75	-9.25
#2	Open repair / EVAR for primary ruptured or symptomatic AAA	37 (1.67)	47 (2.39)	0.11	27.03
#3	Post-EVAR surveillance	370 (16.67)	298 (15.14)	0.16	-19.46
#4	Previous EVAR treated again for recurring symptomatic or ruptured AAA, or endoleak type 1, 3, or 2 with sac expansion	27 (1.22)	23 (1.17)	1.00	-14.81
#5	Treatment for thrombotic acute lower limb ischemia	106 (4.77)	89 (4.52)	0.65	-16.04
#6	Treatment for R3-PAD	328 (14.77)	300 (15.24)	0.72	-8.54
#7	Revascularizations for CLTI	310 (13.96)	331 (16.82)	0.01	6.77
#8	Major amputations for CLTI	74 (3.33)	82 (4.17)	0.12	10.81
#9	Revascularizations for asymptomatic severe ICA stenosis	379 (17.07)	270 (13.72)	0.002	-28.76
#10	Asymptomatic severe ICA stenosis on surgical waiting list complicated to total obstruction	3 (0.14)	2 (0.1)	1.00	-33.33
#11	Symptomatic ICA stenosis operated in urgency	40 (1.8)	34 (1.73)	0.81	-15.00
#12	Treatment for venous ulcers	143 (6.44)	115 (5.84)	0.42	-19.58
#13	Diagnosis of deep vein thrombosis	176 (7.93)	171 (8.69)	0.35	-2.84

EVAR, endovascular aneurysm repair; AAA, abdominal aortic aneurysm; R3-PAD, Rutherford category 3 peripheral arterial disease; CLTI, chronic limb-threatening ischemia; ICA, internal carotid artery.

The comparison of November-December 2019 and November-December 2020, showed the same significant decrease in treatment for R3-PAD and asymptomatic ICA stenosis revascularization (15.4% vs 12.98%,  $p=0.04$ , and 17.18% vs 12.8%,  $p<0.0002$ , respectively), as well as the same significant increase in open or endovascular revascularization for CLTI, major amputations for CLTI, and urgent revascularization for symptomatic ICA stenosis (17.29% vs 14.14%,  $p=0.007$ ; 4.49% vs 3.09%,  $p=0.02$ ; 2.52% vs 1.69%,  $p=0.09$ , respectively, table 7).

**Table 7.** Summary of the responses to the questionnaire for the COVID months of November/December 2020, compared with the non-COVID months of November/December 2019.

	Activities	November/ December <b>2019</b> <b>(no COVID)</b> (n= 2136) n (%)	November/ December <b>2020</b> <b>(COVID)</b> (n= 1625) n (%)	p- value	Delta %
#1	Open repair / EVAR for asymptomatic AAA	225 (10.53)	168 (10.34)	0.84	-25.33
#9	Open repair / EVAR for primary ruptured or symptomatic AAA	62 (2.9)	33 (2.03)	0.08	-46.77
#2	Post-EVAR surveillance	320 (14.98)	275 (16.92)	0.11	-14.06
#3	Previous EVAR treated again for recurring symptomatic or ruptured AAA, or endoleak type 1, 3, or 2 with sac expansion	21 (0.98)	15 (0.92)	0.75	-28.57
#5	Treatment for thrombotic acute lower limb ischemia	113 (5.29)	76 (4.68)	0.4	-32.74
#4	Treatment for R3-PAD	329 (15.4)	211 (12.98)	0.04	-35.87
#10	Revascularizations for CLTI	302 (14.14)	281 (17.29)	0.007	-6.95
#11	Major amputations for CLTI	66 (3.09)	73 (4.49)	0.02	10.61
#8	Revascularizations for asymptomatic severe ICA stenosis	367 (17.18)	208 (12.8)	0.0002	-43.32
#12	Asymptomatic severe ICA stenosis on surgical waiting list complicated to total obstruction	1 (0.05)	2 (0.12)	0.14	100.00
#13	Symptomatic ICA stenosis operated in urgency	36 (1.69)	41 (2.52)	0.09	13.89
#6	Treatment for venous ulcers	129 (6.04)	104 (6.4)	0.61	-19.38
#7	Diagnosis of deep vein thrombosis	165 (7.72)	138 (8.49)	0.37	-16.36

EVAR, endovascular aneurysm repair; AAA, abdominal aortic aneurysm; R3-PAD, Rutherford category 3 peripheral arterial disease; CLTI, chronic limb-threatening ischemia; ICA, internal carotid artery.

Groupings of the initial months of 2020 (January-February vs March-April) were characterized by a significant decrease of imaging for post-EVAR surveillance, treatment for R3-PAD, and asymptomatic ICA stenosis revascularization (16.11% vs 10.89%,  $p=0.0001$ ; 15.4% vs 11.73%,  $p=0.005$ ; 16.36% vs 10.99%,  $p=0.0001$ , respectively), while an increase of major amputations for CLTI and diagnoses of DVT was shown (6.89% vs 3.61%,  $p<0.0001$  and 12.1% vs 8.79%,  $p=0.004$ , respectively). Furthermore, a significant increase in the treatment of acute thrombotic lower limb ischemia occurred (7.91% vs 5.49%,  $p=0.01$ , table 8).

**Table 8.** Summary of the responses to the questionnaire for the COVID months of March/April 2020, compared with the non-COVID months of January/February 2020.

	Activities	January/ February 2020 (no COVID) (n= 1968) n (%)	March/ April 2020 (COVID) (n= 1074) n (%)	p- value	Delta %
#1	Open repair / EVAR for asymptomatic AAA	192 (9.76)	122 (11.36)	0.17	-36.46
#2	Open repair / EVAR for primary ruptured or symptomatic AAA	35 (1.78)	28 (2.61)	0.14	-20.00
#3	Post-EVAR surveillance	317 (16.11)	117 (10.89)	0.0001	-63.09
#4	Previous EVAR treated again for recurring symptomatic or ruptured AAA, or endoleak type 1, 3, or 2 with sac expansion	21 (1.07)	10 (0.93)	0.60	-52.38
#5	Treatment for thrombotic acute lower limb ischemia	108 (5.49)	85 (7.91)	0.01	-21.30
#6	Treatment for R3-PAD	303 (15.4)	126 (11.73)	0.005	-58.42
#7	Revascularizations for CLTI	277 (14.08)	179 (16.67)	0.06	-35.38
#8	Major amputations for CLTI	71 (3.61)	74 (6.89)	<0.0001	4.23
#9	Revascularizations for asymptomatic severe ICA stenosis	322 (16.36)	118 (10.99)	0.0001	-63.35
#10	Asymptomatic severe ICA stenosis on surgical waiting list complicated to total obstruction	1 (0.05)	4 (0.37)	0.08	300.00
#11	Symptomatic ICA stenosis operated in urgency	29 (1.47)	24 (2.23)	0.16	-17.24
#12	Treatment for venous ulcers	119 (6.05)	57 (5.31)	0.43	-52.10
#13	Diagnosis of deep vein thrombosis	173 (8.79)	130 (12.1)	0.004	-24.86

EVAR, endovascular aneurysm repair; AAA, abdominal aortic aneurysm; R3-PAD, Rutherford category 3 peripheral arterial disease; CLTI, chronic limb-threatening ischemia; ICA, internal carotid artery.

When comparing only January 2020 and January 2021, treatment for R3-PAD and asymptomatic ICA stenosis revascularization significantly decreased (16.75% vs 11.37%,  $p=0.001$ , and 15.69% vs 10.75%,  $p=0.002$ , respectively); and open or endovascular revascularization for CLTI and major amputations for CLTI significantly increased (17.55% vs 13.49%,  $p=0.02$ , and 5.44% vs 3.25%,  $p=0.02$ , respectively, table 9).

**Table 9.** Summary of the responses to the questionnaire for the COVID month of January 2021, compared with the non-COVID month of January 2021.

	Activities	January 2020 (no COVID) (n= 1045) n (%)	January 2021 (COVID) (n= 809) n (%)	p-value	Delta %
#1	Open repair / EVAR for asymptomatic AAA	102 (9.76)	85 (10.51)	0.62	-16.67
#2	Open repair / EVAR for primary ruptured or symptomatic AAA	18 (1.72)	15 (1.85)	0.87	-16.67
#3	Post-EVAR surveillance	162 (15.5)	144 (17.8)	0.19	-11.11
#4	Previous EVAR treated again for recurring symptomatic or ruptured AAA, or endoleak type 1, 3, or 2 with sac expansion	11 (1.05)	6 (0.74)	0.49	-45.45
#5	Treatment for thrombotic acute lower limb ischemia	59 (5.65)	44 (5.44)	0.85	-25.42
#6	Treatment for R3-PAD	175 (16.75)	92 (11.37)	0.001	-47.43
#7	Revascularizations for CLTI	141 (13.49)	142 (17.55)	0.02	0.71
#8	Major amputations for CLTI	34 (3.25)	44 (5.44)	0.02	29.41
#9	Revascularizations for asymptomatic severe ICA stenosis	164 (15.69)	87 (10.75)	0.002	-46.95
#10	Asymptomatic severe ICA stenosis on surgical waiting list complicated to total obstruction	0 (0)	0 (0)	-	
#11	Symptomatic ICA stenosis operated in urgency	16 (1.53)	13 (1.61)	0.86	-18.75
#12	Treatment for venous ulcers	67 (6.41)	61 (7.54)	0.35	-8.96
#13	Diagnosis of deep vein thrombosis	96 (9.19)	76 (9.39)	0.88	-20.83

EVAR, endovascular aneurysm repair; AAA, abdominal aortic aneurysm; R3-PAD, Rutherford category 3 peripheral arterial disease; CLTI, chronic limb-threatening ischemia; ICA, internal carotid artery.

During the pandemic period from March 2020 to January 2021, 36/1,713 (2.1%) patients who presented with CLTI, 33/501 (6.6%) patients who required major amputation, and 9/207 (4.4%) patients with stroke or transient ischemic attacks tested positive for COVID-19.

The numbers of EVAR or open repair for asymptomatic AAA, treatment for venous ulcers, and severe ICA stenosis >80% (according to the European Carotid Surgery Trial, ECST, parameters) on operating waiting list complicated to total obstruction (detected at duplex control before revascularization, or because become symptomatic) did not change throughout the study period.

#### 4. Discussion

Early identification of life-threatening vascular conditions, which are mostly asymptomatic, is key. Changes during the COVID-19 pandemic could have affected patient prognosis. Several researchers, clinicians, and policymakers have been trying to understand the real impact of the pandemic on clinical activities.

A study carried out in the metropolitan city of Bologna, Italy, focusing on the first 30 days of the COVID-19 pandemic showed that the number of surgical interventions was similar to those recorded in 2018 and 2019. No differences were found in the acute/emergency setting, including interventions for acute ischemia, although SARS-CoV-2 infections trigger thrombogenic mechanisms [1]. On the contrary, in The Netherlands it has been reported that during the lockdown period of March 16th until April 30th 2020, there was a statistically significant increase in CLTI severity and the rates of major amputations, compared to the same time period of the two previous years. No difference in vascular surgical care for patients with a AAA has been observed [2].

A US cross-sectional study focusing on the period from April 14<sup>th</sup> to 24<sup>th</sup> 2020 showed a significant impact on the practice of vascular surgery across the country, with unprecedented number of surgical cases cancelled, and changes in on-call schedules. The

majority of continued elective cases were on aortic repair and maintenance of dialysis function rather than peripheral arterial disease or venous procedures [3]. Similarly, in Indochina almost all vascular interventions were suspended during the COVID-19 outbreak [4].

Our multicenter study, covering more than one-fifth of the Italian geographical area and population, over a longer time-period (11 months before and 11 months during the COVID-19 pandemic) showed a significant decrease in elective interventions for:

- prophylactic ICA revascularization during each month of the pandemic compared to the prior year, as well as during the first two months of the pandemic compared to the prior two months;
- imaging for post-EVAR surveillance from April to June, 2020, compared to the corresponding time-period of 2019, as well as during the first two months of the pandemic (March-April, 2020) in comparison with the two months before it (January-February, 2020);
- treatment for R3-PAD during the first two months of the pandemic in comparison with the two prior months, and in April 2020 and January 2021 when compared with the corresponding month of the previous year.

On the other hand, a significant increase in urgent revascularization for symptomatic ICA stenosis, revascularization for CLTI, major amputations, diagnosis of DVT, open repair or EVAR for primary ruptured or symptomatic AAA, and treatment of acute, thrombotic lower limb ischemia.

The decrease of prophylactic ICA revascularization could be associated with the increased rate of urgent revascularization for symptomatic carotid stenosis.

Furthermore, the decrease in the treatment for R3-PAD in the first two months of the pandemic could explain the increased rate of revascularization and major amputation for CLTI in April and November-December 2020, and January 2021. Around 20% of patients with intermittent claudication experience deterioration of limb status over a 5-year period, and symptomatic deterioration is greatest within the first year after diagnosis [5].

Interestingly, in January 2021 (when the immediate pandemic restrictions were lifted) a major decrease in the treatment of R3-PAD and severe asymptomatic ICA stenosis persisted compared to pre-pandemic levels. Our analysis suggests that the delays may have further consequences in the coming months. Project 1 (Impact of COVID-19 on scheduled vascular operations) of the international Vascular Surgery COVID-19 Collaborative (VASCC) registry aims to answer this particular question. VASCC is a combined international effort to obtain prospective data on the impact of widespread vascular surgical care delays due to an international crisis or pandemic [6,7].

An increased rate of DVT during the first four months of the pandemic and of thrombotic acute lower limb ischemia recalls the prothrombotic effects of the SARS-CoV-2 infection [8,9]. The broad spectrum of clinical manifestations, affecting almost all organs and systems, is a consequence of the endothelial dysfunction and systemic inflammatory response. Endothelial cells activated by a hyperinflammatory state induced by viral infection may promote localized inflammation, increase reactive oxidative species production, and alter dynamic interplay between the procoagulant and fibrinolytic factors in the vascular system, leading to thrombotic disease not only in the pulmonary circulation but also in peripheral veins and arteries [10].

Although the US national trends in Vascular Surgical Practice showed a decreased rate of urgent and emergency aortic and carotid interventions, our study described an increased rate of open repair or EVAR for ruptures or symptomatic AAA, and of symptomatic carotid stenosis treated with urgency [11].

The constant trends of patients who underwent EVAR or open repair for primary asymptomatic AAA during the current pandemic could be associated with the positive organization of healthcare delivery in the participating centers, although no specific data was collected to support this hypothesis. Similar explanations could support the trends of



conservative or surgical treatment for venous ulcers, although they are managed in wards other than vascular surgery (i.e., vascular medicine and dermatology).

Several study limitations can be highlighted: some vascular diseases (e.g., thoracic or thoraco-abdominal aortic aneurysms and dialysis access) were not considered. Complex aortic procedures are often referred to specialist centers, and we thought numbers would have been too low. In Italy, arteriovenous fistulas are also performed by nephrologists. Likewise, varicose vein surgery was excluded based on its postponement caused by their low priority. We evaluated only the first eleven months of the COVID-19 pandemic against the corresponding 2019 months; as such, inter-annual variability cannot be excluded. The stratification of the findings based on SARS-CoV-2 positivity was not always performed: the infection could have increased the incidence of some vascular diseases (e.g., DVT). Asymptomatic severe ICA stenosis that progressed to occlusion (and thus was managed non surgically) could have been missed, since it can cause cerebral ischemia which can be managed in different medical wards (e.g., stroke unit, intensive care unit, neurology, internal medicine) and thus under-reported.

## 5. Conclusion

The interruption of elective surgery during the COVID-19 pandemic caused decreased rates of prophylactic carotid revascularization, treatment for very short-distance intermittent claudication, and post-EVAR surveillance. Those findings are associated with the increased rate of urgent revascularization for symptomatic carotid stenosis, CLTI and subsequent major amputations.

The vascular community is called upon to raise awareness of the dangers arising from restrictions in the management of these elective vascular patients during the pandemic crisis.

The long-term effects on the management of vascular patients should be evaluated in the near future.

**Author Contributions:** Conceptualization, EM, GS, LS, MF, GS, MZ, ARM, GA, GB, FB, UMB, EC, GC, GC, AC, SDV, CPD, LF, GI, FI, LI, GM, PM, MM, GN, VP, FP, FP, RP, DR, MRR, CR, PS, GV, PV, AMS; Methodology, EM, GS, LS, MF, GS, MZ, ARM, AB, PB, MB, EMC, FC, LC, ASDA, MDL, CD, DDL, GDN, AD, IF, AG, ANG, AL, MM, VM, AP, MP, AP, SP, RP, MT, AMS; Validation, EM, GS, LS, MF, GS, MZ, ARM, AB, PB, MB, EMC, FC, LC, ASDA, MDL, CD, DDL, GDN, AD, IF, AG, ANG, AL, MM, VM, AP, MP, AP, SP, RP, MT, AMS; Formal analysis, EM, GS, LS, MF, GS, MZ, ARM, AMS; Investigation, EM, GS, LS, MF, GS, MZ, ARM, AB, PB, MB, EMC, FC, LC, ASDA, MDL, CD, DDL, GDN, AD, IF, AG, ANG, AL, MM, VM, AP, MP, AP, SP, RP, MT, AMS; Resources, EM, GS, LS, MF, GS, MZ, ARM, GA, GB, FB, UMB, EC, GC, GC, AC, SDV, CPD, LF, GI, FI, LI, GM, PM, MM, GN, VP, FP, FP, RP, DR, MRR, CR, PS, GV, PV, AMS; Data curation, EM, GS, LS, MF, GS, MZ, ARM, AB, PB, MB, EMC, FC, LC, ASDA, MDL, CD, DDL, GDN, AD, IF, AG, ANG, AL, MM, VM, AP, MP, AP, SP, RP, MT, AMS; Writing—original draft preparation, EM, GS, LS, MF, GS, MZ, ARM, AMS; Writing—review and editing, EM, GS, LS, MF, GS, MZ, ARM, GA, GB, FB, UMB, EC, GC, GC, AC, SDV, CPD, LF, GI, FI, LI, GM, PM, MM, GN, VP, FP, FP, RP, DR, MRR, CR, PS, GV, PV, AB, PB, MB, EMC, FC, LC, ASDA, MDL, CD, DDL, GDN, AD, IF, AG, ANG, AL, MM, VM, AP, MP, AP, SP, RP, MT, AMS; Visualization, EM, GS, LS, MF, GS, MZ, ARM, AB, PB, MB, EMC, FC, LC, ASDA, MDL, CD, DDL, GDN, AD, IF, AG, ANG, AL, MM, VM, AP, MP, AP, SP, RP, MT, AMS; Supervision, EM, GS, LS, MF, GS, MZ, ARM, GA, GB, FB, UMB, EC, GC, GC, AC, SDV, CPD, LF, GI, FI, LI, GM, PM, MM, GN, VP, FP, FP, RP, DR, MRR, CR, PS, GV, PV, AMS; Project administration, EM, GS, LS, MF, GS, MZ, ARM, GA, GB, FB, UMB, EC, GC, GC, AC, SDV, CPD, LF, GI, FI, LI, GM, PM, MM, GN, VP, FP, FP, RP, DR, MRR, CR, PS, GV, PV, AMS; All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Ethical review and approval were waived. Being an observational study, according to the Italian law, a mandatory approval is not needed.

**Informed Consent Statement:** Patient consent was waived due to the retrospective and aggregated nature of the study analysis.

**Data Availability Statement:** Raw data was obtained from the vascular surgery divisions of the southern regions of the Italian peninsula and are readily available for presentation to the referees and the editors of the journal, if requested.

**Acknowledgments:** The authors gratefully acknowledge Edoardo Guarino, M Eng, M Sc, for the English revision of this manuscript.

**Conflicts of Interest:** The authors declare no conflict of interest.

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